Jyothi Engineering College

NAAC Accredited College with NBA Accredited Programmes*

Approved by AICTE & affiliated to APJ Abdul Kalam Technological University

A CENTRE OF EXCELLENCE IN SCIENCE & TECHNOLOGY BY THE CATHOLIC ARCHDIOCESE OF TRICHUR

JYOTHI HILLS, VETTIKATTIRI P.O. CHERUTHURUTHY, THRISSUR, PIN-679531 PH : +91- 4884-259000, 274423 FAX : 04884-274777

NBA accredited B.Tech Programmes in Computer Science & Engineering, Electronics & Communication Engineering, Electrical & Electronics Engineering and Mechanical Engineering valid for the academic years 2016-2022. NBA accredited B.Tech Programme in Civil Engineering valid for the academic years 2019-2022.

CURRICULUM

B.TECH (2019 SCHEME)

Dr. SUNNY JOSEPH KALAYATHANKAL
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CIVIL ENGINEERING

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SEMESTER I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B 1/2	PHT 110	ENGINEERING PHYSICS B	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	--
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		**23/24 ***	**17**

*Minimum hours per week

NOTE:

To make up for the hours lost due to induction program, one extra hour may be allotted to each course

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SEMESTER II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B 1/2	PHT 110	ENGINEERING PHYSICS B	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	4	—
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		28/29	21

NOTE:

1. Engineering Physics B and Engineering Chemistry shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Physics B in SI and Engineering Chemistry in S2 & vice versa. Students opting for Engineering Physics B in a semester should attend Physics Lab in the same semester and students opting for Engineering Chemistry in one semester should attend Engineering Chemistry Lab in the same semester.
2. Engineering Mechanics and Engineering Graphics shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Mechanics in SI and Engineering Graphics in S2 & vice versa.
3. Basics of Civil & Mechanical Engineering and Basics of Electrical & Electronics Engineering shall be offered in both semesters. Basics of Civil & Mechanical Engineering contain equal weightage for Civil Engineering and Mechanical Engineering. Slot for the course is D with CIE marks of [illegible] and ESE marks of 50 each. Students belonging to branches of AEI, EI, BME, ECE, EEE, [illegible] RA can choose this course in S1.

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Basics of Electrical & Electronics Engineering contain equal weightage for Electrical Engineering and Electronics Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to AERO, AUTO, CE, FSE, IE, ME, MECHATRONICS, PE, METTULURGY, BT, BCE, CHEM, FT, POLY can choose this course in S1. Students having Basics of Civil & Mechanical Engineering in one semester should attend Civil & Mechanical Workshop in the same semester and students having Basics of Electrical & Electronics Engineering in a semester should attend Electrical & Electronics Workshop in the same semester.

4. LIFE SKILLS

Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underlie personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

5. PROFESSIONAL COMMUNICATION

Objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. Coverage: Listening, Barriers to listening, Steps to overcome them, Purposive listening practice, Use of technology in the professional world. Speaking, Fluency & accuracy in speech, Positive thinking, Improving self-expression, Tonal variations, Group discussion practice. Reading, Speed reading practice, Use of extensive readers, Analytical and critical reading practice, Writing Professional Correspondence, Formal and informal letters, Tone in formal writing, Introduction to reports. Study Skills, Use of dictionary, thesaurus etc., Importance of contents page, cover & back pages, Bibliography, Language Lab.

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SEMESTER III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT201	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
B	CET201	MECHANICS OF SOLIDS	3-1-0	4	4
C	CET203	FLUID MECHANICS& HYDRAULICS	3-1-0	4	4
D	CET205	SURVEYING & GEOMATICS	4-0-0	4	4
E 1/2	EST200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	CEL201	CIVIL ENGINEERING PLANNING &DRAFTING LAB	0-0-3	3	2
T	CEL203	SURVEY LAB	0-0-3	3	2
R/M	VAC	Remedial/Minor course	3-1-0	4 *	4
		TOTAL		**26/30**	**22/26**

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions shall keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT202	PROBABILITY, STATISTICS AND NUMERICAL METHODS	3-1-0	4	4
B	CET202	ENGINEERING GEOLOGY	3-0-1	4	4
C	CET204	GEOTECHNICAL ENGINEERING – I	4-0-0	4	4
D	CET206	TRANSPORTATION ENGINEERING	4-0-0	4	4
E 1/2	EST200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN202	CONSTITUTION OF INDIA	2-0-0	2	--
S	CEL202	MATERIAL TESTING LAB– I	0-0-3	3	2
T	CEL204	FLUID MECHANICS LAB	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
		TOTAL		26/30	22/26

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CET301	STRUCTURAL ANALYSIS – I	3-1-0	4	4
B	CET303	DESIGN OF CONCRETE STRUCTURES	3-1-0	4	4
C	CET305	GEOTECHNICAL ENGINEERING – II	4-0-0	4	4
D	CET307	HYDROLOGY & WATER RESOURCES ENGINEERING	4-0-0	4	4
E	CET309	CONSTRUCTION TECHNOLOGY& MANAGEMENT	3-0-0	3	3
F	MCN301	DISASTER MANAGEMENT	2-0-0	2	--
S	CEL331	MATERIAL TESTING LAB – II	0-0-3	3	2
T	CEL333	GEOTECHNICAL ENGINEERING LAB	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
		TOTAL		27/31	23/27

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 3 to 5 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.

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SEMESTER VI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CET302	STRUCTURAL ANALYSIS – II	3-1-0	4	4
B	CET304	ENVIRONMENTAL ENGINEERING	4-0-0	4	4
C	CET306	DESIGN OF HYDRAULIC STRUCTURES	4-0-0	4	4
D	CETXXX	PROGRAM ELECTIVE I	3-0-0	3	3
E	HUT300	INDUSTRIAL ECONOMICS & FOREIGN TRADE	3-0-0	3	3
F	CET308	COMREHENSIVE COURSE WORK	1-0-0	1	1
S	CEL332	TRANSPORTATION ENGINEERING LAB	0-0-3	3	2
T	CEL334	CIVIL ENGINEERING SOFTWARE LAB	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
		TOTAL		**25/29**	**23/27**

PROGRAM ELECTIVE I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	CET312	ADVANCED COMPUTATIONAL METHODS	3-0-0	3	3
	CET322	GEOTECHNICAL INVESTIGATION	3-0-0		
	CET332	TRAFFIC ENGINEERING & MANAGEMENT	3-0-0		
	CET342	MECHANICS OF FLUID FLOW	3-0-0		
	CET352	ADVANCED CONCRETE TECHNOLOGY	3-0-0		
	CET362	ENVIRONMENTAL IMPACT ASSESSMENT	3-0-0		
	CET372	FUNCTIONAL DESIGN OF BUILDINGS	3-0-0		

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NOTE:

1. **All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 2 to 4 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honors programme, he/she can be given remedial class.
2. Comprehensive Course Work: The comprehensive course work in the sixth semester of study shall have a written test of 50 marks. The written examination will be of objective type similar to the GATE examination and will be conducted online by the University. **Syllabus for comprehensive examination shall be prepared by the respective BoS choosing any 5 core courses studied from semester 3 to 5.** The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum.

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SEMESTER VII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CET401	DESIGN OF STEEL STRUCTURES	3-0-0	3	3
B	CETXXX	PROGRAM ELECTIVE II	3-0-0	3	3
C	CETXXX	OPEN ELECTIVE	3-0-0	3	3
D	MCN401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	CEL411	ENVIRONMENTAL ENGG LAB	0-0-3	3	2
T	CEQ413	SEMINAR	0-0-3	3	2
U	CED415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
TOTAL				24/28	15/19

PROGRAM ELECTIVE II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	CET413	PRESTRESSED CONCRETE	3-0-0	3	3
	CET423	GROUND IMPROVEMENT TECHNIQUES	3-0-0		
	CET433	HIGHWAY MATERIALS AND DESIGN	3-0-0		
	CET443	APPLIED HYDROLOGY	3-0-0		
	CET453	CONSTRUCTION PLANNING & MANAGEMENT	3-0-0		
	CET463	ADVANCED ENVIRONMENTAL ENGINEERING	3-0-0		
	CET473	OPTIMISATION TECHNIQUES IN CIVIL ENGINEERING	3-0-0		

OPEN ELECTIVE

The open elective is offered in semester 7. Each program should specify the courses (maximum 5) they would like to offer as electives for other programs. The courses listed below are offered by the **Department of CIVIL ENGINEERING for students of other undergraduate branches offered in the college.**

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	CET415	ENVIRONMENTAL IMPACT ASSESSMENT	2-1-0	3	3
	CET425	APPLIED EARTH SYSTEMS	2-1-0		
	CET435	INFORMATICS FOR INFRASTRUCTURE MANAGEMENT	2-1-0		
	CET445	NATURAL DISASTERS AND MITIGATION	2-1-0		
	CET455	ENVIRONMENTAL HEALTH AND SAFETY	2-1-0		
	CET465	GEOINFORMATICS	2-1-0		

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honors course (Mondays from 10 to 12 and Wednesdays from 10 to 12 Noon). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Seminar: To encourage and motivate the students to read and collect recent and reliable information from their area of interest confined to the relevant discipline from technical publications including peer reviewed journals, conference, books, project reports etc., prepare a report based on a central theme and present it before a peer audience. Each student shall present the seminar for about 20 minutes duration on the selected topic. The report and the presentation shall be evaluated by a team of internal members comprising three senior faculty members based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the report.

Total marks: 100, only CIE, minimum required to pass 50

Attendance	10
Guide	20
Technical Content of the Report	30
Presentation	40

3. Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Civil Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:
   - Survey and study of published literature on the assigned topic;
   - Preparing an Action Plan for conducting the investigation, including team work;
   - Working out a preliminary Approach to the Problem relating to the assigned topic;
   - Block level design documentation
   - Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility

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- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final Seminar, as oral Presentation before the evaluation committee.

Total marks: 100, only CIE, minimum required to pass 50

Guide	: 30
Interim evaluation by the evaluation committee	: 20
Final Seminar	: 30
The report evaluated by the evaluation committee	: 20

The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor

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SEMESTER VIII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CET402	QUANTITY SURVEYING & VALUATION	3-0-0	3	3
B	CETXXX	PROGRAM ELECTIVE III	3-0-0	3	3
C	CETXXX	PROGRAM ELECTIVE IV	3-0-0	3	3
D	CETXXX	PROGRAM ELECTIVE V	3-0-0	3	3
E	CET404	COMPREHENSIVE VIVA VOCE	1-0-0	1	1
U	CED416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
		TOTAL		25/29	17/21

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PROGRAM ELECTIVE III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	CET414	ADVANCED STRUCTURAL DESIGN	3-0-0	3	3
	CET424	GEOENVIRONMENTAL ENGINEERING	3-0-0		
	CET434	RAILWAY AND TUNNEL ENGINEERING	3-0-0		
	CET444	IRRIGATION & DRAINAGE ENGINEERING	3-0-0		
	CET454	CONSTRUCTION METHODS & EQUIPMENT	3-0-0		
	CET464	AIRQUALITY MANAGEMENT	3-0-0		
	CET474	URBAN PLANNING & ARCHITECTURE	3-0-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	CET416	BRIDGE ENGINEERING	3-0-0	3	3
	CET426	ADVANCED FOUNDATION DESIGN	3-0-0		
	CET436	TRANSPORTATION PLANNING	3-0-0		
	CET446	INFORMATICS FOR INFRASTRUCTURE MANAGEMENT	3-0-0		
	CET456	REPAIR AND REHABILITATION OF BUILDINGS	3-0-0		
	CET466	ENVIRONMENTAL REMOTESENSING	3-0-0		
	CET476	BULDING SERVICES	3-0-0		

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PROGRAM ELECTIVE V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	CET418	EARTHQUAKERESISTANT DESIGN	3-0-0	3	3
	CET428	SOIL STRUCTURE INTERACTION	3-0-0		
	CET438	AIRPORT, SEAPORT AND HARBOUR ENGINEERING	3-0-0		
	CET448	HYDROCLIMATOLOGY	3-0-0		
	CET458	SUSTAINABLE CONSTRUCTION	3-0-0		
	CET468	CLIMATE CHANGE & SUSTAINABILITY	3-0-0		
	CET478	BUILDING INFORMATION MODELLING	3-0-0		

NOTE

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12). If a student does not opt for minor/honors programme, he/she can be given remedial class.
2. Comprehensive Course Viva: The comprehensive course viva in the eighth semester of study shall have a viva voce for 50 marks. The viva voce shall be conducted based on the syllabus mentioned for comprehensive course work in the sixth semester. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation towards the end of the semester. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
3. **Project Phase II:** The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up in Project 1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:
    - In depth study of the topic assigned in the light of the Report prepared under PhaseI;
    - Review and finalization of the Approach to the Problem relating to the assigned topic;
    - Detailed Analysis/ Modelling/ Simulation/ Design/ Problem Solving/ Experiment as needed;
    - Final development of product/process, testing, results, conclusions and future directions;
    - Preparing a paper for Conference presentation/Publication in Journals, if possible;
    - Preparing a Dissertation in the standard format for being evaluated by the Department;
    - Final Presentation before a Committee

Total marks: 150, only CIE, minimum required to pass 75

Guide	30
Interim evaluation, 2 times in the semester by the evaluation committee	50
Quality of the report evaluated by the above committee	30
Final evaluation by a three member committee	40

(The final evaluation committee comprises Project coordinator, expert from industry/research institute

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and a senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks).

MINOR

Minor is an additional credential a student may earn if s/he does 20 credits worth of additional learning in a discipline other than her/his major discipline of B.Tech. degree. The objective is to permit a student to customize their Engineering degree to suit their specific interests. Upon completion of an Engineering Minor, a student will be better equipped to perform interdisciplinary research and will be better employable. Engineering Minors allow a student to gain interdisciplinary experience and exposure to concepts and perspectives that may not be a part of their major degree programs.

The academic units offering minors in their discipline will prescribe the set of courses and/or other activities like projects necessary for earning a minor in that discipline. A specialist basket of 3-6 courses is identified for each Minor. Each basket may rest on one or more foundation courses. A basket may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. S/he accumulates credits by registering for the required courses, and if the requirements for a particular minor are met within the time limit for the course, the minor will be awarded. This will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx with Minor in yyy". The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, that minor will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from third to eight semesters for all branches. The minor courses shall be identified by **M slot courses.**

(ii) Registration is permitted for Minor at the beginning of third semester. Total credits required is 182 (162 + 20 credits from value added courses)

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for minor, of which one course shall be a mini project based on the chosen area. They can do miniproject either in S7 or in S8. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Minor shall be conducted along with regular classes and no extra time shall be required for conducting the courses.

(iv) There won't be any supplementary examination for the courses chosen for Minor.

(v) On completion of the program, "Bachelor of Technology in xxx with Minor in yyy" will be awarded.

(vi) The registration for minor program will commence from semester 3 and the all academic units offering minors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 baskets. The basket of courses may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. Reshuffling of courses between various baskets will not be allowed. In any case, they should carry out a mini project based on the chosen area in S7 or S8. Students who have registered **for B.Tech Minor in CIVIL ENGINEERING Branch** can opt to study the courses listed below:

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Semester	BASKET I				BASKET II				BASKET III			
	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT
S3	CET281	Building construction & structural systems	4	4	CET283	Introduction to Geotechnical Engineering	4	4	CET285	Informatics for Infrastructure Management	4	4
S4	CET282	Building drawing	4	4	CET284	Introduction to Transportation Engineering	4	4	CET286	Climate change & hazard mitigation	4	4
S5	CET381	Structural mechanics	4	4	CET383	Eco-friendly transportation systems	4	4	CET385	Sustainability analysis & design	4	4
S6	CET382	Estimation & costing	4	4	CET384	Geotechnical investigation & ground improvement techniques	4	4	CET386	Environmental health& safety	4	4
S7	CED481	MINI PROJECT	4	4	CED481	MINI PROJECT	4	4	CED481	MINI PROJECT	4	4
S8	CED482	MINI PROJECT	4	4	CED482	MINI PROJECT	4	4	CED482	MINI PROJECT	4	4

HONOURS

Honours is an additional credential a student may earn if s/he opts for the extra 20 credits needed for this in her/his own discipline. Honours is not indicative of class. KTU is providing this option for academically extra brilliant students to acquire Honours. Honours is intended for a student to gain expertise/specialise in an area inside his/her major B.Tech discipline and to enrich knowledge in emerging/advanced areas in the branch of engineering concerned. It is particularly suited for students aiming to pursue higher studies. Upon completion of Honours, a student will be better equipped to perform research in her/his branch of engineering. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx, with Honours." The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, Honours will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. The internal evaluation, examination and grading shall be exactly as for other mandatory courses. The Honours courses shall be identified by H slot courses.

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(i) The curriculum/syllabus committee/BOS shall prepare syllabus for courses to be included in the curriculum from fourth to eight semesters for all branches. The honours courses shall be identified by H slot courses.

(ii) Registration is permitted for Honours at the beginning of fourth semester. Total credits required is 182 (162 + 20 credits from value added courses).

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for honours, of which one course shall be a mini project based on the chosen area. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Honours shall be conducted along with regular classes and no extra time shall be required for conducting the courses. The students should earn a grade of 'C' or better for all courses under honours.

(iv) There won't be any supplementary examination for the courses chosen for honours.

(v) On successful accumulation of credits at the end of the programme, "Bachelor of Technology in xxx, with Honours" will be awarded if overall CGPA is greater than or equal to 8.5, earned a grade of 'C' or better for all courses chosen for honours and without any history of 'F' Grade.

(vi) The registration for honours program will commence from semester 4 and the all academic units offering honours in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. In any case, they should carry out a mini project based on the chosen area in S8. Students who have registered for **B.Tech Honours in CIVIL ENGINEERING** can opt to study the courses listed below:

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Semester	GROUP I				GROUP II				GROUP III			
	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT
S4	CET292	ADVANCED MECHANICS OF SOLIDS	4	4	CET294	PAVEMENT CONSTRUCTION AND MANAGEMENT	4	4	CET296	GEOGRAPHICAL INFORMATION SYSTEMS	4	4
S5	CET393	STRUCTURAL DYNAMICS	4	4	CET395	TRANSPORTATION SYSTEMS MANAGEMENT	4	4	CET397	GROUND WATER HYDROLOGY	4	4
S6	CET394	FINITE ELEMENT METHODS	4	4	CET396	EARTH DAMS AND EARTH RETAINING STRUCTURES	4	4	CET398	ENVIRONMENTAL POLLUTION MODELLING	4	4
S7	CET495	MODERN CONSTRUCTION MATERIALS	4	4	CET497	SOIL DYNAMICS AND MACHINE FOUNDATIONS	4	4	CET499	ENVIRONMENTAL POLLUTION CONTROL TECHNIQUES	4	4
S8	CED496	MINI PROJECT	4	4	CED496	MINI PROJECT	4	4	CED496	MINI PROJECT	4	4

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INDUCTION PROGRAM

There will be three weeks induction program for first semester students. It is a unique three-week immersion Foundation Programme designed especially for the fresher's which includes a wide range of activities right from workshops, lectures and seminars to sports tournaments, social work and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, inculcate values and ethics, and help students to discover their passion. Foundation Programme also serves as a platform for the fresher's to interact with their batchmates and seniors and start working as a team with them. The program is structured around the following five themes:

The programme is designed keeping in mind the following objectives:

- **Values and Ethics**: Focus on fostering a strong sense of ethical judgment and moral fortitude.
- **Creativity**: Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and other creative activities.
- **Leadership, Communication and Teamwork**: Develop a culture of teamwork and group communication.
- **Social Awareness**: Nurture a deeper understanding of the local and global world and our place in at as concerned citizens of the world.
- **Physical Activities & Sports**: Engage students in sports and physical activity to ensure healthy physical and mental growth.

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CURRICULUM FROM SEMESTERS I TO VIII

Every course of B. Tech. Programme shall be placed in one of the nine categories as listed in table below.

Sl. No	Category	Code	Credits
1	Humanities and Social Sciences including Management courses	HMC	5
2	Basic Science courses	BSC	26
3	Engineering Science Courses	ESC	22
4	Program Core Courses	PCC	79
5	Program Elective Courses	PEC	15
6	Open Elective Courses	OEC	3
7	Project work and Seminar	PWS	10
8	Mandatory Non-credit Courses (P/F) with grade	MNC	--
9	Mandatory Student Activities (P/F)	MSA	2
	Total Mandatory Credits		**162**
10	Value Added Course (Optional)	VAC	20

No semester shall have more than five lecture-based courses and two laboratory and/or drawing/seminar/project courses in the curriculum. Semester-wise credit distribution shall be as below:

Sem	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Credits	17	21	22	22	23	23	15	17	160
Activity Points	50				50				---
Credits for Activity	2								2
G.Total									**162**

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SEMESTER 1

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B 1/2	PHT 100	ENGINEERING PHYSICS A	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	--
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
TOTAL				23/24	17

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SEMESTER II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTORCALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B 1/2	PHT 100	ENGINEERING PHYSICS A	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	4	--
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
TOTAL				28/29	21

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NOTE:

1. Engineering Physics A and Engineering Chemistry shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Physics A in S1 and Engineering Chemistry in S2 & vice versa. Students opting for Engineering Physics A in a semester should attend Physics Lab in the same semester and students opting for Engineering Chemistry in one semester should attend Engineering Chemistry Lab in the same semester
2. Engineering Mechanics and Engineering Graphics shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Mechanics in S1 and Engineering Graphics in S2 & vice versa.
3. Basics of Civil & Mechanical Engineering and Basics of Electrical & Electronics Engineering shall be offered in both semesters. Basics of Civil & Mechanical Engineering contain equal weightage for Civil Engineering and Mechanical Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to branches of AEI, EI, BME, ECE, EEE, ICE, CSE, IT, RA can choose this course in S1.

   Basics of Electrical & Electronics Engineering contain equal weightage for Electrical Engineering and Electronics Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to AERO, AUTO, CE, FSE, IE, ME, MECHATRONICS, PE, METALLURGY, BT, BCE, CHEM, FT, POLY can choose this course in S1. Students having Basics of Civil & Mechanical Engineering in one semester should attend Civil & Mechanical Workshop in the same semester and students having Basics of Electrical & Electronics Engineering in a semester should attend Electrical & Electronics Workshop in the same semester.
4. LIFE SKILLS

   Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underlie personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.
5. PROFESSIONAL COMMUNICATION

   Objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. Coverage: Listening, Barriers to listening, Steps to overcome them, Purposive listening

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practice, Use of technology in the professional world. Speaking, Fluency & accuracy in speech, Positive thinking, Improving self-expression, Tonal variations, Group discussion practice, Reading, Speed reading practice, Use of extensive readers, Analytical and critical reading practice, Writing Professional Correspondence, Formal and informal letters, Tone in formal writing, Introduction to reports. Study Skills, Use of dictionary, thesaurus etc., Importance of contents page, cover & back pages, Bibliography, Language Lab.

SEMESTER III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 203	DISCRETE MATHEMATICAL STRUCTURES	3-1-0	4	4
B	CST 201	DATA STRUCTURES	3-1-0	4	4
C	CST 203	LOGIC SYSTEM DESIGN	3-1-0	4	4
D	CST 205	OBJECT ORIENTED PROGRAMMING USING JAVA	3-1-0	4	4
E (1/2)	EST 200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT 200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN 201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	CSL 201	DATA STRUCTURES LAB	0-0-3	3	2
T	CSL 203	OBJECT ORIENTED PROGRAMMING LAB (IN JAVA)	0-0-3	3	2
R/M	VAC	Remedial/Minor course	3-1-0	4	4
TOTAL				26*	22/26

* Excluding Hours to be engaged for Remedial/Minor course.

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SEMESTER IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 206	GRAPH THEORY	3-1-0	4	4
B	CST 202	COMPUTER ORGANISATION AND ARCHITECTURE	3-1-0	4	4
C	CST 204	DATABASE MANAGEMENT SYSTEMS	3-1-0	4	4
D	CST 206	OPERATING SYSTEMS	3-1-0	4	4
E (1/2)	EST 200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT 200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN 202	CONSTITUTION OF INDIA	2-0-0	2	--
S	CSL 202	DIGITAL LAB	0-0-3	3	2
T	CSL204	OPERATING SYSTEMS LAB	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honors course	3-1-0	4	4
TOTAL				26*	22/26

* Excluding Hours to be engaged for Remedial/Minor/Honors course.

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.

2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SEMESTER V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CST 301	FORMAL LANGUAGES AND AUTOMATA THEORY	3-1-0	4	4
B	CST 303	COMPUTER NETWORKS	3-1-0	4	4
C	CST 305	SYSTEM SOFTWARE	3-1-0	4	4
D	CST 307	MICROPROCESSORS AND MICROCONTROLLERS	3-1-0	4	4
E	CST 309	MANAGEMENT OF SOFTWARE SYSTEMS	3-0-0	3	3
F	MCN 301	DISASTER MANAGEMENT	2-0-0	2	--
S	CSL 331	SYSTEM SOFTWARE AND MICROPROCESSORS LAB	0-0-4	4	2
T	CSL 333	DATABASE MANAGEMENT SYSTEMS LAB	0-0-4	4	2
R/M/H	VAC	Remedial/Minor/Honors course*	2-0-0	4	4
TOTAL				29*	23/27

* Excluding Hours to be engaged for Remedial/Minor/Honors course.

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/ Honors course (Tuesdays from 3 to 5 PM and Wednesdays from 3 to 5 PM). If a student does not opt for minor/honors programme, he/she can be given remedial class.

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SEMESTER VI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CST 302	COMPILER DESIGN	3-1-0	4	4
B	CST 304	COMPUTER GRAPHICS AND IMAGE PROCESSING	3-1-0	4	4
C	CST 306	ALGORITHM ANA LYSIS AND DESIGN	3-1-0	4	4
D	CST ---	PROGRAM ELECTIVE I	2-1-0	3	3
E	HUT 300	INDUSTRIAL ECONOMICS & FOREIGN TRADE	3-0-0	3	3
F	CST 308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	CSL 332	NETWORKING LAB	0-0-3	3	2
T	CSD 334	MINIPROJECT	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honors course*	3-1-0	4	4
TOTAL				25*	23/27

* Excluding Hours to be engaged for Remedial/Minor/Honors course.

Note:

Electives: This curriculum envisages to offer a learner an opportunity to earn proficiency in one of the five trending areas in Computer Science, namely Machine Learning, Data Science, Security in Computing, Formal Methods in Software Engineering and Hardware Technologies. Three courses each from the above areas are included through Elective Courses in different Elective Buckets. For example, a learner who is interested in the ***Machine Learning*** area may opt to take the elective courses - ***Foundations of Machine Learning*** from Elective-I in S6, ***Machine Learning*** from Elective-II in S7 and ***Deep Learning*** from Elective-III in S8. The Department may offer Elective Courses to enable students to utilize this opportunity, depending on the availability of faculty. The courses included from these areas under various Elective Buckets are shown in the table below.

Different Specializations introduced through various Elective Buckets				
Bucket	Specialisation	Semester		
		S6	S7	S8
1	Machine Learning	FOUNDATIONS OF MACHINE LEARNING (E-I)	MACHINE LEARNING (E-II)	DEEP LEARNING (E-III)
2	Data Science	DATA ANALYTICS (E-I)	CLOUD COMPUTING (E-II)	BLOCK CHAIN TECHNOLOGIES (E-V)
3	Security in Computing	FOUNDATIONS OF SECURITY IN COMPUTING (E-I)	SECURITY IN COMPUTING (E-II)	CRYPTOGRAPHY (E-III)
4	Formal Methods in Software Engineering	AUTOMATED VERIFICATION (E-I)	MODEL BASED SOFTWARE DEVELOPMENT (E-II)	SOFTWARE TESTING (E-V)
5	Hardware Technologies	INTRODUCTION TO IA32 ARCHITECTURE (E-I)	ADVANCED TOPICS IN IA32 ARCHITECTURE (E-II)	UNIFIED EXTENDED FIRMWARE INTERFACE (E-IV)

PROGRAM ELECTIVE I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	CST 312	i FOUNDATIONS OF MACHINE LEARNING	2-1-0	3	3
	CST 322	ii DATA ANALYTICS	2-1-0		
	CST 332	iii FOUNDATIONS OF SECURITY IN COMPUTING	2-1-0		
	CST 342	iv AUTOMATED VERIFICATION	2-1-0		
	CST 352	v INTRODUCTION TO IA32 ARCHITECTURE	2-1-0		
	CST 362	vi PROGRAMMING IN PYTHON	2-1-0		
	CST 372	vii DATA AND COMPUTER COMMUNICATION	2-1-0		

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COURSES TO BE CONSIDERED FOR COMPREHENSIVE COURSE WORK

I DISCRETE MATHEMATICAL STRUCTURES
ii DATA STRUCTURES
iii OPERATING SYSTEMS
iv COMPUTER ORGANIZATION AND ARCHITECTURE
v DATABASE MANAGEMENT SYSTEMS
vi FORMAL LANGUAGES AND AUTOMATA THEORY

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honors course (Tuesdays from 3 to 5 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honors programme, he/she can be given remedial class.

2. Comprehensive Course Work: The comprehensive course work in the sixth semester of study shall have a written test of 50 marks. The written examination will be of objective type similar to the GATE examination and will be conducted by the University. Syllabus for comprehensive examination shall be prepared by the respective BoS choosing the above listed 6 core courses studied from semesters 3 to 5. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum.

3. Mini project: It is introduced in the sixth semester with a specific objective to strengthen the understanding of student's fundamentals through effective application of theoretical concepts. Mini project can help to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. Student Groups with 3 or 4 members should identify a topic of interest in consultation with Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be

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demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight. The internal evaluation will be made based on the product, the report and a viva-voce examination, conducted internally by a 3 member committee appointed by Head of the Department comprising HoD or a senior faculty member, Mini Project coordinator for that program and project guide.

Total marks: 150 - CIE 75 marks and ESE 75 marks

Split up for CIE

Attendance	10
Project Guide	15
Project Report	10

Evaluation by the Committee (will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement) 40

SEMESTER VII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CST 401	ARTIFICIAL INTELLIGENCE	2-1-0	3	3
B	CST ---	PROGRAM ELECTIVE II	2-1-0	3	3
C	CST ---	OPEN ELECTIVE	2-1-0	3	3
D	MCN 401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	CSL 411	COMPILER LAB	0-0-3	3	2
T	CSQ 413	SEMINAR	0-0-3	3	2
U	CSD 415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	Remedial/Minor/Honors course*	3-1-0	4	4
TOTAL				24*	15/19

* Excluding Hours to be engaged for Remedial/Minor/Honors course.

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PROGRAM ELECTIVE II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	CST 413	i MACHINE LEARNING	2-1-0	3	3
	CST 423	ii CLOUD COMPUTING	2-1-0		
	CST 433	iii SECURITY IN COMPUTING	2-1-0		
	CST 443	iv MODEL BASED SOFTWARE DEVELOPMENT	2-1-0		
	CST 453	v ADVANCED TOPICS IN IA32 ARCHITECTURE	2-1-0		
	CST 463	vi WEB PROGRAMMING	2-1-0		
	CST 473	vii NATURAL LANGUAGE PROCESSING	2-1-0		

OPEN ELECTIVE

The open elective is offered in semester 7. Each program should specify the courses (maximum 5) they would like to offer as electives for other programs. The courses listed below are offered by the Department of **COMPUTER SCIENCE & ENGINEERING** for students of other undergraduate branches except Computer Science & Engineering and Information Technology, offered in the colleges under KTU.

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	CST 415	i INTRODUCTION TO MOBILE COMPUTING	2-1-0	3	3
	CST 425	ii INTRODUCTION TO DEEP LEARNING	2-1-0		
	CST 435	iii COMPUTER GRAPHICS	2-1-0		
	CST 445	iv PYTHON FOR ENGINEERS	2-1-0		
	CST 455	v OBJECT ORIENTED CONCEPTS	2-1-0		

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NOTE:

1. All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honors course (Mondays from 10 to 12 and Wednesdays from 10 to 12 Noon). If a student does not opt for minor/honors programme, he/she can be given remedial class.

2. Seminar: To encourage and motivate the students to read and collect recent and reliable information about their area of interest confined to the relevant discipline, from technical publications including peer reviewed journals, conferences, books, project reports etc., prepare a report based on a central theme and present it before a peer audience. Each student shall present the seminar for about 20 minutes duration on the selected topic. The report and the presentation shall be evaluated by a team of faculty members comprising Academic coordinator for that program, seminar coordinator and seminar guide based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the report.

   Total marks: 100, only CIE, minimum required to pass 50

Attendance	10
Seminar Guide	20
Technical Content of the Report	30
Presentation	40

3. Project Phase-I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The objective of Project Work Phase-I is to enable the student to take up investigative study in the broad field of Computer Science and Engineering, either fully theoretical/ practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the mentoring of a Project Guide(s). This is expected to provide a good initiation for the student(s) in R&D work. The assignment shall normally include:

   - Survey and study of published literature on the assigned topic;
   - Preparing an Action Plan for conducting the investigation, including team work;
   - Working out a preliminary Approach to the Problem relating to the assigned topic;
   - Block level design documentation
   - Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;

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- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final project presentation before the concerned departmental committee.

Total marks: 100, only CIE, minimum required to pass 50

Project Guide(s)	30
Interim evaluation by the evaluation committee	20
Final project presentation	30
Final evaluation by the evaluation committee	20

The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project guide(s).

SEMESTER VIII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	CST 402	DISTRIBUTED COMPUTING	2-1-0	3	3
B	CST ---	PROGRAM ELECTIVE III	2-1-0	3	3
C	CST ---	PROGRAM ELECTIVE IV	2-1-0	3	3
D	CST ---	PROGRAM ELECTIVE V	2-1-0	3	3
T	CST 404	COMPREHENSIVE COURSE VIVA	1-0-0	1	1
U	CSD 416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	Remedial/Minor/Honors course	3-1-0	4	4
TOTAL				25*	17/21

* Excluding Hours to be engaged for Remedial/Minor/Honors course.

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PROGRAM ELECTIVE III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
	CST 414	i DEEP LEARNING	2-1-0		
	CST 424	ii PROGRAMMING PARADIGMS	2-1-0		
	CST 434	iii CRYPTOGRAPHY	2-1-0		
B	CST 444	iv SOFT COMPUTING	2-1-0	3	3
	CST 454	v FUZZY SET THEORY AND APPLICATIONS	2-1-0		
	CST 464	vi EMBEDDED SYSTEMS	2-1-0		
	CST 474	vii COMPUTER VISION	2-1-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
	CST 416	i FORMAL METHODS AND TOOLS IN SOFTWARE ENGINEERING	2-1-0		
	CST 426	ii CLIENT SERVER ARCHITECTURE	2-1-0		
C	CST 436	iii PARALLEL COMPUTING	2-1-0		
	CST 446	iv DATA COMPRESSION TECHNIQUES	2-1-0	3	3
	CST 456	v UNIFIED EXTENDED FIRMWARE INTERFACE	2-1-0		
	CST 466	vi DATA MINING	2-1-0		
	CST 476	vii MOBILE COMPUTING	2-1-0		

PROGRAM ELECTIVE V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	CST 418	i HIGH PERFORMANCE COMPUTING	2-1-0	3	3
	CST 428	ii BLOCK CHAIN TECHNOLOGIES	2-1-0		
	CST 438	iii IMAGE PROCESSING TECHNIQUE	2-1-0		
	CST 448	iv INTERNET OF THINGS	2-1-0		
	CST 458	v SOFTWARE TESTING	2-1-0		
	CST 468	vi BIOINFORMATICS	2-1-0		
	CST 478	vii COMPUTATIONAL LINGUISTICS	2-1-0		

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honors course (Mondays from 10 to 12 and Wednesdays from 10 to 12 PM). If a student does not opt for minor/honors programme, he/she can be given remedial class.
2. Comprehensive Viva Voce: The comprehensive viva voce in the eighth semester of study shall have a viva voce for 50 marks. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation towards the end of the semesters. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
3. **Project Phase II:** The objective of Project Work Phase II & Dissertation is to enable the student to extend further the investigative study taken up in Project Phase I, either fully theoretical/practical or involving both theoretical and practical work, under the mentoring of a Project Guide from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment shall normally include:

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- In depth study of the topic assigned in the light of the Report prepared in Phase I;
- Review and finalization of the Approach to the Problem relating to the assigned topic;
- Detailed Analysis/Modeling/Simulation/Design/Problem Solving/Experiment as needed;
- Final development of product/process, testing, results, conclusions and future directions;
- Preparing a paper for Conference presentation/Publication in Journals, if possible;
- Preparing a Dissertation in the standard format for being evaluated by the Department;
- Final Presentation before the concerned evaluation committee

Total marks: 150, only CIE, minimum required to pass 75

Project Guide	30
Interim evaluation, twice in the semester by the evaluation committee	70
Quality of the report evaluated by the above committee	10

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project guide).

Final evaluation by a three member committee	40

(The final evaluation committee comprises Project coordinator, expert from Industry/ research Institute and a senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks).

MINOR

Minor is an additional credential a student may earn if she/he does 20 credits worth of additional learning in a discipline other than her/his major discipline of B.Tech. degree. The objective is to permit a student to customize their Engineering degree to suit their specific interests. Upon completion of an Engineering Minor, a student will be better equipped to perform interdisciplinary research and will be better employable. Engineering Minors allow a student to gain interdisciplinary experience and exposure to concepts and perspectives that may not be a part of their major degree programs.

The academic units offering minors in their discipline will prescribe the set of courses and/or other activities like projects necessary for earning a minor in that discipline. A specialist bucket of 3-6 courses is identified for each Minor. Each bucket may rest on one or more

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foundation courses. A bucket may have sequences within it, i.e., advanced courses may rest on basic courses in the bucket. She/he accumulates credits by registering for the required courses, and if the requirements for a particular minor are met within the time limit for the course, the minor will be awarded. This will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx with Minor in yyy". The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, that minor will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from third to eight semesters for all branches. The minor courses shall be identified by M slot courses.

(ii) Registration is permitted for Minor at the beginning of third semester. Total credits required to award B.tech with Minor is 182 (162 + 20)

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses, of which one course shall be a mini project based on the chosen area. They can do miniproject either in S7 or in S8. The remaining 8 credits could be acquired through 2 MOOCs recommended by the Board of Studies and approved by the Academic Council or 2 courses from the minor buckets listed here. The classes for Minor shall be conducted along with regular classes and no extra time shall be required for conducting the courses.

(iv) There won't be any supplementary examination for the courses chosen for Minor.

(v) On completion of the program, "Bachelor of Technology in xxx with Minor in yyy" will be awarded if the registrant earn 20 credits form the minor courses.

(vi) The registration for minor program will commence from semester 3 and all the academic units offering minors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 5 buckets. The bucket of courses may have sequences within it, i.e., advanced courses may rest on basic courses in the bucket. Reshuffling of courses between various buckets will not be allowed. There is option to skip any two courses listed here and to opt for equivalent MOOC courses approved by the Academic Council. In any case, they should carry out a mini project based on the chosen area in S7 or S8. For example: Students who have registered **for B.Tech Minor in Computer Science & Engineering** can opt to study the courses listed below:

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MINOR BUCKETS												
SEMESTER	BUCKET-1				BUCKET-2				BUCKET-3			
	Specialization - **Software Engineering**				Specialization - **Machine Learning**				Specialization - **Networking**			
	COURSE NO	COURSE NAME	HOURS	CREDIT	COURSE NO	COURSE NAME	HOURS	CREDIT	COURSE NO	COURSE NAME	HOURS	CREDIT
S3	CST 281	OBJECT ORIENTED PROGRAMMING	4	4	CST 283	PYTHON FOR MACHINE LEARNING	4	4	CST 285	DATA COMMUNICATION	4	4
S4	CST 282	PROGRAMMING METHODOLOGIES	4	4	CST 284	MATHEMATICS FOR MACHINE LEARNING	4	4	CST 286	INTRODUCTION TO COMPUTER NETWORKS	4	4
S5	CST 381	CONCEPTS IN SOFTWARE ENGINEERING	4	4	CST 383	CONCEPTS IN MACHINE LEARNING	4	4	CST 385	CLIENT SERVER SYSTEMS	4	4
S6	CST 382	INTRODUCTION TO SOFTWARE TESTING	4	4	CST 384	CONCEPTS IN DEEP LEARNING	4	4	CST 386	WIRELESS NETWORKS AND IOT APPLICATIONS	4	4
S7	CSD 481	Miniproject	4	4	CSD 481	Miniproject	4	4	CSD 481	Miniproject	4	4
S8	CSD 482	Miniproject	4	4	CSD 482	Miniproject	4	4	CSD 482	Miniproject	4	4
Note-1: Name of the specialization shall be mentioned in the Minor Degree to be awarded												
Note-2: Any B.Tech students from non-Computer Science/non-IT streams can register for the courses in the minor buckets.												

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HONORS

Honors is an additional credential a student may earn if she/he opts for the extra 20 credits needed for this in her/his own discipline. Honors is not indicative of a class. The University is providing this option for academically extra brilliant students to acquire Honors. Honors is intended for a student to *gain expertise*/get *specialized* in an area inside his/her major B.Tech discipline and to enrich knowledge in emerging/advanced areas in the concerned branch of engineering. It is particularly suited for students aiming to pursue higher studies. Upon completion of Honors, a student will be better equipped to perform research in her/his branch of engineering. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx, with Honors." The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If a student is not earning credits for any one of the specified course for getting Honors, she/he is not entitled to get Honors. The individual course credits earned, however, will be reflected in the consolidated grade card.

The courses shall be grouped into maximum of 3 buckets, each bucket representing a particular specialization in the branch. The students shall select only the courses from same bucket in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. The internal evaluation, examination and grading shall be exactly as for other mandatory courses. The Honors courses shall be identified by H slot courses.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from fourth to eight semesters for all branches. The Honors courses shall be identified by H slot courses.

(ii) Registration is permitted for Honors at the beginning of fourth semester. Total credits required is 182 (162 + 20).

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses, of which one course shall be a mini project based on the chosen area. The remaining 8 credits could be acquired through 2 MOOCs recommended by the Board of studies and approved by the Academic Council or 2 courses from the same bucket as the above 3 courses. The classes for Honors shall be conducted along with regular classes and no extra time shall be required for conducting the courses. The students should earn a grade of 'C' or better for all courses under Honors.

(iv) There won't be any supplementary examination for the courses chosen for Honors.

(v) On successful accumulation of credits at the end of the programme, "Bachelor of Technology in xxx, with Honors" will be awarded if overall CGPA is greater than

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or equal to 8.5, earned a grade of 'C' or better for all courses chosen for Honors and there is no history of 'F' Grade in the entire span of the BTech Course.

(vi) The registration for Honors program will commence from semester 4 and the all academic units offering Honors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 5 buckets, each bucket representing a particular specialization in the branch. The students shall select only the courses from same bucket in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. There is option to skip any two courses listed here if required, and to opt for equivalent MOOC courses approved by the Academic Council. In any case, they should carry out a mini project based on the chosen area in S8. For example: Students who have registered for **B.Tech in Computer Science and Engineering with Honors** can opt to study the courses listed in one of the buckets shown below:

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HONORS BUCKETS												
SEMESTER	BUCKET-1				BUCKET-2				BUCKET-3			
	Specialization - **Security in Computing**				Specialization - **Machine Learning**				Specialization - **Formal Methods**			
	COURSE NO	COURSE NAME	HOURS	CREDIT	COURSE NO	COURSE NAME	HOURS	CREDIT	COURSE NO	COURSE NAME	HOURS	CREDIT
S4	CST 292	NUMBER THEORY	4	4	CST 294	COMPUTATIONAL FUNDAMENTALS FOR MACHINE LEARNING	4	4	CST 296	PRINCIPLES OF PROGRAM ANALYSIS AND VERIFICATION	4	4
S5	CST 393	CRYPTOGRAPHIC ALGORITHMS	4	4	CST 395	NEURAL NETWORKS AND DEEP LEARNING	4	4	CST 397	PRINCIPLES OF MODEL CHECKING	4	4
S6	CST 394	NETWORK SECURITY	4	4	CST 396	ADVANCED TOPICS IN MACHINE LEARNING	4	4	CST 398	THEORY OF COMPUTABILITY AND COMPLEXITY	4	4
S7	CST 495	CYBER FORENSICS	4	4	CST 497	ADVANCED TOPICS IN ARTIFICIAL INTELLIGENCE	4	4	CST 499	LOGIC FOR COMPUTER SCIENCE	4	4
S8	CSD 496	Miniproject	4	4	CSD 496	Miniproject	4	4	CSD 496	Miniproject	4	4
Note: Name of the specialization shall be mentioned in the Honors Degree to be awarded												

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ELECTRONICS & COMMUNICATION ENGINEERING

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SEMESTERI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B 1/2	PHT 100	ENGINEERING PHYSICS A	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	--
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		23/24 *	17

*Minimum hours per week

Note:

To make up for the hours lost due to induction program, one extra hour may be allotted to each course

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SEMESTER II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B 1/2	PHT 100	ENGINEERING PHYSICS A	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	4	—
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		28/29	21

NOTE:

1. Engineering Physics A and Engineering Chemistry shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Physics A in SI and Engineering Chemistry in S2 & vice versa. Students opting for Engineering Physics A in a semester should attend Physics Lab in the same semester and students opting for Engineering Chemistry in one semester should attend Engineering Chemistry Lab in the same semester.

2. Engineering Mechanics and Engineering Graphics shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the institution to opt for Engineering Mechanics in SI and Engineering Graphics in S2 & vice versa.
3. Basics of Civil & Mechanical Engineering and Basics of Electrical & Electronics Engineering shall be offered in both semesters. Basics of Civil & Mechanical Engineering contains equal weightage for

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Civil Engineering and Mechanical Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to branches of AEI, EI, BME, ECE, EEE, ICE, CSE, IT, RA can choose this course in S1.

Basics of Electrical & Electronics Engineering contain equal weightage for Electrical Engineering and Electronics Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to AERO, AUTO, CE, FSE, IE, ME, MECHATRONICS, PE, METTULURGY, BT, BCE, CHEM, FT, POLY can choose this course in S1. Students having Basics of Civil & Mechanical Engineering in one semester should attend Civil & Mechanical Workshop in the same semester and students having Basics of Electrical & Electronics Engineering in a semester should attend Electrical & Electronics Workshop in the same semester.

4. LIFE SKILLS

Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underlie personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

5. PROFESSIONAL COMMUNICATION

Objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. Coverage: Listening, Barriers to listening, Steps to overcome them, Purposive listening practice, Use of technology in the professional world. Speaking, Fluency & accuracy in speech, Positive thinking, Improving self-expression, Tonal variations, Group discussion practice, Reading, Speed reading practice, Use of extensive readers, Analytical and critical reading practice, Writing Professional Correspondence, Formal and informal letters, Tone in formal writing, Introduction to reports. Study Skills, Use of dictionary, thesaurus etc., Importance of contents page, cover & back pages, Bibliography, Language Lab.

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Semester III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT201	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
B	ECT 201	SOLID STATE DEVICES	3-1-0	4	4
C	ECT 203	LOGIC CIRCUIT DESIGN	3-1-0	4	4
D	ECT 205	NETWORK THEORY	3-1-0	4	4
E 1/2	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	ECL 201	SCIENTIFIC COMPUTING LAB	0-0-3	3	2
T	ECL 203	LOGIC DESIGN LAB	0-0-3	3	2
R/M	VAC	Remedial/Minor course	3-1-0	4**	4
		TOTAL		26/30	22/26

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.

2. *All Institutions shall keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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Semester IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 204	PROBABILITY, RANDOM PROCESS AND NUMERICAL METHODS	3-1-0	4	4
B	ECT 202	ANALOG CIRCUITS	3-1-0	4	4
C	ECT 204	SIGNALS AND SYSTEMS	3-1-0	4	4
D	ECT 206	COMPUTER ARCHITECTURE AND MICROCONTROLLERS	3-1-0	4	4
E 1/2	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN202	CONSTITUTION OF INDIA	2-0-0	2	--
S	ECL 202	ANALOG CIRCUITS AND SIMULATION LAB	0-0-3	3	2
T	ECL 204	MICROCONTROLLER LAB	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4**	4
		TOTAL		26/30	22/26

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.

2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	ECT 301	LINEAR INTEGRATED CIRCUITS	3-1-0	4	4
B	ECT 303	DIGITAL SIGNAL PROCESSING	3-1-0	4	4
C	ECT 305	ANALOG AND DIGITAL COMMUNICATION	3-1-0	4	4
D	ECT 307	CONTROL SYSTEMS	3-1-0	4	4
E 1/2	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MCN301	DISASTER MANAGEMENT	2-0-0	2	--
S	ECL 331	ANALOG INTEGRATED CIRCUITS AND SIMULATION LAB	0-0-3	3	2
T	ECL 333	DIGITAL SIGNAL PROCESSING LAB	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4**	4
		TOTAL		27/31	23/27

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.

2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 3 to 5 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.

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Semester VI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	ECT 302	ELECTROMAGNETICS	3-1-0	4	4
B	ECT 304	VLSI CIRCUIT DESIGN	3-1-0	4	4
C	ECT 306	INFORMATION THEORY AND CODING	3-1-0	4	4
D	ECTXXX	PROGRAM ELECTIVE I	2-1-0	3	3
E ½	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	ECT 308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	ECL 332	COMMUNICATION LAB	0-0-3	3	2
T	ECD 334	MINIPROJECT	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4**	4
		TOTAL		25/29	23/27

PROGRAM ELECTIVE I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	ECT 312	Digital System Design	2-1-0	3	3
	ECT 322	Power Electronics	2-1-0		
	ECT 332	Data Analysis	2-1-0		
	ECT 342	Embedded Systems	2-1-0		
	ECT 352	Digital Image Processing	2-1-0		
	ECT 362	Introduction to MEMS	2-1-0		
	ECT 372	Quantum Computing	2-1-0		

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.

2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.
3. Comprehensive Course Work: The comprehensive course work in the sixth semester of study shall have a written test of 50 marks. The written examination will be of objective type similar to the GATE examination and will be conducted by the University. **Syllabus for comprehensive examination shall be prepared by the respective BoS choosing any 5 core courses studied from semester 3 to 5.** The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum.
4. Mini project: It is introduced in sixth semester with a specific objective to strengthen the understanding of student's fundamentals through application of theoretical concepts. Mini project can help to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. Students should identify a topic of interest in consultation with Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight. The internal evaluation will be made based on the product, the report and a viva- voce examination, conducted by a 3 member committee appointed by Head of the Department comprising HoD or a senior faculty member, Academic coordinator for that program, project guide/coordinator.

   Total marks: 150, CIE 75 marks and ESE 75 marks

   Split up for CIE

Attendance	10
Guide	15
Project Report	10

   Evaluation by the Committee (will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement) : 40

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Semester VII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	ECT 401	WIRELESS COMMUNICATION	2-1-0	3	3
B	ECTXXX	PROGRAM ELECTIVE II	2-1-0	3	3
C	ECTXXX	OPEN ELECTIVE	2-1-0	3	3
D	MCN401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	ECL 411	ELECTROMAGNETICS LAB	0-0-3	3	2
T	ECQ 413	SEMINAR	0-0-3	3	2
U	ECD 415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	Remedial/Minor/Honors course	3-1-0	4*	4
		TOTAL		24/28	15/19

PROGRAM ELECTIVE II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	ECT 413	Optical Fiber Communication	2-1-0	3	3
	ECT 423	Computer Networks	2-1-0		
	ECT 433	Opto-electronic Devices	2-1-0		
	ECT 443	Antenna and Wave propagration	2-1-0		
	ECT 453	Error Control Codes	2-1-0		
	ECT 463	Machine Learning	2-1-0		
	ECT 473	DSP Architectures	2-1-0		

OPEN ELECTIVE (OE)

The open elective is offered in semester 7. Each program should specify the courses (maximum 5) they would like to offer as electives for other programs. The courses listed below are offered by **the Department of ELECTRONICS AND COMMUNICATION ENGINEERING for students of other undergraduate branches offered in the college under KTU.**

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SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	ECT 415	Mechatronics	2-1-0	3	3
	ECT 425	Biomedical Instrumentation	2-1-0		
	ECT 435	Electronic Hardware for Engineers	2-1-0		
	ECT 445	IoT and Applications	2-1-0		
	ECT 455	Entertainment Electronics	2-1-0		

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12 Noon). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Seminar: To encourage and motivate the students to read and collect recent and reliable information from their area of interest confined to the relevant discipline from technical publications including peer reviewed journals, conference, books, project reports etc., prepare a report based on a central theme and present it before a peer audience. Each student shall present the seminar for about 20 minutes duration on the selected topic. The report and the presentation shall be evaluated by a team of faculty members comprising Academic coordinator for that program, seminar coordinator and seminar guide based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the report.

   Total marks: 100, only CIE, minimum required to pass 50

Attendance	10
Guide	20
Technical Content of the Report	30
Presentation	40

3. Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Electronics and Communication Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:
   - Survey and study of published literature on the assigned topic;
   - Preparing an Action Plan for conducting the investigation, including team work;
   - Working out a preliminary Approach to the Problem relating to the assigned topic;
   - Block level design documentation
   - Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;

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- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final Seminar, as oral Presentation before the evaluation committee.

Total marks: 100, only CIE, minimum required to pass 50

Guide	: 30
Interim evaluation by the evaluation committee	: 20
Final Seminar	: 30
The report evaluated by the evaluation committee	: 20

The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor.

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Semester VIII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	ECT 402	INSTRUMENTATION	2-1-0	3	3
B	ECTXXX	PROGRAM ELECTIVE III	2-1-0	3	3
C	ECTXXX	PROGRAM ELECTIVE IV	2-1-0	3	3
D	ECTXXX	PROGRAM ELECTIVE V	2-1-0	3	3
E	ECT 404	COMPREHENSIVE VIVA VOCE	1-0-0	1	1
U	ECD 416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	Remedial/Minor/Honors course	3-1-0	4*	4
		TOTAL		25/28	17/21

PROGRAM ELECTIVE III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	ECT 414	Biomedical Engineering	2-1-0	3	3
	ECT 424	Satellite Communication	2-1-0		
	ECT 434	Secure Communication	2-1-0		
	ECT 444	Pattern Recognition	2-1-0		
	ECT 454	RF Circuit Design	2-1-0		
	ECT 464	Mixed Signal Circuit Design	2-1-0		
	ECT 474	Entrepreneurship	2-1-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	ECT 416	Modern Communication Systems	2-1-0	3	3
	ECT 426	Real Time Operating Systems	2-1-0		
	ECT 436	Adaptive Signal Processing	2-1-0		
	ECT 446	Microwave Devices and Circuits	2-1-0		
	ECT 456	Speech and Audio Processing	2-1-0		
	ECT 466	Analog CMOS Design	2-1-0		
	ECT 476	Robotics	2-1-0		

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PROGRAM ELECTIVE V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	ECT 418	Mechatronics	2-1-0	3	3
	ECT 428	Optimization Techniques	2-1-0		
	ECT 438	Computer Vision	2-1-0		
	ECT 448	Low Power VLSI	2-1-0		
	ECT 458	Internet of Things	2-1-0		
	ECT 468	Renewable Energy Systems	2-1-0		
	ECT 478	Organic Electronics	2-1-0		

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Comprehensive Course Viva: The comprehensive course viva in the eighth semester of study shall have a viva voce for 50 marks. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation towards the end of the semester. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum. The mark will be treated as internal and should be uploaded along with internal marks of other courses.

3. Project Phase II: The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up in Project 1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:
   - In depth study of the topic assigned in the light of the Report prepared under PhaseI;
   - Review and finalization of the Approach to the Problem relating to the assigned topic;
   - Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;
   - Final development of product/process, testing, results, conclusions and future directions;
   - Preparing a paper for Conference presentation/Publication in Journals, if possible;
   - Preparing a Dissertation in the standard format for being evaluated by the Department;
   - Final Presentation before a Committee

Total marks: 150, only CIE, minimum required to pass 75

Guide	30
Interim evaluation, 2 times in the semester by the evaluation committee	50
Quality of the report evaluated by the above committee	30

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor).

Final evaluation by a three member committee	40

(The final evaluation committee comprises Project coordinator, expert from industry/research institute and a senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks).

MINOR

Minor is an additional credential a student may earn if s/he does 20 credits worth of additional learning in a discipline other than her/his major discipline of B.Tech degree. The objective is to permit a student to customize their Engineering degree to suit their specific interests. Upon completion of an Engineering Minor, a student will be better equipped to perform interdisciplinary research and will be better employable. Engineering Minors allow a student to gain interdisciplinary experience and exposure to concepts and perspectives that may not be a part of their major degree programs.

The academic units offering minors in their discipline will prescribe the set of courses and/or other activities like projects necessary for earning a minor in that discipline. A specialist basket of 3-6 courses is identified for each Minor. Each basket may rest on one or more foundation courses. A basket may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. S/he accumulates credits by registering for the required courses, and if the requirements for a particular minor are met within the time limit for the course, the minor will be awarded. This will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx with Minor in yyy". The fact will also be reflected in the consolidated grade card, along with thelist of courses taken. If one specified course cannot be earned during the course of the programme, that minor will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from third to eight semesters for all branches. The minor courses shall be identified by **M slot courses**.

(ii) Registration is permitted for Minor at the beginning of third semester. Total credits required is 182 (162 + 20 credits from value added courses)

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for minor, of which one course shall be a mini project based on the chosen area. They can do miniproject either in S7 or in S8. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Minor shall be conducted along with regular classes and no extra time shall be required for conducting the courses.

(iv)There won't be any supplementary examination for the courses chosen for Minor.

(v) On completion of the program, "Bachelor of Technology in xxx with Minor in yyy" will be awarded.

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(vi)The registration for minor program will commence from semester 3 and the all academic units offering minors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 baskets. The basket of courses may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. Reshuffling of courses between various baskets will not be allowed. In any case, they should carry out a mini project based on the chosen area in S7 or S8. Students who have registered for B.Tech Minor in **ELECTRONICS AND COMMUNICATION** can opt to study the courses listed below:

SEMESTER	BASKET I					BASKET II				BASKET III			
	COURSE NO.	COURSE NAME	HOURS	CREDIT	HOURS	COURSE NO.	COURSE NAME	HOURS	CREDIT	COURSE NO.	COURSE NAME	HOURS	CREDIT
S3	ECT281	ELECTRONIC CIRCUITS	4	4		ECT283	ANALOG COMMUNICATION	4	4	ECT285	INTRODUCTION TO SIGNALS AND SYSTEMS	4	4
S4	ECT282	MICROCONTROLLERS	4	4		ECT284	DIGITAL COMMUNICATION	4	4	ECT286	INTRODUCTION TO DIGITAL SIGNAL PROCESSING	4	4
S5	ECT381	EMBEDDED SYSTEM DESIGN	4	4		ECT383	COMMUNICATION SYSTEMS	4	4	ECT385	TOPICS IN DIGITAL IMAGE PROCESSING	4	4
S6	ECT382	VLSI CIRCUITS	4	4		ECT384	DATA NETWORKS	4	4	ECT386	TOPICS IN COMPUTER VISION	4	4
S7	ECD481	MINIPROJECT	4	4		ECD481	MINIPROJECT	4	4	ECD481	MINIPROJECT	4	4
S8	ECD482	MINIPROJECT	4	4		ECD482	MINIPROJECT	4	4	ECD482	MINIPROJECT	4	4

HONOURS

Honours is an additional credential a student may earn if s/he opts for the extra 20 credits needed for this in her/his own discipline. Honours is not indicative of class. KTU is providing this option for academically extra brilliant students to acquire Honours. Honours is intended for a student to gain expertise/specialise in an area inside his/her major B.Tech discipline and to enrich knowledge in emerging/advanced areas in the branch of engineering concerned. It is particularly suited for students aiming to pursue higher studies. Upon completion of Honours, a student will be better equipped to perform research in her/his branch of engineering. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx, with Honours." The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, Honours will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

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The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. The internal evaluation, examination and grading shall be exactly as for other mandatory courses. The Honours courses shall be identified by H slot courses.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from fourth to eight semesters for all branches. The honours courses shall be identified by H slot courses.

(ii) Registration is permitted for Honours at the beginning of fourth semester. Total credits required is 182 (162 + 20 credits from value added courses).

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for honours, of which one course shall be a mini project based on the chosen area. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Honours shall be conducted along with regular classes and no extra time shall be required for conducting the courses. The students should earn a grade of 'C' or better for all courses under honours.

(iv) There won't be any supplementary examination for the courses chosen for honours.

(v) On successful accumulation of credits at the end of the programme, "Bachelor of Technology in xxx, with Honours" will be awarded if overall CGPA is greater than or equal to 8.5, earned a grade of 'C' or better for all courses chosen for honours and without any history of 'F' Grade.

(vi) The registration for Honours program will commence from semester 4 and the all academic units offering honours in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. In any case, they should carry out a mini project based on the chosen area in S8. Students who have registered for B.Tech Honours in **ELECTRONICS AND COMMUNICATION ENGINEERING** can opt to study the courses listed below:

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	GROUP I				GROUP II				GROUP III			
SEMESTER	COURSE NO.	COURSE NAME	HOURS	CREDIT	COURSE NO.	COURSE NAME	HOURS	CREDIT	COURSE NO.	COURSE NAME	HOURS	CREDIT
S4	ECT292	NANOELECTRONICS	4	4	ECT294	STOCHASTIC PROCESSES FOR COMMUNICATION	4	4	ECT296	STOCHASTIC SIGNAL PROCESSING	4	4
S5	ECT393	FPGA BASED SYSTEM DESIGN	4	4	ECT395	DETECTION AND ESTIMATION THEORY	4	4	ECT397	COMPUTATIONAL TOOLS FOR SIGNAL PROCESSING	4	4
S6	ECT394	ELECTRONIC DESIGN AND AUTOMATION TOOLS	4	4	ECT396	MIMO AND MULTIUSER COMMUNICATION SYSTEMS	4	4	ECT398	DETECTION AND ESTIMATION THEORY	4	4
S7	ECT495	RF MEMS	4	4	ECT497	DESIGN AND ANALYSIS OF ANTENNAS	4	4	ECT499	MULTIRATE SIGNAL PROCESSING AND WAVELETS	4	4
S8	ECD496	MINIPROJECT	4	4	ECD496	MINIPROJECT	4	4	ECD496	MINIPROJECT	4	4

INDUCTION PROGRAM

There will be three weeks induction program for first semester students. It is a unique three- week immersion Foundation Programme designed especially for the fresher's which includes a wide range of activities right from workshops, lectures and seminars to sports tournaments, social work and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, inculcate values and ethics, and help students to discover their passion. Foundation Programme also serves as a platform for the fresher's to interact with their batchmates and seniors and start working as a team with them. The program is structured around the following five themes:

The programme is designed keeping in mind the following objectives:

Values and Ethics: Focus on fostering a strong sense of ethical judgment and moral fortitude.

Creativity: Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and other creative activities.

Leadership, Communication and Teamwork: Develop a culture of teamwork and group communication.

Social Awareness: Nurture a deeper understanding of the local and global world and our place in at as concerned citizens of the world.

Physical Activities & Sports: Engage students in sports and physical activity to ensurehealthy physical and mental growth

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SEMESTER I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B 1/2	PHT 100	ENGINEERING PHYSICS	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	--
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		23/24 *	17

*Minimum hours per week

Note: To make up for the hours lost due to induction program, one extra hour may be allotted to each course

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SEMESTER II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B 1/2	PHT 100	ENGINEERING PHYSICS A	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	4	—
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		28/29	21

NOTE:

1. Engineering Physics A and Engineering Chemistry shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Physics A in S1 and Engineering Chemistry in S2 & vice versa. Students opting for Engineering Physics A in a semester should attend Physics Lab in the same semester and students opting for Engineering Chemistry in one semester should attend Engineering Chemistry Lab in the same semester.

2. Engineering Mechanics and Engineering Graphics shall be offered in both semesters.

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in the Institution to opt for Engineering Mechanics in SI and Engineering Graphics in S2 & vice versa.

3. Basics of Civil & Mechanical Engineering and Basics of Electrical & Electronics Engineering shall be offered in both semesters. Basics of Civil & Mechanical Engineering contain equal weightage for Civil Engineering and Mechanical Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to branches of AEI, EI, BME, ECE, EEE, ICE, CSE, IT, RA can choose this course in S1.

   Basics of Electrical & Electronics Engineering contain equal weightage for Electrical Engineering and Electronics Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to AERO, AUTO, CE, FSE, IE, ME, MECHATRONICS, PE, METTULURGY, BT, BCE, CHEM, FT, POLY can choose this course in S1. Students having Basics of Civil & Mechanical Engineering in one semester should attend Civil & Mechanical Workshop in the same semester and students having Basics of Electrical & Electronics Engineering in a semester should attend Electrical & Electronics Workshop in the same semester.

4. LIFE SKILLS

   Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underlie personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

5. PROFESSIONAL COMMUNICATION

   Objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. Coverage: Listening, Barriers to listening, Steps to overcome them, Purposive listening practice, Use of technology in the professional world. Speaking, Fluency & accuracy in speech, Positive thinking, Improving self-expression, Tonal variations, Group discussion practice, Reading, Speed reading practice, Use of extensive readers, Analytical and critical reading practice, Writing Professional Correspondence, Formal and informal letters, Tone in formal writing, Introduction to reports. Study Skills, Use of dictionary, thesaurus etc., Importance of contents page, cover & back pages, Bibliography, Language Lab.

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Jyothi Engineering College

NAAC Accredited College with NBA Accredited Programmes*

Approved by AICTE & affiliated to APJ Abdul Kalam Technological University

A CENTRE OF EXCELLENCE IN SCIENCE & TECHNOLOGY BY THE CATHOLIC ARCHDIOCESE OF TRICHUR

JYOTHI HILLS, VETTIKATTIRI P.O. CHERUTHURUTHY, THRISSUR, PIN-679531 PH : +91- 4884-259000, 274423 FAX : 04884-274777

NBA accredited B.Tech Programmes in Computer Science & Engineering, Electronics & Communication Engineering, Electrical & Electronics Engineering and Mechanical Engineering valid for the academic years 2016-2022. NBA accredited B.Tech Programme in Civil Engineering valid for the academic years 2019-2022.

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
A	MAT201	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
B	EET201	CIRCUITS AND NETWORKS	2-2-0	4	4
C	EET203	MEASUREMENTS AND INSTRUMENTATION	3-1-0	4	4
D	EET205	ANALOG ELECTRONICS	3-1-0	4	4
E 1/2	EST200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	EEL201	CIRCUITS AND MEASUREMENTS LAB	0-0-3	3	2
T	EEL203	ANALOG ELECTRONICS LAB	0-0-3	3	2
R/M	VAC	REMEDIAL/MINOR COURSE	3-1-0	4 *	4
		TOTAL		26/30	22/26

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions shall keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
A	MAT 204	PROBABILITY, RANDOM PROCESSES AND NUMERICAL METHODS	3-1-0	4	4
B	EET202	DC MACHINES AND TRANSFORMERS	2-2-0	4	4
C	EET204	ELECTROMAGNETIC THEORY	3-1-0	4	4
D	EET206	DIGITAL ELECTRONICS	3-1-0	4	4
E 1/2	EST200	DESIGN & ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN202	CONSTITUTION OF INDIA	2-0-0	2	--
S	EEL202	ELECTRICAL MACHINES LAB I	0-0-3	3	2
T	EEL204	DIGITAL ELECTRONICS LAB	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		26/30	22/26

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.

2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student doesnot opt for minor programme, he/she can be given remedial class.

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SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
A	EET301	POWER SYSTEMS I	3-1-0	4	4
B	EET303	MICROPROCESSORS AND MICROCONTROLLERS	3-1-0	4	4
C	EET305	SIGNALS AND SYSTEMS	3-1-0	4	4
D	EET307	SYNCHRONOUS AND INDUCTION MACHINES	3-1-0	4	4
E 1/2	HUT300	INDUSTRIAL ECONOMICS & FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MCN301	DISASTER MANAGEMENT	2-0-0	2	--
S	EEL331	MICROPROCESSORS AND MICROCONTROLLERS LAB	0-0-3	3	2
T	EEL333	ELECTRICAL MACHINES LAB II	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		27/31	23/27

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.

2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 3 to 5 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.

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SEMESTER VI

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
A	EET302	LINEAR CONTROL SYSTEMS	2-2-0	4	4
B	EET304	POWER SYSTEMS II	3-1-0	4	4
C	EET306	POWER ELECTRONICS	3-1-0	4	4
D	EETXXX	PROGRAM ELECTIVE I	2-1-0	3	3
E 1/2	HUT300	INDUSTRIAL ECONOMICS & FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	EET308	COMREHENSIVE COURSE WORK	1-0-0	1	1
S	EEL332	POWER SYSTEMS LAB	0-0-3	3	2
T	EEL334	POWER ELECTRONICS LAB	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		**28/32**	**23/27**

PROGRAM ELECTIVE I

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
D	EET312	BIOMEDICAL INSTRUMENTATION	2-1-0	3	3
	EET322	RENEWABLE ENERGY SYSTEMS	2-1-0		
	EET332	COMPUTER ORGANIZATION	2-1-0		
	EET342	HIGH VOLTAGE ENGINEERING	2-1-0		
	EET352	OBJECT ORIENTED PROGRAMMING	2-1-0		
	EET362	MATERIAL SCIENCE	2-1-0		
	EET372	SOFT COMPUTING	2-1-0		

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.

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2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.
3. Comprehensive Course Work: The comprehensive course work in the sixth semester of study shall have a written test of 50 marks. The written examination will be of objective type similar to the GATE examination and will be conducted by the University. **Syllabus for comprehensive examination shall be prepared by the respective BoS choosing any 5 core courses studied from semester 3 to 5.** The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum.

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SEMESTER VII

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
A	EET401	ADVANCED CONTROL SYSTEMS	2-1-0	3	3
B	EETXXX	PROGRAM ELECTIVE II	2-1-0	3	3
C	EETXXX	OPEN ELECTIVE	2-1-0	3	3
D	MCN401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	EEL411	CONTROL SYSTEMS LAB	0-0-3	3	2
T	EEQ413	SEMINAR	0-0-3	3	2
U	EED415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		**24/28**	**15/19**

PROGRAM ELECTIVE II

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
B	EET413	ELECTRIC DRIVES	2-1-0	3	3
	EET423	DIGITAL CONTROL SYSTEMS	2-1-0		
	EET433	MODERN OPERATING SYSTEMS	2-1-0		
	EET443	DATA STRUCTURES	2-1-0		
	EET453	DIGITAL SIGNAL PROCESSING	2-1-0		
	EET463	ILLUMINATION TECHNOLOGY	2-1-0		
	EET473	DIGITAL PROTECTION OF POWER SYSTEMS	2-1-0		

OPEN ELECTIVES

The open elective is offered in semester 7. Each program should specify the courses (maximum 5) they would like to offer as electives for other programs. For example the courses listed below are offered by **the Department of ELECTRICAL & ELECTRONICS ENGINEERING for students of other undergraduate branches offered in the college under KTU.**

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SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	EET415	CONTROL SYSTEMS ENGINEERING	2-1-0	3	3
	EET425	INTRODUCTION TO POWER PROCESSING	2-1-0		
	EET435	RENEWABLE ENERGY SYSTEMS	2-1-0		
	EET445	ELECTRIC VEHICLES	2-1-0		
	EET455	ENERGY MANAGEMENT	2-1-0		

NOTE:

1. *All institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12 Noon). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Seminar: To encourage and motivate the students to read and collect recent and reliable information from their area of interest confined to the relevant discipline from technical publications including peer reviewed journals, conference, books, project reports etc., prepare a report based on a central theme and present it before a peer audience. Each student shall present the seminar for about 20 minutes duration on the selected topic. The report and the presentation shall be evaluated by a team of faculty members comprising Academic coordinator for that program, seminar coordinator and seminar guide based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the report.

   Total marks: 100, only CIE, minimum required to pass 50

Attendance	10
Guide	20
Technical Content of the Report	30
Presentation	40

3. Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Electrical &Electronics Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:
   - Survey and study of published literature on the assigned topic;
   - Preparing an Action Plan for conducting the investigation, including team work;
   - Working out a preliminary Approach to the Problem relating to the assigned topic;
   - Block level design documentation

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- Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;
- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final Seminar, as oral Presentation before the evaluation committee.

Total marks: 100, only CIE, minimum required to pass 50

Guide	30
Interim evaluation by the evaluation committee	20
Final Seminar	30
The report evaluated by the evaluation committee	20

The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor.

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SEMESTER VIII

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
A	EET402	ELECTRICAL SYSTEM DESIGN AND ESTIMATION	2-1-0	3	3
B	EETXXX	PROGRAM ELECTIVE III	2-1-0	3	3
C	EETXXX	PROGRAM ELECTIVE IV	2-1-0	3	3
D	EETXXX	PROGRAM ELECTIVE V	2-1-0	3	3
T	EET404	COMPREHENSIVE COURSE VIVA	1-0-0	1	1
U	EED416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		25/29	17/21

PROGRAM ELECTIVE III

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
B	EET414	ROBOTICS	2-1-0	3	3
	EET424	ENERGY MANAGEMENT	2-1-0		
	EET434	SMART GRID TECHNOLOGIES	2-1-0		
	EET444	ELECTRICAL MACHINE DESIGN	2-1-0		
	EET454	SWITCHED MODE POWER CONVERTERS	2-1-0		
	EET464	COMPUTER AIDED POWER SYSTEM ANALYSIS	2-1-0		
	EET474	MACHINE LEARNING	2-1-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
C	EET416	NONLINEAR SYSTEMS	2-1-0	3	3
	EET426	SPECIAL ELECTRIC MACHINES	2-1-0		
	EET436	POWER QUALITY	2-1-0		
	EET446	COMPUTER NETWORKS	2-1-0		
	EET456	DESIGN OF POWER ELECTRONIC SYSTEMS	2-1-0		
	EET466	HVDC & FACTS	2-1-0		
	EET476	ADVANCED ELECTRONIC DESIGN	2-1-0		

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PROGRAM ELECTIVE V

SLOT	COURSE NO	COURSES	L-T-P	HOURS	CREDIT
D	EET418	ELECTRIC AND HYBRID VEHICLES	2-1-0	3	3
	EET428	INTERNET OF THINGS	2-1-0		
	EET438	ENERGY STORAGE SYSTEMS	2-1-0		
	EET448	ROBUST AND ADAPTIVE CONTROL	2-1-0		
	EET458	SOLAR PV SYSTEMS	2-1-0		
	EET468	INDUSTRIAL INSTRUMENTATION &AUTOMATION	2-1-0		
	EET478	BIG DATA ANALYTICS	2-1-0		

NOTE

1. *All institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Comprehensive Course Viva: The comprehensive course viva in the eighth semester of study shall have a viva voce for 50 marks. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation towards the end of the semester. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum. The mark will be treated as internal and should be uploaded along with internal marks of other courses.

3. **Project Phase II:** The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up in Project 1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:
   - In depth study of the topic assigned in the light of the Report prepared under PhaseI;
   - Review and finalization of the Approach to the Problem relating to the assigned topic;
   - Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;

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- Final development of product/process, testing, results, conclusions and future directions;
- Preparing a paper for Conference presentation/Publication in Journals, if possible;
- Preparing a Dissertation in the standard format for being evaluated by the Department;
- Final Presentation before a Committee

Total marks: 150, only CIE, minimum required to pass 75

Guide	30
Interim evaluation, 2 times in the semester by the evaluation committee	50
Quality of the report evaluated by the above committee	30

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor).

Final evaluation by a three-member committee	40

(The final evaluation committee comprises Project coordinator, expert from industry/research Institute and a senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks).

MINOR

Minor is an additional credential a student may earn if s/he does 20 credits worth of additional learning in a discipline other than her/his major discipline of B.Tech. degree. The objective is to permit a student to customize their Engineering degree to suit their specific interests. Upon completion of an Engineering Minor, a student will be better equipped to perform interdisciplinary research and will be better employable. Engineering Minors allow a student to gain interdisciplinary experience and exposure to concepts and perspectives that may not be a part of their major degree programs.

The academic units offering minors in their discipline will prescribe the set of courses and/or other activities like projects necessary for earning a minor in that discipline. A specialist basket of 3-6 courses is identified for each Minor. Each basket may rest on one or more foundation courses. A basket may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. S/he accumulates credits by registering for the required courses, and if the requirements for a particular minor are met within the time limit for the course, the minor will be awarded. This will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx with Minor in yyy". The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, that minor will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

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(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from third to eight semesters for all branches. The minor courses shall be identified by **M slot courses.**

(ii) Registration is permitted for Minor at the beginning of third semester. Total credits required is 182 (162 + 20 credits from value added courses)

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for minor, of which one course shall be a mini project based on the chosen area. They can do miniproject either in S7 or in S8. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Minor shall be conducted along with regular classes and no extra time shall be required for conducting the courses.

(iv) There won't be any supplementary examination for the courses chosen for Minor.

(v) On completion of the program, "Bachelor of Technology in xxx with Minor in yyy" will be awarded.

(vi) The registration for minor program will commence from semester 3 and the all academic units offering minors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3baskets. The basket of courses may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. Reshuffling of courses between various baskets will not be allowed. In any case, they should carry out a mini project based on the chosen area in S7 or S8. Students who have registered **for B. Tech Minor in ELECTRICAL & ELECTRONICS ENGINEERING** can opt to study the courses listed below:

Semester	BASKET I				BASKET II				BASKET III			
	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT
S3	EET281	ELECTRIC CIRCUITS	4	4	EET 283	INTRODUCTION TO POWER ENGINEERING	4	4	EET 285	DYNAMIC CIRCUITS AND SYSTEMS	4	4
S4	EET 282	ELECTRICAL MACHINES	4	4	EET 284	ENERGY SYSTEMS	4	4	EET 286	PRINCIPLES OF INSTRUMENTATION	4	4
S5	EET 381	SOLID STATE POWER CONVERSION	4	4	EET 383	SOLAR AND WINDENERGY CONVERSION SYSTEMS	4	4	EET 385	CONTROL SYSTEMS	4	4
S6	EET 382	POWER SEMICONDUCTOR DRIVES	4	4	EET 384	INSTRUMENTATION AND AUTOMATION OF POWER PLANTS	4	4	EET 386	DIGIT[illegible]	[illegible]	4

S7	EED 481	MINIPROJECT	4	4	EED 481	MINIPROJECT	4	4	EED 481	MINIPROJECT	4	4

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S8	EED 482	MINIPROJECT	4	4	EED 482	MINIPROJECT	4	4	EED 482	MINIPROJECT	4	4

Notes on Minor from Electrical Engineering Department:

Students have to credit additional 5 courses (20 credits) to receive minor in Electrical and Electronics Engineering. While choosing the minor basket, at least two courses in the selected basket should have contents different from the courses in the curriculum of the parent branch. (This is necessary in the case of related branches like Electronics and Communication, Electronics and Instrumentation, Applied Electronics and Instrumentation, Electronics and Biomedical, Computer Science and Engineering etc.) In case where the student chooses a basket with only two courses different from their parent curriculum, the remaining courses have to be selected from the approved MOOC courses. This restriction may be incorporated in the regulations/curriculum.

HONOURS

Honours is an additional credential a student may earn if she/he opts for the extra 20 credits needed for this in her/his own discipline. Honours is not indicative of class. KTU is providing this option for academically extra brilliant students to acquire Honours. Honours is intended for a student to gain expertise/specialise in an area inside his/her major B.Tech discipline and to enrich knowledge in emerging/advanced areas in the branch of engineering concerned. It is particularly suited for students aiming to pursue higher studies. Upon completion of Honours, a student will be better equipped to perform research in her/his branch of engineering. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx, with Honours." The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, Honours will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. The internal evaluation, examination and grading shall be exactly as for other mandatory courses. The Honours courses shall be identified by H slot courses.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from fourth to eight semesters for all branches. The honours courses shall be identified by H slot courses.

(ii) Registration is permitted for Honours at the beginning of fourth semester. Total credits required is 182 (162 + 20 credits from value added courses).

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for honours, of which one course shall be a mini project based on the chosen area. The remaining 8 credits could be acquired through 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Honours shall be conducted along with regular classes and no extra time shall be required for conducting the courses. The students should earn a grade of 'C' or better for all courses under honours.

(iv) There won't be any supplementary examination for the courses chosen for honours.

(v) On successful accumulation of credits at the end of the programme, "Bachelor of Technology in xxx, with Honours" will be awarded if overall CGPA is greater than or equal to 8.5, earned a grade of 'C' or better for all courses chosen for honours and without any history of 'F' Grade.

(vi) The registration for honours program will commence from semester 4 and the all academic units offering honours in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. In any case, they should carry out a mini project based on the chosen area in S8. For example: Students who have registered for **B.Tech Honours in ELECTRICAL & ELECTRONICS ENGINEERING** can opt to study the courses listed below:

Semester	GROUP I				GROUP II				GROUP III			
	Course No	Course Name	HOURS	CREDIT	Course No	Course Name	HOURS	CREDIT	Course No	Course Name	HOURS	CREDIT
S4	EET292	NETWORK ANALYSIS AND SYNTHESIS	4	4	EET 292	NETWORK ANALYSIS AND SYNTHESIS	4	4	EET 292	NETWORK ANALYSIS AND SYNTHESIS	4	4
S5	EET393	DIGITAL SIMULATION	4	4	EET 393	DIGITAL SIMULATION	4	4	EET 393	DIGITAL SIMULATION	4	4
S6	EET394	GENERALISED MACHINE THEORY	4	4	EET 396	ANALYSIS OF POWER ELECTRONIC CIRCUITS	4	4	EET 398	OPERATION AND CONTROL OF POWER SYSTEMS	4	4
S7	EET495	OPERATION AND CONTROL OF GENERATORS	4	4	EET 497	DYNAMICS OF POWER CONVERTERS	4	4	EET 499	CONTROL AND DYNAMICS OF MICROGRIDS	4	4
S8	EED496	MINIPROJECT	4	4	EED 496	MINIPROJECT	4		EED 496	MINIPROJECT	4	[illegible]

INDUCTION PROGRAM

There will be three weeks induction program for first semester students. It is a unique three-week immersion Foundation Programme designed especially for the fresher's which includes a wide range of activities right from workshops, lectures and seminars to sports tournaments, social work and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, inculcate values and ethics, and help students to discover their passion. Foundation Programme also serves as a platform for the fresher's to interact with their batchmates and seniors and start working as a team with them. The program is structured around the following five themes:

The programme is designed keeping in mind the following objectives:

- **Values and Ethics**: Focus on fostering a strong sense of ethical judgment and moral fortitude.
- **Creativity**: Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and other creative activities.
- **Leadership, Communication and Teamwork**: Develop a culture of teamwork and group communication.
- **Social Awareness**: Nurture a deeper understanding of the local and global world and our place in at as concerned citizens of the world.
- **Physical Activities & Sports**: Engage students in sports and physical activity to ensure healthy physical and mental growth.

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SEMESTER I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B 1/2	PHT 110	ENGINEERING PHYSICS	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	--
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		23/24 *	17

*Minimum hours per week

NOTE:

To make up for the hours lost due to induction program, one extra hour may be allotted to each course

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SEMESTER II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B 1/2	PHT 110	ENGINEERING PHYSICS B	3-1-0	4	4
	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C 1/2	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
	EST 110	ENGINEERING GRAPHICS	2-0-2	4	3
D 1/2	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	4	--
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S 1/2	PHL 120	ENGINEERING PHYSICS LAB	0-0-2	2	1
	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T 1/2	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
	ESL 130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
		TOTAL		**28/29**	**21**

NOTE:

1. Engineering Physics B and Engineering Chemistry shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Engineering Physics B in S1 and Engineering Chemistry in S2 & vice versa. Students opting for Engineering Physics B in a semester should attend Physics Lab in the same semester and students opting for Engineering Chemistry in one semester should attend Engineering Chemistry Lab in the same semester.

2. Engineering Mechanics and Engineering Graphics shall be offered in both semesters. Institutions can advise students belonging to about 50% of the number of branches in the

3. Basics of Civil & Mechanical Engineering and Basics of Electrical & Electronics Engineering shall be offered in both semesters. Basics of Civil & Mechanical Engineering contain equal weightage for Civil Engineering and Mechanical Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to branches of AEI, EI, BME, ECE, EEE, ICE, CSE, IT, RA can choose this course in S1.

Basics of Electrical & Electronics Engineering contain equal weightage for Electrical Engineering and Electronics Engineering. Slot for the course is D with CIE marks of 25 each and ESE marks of 50 each. Students belonging to AERO, AUTO, CE, FSE, IE, ME, MECHATRONICS, PE, METTULURGY, BT, BCE, CHEM, FT, POLY can choose this course in S1. Students having Basics of Civil & Mechanical Engineering in one semester should attend Civil & Mechanical Workshop in the same semester and students having Basics of Electrical & Electronics Engineering in a semester should attend Electrical & Electronics Workshop in the same semester.

4. LIFE SKILLS

Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underlie personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

5. PROFESSIONAL COMMUNICATION

Objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs. Coverage: Listening, Barriers to listening, Steps to overcome them, Purposive listening practice, Use of technology in the professional world. Speaking, Fluency & accuracy in speech, Positive thinking, Improving self-expression, Tonal variations, Group discussion practice, Reading, Speed reading practice, Use of extensive readers, Analytical and critical reading practice, Writing Professional Correspondence, Formal and informal letters, Tone in formal writing, Introduction to reports. Study Skills, Use of dictionary, thesaurus etc., Importance of contents page, cover & back pages, Bibliography, Language Lab.

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SEMESTER III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT201	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
B	MET201	MECHANICS OF SOLIDS	3-1-0	4	4
C	MET203	MECHANICS OF FLUIDS	3-1-0	4	4
D	MET205	METALLURGY & MATERIAL SCIENCE	3-1-0	4	4
E 1/2	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN201	SUSTAINABLE ENGINEERING	2-0-0	2	--
S	MEL201	COMPUTER AIDED MACHINE DRAWING	0-0-3	3	2
T	MEL203	MATERIALS TESTING LAB	0-0-3	3	2
R/M	VAC	REMEDIAL/MINOR COURSE	3-1-0	4**	4
		TOTAL		**26/30**	**22/26**

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions shall keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SEMESTER IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT202	PROBABILITY, STATISTICS AND NUMERICAL METHODS	3-1-0	4	4
B	MET202	ENGINEERING THERMODYNAMICS	3-1-0	4	4
C	MET204	MANUFACTURING PROCESS	3-1-0	4	4
D	MET206	FLUID MACHINERY	3-1-0	4	4
E 1/2	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN202	CONSTITUTION OF INDIA	2-0-0	2	--
S	MEL202	FM & HM LAB	0-0-3	3	2
T	MEL204	MACHINE TOOLS LAB-I	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
		TOTAL		26/30	22/26

NOTE:

1. Design & Engineering and Professional Ethics shall be offered in both S3 and S4. Institutions can advise students belonging to about 50% of the number of branches in the Institution to opt for Design & Engineering in S3 and Professional Ethics in S4 & vice versa.
2. *All Institutions should keep 4 hours exclusively for Remedial class/Minor course (Thursdays from 3 to 5 PM and Fridays from 2 to 4 PM). If a student does not opt for minor programme, he/she can be given remedial class.

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SEMESTER V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET301	MECHANICS OF MACHINERY	3-1-0	4	4
B	MET303	THERMAL ENGINEERING	3-1-0	4	4
C	MET305	INDUSTRIAL & SYSTEMS ENGINEERING	3-1-0	4	4
D	MET307	MACHINE TOOLS AND METROLOGY	3-1-0	4	4
E 1/2	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MCN301	DISASTER MANAGEMENT	2-0-0	2	---
S	MEL331	MACHINE TOOLS LAB-II	0-0-3	3	2
T	MEL333	THERMAL ENGINEERING LAB-I	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
		TOTAL		27/31	23/27

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of branches in the institution to opt for Industrial Economics & Foreign Trade in S5 and Management for Engineers in S6 and vice versa.
2. *All institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 3 to 5 PM and Wednesdays from 3 to 5 PM). If a student does not opt for minor/honours programme, he/she can be given remedial class.

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SEMESTER VI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET302	HEAT & MASS TRANSFER	3-1-0	4	4
B	MET304	DYNAMICS OF MACHINERY & MACHINE DESIGN	3-1-0	4	4
C	MET306	ADVANCED MANUFACTURING ENGINEERING	3-1-0	4	4
D	METXXX	PROGRAM ELECTIVE I	2-1-0	3	3
E	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
½	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MET308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	MEL332	COMPUTER AIDED DESIGN & ANALYSIS LAB	0-0-3	3	2
T	MEL334	THERMAL ENGINEERING LAB-II	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
		TOTAL		25/29	23/27

PROGRAM ELECTIVE I

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	MET312	NONDESTRUCTIVE TESTING	2-1-0	3	3
	MET322	DATA ANALYTICS FOR ENGINEERS	2-1-0		
	MET332	ADVANCED MECHANICS OF SOLIDS	2-1-0		
	MET342	IC ENGINE COMBUSTION AND POLLUTION	2-1-0		
	MET352	AUTOMOBILE ENGINEERING	2-1-0		
	MET362	PRODUCT DESIGN AND DEVELOPMENT	2-1-0		
	MET372	ADVANCED METAL JOINING TECHNIQUES	2-1-0		

NOTE:

1. Industrial Economics & Foreign Trade and Management for Engineers shall be offered in both S5 and S6. Institutions can advise students belonging to about 50% of the number of

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2. **All institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Tuesdays from 2 to 4 PM and Wednesdays from 2 to 4 PM). If a student does not opt for minor/honors programme, he/she can be given remedial class.

3. Comprehensive Course Work: The comprehensive course work in the sixth semester of study shall have a written test of 50 marks. The written examination will be of objective type similar to the GATE examination and will be conducted online by the University. **Syllabus for comprehensive examination shall be prepared by the respective BoS choosing any 5 core courses studied from semester 3 to 5.** The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum.

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SEMESTER VII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET401	DESIGN OF MACHINE ELEMENTS	2-1-0	3	3
B	METXXX	PROGRAM ELECTIVE II	2-1-0	3	3
C	METXXX	OPEN ELECTIVE	2-1-0	3	3
D	MCN401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	---
S	MEL411	MECHANICAL ENGINEERING LAB	0-0-3	3	2
T	MEQ413	SEMINAR	0-0-3	3	2
U	MED415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
		TOTAL		**24/28**	**15/19**

PROGRAM ELECTIVE II

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	MET413	ADVANCED METHODS IN NONDESTRUCTIVE TESTING	2-1-0	3	3
	MET423	OPTIMIZATION TECHNIQUES AND APPLICATIONS	2-1-0		
	MET433	FINITE ELEMENT METHOD	2-1-0		
	MET443	AEROSPACE ENGINEERING	2-1-0		
	MET453	HYBRID AND ELECTRIC VEHICLES	2-1-0		
	MET463	OPERATIONS MANAGEMENT	2-1-0		
	MET473	AIR CONDITIONING AND REFRIGERATION	2-1-0		

OPEN ELECTIVE

The open elective is offered in semester 7. Each program should specify the courses (maximum 5) they would like to offer as electives for other programs. The courses listed below are offered by the **Department of MECHANICAL ENGINEERING** for students of

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SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	MET415	INTRODUCTION TO BUSINESS ANALYTICS	2-1-0	3	3
	MET425	QUANTITATIVE TECHNIQUES FOR ENGINEERS	2-1-0		
	MET435	AUTOMOTIVE TECHNOLOGY	2-1-0		
	MET445	RENEWABLE ENERGY ENGINEERING	2-1-0		
	MET455	QUALITY ENGINEERING AND MANAGEMENT	2-1-0		

NOTE:

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honors course (Mondays from 10 to 12 and Wednesdays from 10 to 12 Noon). If a student does not opt for minor/honours programme, he/she can be given remedial class.
2. Seminar: To encourage and motivate the students to read and collect recent and reliable information from their area of interest confined to the relevant discipline from technical publications including peer reviewed journals, conference, books, project reports etc., prepare a report based on a central theme and present it before a peer audience. Each student shall present the seminar for about 20 minutes duration on the selected topic. The report and the presentation shall be evaluated by a team of internal members comprising three senior faculty members based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the report.

Total marks: 100, only CIE, minimum required to pass 50

Attendance	10
Guide	20
Technical Content of the Report	30
Presentation	40

3. Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Mechanical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:
   - Survey and study of published literature on the assigned topic;
   - Preparing an Action Plan for conducting the investigation, including team work;
   - Working out a preliminary Approach to the Problem relating to the assigned topic;
   - Block level design documentation

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Feasibility;

- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final Seminar, as oral Presentation before the evaluation committee.

Total marks: 100, only CIE, minimum required to pass 50

Guide	30
Interim evaluation by the evaluation committee	20
Final Seminar	30
The report evaluated by the evaluation committee	20

The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor.

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SEMESTER VIII

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET402	MECHATRONICS	2-1-0	3	3
B	METXXX	PROGRAM ELECTIVE III	2-1-0	3	3
C	METXXX	PROGRAM ELECTIVE IV	2-1-0	3	3
D	METXXX	PROGRAM ELECTIVE V	2-1-0	3	3
E	MET404	COMPREHENSIVE VIVA VOCE	1-0-0	1	1
U	MED416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	REMEDIAL/MINOR/HONORS COURSE	3-1-0	4*	4
		TOTAL		25/28	17/21

PROGRAM ELECTIVE III

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
B	MET414	QUALITY MANAGEMENT	2-1-0	3	3
	MET424	DECISIONS WITH METAHEURISTICS	2-1-0		
	MET434	PRESSURE VESSEL AND PIPING DESIGN	2-1-0		
	MET444	COMPUTATIONAL FLUID DYNAMICS	2-1-0		
	MET454	INDUSTRIAL TRIBOLOGY	2-1-0		
	MET464	MICRO AND NANO MANUFACTURING	2-1-0		
	MET474	HEATING AND VENTILATION SYSTEMS	2-1-0		

PROGRAM ELECTIVE IV

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
C	MET 416	COMPOSITE MATERIALS	2-1-0	3	3
	MET 426	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	2-1-0		
	MET 436	ACOUSTICS AND NOISE CONTROL	2-1-0		
	MET 446	HEAT TRANSFER EQUIPMENT DESIGN	2-1-0		
	MET 456	ROBOTICS AND AUTOMATION	2-1-0		
	MET 466	TECHNOLOGY MANAGEMENT	2-1-0		

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	MET 476	CRYOGENIC ENGINEERING	2-1-0		

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PROGRAM ELECTIVE V

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
D	MET 418	RELIABILITY ENGINEERING	2-1-0	3	3
	MET 428	INDUSTRIAL INTERNET OF THINGS	2-1-0		
	MET438	FRACTURE MECHANICS	2-1-0		
	MET 448	GAS TURBINES AND JET PROPULSION	2-1-0		
	MET 458	ADVANCED ENERGY ENGINEERING	2-1-0		
	MET 468	ADDITIVE MANUFACTURING	2-1-0		
	MET 478	POWER PLANT ENGINEERING	2-1-0		

NOTE

1. *All Institutions should keep 4 hours exclusively for Remedial class/Minor/Honours course (Mondays from 10 to 12 and Wednesdays from 10 to 12). If a student does not opt for minor/honors programme, he/she can be given remedial class.
2. Comprehensive Course Viva: The comprehensive course viva in the eighth semester of study shall have a viva voce for 50 marks. The viva voce shall be conducted based on the syllabus mentioned for comprehensive course work in the sixth semester. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation towards the end of the semester. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practising questions based on the core courses listed in the curriculum. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
3. **Project Phase II:** The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up in Project 1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:
   - In depth study of the topic assigned in the light of the Report prepared under PhaseI;
   - Review and finalization of the Approach to the Problem relating to the assigned topic;
   - Detailed Analysis/ Modelling/ Simulation/ Design/ Problem Solving/ Experiment as needed;
   - Final development of product/process, testing, results, conclusions and future

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- Preparing a Dissertation in the standard format for being evaluated by the Department;
- Final Presentation before a Committee

Total marks: 150, only CIE, minimum required to pass 75

Guide	30
Interim evaluation, 2 times in the semester by the evaluation committee	50
Quality of the report evaluated by the above committee	30
Final evaluation by a three member committee	40

(The final evaluation committee comprises Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks).

MINOR

Minor is an additional credential a student may earn if s/he does 20 credits worth of additional learning in a discipline other than her/his major discipline of B.Tech. degree. The objective is to permit a student to customize their Engineering degree to suit their specific interests. Upon completion of an Engineering Minor, a student will be better equipped to perform interdisciplinary research and will be better employable. Engineering Minors allow a student to gain interdisciplinary experience and exposure to concepts and perspectives that may not be a part of their major degree programs.

The academic units offering minors in their discipline will prescribe the set of courses and/or other activities like projects necessary for earning a minor in that discipline. A specialist basket of 3-6 courses is identified for each Minor. Each basket may rest on one or more foundation courses. A basket may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. S/he accumulates credits by registering for the required courses, and if the requirements for a particular minor are met within the time limit for the course, the minor will be awarded. This will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx with Minor in yyy". The fact will also be reflected in the consolidated grade card, along with the list of courses taken. If one specified course cannot be earned during the course of the programme, that minor will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

(i) The curriculum/syllabus committee/BoS shall prepare syllabus for courses to be included in the curriculum from third to eight semesters for all branches. The minor courses shall be identified by **M slot courses.**

(ii) Registration is permitted for Minor at the beginning of third semester. Total credits required is 182 (162 + 20 credits from value added courses)

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for minor, of which one course shall be a mini project based on the chosen area. They can do miniproject either in S7 or in S8. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic

(iv) There won't be any supplementary examination for the courses chosen for Minor.

(v) On completion of the program, "Bachelor of Technology in xxx with Minor in yyy" will be awarded.

(vi) The registration for minor program will commence from semester 3 and the all academic units offering minors in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 baskets. The basket of courses may have sequences within it, i.e., advanced courses may rest on basic courses in the basket. Reshuffling of courses between various baskets will not be allowed. In any case, they should carry out a mini project based on the chosen area in S7 or S8. Students who have registered **for B.Tech Minor in MECHANICAL ENGINEERING Branch** can opt to study the courses listed below:

Semester	BASKET I				BASKET II				BASKET III			
	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT
S3	MET281	MECHANICS OF MATERIALS	4	4	MET283	FLUID MECHANICS & MACHINERY	4	4	MET285	MATERIAL SCIENCE & TECHNOLOGY	4	4
S4	MET282	THEORY OF MACHINES	4	4	MET284	THERMODYNAMICS	4	4	MET286	MANUFACTURIN G TECHNOLOGY	4	4
S5	MET381	DYNAMICS OF MACHINES	4	4	MET383	THERMAL ENGINEERING	4	4	MET385	MACHINE TOOLS ENGINEERING	4	4
S6	MET382	MACHINE DESIGN	4	4	MET384	HEAT TRANSFER	4	4	MET386	INDUSTRIAL ENGINEERING	4	4
S7	MED481	MINIPROJECT	4	4	MED481	MINIPROJECT	4	4	MED481	MINIPROJECT	4	4
S8	MED482	MINIPROJECT	4	4	MED482	MINIPROJECT	4	4	MED482	MINIPROJECT	4	4

HONOURS

Honours is an additional credential a student may earn if s/he opts for the extra 20 credits needed for this in her/his own discipline. Honours is not indicative of class. KTU is providing this option for academically extra brilliant students to acquire Honours. Honours is intended for a student to gain expertise/specialise in an area inside his/her major B.Tech discipline and to enrich knowledge in emerging/advanced areas in the branch of engineering concerned. It is particularly suited for students aiming to pursue higher studies. Upon completion of Honours, a student will be better equipped to perform research in her/his branch of engineering. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as "Bachelor of Technology in xxx, with Honours." The fact will also be reflected in the consolidated grade card along with the list of courses taken. If one specified course cannot be earned during the course of the programme, Honours will not be awarded. The individual course credits earned, however, will be reflected in the consolidated grade card.

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semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. The internal evaluation, examination and grading shall be exactly as for other mandatory courses. The Honours courses shall be identified by H slot courses.

(i) The curriculum/syllabus committee/BOS shall prepare syllabus for courses to be included in the curriculum from fourth to eight semesters for all branches. The honours courses shall be identified by H slot courses.

(ii) Registration is permitted for Honours at the beginning of fourth semester. Total credits required is 182 (162 + 20 credits from value added courses).

(iii) Out of the 20 Credits, 12 credits shall be earned by undergoing a minimum of three courses listed in the curriculum for honours, of which one course shall be a mini project based on the chosen area. The remaining 8 credits could be acquired by undergoing 2 MOOCs recommended by the Board of studies and approved by the Academic Council or through courses listed in the curriculum. The classes for Honours shall be conducted along with regular classes and no extra time shall be required for conducting the courses. The students should earn a grade of 'C' or better for all courses under honours.

(iv) There won't be any supplementary examination for the courses chosen for honours.

(v) On successful accumulation of credits at the end of the programme, "Bachelor of Technology in xxx, with Honours" will be awarded if overall CGPA is greater than or equal to 8.5, earned a grade of 'C' or better for all courses chosen for honours and without any history of 'F' Grade.

(vi) The registration for honours program will commence from semester 4 and the all academic units offering honours in their discipline should prescribe set of such courses. The courses shall be grouped into maximum of 3 groups, each group representing a particular specialization in the branch. The students shall select only the courses from same group in all semesters. It means that the specialization is to be fixed by the student and cannot be changed subsequently. In any case, they should carry out a mini project based on the chosen area in S8. Students who have registered for **B.Tech Honours in MECHANICAL ENGINEERING** can opt to study the courses listed below.

SEMESTER	GROUP I				GROUP II				GROUP III			
	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT	Course No.	Course Name	HOURS	CREDIT
S4	MET292	CONTINUUM MECHANICS	4	4	MET294	ADVANCED MECHANICS OF FLUIDS	4	4	MET296	MATERIALS IN MANUFACTURING	4	4

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55	MET393	EXPERIMENTAL STRESS	4	4	MET395	ADVANCED THERMODYNA	4	4	MET397	FLUID POWER	4	4

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		ANALYSIS				MICS				AUTOMATION		
S6	MET394	ADVANCED DESIGN SYNTHESIS	4	4	MET396	COMPRESSIBL E FLUID FLOW	4	4	MET398	ADVANCED NUMERICAL CONTROLLED MACHINING	4	4
S7	MET495	ADVANCED THEORY OF VIBRATIONS	4	4	MET497	COMPUTATIO NAL METHODS IN FLUID FLOW & HEAT TRANSFER	4	4	MET499	PRECISION MACHINING	4	4
S8	MED496	MINIPROJEC T	4	4	MED496	MINIPROJECT	4	4	MED496	MINIPROJECT	4	4

INDUCTION PROGRAM

There will be three weeks induction program for first semester students. It is a unique three-week immersion Foundation Programme designed especially for the fresher's which includes a wide range of activities right from workshops, lectures and seminars to sports tournaments, social work and much more. The programme is designed to mould students into well-rounded individuals, aware and sensitized to local and global conditions and foster their creativity, inculcate values and ethics, and help students to discover their passion. Foundation Programme also serves as a platform for the fresher's to interact with their batchmates and seniors and start working as a team with them. The program is structured around the following five themes:

The programme is designed keeping in mind the following objectives:

- **Values and Ethics**: Focus on fostering a strong sense of ethical judgment and moral fortitude.
- **Creativity**: Provide channels to exhibit and develop individual creativity by expressing themselves through art, craft, music, singing, media, dramatics, and other creative activities.
- **Leadership, Communication and Teamwork**: Develop a culture of teamwork and group communication.
- **Social Awareness:** Nurture a deeper understanding of the local and global world and our place in at as concerned citizens of the world

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SEMESTER -3

RAT 201	PROCESSING AND PROPERTIES OF MATERIALS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze the Structure of materials at different levels, basic conceptsof crystalline materials like unit cell, FCC, BCC.HCP.
CO 2	Explain the concept of phase & phase diagram & understand thebasic terminologies associated with metallurgy. Construction and Understanding,identification of phase diagrams and reactions
CO 3	Understand and suggest the heat treatment process & types.Significance of properties Vs microstructure. demonstrate the test used to find hardenability of steels
CO 4	Analyze the various surface hardening methods and understand their applications
CO 5	Explain features, classification, applications of non ferrous materials like Aluminium, Copper,Magnesium , composite, Polymers etc.
CO 6	Understand the electrical,thermal,magnetic and optical properties of materials

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									2
CO 2	3	2	3									2
CO 3	3	2	2									2
CO 4	3	3	3									2
CO 5	3	2	2									2
CO 6	3	1	2									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

Analyze the Structure of materials at different levels, basic conceptsof crystalline materials like unit cell, FCC, BCC,HCP.

Course Outcome 2 (CO2) :

Explain the concept of phase & phase diagram & understand thebasic terminologies associated with metallurgy. Construction and Understanding,identification of phase diagrams and reactions

Course Outcome 3(CO3):

Understand and suggest the heat treatment process & types.Significance of properties Vs microstructure.demonstrate the test used to find hardenability of steels

Course Outcome 4 (CO4):

Analyze the various surface hardening methodes and understand their applications

Course Outcome 5 (CO5):

Explain features, classification, applications of non ferrous materials likeAluminum, Copper,Magnesium , composite, Polymers etc.

Course Outcome 6 (CO6):

Understand the electrical, thermal,magnetic and optical properties of materials

Syllabus

Module 1

Primary bonds: - characteristics of covalent, ionic and metallic bond, bond energy.Crystallography:- Crystal, space lattice, unit cell- BCC,FCC, HCP structures - short and long range order – effects of crystalline and amorphous structure on mechanical properties.Coordination number and radius ratio; theoretical density;simple problems - Polymorphism and allotropy.Miller Indices: - crystal plane and direction (brief review)- Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning properties.Schmid's law, equation, critical resolved shear stress,correlation of slip system with plastic deformation in metals and applications.Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity.Effects of grain size, grain size distribution, grain shape,grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems

Module 2

Classification of crystal imperfections: - types of dislocation– effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation.Significance of high and low angle grain boundaries on dislocation – driving force for grain growth and applications during heat treatment.Polishing and etching to determine the microstructure and grain size.Diffusion in solids, Fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.

Module 3

Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types.Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, special features of martensitetransformation, bainite, spheroidite etc. TTT for a eutectoid iron–carbon alloy, CCT diagram, applications - annealing, normalizing, hardening, spheroidizing.Tempering:-austermpering, martempering and ausforming- Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming.Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications.

Module 4

Principal Non ferrous Alloys: - Aluminium, Copper,Magnesium, Nickel, study of composition, properties,applications.Composites:- Need of development of composites -geometrical and spatial Characteristics of particles –classification - fiber phase: - characteristics, classifications -matrix phase:- functions – only need and characteristics of PMC, MMC, and CMC – applications of composites: aircraft applications, aerospace equipment and instrument structure, industrial applications of composites, marine applications, composites in the sporting goods industry, composite biomaterials. Deformation of Semi crystalline Polymers , Factors That Influence the Mechanical Properties of Semi crystalline Polymers ,Polymer Films,Deformation of Elastomers

Module 5

Electrical Properties-Ohm's Law,Electrical Conductivity,Electronic and Ionic Conduction,Energy Band Structures in Solids ,Conduction in Terms of Band and Atomic,Bonding Models ,Electron Mobility,Electrical Resistivity of Metals,Electrical Characteristics of Commercial Alloys .Thermal Properties-Heat Capacity,Thermal Expansion ,Materials of Importance—Invar and Other Low-Expansion Alloys ,Thermal Conductivity ,Thermal Stresses . Magnetic Properties- Basic Concepts Diamagnetism and Paramagnetism , Ferromagnetism , Antiferromagnetism and Ferrimagnetism The Influence of Temperature on Magnetic Behavior ,Hysteresis , Magnetic Anisotropy. Optical Properties-Electromagnetic Radiation, Light Interactions with Solids , Atomic and Electronic Interactions,Refraction, Reflection , Absorption , Transmission , Color, Opacity and Translucency in Insulators.

Text Books

1. Fundamentals of Materials Science and Engineering: An Integrated Approach - William D callister, David G. Rethwisch
2. Raghavan V, Material Science and Engineering, Prentice Hall,2004

Reference Books

1. Shackelford J., Introduction to Materials Science for Engineers, 7/e, Pearson, 2009.
2. Van Vlack L. H., Elements of Materials Science and Engineering, Addison-Wesley, 1989.
3. Lakhtin Y., Engineering Physical Metallurgy, Gordon and Breach Science Publishers, 1965.
4. Dieter G. E., Mechanical Metallurgy, McGraw-Hill, 1976.
5. Reed-Hill R. E., Physical Metallurgy, PWS-Kent Publishing Company, 1992.
6. Avner S. H., Introduction to Physical Metallurgy, McGraw-Hill, 1974.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module -1**	
1.1	Primary bonds,covalent, ionic and metallic bond, bond energy	1
1.2	Crystallography,Crystal, space lattice, unit cell-simple problems	2
1.3	BCC,FCC, HCP structures,Coordination number and radius ratio, theoretical density;simple problems	2
1.4	Polymorphism and allotropy.Miller Indices: - crystal plane and direction	2
1.5	Modes of plastic deformation,Slip and twinning properties.Schmid's law, equation, critical resolved shear stress,correlation of slip system with plastic deformation in metals and applications	2
1.6	Mechanism of crystallization,Homogeneous and heterogeneous nuclei formation, under cooling	2
1.7	Dendritic growth, grain boundary irregularity.Effects of grain size, grain size distribution, grain shape	2
1.8	Strength and creep resistance - Hall - Petch theory, simple problems	2
2	**Module -2**	
2.1	Classification of crystal imperfections,types of dislocation,effect of point defects on mechanical properties , forest of dislocation, role of surface defects on crack initiation	2
2.2	Significance of high and low angle grain boundaries on dislocation , driving force for grain growth and applications during heat treatment	2
2.3	Polishing and etching to determine the microstructure and grain size	1
2.4	Fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.	2
3	**Module -3**	
	Classification of alloys, solid solutions, Hume Rothery`s rule , equilibrium diagram of common types of binary systems: five types	2
	Detailed discussion on Iron-Carbon equilibrium diagram	2
	TTT for a eutectoid iron–carbon alloy, CCT diagram, applications	2
	Annealing, normalizing, hardening, spheroidizing.Tempering:-austermpering, martempering and ausforming	2
	Study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming	2

	Hardenability, Jominy end quench test, applications-Surface hardening methods:- no change in surface composition methods:- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications.	2
4	**Module -4**	
	Non ferrous Alloys,Aluminum, Copper,Magnesium, Nickel, study of composition, properties,applications	1
	Composites,Need of development of composites ,fiberphase,matrix phase, characteristics of PMC, MMC, and CMC .	2
	Applications of composites: aircraft applications, aerospace equipment and instrument structure, industrial applications of composites, marine applications, composites in the sporting goods industry, composite biomaterials.	1
	Mechanical Properties of Semicrystalline Polymers ,Polymer Films,Deformation of Elastomers	1
5	**Module -5**	
	Electrical Properties-Ohm's Law,Electrical Conductivity,Electronic and Ionic Conduction,Energy Band Structures in Solids ,Conduction in Terms of Band and Atomic, Bonding Models,Electron Mobility,Electrical Resistivity of Metals,Electrical Characteristics of Commercial Alloys	1
	Thermal Properties-Heat Capacity,Thermal Expansion ,Materials of Importance—Invar and Other Low-Expansion Alloys ,Thermal Conductivity ,Thermal Stresses	1
	Magnetic Properties- Basic Concepts Diamagnetism and Paramagnetism , Ferromagnetism , Antiferromagnetism and Ferrimagnetism The Influence of Temperature on Magnetic Behavior ,Hysteresis , Magnetic Anisotropy	2
	Optical Properties- Electromagnetic Radiation, Light Interactions with Solids , Atomic and Electronic Interactions,Refraction, Reflection , Absorption , Transmission , Color, Opacity and Translucency in Insulators.	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 201

Course Name:PROCESSING AND PROPERTIES OF MATERIALS

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all questions, each carries 3 marks. Marks

1		Cite the difference between atomic mass and atomic weight	(3)
2		What is the difference between atomic structure and crystal structure?	(3)
3		Draw an orthorhombic unit cell and within that cell a (210) plane	(3)
4		Calculate the number of atoms per cubic meter in aluminium	(3)
5		Briefly explain the difference between self-diffusion and inter diffusion.	(3)
6		Draw a general unary phase diagram and explain its various regions.	(3)
7		Derive the lever rule using in phase diagram.	(3)
8		Explain the flame hardening process.	(3)
9		Explain the surface nitriding process.	(3)
10		Briefly describe sandwich panels.	(3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11	a)	For the HCP crystal structure,show that the ideal c/a ratio is 1.633	(6)
	b)	Show that the body centered cubic crystal structure that the unit cell edge length a and atomic radius R are related through $a = 4\,R/\sqrt{3}$	(8)
12	a)	Iron has a BCC crystal structure,an atomic radius of 0.124nm,and an atomic weight of 55.85g/mol. Compute its theoretical density.	(10)
	b)	Convert the (010) and (101) plane in to the four index Miller Bravies scheme for hexagonal unit cell	(4)

MODULE II

13	a)	Calculate the fraction of atom sites that are vacant for lead at its melting temperature of 600K .Assume an energy for vacancy formation of 0.55eV/atom.	(6)

	b)	For a given material,would you expect the surface energy to be greater than,the same as ,or less than the grain boundary energy? Why?	(8)
14	a)	Explain different types of crystal imperfections.	(10)
	b)	Cite the relative Burgers vector-dislocation line orientation for edge,screw and mixed dislocation.	(4)

MODULE III

15	a)	Explain Jominy end quench test.	(6)
	b)	Explain The TTT diagram for iron carbon alloy	(8)
16	a)	Explain the iron carbon phase diagram	(10)
	b)	Explain austempering process	(4)

MODULE IV

17	a)	Explain briefly why the tendency of a polymer to crystallize decrease with increasing molecular weight.	(8)
	b)	For a polymer matrix fiber reinforced composite (a)list three functions of matrix phase and (b)Compare the desired mechanical characteristics of matrix and fiber phase	(6)
18	a)	Make comparison of thermoplastic and thermosetting polymer on the basis of mechanical characteristics up on heating and according to possible molecular structure	(10)
	b)	What is a hybrid composite?. List two important advantages of hybrid composite over normal fiber composite.	(4)

MODULE V

19	a)	Briefly explain why some transparent material appeared colored where as others are colorless	(8)
	b)	What is the distinction between electronic and ionic conduction?	(6)
20	a)	Briefly describe the phenomenon of magnetic hysteresis and why it occur for ferromagnetic and ferrimagnetic materials.	(7)
	b)	For some ceramic materials,why does the thermal conductivity first decrease and then increase with rising temperature?	(7)

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RAT 203	ELECTRONIC DEVICES AND CIRCUITS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design of wave shaping circuits
CO 2	Design and analyse biasing schemes for transistor circuits
CO 3	Model and evaluate amplifier circuits
CO 4	Choose an amplifier with appropriate specifications for electronic circuit applications
CO 5	Design and analyse oscillator circuits
CO 6	Build and evaluate different waveform generation circuits using Op-amps and timer ICs

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	2		2						3
CO 2	3	2	2	2		1						3
CO 3	3	2	2	2		2						3
CO 4	3	2	2	2		2						3
CO 5	3	2	2	2		2						3
CO 6	3	2	2	2		2						3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
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Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Module 1

Diode Circuits: Clipping circuits- Single level and two level clippers, Clamping circuits-Design of Zener voltage regulators

BJT biasing circuits: DC load line, Operating point of a BJT, Factors affecting stability of Q point, Fixing of operating point.

Biasing circuits - fixed bias, collector feedback bias, emitter bias and voltage divider bias, Bias compensation using diode and thermistor, Low frequency equivalent circuit of BJT. Common Emitter amplifier - Role of coupling and emitter bypass capacitors – AC Equivalent Circuit – h parameter model of BJT -Amplifier gains and impedances calculations using h equivalent circuit

Module 2

Field effect Transistors: Review of JFET and MOSFET construction, working and characteristics- Biasing a JFET and MOSFET using voltage divider bias–- CS and CD amplifiers – small signal models- FET as switch and voltage controlled resistance.

Frequency response of Amplifiers: Frequency Response characteristics of BJT and FET amplifier, Low frequency and High frequency analysis of BJT (Common Emitter) and FET (Common Source) amplifier **:** Miller effect capacitance, Miller’s Theorem, Gain bandwidth product, hybrid Pi Model of BJT amplifier

Module 3

Multistage amplifiers: Different types of coupling - Direct, RC, & transformer coupled amplifiers - operation, advantages and disadvantages (Analysis not required)

Power amplifiers using BJT: Class A, Class B, Class AB and Class C power amplifiers, Conversion efficiency and distortion in power amplifiers

Feedback amplifiers: Positive and negative feedback, Effect of negative feedback on gain, input impedance, output impedance, band width and distortion, Basic feedback topologies - Gain, input and output impedance with feedback

Module 4

Oscillators: Oscillator operation, Bark Hausen’s criterion, RC oscillators – working of BJT based RC phase shift and Wien bridge oscillators, LC Oscillators - working of BJT based Hartley, Colpitts - with derivation of frequency of oscillation for the above mentioned oscillators and Crystal oscillators

Operational amplifiers: Introduction, Basic block diagram, Ideal op-amp, transfer characteristics and op-amp parameters, gain, CMRR, slew rate etc, Equivalent circuit of ideal and practical op-amp, op-amp configurations- Open loop and closed loop configurations, -properties of ideal and practical opamp.

Basic Op-amp Circuits: Inverting and non-inverting amplifier, Scale changer, Voltage follower, Summing amplifier, Subtractor, Adder-subtractor

Module 5

Op-amp applications: Differential amplifier with single op-amp, Instrumentation amplifier, Integrators, Differentiators, Comparators, Zero crossing detector, Schmitt trigger; square, triangular and ramp generator using opamp, Effect of slew rate on wave form generation.

Specialized ICs and their applications:

Timer IC 555 - Block Diagram of IC 555, Astable and Monostable operations
Phase Locked Loop - Block Diagram of PLL IC 565, Operation, Lock and capture range
Voltage Regulators - Fixed voltage regulators, 78XX and 79XX series, Adjustable voltage regulators, IC 723 Voltage regulator.

Text Books

1. Robert L. Boylestad and Louis Nashelsky, “Electronic Devices and Circuit Theory”, Pearson Education India, 11/e, 2013
2. Albert Malvino and David J. Bates, “Electronic Principles”, Tata McGraw-Hill, 7/e, 2007
3. Gayakwad R. A., “Op-Amps and Linear Integrated Circuits”, Pearson Education India, 4/e, 2015
4. Salivahanan S. and V. S. Kanchana Bhaaskaran, “Linear Integrated Circuits”, McGraw Hill Education India, 2/e, 2015

Reference Books

1. Sedra A.S. and Smith K.C., “Microelectronics Circuits-Theory and Applications”, Oxford University Press, 6/e, 2011
2. Jacob Millman and Arvin Grabel, “Micro Electronics”, Tata McGraw-Hill, 2/e, 1999
3. Donald A. Neamen, “Electronic Circuits-Analysis and Design”, McGraw Hill Education India, 3/e, 2007

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	MODULE 1	
1.1	**Diode Circuits:** Clipping circuits- Single level and two-level clippers, Clamping circuits-Design of Zener voltage regulators	3
1.2	**BJT biasing circuits:** DC load line, Operating point of a BJT, Factors affecting stability of Q point, Fixing of operating point. Biasing circuits - fixed bias, collector feedback bias, emitter bias and voltage divider bias, Bias compensation using diode and thermistor, Low frequency equivalent circuit of BJT. Common Emitter amplifier - Role of coupling and emitter bypass capacitors – AC Equivalent Circuit – h parameter model of BJT -Amplifier gains and impedances calculations using h equivalent circuit	7
2	MODULE 2	
2.1	**Field effect Transistors:** Review of JFET and MOSFET construction, working and characteristics, Biasing a JFET and MOSFET using voltage divider bias, CS and CD amplifiers, small signal models-FET as switch and voltage controlled resistance.	4
2.2	**Frequency response of Amplifiers** Frequency Response characteristics of BJT and FET amplifier Low frequency and High frequency analysis of BJT (Common Emitter) and FET (Common Source)amplifier Miller effect capacitance, Miller’s Theorem, Gain bandwidth product, hybrid Pi Model of BJT amplifier	5
3	MODULE 3	

3.1	Multistage amplifiers**:** Different types of coupling - Direct, RC, & transformer coupled amplifiers -operation, advantages and disadvantages (Analysis not required)	1
3.2	**Power amplifiers using BJT:** Class A, Class B, Class AB and Class C power amplifiers, Conversion efficiency and distortion in power amplifiers.	3
3.3	**Feedback amplifiers:** Positive and negative feedback, Effect of negative feedback on gain, input impedance, output impedance, band width and distortion, Basic feedback topologies - Gain, input and output impedance with feedback	4
4	MODULE 4	
4.1	**Oscillators:** Oscillator operation, Bark Hausen's criterion, RC oscillators – working of BJT based RC phase shift and Wien bridge oscillators, LC Oscillators - working of BJT based Hartley, Colpitts - with derivation of frequency of oscillation for the above mentioned oscillators and Crystal oscillators.	4
4.2	**Operational amplifiers:** Introduction, Basic block diagram, Ideal op-amp transfer characteristics and op-amp parameters, gain, CMRR, slew rate etc Equivalent circuit of ideal and practical op-amp, op-amp configurations- Open loop and closed loop configurations, -properties of ideal and practical opamp.	3
4.3	**Basic Op-amp Circuits:** Inverting and non-inverting amplifier, Scale changer, Voltage follower, Summing amplifier, Subtractor, Adder-subtractor	2
5	MODULE 5	
5.1	**Op-amp applications:** Differential amplifier with single op-amp, Instrumentation amplifier-derivation of gain Integrators, Differentiators, Comparators, Zero crossing detector, Schmitt trigger; square, triangular and ramp generator using opamp, Effect of slew rate on wave form generation.	4
5.2	Specialized ICs and their applications: **Timer IC 555** - Block Diagram of IC 555, Astable and Monostable operations	2
5.3	**Phase Locked Loop** - Block Diagram of PLL IC 565, Operation, Lock and capture range.	1
5.4	**Voltage Regulators -** Fixed voltage regulators, 78XX and 79XX series, Adjustable voltage regulators, IC 723 Voltage regulator	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 203

Course Name: ELECTRONIC DEVICES AND CIRCUITS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		A positive voltage clamping circuit and a positive shunt clipping circuit each have a ± 5V square wave input. Sketch the output waveform of each circuit.	(3)
2		Draw the h parameter model of BJT.	(3)
3		In a CE amplifier circuit, hfe =50, hie =1.3kΩ, Cbc= 5pF, RC =3kΩ, RL= 2.2 kΩ. Calculate the Miller capacitance.	(3)
4		Draw and Explain the drain characteristics of N channel Enhancement MOSFET.	(3)
5		Compare different multistage amplifiers.	(3)
6		Explain how cross over distortion is avoided in class AB amplifier.	(3)
7		Design a Wein bridge oscillator to generate a sinusoidal waveform of 2 kHz.	(3)
8		List the properties of ideal opamp.	(3)
9		Explain the effect of slew rate on waveform generation.	(3)
10		In an astable multivibrator using 555, RB = 750 Ω. Determine the values of RA and C to generate a 1.0 MHz clock that has a duty cycle of 25%.	(3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11	a)	Define operating point and explain the factors affecting the operating point stability.	(6)
	b)	Explain any one compensation technique used for reducing the drift of operating point.	(8)
12	a)	Design a voltage divider bias circuit to operate from 15 V supply. The bias conditions are to be VCE = VE = 5V and IC = 5mA. Assume the transistor β is 100. Calculate the stability factors of the designed circuit.	(10)
	b)	Explain the role of coupling and emitter bypass capacitors in amplifier circuits.	(4)

MODULE II

13	a)	Draw the frequency response curve of CE amplifier and explain why the gain decreases at low and high frequencies	(6)
	b)	With a neat diagram explain the construction and characteristics of JFET.	(8)
14	a)	Using small signal model, derive the expression for Zi, Zo, AV, Ai of a CS amplifier circuit	(10)
	b)	Draw the hybrid pi model of BJT amplifier.	(4)

MODULE III

15	a)	Explain the effects of negative feedback.	(6)
	b)	Draw the circuit diagram and explain the working of two stage Transformer coupled amplifier. Discuss the important features and applications.	(8)
16	a)	Draw a negative voltage shunt feedback topology. Derive the Gain, input impedance and output impedance.	(10)
	b)	A transformer coupled class A power amplifier draws a current of 200mA from a collector supply of 10V, when no signal is applied to it. Determine i) Maximum output power ii) Maximum collector efficiency iii) Power rating of the transistor.	(4)

MODULE IV

17	a)	Draw the circuit of Hartley oscillator and derive the frequency of oscillation.	(8)
	b)	Explain the working of op-amp inverting amplifier. Derive the expression for its voltage gain.	(6)
18	a)	Draw the circuit of a three channel summer amplifier and derive the expression for output voltage. Design a summer having gains of 5dB, 10 dB and 15dB respectively for each channel.	(10)
	b)	Explain the basic principle of oscillator.	(4)

MODULE V

19	a)	Draw the elementary block diagram of PLL and explain.	(8)
	b)	Design a monostable multivibrator which produces an output pulse width of 1 ms using 555.	(6)
20	a)	Derive the overall gain in an instrumentation amplifier.	(7)
	b)	Draw the functional block diagram of IC 723 and explain its operation.	(7)

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RAT 205	DIGITAL ELECTRONICS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Course Outcomes: After the completion of the course the student will be able to

CO 1	Represent numbers in different digital formats and to perform logical operations
CO 2	Choose a digital IC based on its characteristics
CO 3	Analyse and synthesise combinational logic circuits and to derive minimal logic functions
CO 4	Analyse and design sequential logic circuits
CO 5	Familiarize A/D and D/A conversion techniques
CO 6	Familiarizethe basic concepts of memory, programmable logic devices
CO 7	Design basic combinational and sequential logic circuits using Verilog

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	2	2	1	-							2
CO 2	2	3	3	2								2
CO 3	3	3	3	2		2						3
CO 4	3	3	3	2		2						3
CO 5	3	3	3	2		2						3
CO 6	3	2	2	2								2
CO 7	3	3	3	2	2	2						3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Module 1

Number Systems and Codes- Decimal, Binary, Octal and hexadecimal and their conversions, ASCII code, Excess -3 code, Gray code; Binary addition and subtraction, unsigned and signed numbers, 1's complement and 2's complement arithmetic

Logic Gates – NOT, AND, OR, NAND, NOR, XOR, XNOR

Characteristics of digital ICs- Speed, Power dissipation, fan-out, current and voltage parameters, noise margin, operating temperature etc, TTL and CMOS Logic-NAND gate realisations- Comparison of TTL and CMOS families, TTL and CMOS Series Characteristics.

Module 2

Boolean Laws and Theorems- laws and rules of Boolean algebra, De Morgan's theorem; NAND and NOR implementations; Sum of Products form, product of sums form; K map representation and simplification (up to four variables)

Combinational circuits: Adders - Half adder and full adder, Subtractors, half subtractor and full subtractor , Ripple Carry Adder, Carry Look ahead adders,-1, Multiplexers, Demultiplexers, Encoders, BCD to decimal decoders

Module 3

Sequential circuits: Flip-Flops, SR-1, JK-1, D and T flip-flops, JK Master Slave Flip-flop, Conversion of flip-flops

Shift Registers -SISO, SIPO, PISO, PIPO.

Counters: Asynchronous Counters- up counter-down counter-decade counter; Mod N counters.

Module 4

Synchronous counter design: Ring counter -Johnson Counter - Mod N counter - Decade counter.

Digital to Analog conversion – R-2R ladder - weighted resistors; D/A converter specifications, D/A converter ICs, DAC-08-Typical Performance characteristics. Basic connection diagram, Familiarisation of DAC-0808, DAC 80, AD 7524

Analog to Digital Conversion -Flash ADC -Successive approximation; Integrating ADC., A/D converter specifications, A/D converter ICs-ADC 0800-Basic block diagram and working, Familiarisation of ADC 0808, AD 7820

Module 5

Memory - ROM -PROM – EPROM – RAM- Solid state drives

Sequential Programmable Logic Devices - PAL, PLA, FPGA

Introduction to Verilog, Design using Verilog basic gates, arithmetic circuits, basic- combinational and sequentiallogic circuits

Text Books:

1. Thomas L Floyd, Digital Fundamentals, 10e, Pearson Education 2011

2. Tocci R.J and N.S.Widmer, Digital Systems, Principles and Applications, 11/e, , Pearson Education
3. Albert P Malvino, Donald P Leach, Digital Principles and Applications, 8e, McGraw Hill

References:

1. M Morris Mano, Digital Logic and Computer Design, 4e, Pearson Education
2. S Salivahanan, S Arivazhagan, Digital Circuits and Design, 2e, Vikas Publishing House Pvt. Ltd
3. Taub& Shilling, Digital Integrated Electronics, McGraw Hill
4. 4. John F. Wakerly, Digital Design: Principles and Practices, 4/e, , Pearson, 2005

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Number Systems and Codes- Decimal, Binary, Octal and hexadecimal and their conversions, ASCII code, Excess -3 code, Gray code; Binary addition and subtraction, unsigned and signed numbers, 1's complement and 2's complement arithmetic	4
1.2	Logic Gates – NOT, AND, OR, NAND, NOR, XOR, XNOR	1
1.3	Characteristics of digital ICs- Speed, Power dissipation, fan-out, current and voltage parameters, noise margin, operating temperature etc, TTL and CMOS Logic-NAND gate realisations-current sourcing, current sinking, Totem-pole output circuit, Comparison of TTL and CMOS families, TTL and CMOS Series Characteristics.	4
2	**MODULE 2**	
2.1	Boolean Laws and Theorems- laws and rules of Boolean algebra, De Morgan's theorem; NAND and NOR implementations; Sum of Products form, product of sums form; K map representation and simplification (up to four variables)	5
2.2	Combinational circuits: Adders - Half adder and full adder , Subtractors, half subtractor and full subtractor, Ripple Carry Adder, Carry Look ahead adders, Multiplexers, Demultiplexers, Encoders, BCD to decimal decoders	4
3	**MODULE 3**	
3.1	Sequential circuits: Flip-Flops, SR, JK, D and T flip-flops, JK Master Slave Flip-flop, Conversion of flip-flops	4
3.2	Shift Registers -SISO, SIPO, PISO, PIPO.	2
3.3	Counters: Asynchronous Counters- up counter-down counter-decade counter; Mod N counters.	3
4	MODULE 4	

4.1	Synchronous counter design: Ring counter -Johnson Counter - Mod N counter - Decade counter.	3
4.2	Digital to Analog conversion – R-2R ladder - weighted resistors; D/A converter specifications, D/A converter ICs, DAC-08-Typical Performance characteristics. Basic connection diagram, Familiarisation of DAC-0808, DAC 80, AD 7524	3
4.3	Analog to Digital Conversion -Flash ADC -Successive approximation; Integrating ADC., A/D converter specifications, A/D converter ICs-ADC 0800-Basic block diagram and working, Familiarisation of ADC 0808, AD 7820	3
5	MODULE 5	
5.1	Memory - ROM -PROM – EPROM – RAM- Solid state drives	2
5.2	Sequential Programmable Logic Devices - PAL, PLA, FPGA	2
5.3	Introduction to Verilog, Design using Verilog basic gates, arithmetic circuits, basic combinational circuits, sequential logic circuits	5

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 205

Course Name: DIGITAL ELECTRONICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 Prove that A+ A'B + AB' = A + B (3)

2 Convert the hexadecimal number (B2D.FC)16 into decimal, binary and octal (3)

3 Using K map, derive the Boolean expression for (3)

$F(A, B, C, D) = \sum m(0, 1, 3, 4, 6, 9, 11) + d(2, 5)$

4 Draw the truth table for a half subtractor. Implement the circuit using logic gates. (3)

5 Draw the circuit diagram of a typical TTL NAND gate. (3)

6 Differentiate between asynchronous and synchronous counters. (3)

7 Explain the principle of working of a BCD to decimal decoder. (3)

8 Design a 3 bit ring counter. (3)

9 Mention the significance of programmable logic devices. (3)

10 Write a Verilog code for D Flipflop. (3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11 a) Write a short note on classification of binary codes. (6)

b) Perform the unsigned binary subtraction (8)

10101101 – 01110111 by 1's complement method

12 a) Convert the decimal number -25.125 to a single- precision floating point binary number. (6)

b) Determine single error correcting code for the data 01110 using even parity. (8)

MODULE II

13 a) Explain the working of a carry look ahead adder with the help of a diagram. (7)

b) Draw a 4 to 1 multiplexer using logic gates. (7)

14 a) Explain the working of a ripple carry adder with the help of a diagram. (7)

b) Express the output logic function Y in standard SOP form and standard POS form. (7)

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

MODULE III

15 a) Draw and explain the working of a JK Flipflop. (6)

b) Explain with diagram the working of a 3 bit parallel in serial out shift register. (8)

16 a) Design a mod 10 counter and explain its timing diagram. (8)

b) Design a 3 bit asynchronous down counter. (6)

MODULE IV

17	a)	Explain the working of a successive approximation ADC.	(6)
	b)	Design a synchronous 4 bit up counter.	(8)
18	a)	With a neat diagram, explain the operation of a 3 bit Johnson counter.	(7)
	b)	With suitable diagram, explain the operation of a DAC.	(7)

MODULE V

19	a)	Differentiate between SRAM and DRAM with diagrams.	(8)
	b)	Describe the structure of a PLA.	(6)
20	a)	Differentiate between PROM, PLA and PAL.	(7)
	b)	Write Verilog Code for a full adder circuit.	(7)

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RAL 201	MACHINE DRAWING AND SOLID MODELLING LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

CO1	Understand the basic principles of machine drawing as per standards and to get familiar with the different schemes of dimensioning, providing symbols with simple machine parts drawings.
CO2	Understand and get familiar to specifying limits, fits, dimensional and geometric tolerances and surface roughness in machine drawings
CO3	Get familiar to assembly drawing practices and prepare assembly drawings of robotic components.
CO4	Get hands on using CAD software for preparing 2D drawings and 3D models of parts and to export them to various formats for different applications.
CO5	Get hands on preparing the assemblies of various machine parts using cad models and using them for various analysis purposes.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											3
CO 2	3											3
CO 3	3				3							3
CO 4	3	2			3							3
CO 5	3	2			3							3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test*: 30 marks

*First internal evaluation must be based on the first three modules (manual drawing)

*The second internal evaluation is to be done with a mini project, incorporating the CAD of a mechanical assembly, initially creating 2D drawings of the assembly and then designing the parts in 3D modelling and generating 2D from the 3D assembly and comparing with the initial 2D drawings.

End Semester Examination Pattern: This will be based on modules III-V. The following guidelines should be followed regarding award of marks

(a) Completion of parts- 25 marks

(b)Assembly of parts-15 marks

(c) Development of 2D drawing (Annotations, bill of materials, dimensions)-30 marks

(d) Record (File of all manual drawings and CAD print outs)- 5marks

Module	Contents
I	Introduction Principles of drawing: - Free hand sketching, manual drawing, CAD drawing etc. Code of practice for Engineering Drawing: -BIS specifications – lines, types of lines, dimensioning, sectional views,Welding symbols, riveted joints, keys, fasteners –bolts, nuts, screws, keys.
II	Limits, Fits – Tolerances of individual dimensions – Specification of Fits – basic principles of geometric & dimensional tolerances. surface roughness, indication of surface roughness etc.
III	Preparation of production drawings and reading of part and assembly drawings, Exercises on Fasteners, Couplings- Oldham's coupling, flexible couplings, universal joints.
IV	Introduction, input, output devices, introduction to drafting software like Auto CAD, basic commands and development of simple 2D and 3D drawings, Different file formats for 3D modelling(IGES, STL etc.) Drawing, Editing, Dimensioning,Plotting Commands, Layering Concepts, Matching, Detailing, Detailed drawings.
V	Exercises on 3D solid modelling: -Plummer block, bearings, guideways, generating 2D from 3D, assembly drawing of mechanical engineering parts. Exercises on valves, couplings, gears and gear trains, belts, pulleys, modelling of robot grippers. Incorporating electronic components in CAD models.

RAL 203	ELECTRONIC CIRCUITS AND DIGITAL ELECTRONICS LABORATORY	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design and develop various wave shaping circuits, amplifiers and oscillators using discrete components
CO 2	Design and test various circuits using opamps
CO 3	Design and test various combinational and sequential logic circuits
CO 4	Design PCBs
CO 5	Program basic combinational circuits using Verilog

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	2		2			2	2		3
CO 2	3	2	2	2		2			2	2		3
CO 3	3	2	2	2		2			2	2		3
CO 4	3	2	2	2		2			2	2		3
CO 5	3	2	2	2	2	2			2	2		3
CO 6	3	2	2	2	2	2			2	2		3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 Marks
(e) Record : 5 Marks

LIST OF EXPERIMENTS

Any 5 experiments each from Part A and Part B. Part C is compulsory

Part A: Electronic Circuits

1. Clipping and clamping circuits using diodes
2. RC coupled amplifier using BJT in CE configuration- Measurement of gain, input and output impedance and frequency response
3. JFET amplifier- Measurement of voltage gain, current gain, input and output impedance
4. RC phase shift oscillator using BJT and OPAMPS
5. OPAMP circuits – Design and set up of inverting and non-inverting amplifier, scale changer, adder, integrator, differentiator
6. Comparator and Schmitt Trigger using OPAMPs
7. Astable and monostable circuit using IC 555
8. Design and testing of zener voltage regulators

Part B: Digital Electronics

1. Realisation of SOP & POS functions after K map reduction
2. Half adder and Full adder realization using NAND gates
3. 4-bit adder/subtractor using IC 7483
4. BCD to decimal decoder and BCD to 7-segment decoder and display
5. Study of multiplexer IC and realization of combinational circuits using multiplexers
6. Study of counter ICs (7490, 7493)
7. Design of synchronous up, down and modulo N counters
8. Study of shift register IC 7495, Ring counter and Johnson counter

PART C: Part C is compulsory

1. Introduction to PCB layout software
2. Verilog implementation of full adder, 4 bit magnitude comparator

Reference Books

1. Robert L. Boylestad and Louis Nashelsky, “Electronic Devices and Circuit Theory”, Pearson Education India, 11/e, 2013
2. Albert Malvino and David J. Bates, “Electronic Principles”, Tata McGraw-Hill, 7/e, 2007
3. Gayakwad R. A., “Op-Amps and Linear Integrated Circuits”, Pearson Education India, 4/e, 2015

4. Salivahanan S.and V. S. Kanchana Bhaaskaran, “Linear Integrated Circuits”, McGraw Hill Education India, 2/e, 2015
5. Thomas L Floyd, Digital Fundamentals, 10e, Pearson Education 2011
6. Albert P Malvino, Donald P Leach, Digital Principles and Applications, 8e, Mc Graw Hill
7. M Morris Mano, Digital Logic and Computer Design, 4e, Pearson Education

SEMESTER -3

MINOR

RAT 281	BASICS OF ROBOTICS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarise with anatomy, specifications and applications of Robots
CO 2	Choose the appropriate sensors and actuators for robots
CO 3	Choose appropriate Robotic configuration and gripper for a particular application
CO 4	Obtain kinematic model of robotic manipulators
CO 5	Plan trajectories in joint space and Cartesian space
CO 6	Develop dynamic model and design the controller for robotic manipulators

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	**2**	**1**										3
CO 2	**2**	**1**										3
CO 3	**2**	**1**										3
CO 4	**3**	**2**	**2**									3
CO 5	**3**	**2**	**2**									3
CO 6	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

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Module I:

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot considerations for an application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.

Robot Applications- medical, mining, space, defence, security, domestic, entertainment, Industrial Applications-Material handling, welding, Spray painting, Machining.

Module II

Sensors and Actuators

Sensor classification- touch, force, proximity, vision sensors.

Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, noncontact type; Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors.

Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.

Module III

Robotic configurations and end effectors

Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.

Module IV

Kinematics and Motion Planning

Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation-forward Kinematic analysis of a typical robots upto 3 DOF.

Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.

Module V

Dynamics and Control of Robots

Building of a servo controlled robot – 1R two link chain, construction of link and joint and mounting of encoder, actuator, etc.
Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1DOF robot, including motor and gearbox, 2R planar manipulator.
Control Techniques- Transfer function and state space representation, Performance and stability of feed back control, PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques.

Text Books

1. Introduction to Robotics by S K Saha, Mc Graw Hill Eduaction
2. Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996.
3. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
4. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
5. Ashitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
6. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Introduction, Definitions- Robots, Robotics;	1
1.2	Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots;	1
1.3	Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom;	1
1.4	Robot considerations for an application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.	1
1.5	Robot Applications- medical, mining, space, defence, security, domestic, entertainment	2
1.6	Industrial Applications-Material handling, welding, Spray painting, Machining.	2
2	**Sensors and Actuators**	
2.1	Sensor classification- touch, force, proximity, vision sensors	1
2.2	Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors;	2
2.3	External sensors-contact type, noncontact type;	1
2.4	Vision-Elements of vision sensor, image acquisition, image processing; Selection of sensors.	2
2.5	Actuators for robots classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages;	1

2.6	Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors;	2
2.7	Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.	2
3	**Robotic configurations and end effectors**	
3.1	Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots	3
3.2	Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;	2
3.3	Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.	3
4	**Kinematics and Motion Planning**	
4.1	Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations	4
4.2	Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots upto 3 DOF.	4
	Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.	2
5	**Dynamics and Control of Robots**	
5.1	Building of a servo controlled robot – 1R two link chain, construction of link and joint and mounting of encoder, actuator, etc.	2
5.2	Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1DOF robot, including motor and gearbox.	2
5.3	Control Techniques- Transfer function and state space representation, Performance and stability of feed back control, PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques.	4

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 281

Course Name: BASICS OF ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 Define reach and stroke of a robotic manipulator. (3)

2 What are the characteristics of spot welding robot? (3)

3 A strain gauge of gauge factor 2 and resistance of the unreformed wire 100 Ω is used to measure the acceleration of an object of mass 3kg. If the strain is 10^{-6}, cross sectional area=$10mm^2$ and Young's modulus =6.9×10-10N/m^2, compute the acceleration of the object. (3)

4 Compare hydraulic and pneumatic actuators. (3)

5 Explain the features of a SCARA robot (3)

6 What are the advantages and disadvantages of a pneumatic gripper? (3)

7 If a point $P = [3 \quad 0 \quad -1 \quad 1]^T$, find the new location of the point P, if it is rotated by π about z-axis of fixed frame and then translated by 3 units along y axis. (3)

8 How will you compute end effector position and orientation of a robotic arm? (3)

9 What is the necessity of dynamic modelling of robotic manipulators? (3)

10 Is a robotic system linear or nonlinear? Justify your answer. (3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11 a) Explain in detail the specifications of a robotic manipulator. (10)

b) What is the typical anatomy of a robotic manipulator? (8)

12 a) Explain in detail any two industrial applications of Robots. (10)

b) Compare point to point control and continuous path control. (4)

MODULE II

13 a) How will you choose appropriate sensor for a robotic application? (8)

b) Mention the applications of vision sensor (6)

14 a) Outline the method of varying position using servo motor and stepper motor. (8)

b) Explain the working of typical hydraulic actuator. (6)

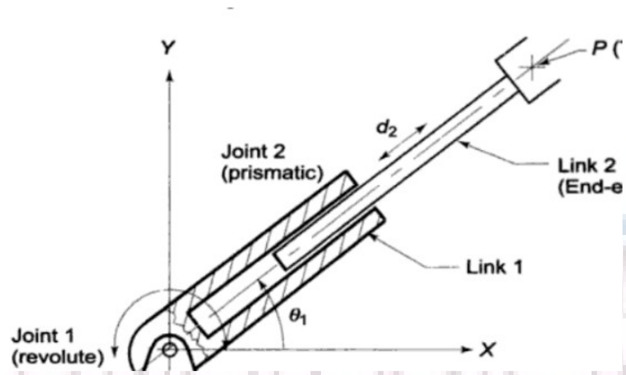
MODULE III

15 a) Explain in detail all robotic configurations. (14)

16 Describe the types of end effector & gripper mechanisms with simple sketches (14)

MODULE IV

17 a) Obtain the forward kinematic model of the following robot (14)



18	a)	The second joint of a SCARA robot has to move from 15^0 to 45^0 in 3 sec. Find the coefficients of the cubic polynomial to interpolate a smooth trajectory. Also obtain the position, velocity and acceleration profiles	(8)
	b)	How will you plan a straight line trajectory in Cartesian space?	(6)

MODULE V

19	a)	Obtain the dynamic model of 1 DOF robot operated by electric motor.	(8)
	b)	How will you build a servo controlled robotic arm?	(6)
20	a)	Describe the schematic of PID controlled robotic manipulator and derive the closed loop transfer function. Explain how gains are computed for the PID controller?	(10)
	b)	Comment on the stability of the above controller	(4)

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SEMESTER -4

RAT 202	KINEMATICS AND DYNAMICS OF MECHANISMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the kinematic details of machines,kinematic pairs and degrees of freedom and determining the loop closure equations of various linkages and find known and unknown coordinates
CO 2	Determine the velocity and acceleration of a point in open loop planar mechanisms.
CO 3	Analyze the static force in simple mechanisms and determine the forces for a particular acceleration using inverse dynamics
CO 4	Determine equations of motion and acceleration equations for various planar mechanisms, and identify the known and unknown variables for forward dynamic analysis
CO 5	Illustrate the derivation of Euler's dynamic equations for pure rotation from Newton's laws and solve simple problems using this method.
CO 6	Understand the free,damped and forced vibration of single DoF systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	1									3
CO 2	3	3	3									3
CO 3	3	3	3									3
CO 4	3	3	3									3
CO 5	3	3	3									3
CO 6	3	3	3									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the kinematic details of machines,kinematic pairs and degrees of freedom and determining the loop closure equations of various linkages and find known and unknown coordinates

Course Outcome 2 (CO2): Determine the velocity and acceleration of a point in open loop planar mechanisms.

Course Outcome 3(CO3): Analyze the static force in simplemechanisms and determine the forces for a particular acceleration using inverse dynamics

Course Outcome 4 (CO4): Determine equations of motion and acceleration equations for various planar mechanisms, and identify the knownandunknown variables for forward dynamic analysis

Course Outcome 5 (CO5): Illustrate the derivation of Euler's dynamic equations for pure rotation from Newton's laws and solve simple problems using this method.

Course Outcome 6 (CO6): Understand the free,damped and forced vibration of single DoF systems

Syllabus

Module 1

Basics of mechanisms: Links, kinematic pairs, kinematic chain, mechanism and machine,schematic diagrams and description of common mechanisms like linkages, cams-followermechanisms, gear trains, belt and chain drives-no derivations, and multi-degrees of planar mechanisms in machines like earth moving machinery and planar versions of manipulators, mobility /degrees of freedom (DoF), Kutzbach's formula, determination of DoF of planar linkages and mechanisms with cam-follower pairs.Definition of position analysis problem, loop closure equations, derivation of solutions for simple mechanisms like fourbar, slider-crank,and multi DoF closed and open loop mechanisms, multiple branches of solution, exposure to graphical approach, inverse pose problem of an open loop 3R planar manipulator, and derivation of solution.

Module 2

Velocity analysis: Definition of the velocity analysis problem, angular velocity of a rigidlink and relative velocity of points, analytical method of velocity analysis, derivation of equations and numerical solutions, forward and inverse velocity analysis of open loop 3R mechanism.**Acceleration analysis:** Definition of the acceleration analysis problem, angular acceleration of a rigid link and relative acceleration of points,Corioli's acceleration, analytical method of acceleration analysis and derivation of equations, numerical solution for simple mechanisms.

Module 3

Static force analysis: Free body diagrams, nature of joint reaction forces, static force analysis, application to simple linkages and cam-follower mechanisms.**Inverse dynamic analysis:** Definition of the inverse dynamic analysis problem, inertia forces and moments, equations of motion, derivation of equations of motion for planar mechanisms with single and multi DoF, D'Alembert's principle, virtual work principle and workless nature of constraint reaction forces, generalized coordinates and forces, derivation of equations using generalized coordinates and virtual work principle.

Module 4

Forward dynamic analysis: Definition of the forward dynamic analysis problem,acceleration of links in terms of acceleration of independent coordinates, combining dynamic equations with acceleration equations, derivation of complete set of equations for single and multi DoF planar mechanisms, introduction to simulation of mechanisms(Assignment only no university questions)

Module 5

Euler's equation for rigid body rotation: Derivation of Euler's dynamic equations for pure rotation from Newton's laws, moments of inertia, principal moments and principal axes, representation of relative orientation of reference frames using rotation matrices,properties of rotation matrices, transformation of moments of inertia matrices from one reference frame to another, Euler's equations in principal reference frame, applications of Euler's equations, simple applications of Euler's equation.**Introduction to vibration of single DoF systems:** Free undamped and damped vibration, underdamped, critically damped, and overdamped systems-no derivations, examples, harmonically forced vibration of undamped and damped systems, phase plane representation.

Text Books

1. Kinematics and Dynamics of Machinery ,Author:Norton R L ,Publisher:McGraw-Hill
2. Theory of Machines and Mechanisms 4th Edition, Author:John J. Uicker. Jr ,Gordon R. Pennock, Joseph E. Shigley,Publisher:Oxford HED

Reference Books

1. Kinematics, Dynamics and Design of Machinery, 3rd Edition, 2016", Authors: Kenneth J. Waldron,Gary L. Kinzel, Sunil K. Agrawal, Publisher: Willey
2. Fundamentals of Kinematics and Dynamics of Machines and Mechanisms, Author:Oleg Vinogradov,Publisher:CRC press
3. Theory of Machines, Author:Rattan S S ,Publisher:Tata McGraw-Hill
4. Mechanism and Machine Theory ,Author:Ambekar ,Publisher : A G, Prentice Hall
5. Theory of Machines ,Author : V P Singh ,Publisher : DhanpatRai& Co

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module-1**	
1.1	Links, kinematic pairs, kinematic chain, mechanism and machine,schematic diagrams and description of common mechanisms like linkages,cams-followermechanisms(no numerical problems), gear trains, belt and chain drives-basic types and selection (no numerical problems,no derivations).	2
1.2	Multi-degrees of planar mechanisms in machines like earth moving machinery and planar versions of manipulators	2
1.3	Mobility /degrees of freedom (DoF), Kutzbach's formula, determination of DoF of planar linkages and mechanisms with cam-follower pairs-practical problems	2
1.4	Definition of position analysis problem, loop closure equations-practical problems , derivation of solutions for simple mechanisms like fourbar, slider-crank,and multi DoF closed and open loop mechanisms, 3R planar manipulator	3
2	**Module-2**	
2.1	Definition of the velocity analysis problem, angular velocity of a rigidlink and relative velocity of points, analytical method of velocity analysis-numerical problems by analytical method only.	3
2.2	forward and inverse velocity analysis of open loop 3R mechanism	2
2.3	Definition of the acceleration analysis problem, angular acceleration of a rigid link and relative acceleration of points, Corioli's acceleration-derivation of Corioli's component of acceleration.	2
2.4	Analytical method of acceleration analysis - numerical solution for simple mechanisms.	2
3	**Module-3**	
3.1	Free body diagrams, nature of joint reaction forces, static force analysis, application to simple linkages and cam-follower mechanisms	2
3.2	Definition of the inverse dynamic analysis problem, inertia forces and moments, equations of motion, derivation of equations of motion for planar mechanisms with single and multi DoF, D'Alembert's principle	3
3.3	Virtual work principle and workless nature of constraint reaction forces-numerical problems	1
3.4	Generalized coordinates and forces, derivation of equations using generalized coordinates and virtual work principle-practical problems(formulation of equations only)	3

4	**Module-4**	
4.1	Definition of the forward dynamic analysis problem,acceleration of links in terms of acceleration of independent coordinates	3
4.2	Derivation of complete set of equations for single and multi DoF planar mechanisms	4
4.3	Introduction to simulation of mechanisms-demonstration and assignment usingmatlabor Scilab.	2
5	**Module-5**	
5.1	Derivation of Euler's dynamic equations for pure rotation from Newton's laws	2
5.2	Moments of inertia, principal moments and principal axes, representation of relative orientation of reference frames using rotation matrices,properties of rotation matrices, transformation of moments of inertia matrices from one reference frame to another, Euler's equations in principal reference frame, simple applications of Euler's equation	3
5.3	Free undamped and damped vibration, underdamped, critically damped, and overdamped systems, examples-numerical problems,no derivations, harmonically forced vibration of undamped and damped systems-numerical problems only,no derivation , phase plane representation-basic concept only.	4

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 202

Course Name: KINEMATICS AND DYNAMICS OF MECHANISMS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Explain the terms links,kinematic pairs and kinematic chain.	(3)
2	With the help of an example explain degree of freedom of a mechanism.	(3)
3	Derive the expression for Corioli's component of acceleration on a slider move up with velocity V m/s along a rotating link with clockwise angular velocityωrad/s	(3)
4	Write various steps to find inverse velocity of a two link planar open chain	(3)

mechanism by analytical approach.

5 Draw the free body diagram of various linkages of a slider crank mechanism. (3)

6 Write the D'Alembert's equations for the connecting rod of a slider crank mechanism. (3)

7 With the help of an example explain the application of principle of virtual work to determine unknown static force in a planar mechanism. (3)

8 Write the Euler's equation for pure rigid body rotation about a point. (3)

9 What is the relevance of principal moment of inertia in rotation motion (3)

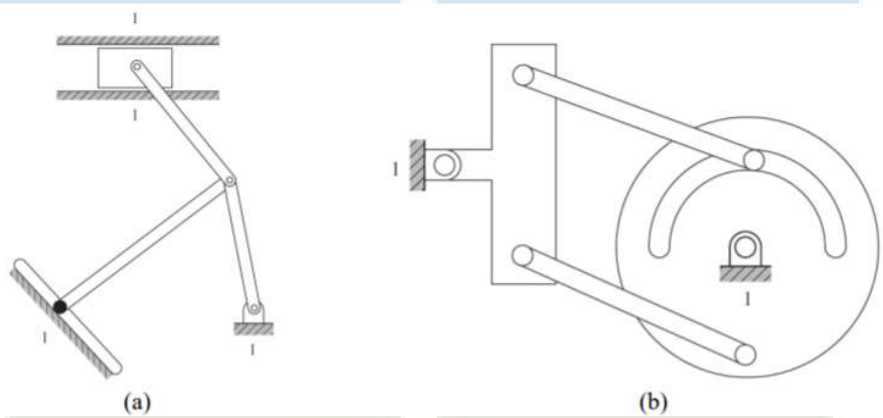
10 Draw the displacement time graph for critically damped,under damped and over damped vibration of a spring mass damper system. (3)

PART B

Answer any one full question from each module, each carries14 marks.

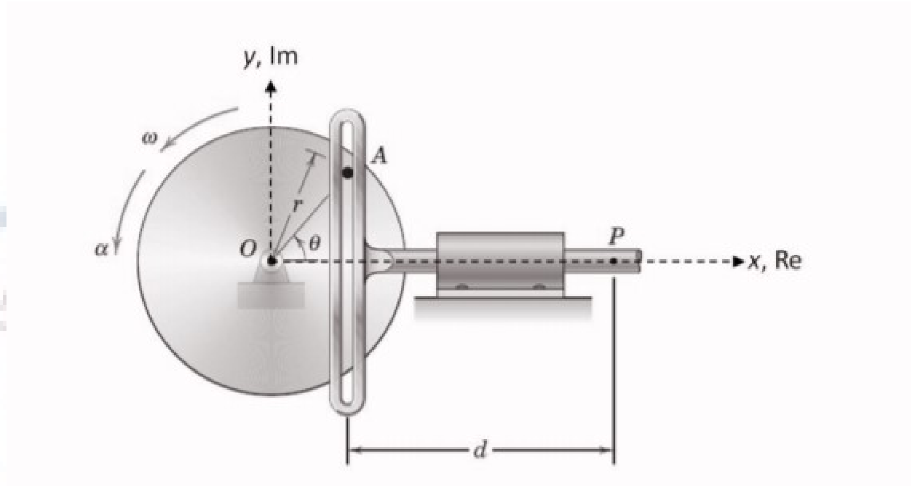
MODULE1

11 14



Use the Kutzbach's criterion determine the mobility of the planar mechanisms illustrated above. Clearly number each link and label lower pair by 'L' and higher pair by 'H'.In the figure 1 represents fixed link.

12 (14)

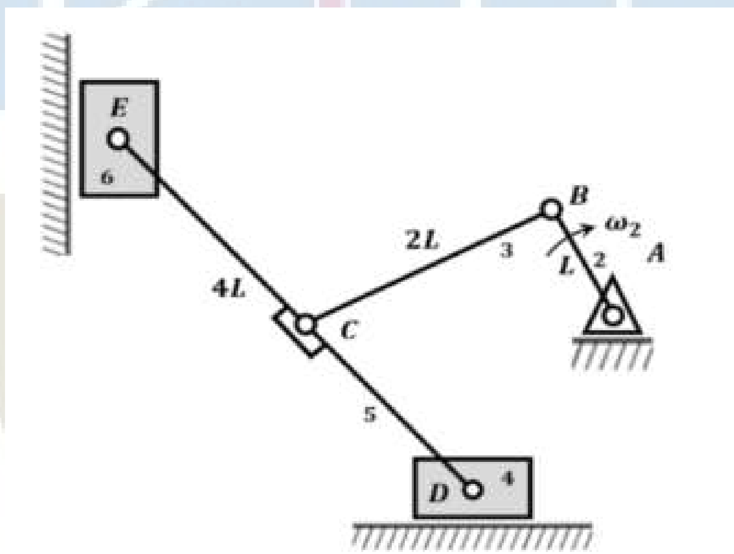


(a)Write the position loop closure equation of the mechanism by indicating position vector using two letters($\vec{AB}$) Show the position vector shown as arrows

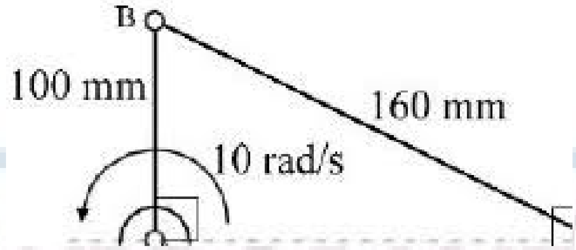
(b) Write the position loop closure equation of the mechanisms by complex number in exponential form.

MODULE II

13 L=1m,C is midpoint of ED,ω=10rad/s,find velocity of D and E (14)



14 (14)

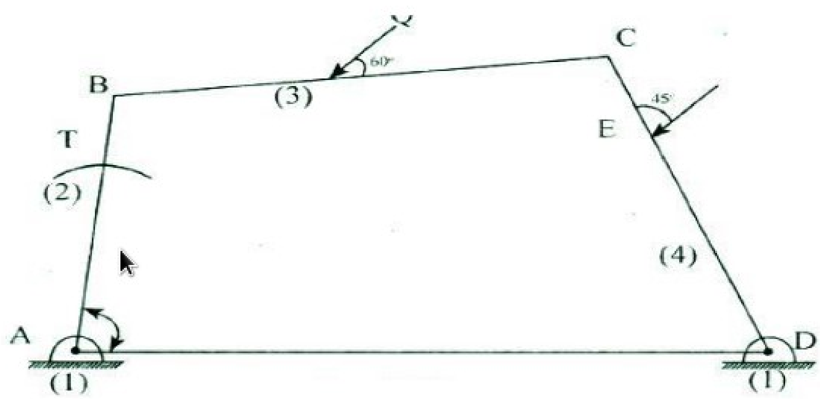


Determine the acceleration of link C by analytical approach

MODULE III

15 Determine the torque required to be applied at the crankshaft of a slider crank mechanism to bring it in equilibrium.The slider is subjected to a horizontal force of 500N and a force of magnitude 1000N applied on the connecting rod at an angle 60 ^{0} The dimension of various linkages are OA=250mm,AB=750mm,and AC=250mm <BOA=40$^{0.}$ (14)

16 A four bar mechanism under the action of two external forces is shown below Determine the torque to be applied on the link AB for static equilibrium. The dimensions of the links are AB = 50 mm, BC = 66 mm, CD = 55 mm, CE = 25 mm, CF = 30 mm, AD=100 mm, angle BAD = 60°, P = 500N and Q = 600N (14)

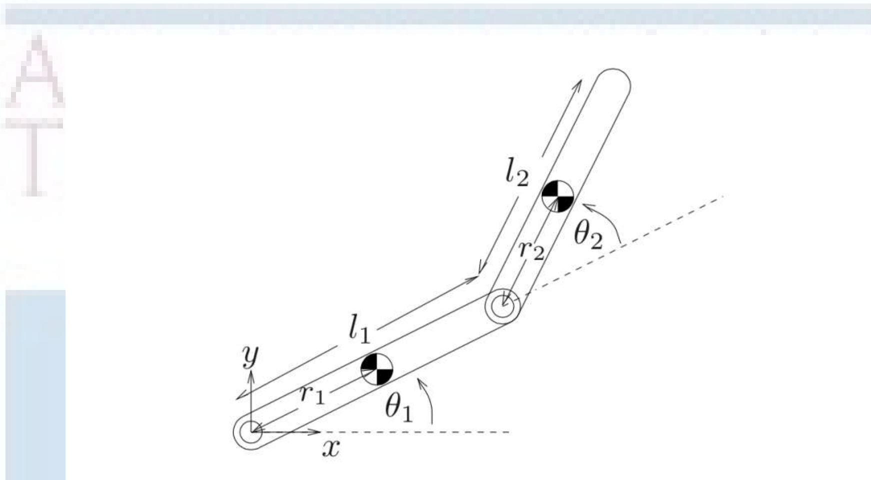


MODULE IV

17 In a four bar mechanism the link AB rotates with angular velocity of 20rad/s and angular acceleration of 100 rad/s both in clockwise direction when it make (14)

an angle of 45^0 with link AD which is fixed .The length of various linkages are AB=CD=400 mm,BC=500mm and AD=750mm .Neglect the gravitational effect and friction.The mass of link is 5kg/m. Find the torque on output link

18 . (14)



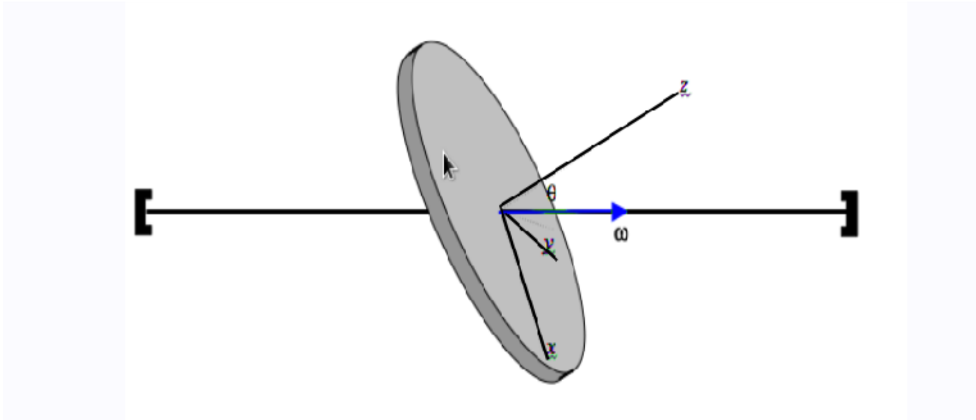
Consider the two link planar manipulator moving in horizontal plane,derive the dynamic equations. Take m1 as mass of first link and m2 as mass of second link

MODULE V

19 A machine part of 2kg mass vibrates in a viscous medium .Determine the damping coefficient when a harmonic excitation force of 25N result in a resonant amplitude of 12.5 mm with a period of 0.1s,if the system is excited by a harmonic force of 4Hz frequency,what will be the percentage increase in amplitude of vibration when the damper is removed as compared to that with damper? (14)

20 a)Write the Euler's equation for rigid body rotation and explain each terms. (4)

b)A disc of mass *m*, radius *a*, spinning at a constant angular speed ω about at axle that is inclined at an angle ϑ to the normal to the disc. Find the torque on the disc (10)


z
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RAT 204	MANUFACTURING PROCESSES	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basics of the primary manufacturing processes and apply the knowledge in designing parts for robotic applications
CO 2	Understand the various joining processes and choose the appropriate mechanical and adhesive joining process for the parts.
CO 3	Understand the conventional machining operations and to decide the optimal parameters for a specific machining requirement.
CO 4	Understand the operations in a CNC machine and optimally choose the parameters and settings for a specific machining requirement.
CO 5	Decide the datum and tool offset parameters for the required machining operation and to manually program the CNC machine.
CO 6	Understand the various nonconventional and net-shape manufacturing techniques and optimally select the appropriate process to realise a part.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	[illegible]	2										3
CO 2	3	2										3
CO 3	3	3										3
CO 4	3	3										3
CO 5	3	2	2		3							3
CO 6	3	2	3									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
When is forging preferred over casting? Evaluate the design considerations when casting is to be the preferred manufacturing process?
Course Outcome 2 (CO2):
Describe a suitable method of welding solder tabs to the terminals of Ni-Cd batteries. What are the major factors to be considered in selecting a process for this application?
Course Outcome 3(CO3):
List out the design considerations for a part made by turning and explain their significances.
Suggest the sequence of operations to be performed for obtaining a given part.
Course Outcome 4 (CO4):
What are the major advantages of CNC machines over conventional machines? Suggest a suitable process sequence and number of work piece setting up required to realise a given part in a cnc turning center.
Course Outcome 5 (CO5):
For a given part, decide the optimal work reference points and write a CNC part program.
Course Outcome 6 (CO6):
Explain the various additive manufacturing process and discuss their relative merits and demerits.
Suggest a suitable sequence of non-conventional process sequence for realising a given part.

Syllabus

Module 1
Primary processes – Casting –Forging – Forming – Extrusion-wire drawing process – Rolling –. Selection of primary forming process for various products.Selection of primary forming process. Defects and Design considerations in casting, forging and rolling.

Module 2
Joining processes – Welding – Gas welding– Arc Welding, shielded metal arc welding, submerged arc welding, GTAW, plasma arc welding, ultrasonic welding, friction welding, resistance spot welding, resistance seam welding, stud welding, percussion welding – Soldering – techniques, types of solders and fluxes- Adhesive bonding-types of adhesives-curing techniques. Selection of joining process for various applications, case studies.

Module 3

Machining operations – Milling – types of operations, types of milling machines, milling cutters Turning – types of operations , tool holders, inserts, operating conditions, work holding devices, Milling and drilling jigs and fixtures. Grinding – types of operations.

Module 4

Numerical controlled Machines – CNC machines, basic structures of machining and turning centers. Tools, tool holders and tool indexing. Axis configurations and fundamentals of CNC codes. Datum and tool offset settings, Incremental and absolute programming, Canned cycles. Practical programming (simple) examples in milling and turning using G, M codes. APT programming

Module 5

Non-conventional processes – EDM, ECM, USM, EBM, LBM, IBM, WJM, AWJM, LJM, ECG, PCM, process capabilities, applications, fused ion beams -principle and application, abrasive water jet machining.

Net shape and near net shape manufacturing, additive manufacturing, Powder metallurgy, selective laser sintering and selective laser melting, fused deposition modelling, laminated object manufacturing, laser engineered net-shaping, laser welding, stereo-lithography, LIGA process;

Rapid prototyping, introduction, product prototyping, solid modelling, reverse engineering, process chain, advantages of RP (Basic concepts). Selection of rapid prototyping process and design considerations

Text Books

1. Manufacturing Engineering and Technology, Kalpakjian and Schmid, Prentice Hall, New Jersey, 2013.
2. Fundamentals of Modern Manufacturing, Mikell P. Groover, John Wiley & Sons, Inc,New Jersey, 2010.
3. Mechatronics by HMT, Tata McGraw Hill, 2010.
4. Manufacturing Engineering, D.K. Singh, Ane Books India, 2008
5. Manufacturing Processes for Engineering Materials, Kalpakjian and Schmid, Pearson Education, 5/e.

Course Contents and Lecture Schedule

Module	Contents	Hrs
1	Primary processes – Casting – sand casting, moulds, types of moulding sand, types of patterns, pattern materials – Forging – forging methods, precision forging, coining, heading, piercing, die design, die materials and lubrication, forging machines – Forming – Extrusion process, hot extrusion, cold extrusion, impact extrusion, wire drawing process – Rolling – principles of rolling, types of rolling mill, hot and cold rolling, rolling mills, ring rolling, thread rolling, applications – rolling of tubes, wheels, axles and I-beams. Importance of material selection for manufacturing processes.	6

	Selection of primary forming process and suitable materials for various products. Defects and Design considerations in casting, forging and rolling.	4
2	Joining processes – Welding – Gas welding, flame characteristics, equipment, fluxes, filler rods – Arc Welding, applications and equipment, electrodes, shielded metal arc welding, submerged arc welding, GTAW, plasma arc welding, ultrasonic welding, friction welding, resistance spot welding, resistance seam welding, stud welding, percussion welding – Soldering – techniques, types of solders and fluxes- Adhesive bonding-types of adhesives-curing techniques. Selection of joining process for various applications,Weldability of different materials -Case studies.	8
3	Machining operations – Milling – types of operations like face milling, end milling, form milling, angular milling, slitting, gear cutting, key way milling, helical milling, profile milling, types of milling machines, milling cutters – Turning – types of operations like chamfering, parting, threading, boring, drilling, knurling, tool holders, inserts, operating conditions, work holding device, Milling and drilling jigs and fixtures. Grinding – types of operations like surface, cylindrical centre less, form and profile, plunge cut, electrochemical, grinders; Machinability of materials and its effect on process parameters.	8
4	Numerical controlled Machines – CNC machines, basic structures of machining and turning centers. Tools, tool holders and tool indexing. Axis configurations and fundamentals of CNC codes. Datum and tool offset settings, Incremental and absolute programming, Canned cycles. Practical programming (simple) examples in milling and turning using G, M codes. APT programming	10
5	Non-conventional processes – EDM, ECM, USM, EBM, LBM, IBM, WJM, AWJM, LJM, ECG, PCM, process capabilities, applications, fused ion beams - principle and application, abrasive water jet machining.	4
	Net shape and near net shape manufacturing, additive manufacturing, Powder metallurgy, selective laser sintering and selective laser melting, fused deposition modelling, laminated object manufacturing, laser engineered net-shaping, laser welding, stereo-lithography, LIGA process; Rapid prototyping, introduction, product prototyping, solid modelling, reverse engineering, process chain, advantages of RP (Basic concepts). Selection of rapid prototyping process and design considerations	5

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 204

Course Name: MANUFACTURING PROCESSES

Max. Marks: 100 Duration: 3 Hours

PART A

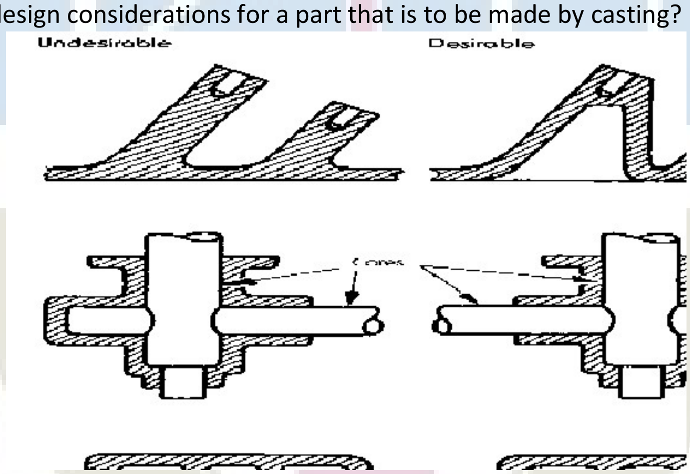
Answer all questions, each carries 3 marks. Marks

1		List any three advantages of forging over casting.	(3)
2		Explain the use of chills in casting.	(3)
3		Explain the different types of oxy-acetylene and their uses.	(3)
4		List any three uses of ultrasonic welding.	(3)
5		Distinguish between up milling and down milling.	(3)
6		Distinguish between jigs and fixtures.	(3)
7		Explain canned cycles in CNC programming.	(3)
8		Explain cutter radius compensation.	(3)
9		Distinguish between selective laser sintering and selective laser melting.	(3)
10		Explain any two additive manufacturing techniques.	(3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11	a)	Explain the advantages of casting over other primary manufacturing processes. What are the design considerations for a part that is to be made by casting?	(6)
	b)	 Three designs of parts that are to be made with casting is shown above with their desirable modifications. State the factors that are considered for the redesigns.	(8)
12	a)	Explain any six defects in castings and the remedies during design of parts and moulds.	(6)
	b)	Explain the various steps involved in rolling of a wheel rim from a circular disc.	(8)

MODULE II

13	a)	Explain the gas metal arc welding process and its advantages. What are the modes in which metal is transferred across the arc in GMAW?	(6)
	b)	Thick steel plates of a ships vertical hull are to be welded effectively. Suggest a suitable welding process for this application and explain the process with suitable schematics.	(8)
14	a)	A FRP tubular shaft is to be fixed with metal end connectors. Explain the various configurations of adhesive bonded joints for this purpose if the torque transmitted through the joint is to be maximized.	(8)
	b)	Describe a suitable method of welding solder tabs to the terminals of Ni-Cd batteries.	(6)

What are the major factors to be considered in selecting a process for this application?

MODULE III

15 a) List out the design considerations for a part made by turning and explain their significances. (6)

b) (8)

Suggest the sequence of operations to be performed for obtaining the given part.

16 a) Explain any two methods for cutting helical gears with neat sketches. (6)

b) A spur gear is to be connected to a shaft with a key. Explain the machining sequences required with necessary sketches to machine the key ways on the gear and the shaft. (8)

MODULE IV

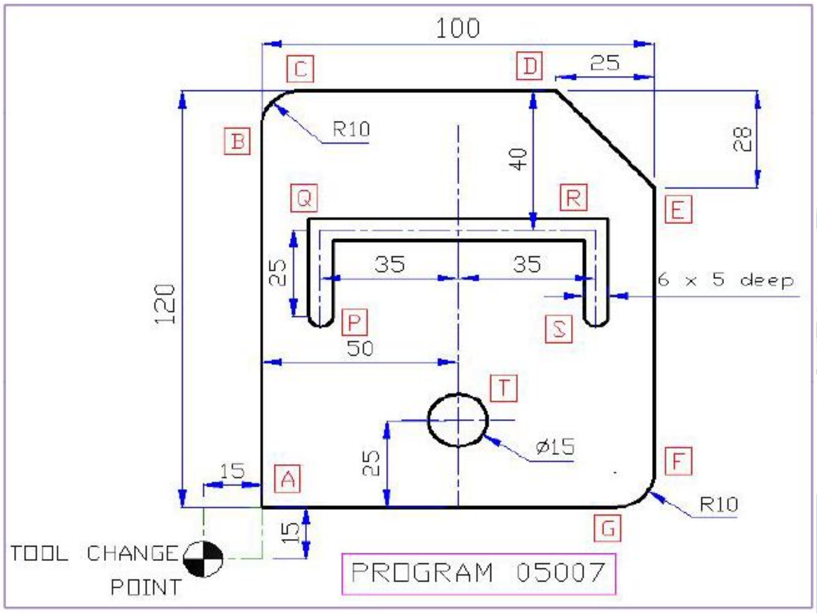
17 a) (8)

Prepare a CNC program for the above rough turning operation.

b) Explain the canned cycle for peck drilling with an example. (6)

18 a) Explain the use of absolute and incremental programming with a suitable CNC program. (6)

b) (8)



Prepare a CNC program for milling the above part.

MODULE V

19 a) A thick metal sheet is to be cut to make a very intricately shaped object. If the profile to be cut is 2D, how will you choose the option between waterjet cutting and electro discharge machining? What are the factors you will consider if the process is done on a mass production level? (8)

b) Compare the process capabilities of LBM and EBM. (6)

20 a) Metal posts of 1micron dia and 3micron length are to be made on a metal surface. Suggest the process sequence for LIGA process to make this product. (6)

b) Compare the process capabilities of Stereo lithography and Fused deposition modelling. (8)

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RAT 206	MICROCONTROLLERS AND EMBEDDED SYSTEMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the internal architecture of 8051 Microcontroller
CO 2	Develop simple programs for 8051 using assembly language programming
CO 3	Interface 8051 microcontroller with peripheral devices using ALP/Embedded C
CO 4	Interpret the architecture and design concept of embedded systems
CO 5	Design embedded systems based on Arduino
CO 6	Explain the concepts of embedded operating system

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1				2					2	2
CO 2	3	3	3			2					2	2
CO 3	3	3	3			2					2	2
CO 4	3	1									2	2
CO 5	3	3	3			2					2	2
CO 6	2	1				1					1	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

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Module 1: 8051 microcontroller

Review-Basics of Computer Architecture

8051 microcontrollers: Difference between microprocessor and microcontroller Architecture, 8051 pin diagram; Architecture, I/O Port structure, Register organization - special function registers, Memory organization

8051 microcontrollers: Instruction set, Addressing modes

Simple Assembly language programs: Arithmetic (Addition, Subtraction, Multiplication & Division), Transfer a block of data from one internal memory location to another

Module 2: 8051 microcontroller Programming and Peripherals.

Timers/Counters- Serial Communication, Interrupt structure-programming

Interfacing of peripherals – LED (ALP and embedded C programming).

OLED, LCD, ADC, DAC, sensors, simple Switch and key board interfacing, 7 segment LED (embedded C programming).

Module 3: Embedded Systems Overview

Introduction to Embedded Systems: Definition, Features, Simple Example of Embedded Systems, Applications of embedded systems-Consumer electronics, Robotics, Automobiles

Embedded System Architecture: HW - Processor, Controller, SoC, Memory, Peripherals; SW - Application, Middleware, OS, Device Drivers, Tool chain- Assembler, Interpreter, Compiler, Linker, Loader, Debugger

Embedded system design process: Requirement Analysis, Specification Development, HW & SW Co-Design and Development, Module Integration, Testing.

Module 4: Embedded System Board Study (Arduino Uno)

Arduino Uno Board: Board Study (Board level Block schematic) - Chip (Features only - Architecture not needed), GPIO, Memory, Programming Interface

Programming: Arduino IDE, Sample Code (LED, Switch, DC motor, Stepper motor control), Temperature monitoring system using LM35 Temperature sensor & Seven Segment display

Module 5: Introduction to OS and Communication Protocols

Embedded Operating system basic concepts: Functional layers in a computer system OS terminology, Kernel Functions (Overview only), Types of Kernels (Monolithic kernel & Microkernel), Tasks/ Processes.

Introduction to RTOS: Real time tasks and Systems, RTOS basics, Comparison of General Purpose OS and Real Time OS.

Communication Protocols: RS232, I2C, SPI and USB

Text Books

1. Muhammad Ali Mazidi, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Pearson, 2nd Edition, 2007.

2. Lyla B Das, “Embedded Systems: An Integrated Approach”, 1e, 2012
3. Michael McRoberts, “Beginning Arduino”, Apress, 1e, 2011
4. Kenneth Ayala,“The 8051 Microcontroller”, Cengage Learning, 3e, 2012

Reference Books

1. Raj Kamal, “Embedded Systems Architecture, programming and Design”, Tata McGraw-Hill, 3e, 2013
2. Tammy Noergaard, Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers, Newnes – Elsevier, 2e, 2012
3. James Arthur, “Arduino: The complete guide to Arduino for beginners, including projects, tips, tricks”, and programming, Ingram, 1e, 2019

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**8051 microcontroller.**	
1.1	Review-Basics of Computer Architecture**:** Basic Block Diagram of a computer, Buses, Processor, System Clock, Memory, I/O, Von Neumann Architecture-Harward Architecture - RISC vs CISC	2
1.2	**8051 microcontrollers:** Microcontroller→ a small computer in a single IC chip-Difference between microprocessor and microcontroller Architecture, 8051 pin diagram**;** Architecture, I/O Port structure, Register organisaton -special function registers, Memory organization	4
1.3	**8051 microcontrollers:** Instruction set, Addressing modes	2
1.4	**Simple Assembly language programs:** Arithmetic (Addition, Subtraction, Multiplication & Division), Transfer a block of data from one internal memory location to another	2
2	**8051 microcontroller Programming and Peripherals.**	
2.1	Timers/Counters- Serial Communication, Interrupt structure- ALP programming	2
2.2	**Interfacing of peripherals - ALP and embedded C programming**	
	i LED,	1
	Interfacing of peripherals - embedded C programming	
	ii OLED	1
	iii LCD	2
	iv ADC, DAC	2
	v sensors, simple Switch and key board interfacing, 7 segment LED	3
3	**Embedded Systems Overview**	
3.1	**Introduction to Embedded Systems:** Definition, Features, Simple Example of Embedded Systems, Applications of embedded systems-Consumer electronics, Robotics, Automobiles	2
3.2	**Embedded System Architecture:** HW - Processor, Controller, SoC, Memory, Peripherals; SW - Application, Middleware, OS, Device Drivers, Tool chain-Assembler, Interpreter, Compiler, Linker, Loader, Debugger	4

3.3	**Embedded system design process:** Requirement Analysis, Specification Development, HW & SW Co-Design and Development, Module Integration, Testing.	2
4	**Embedded System Board Study (Arduino Uno)**	
4.1	**Arduino Uno Board:** Board Study (Board level Block schematic) - Chip (Features only - Architecture not needed), GPIO, Memory, Programming Interface	4
4.2	**Programming:** Arduino IDE, Sample Code (LED, Switch, DC motor, Stepper motor control), Temperature monitoring system using LM35 Temperature sensor & Seven Segment display	4
5	**Introduction to OS and Communication Protocols**	
5.1	**Embedded Operating system basic concepts:** Functional layers in a computer system OS terminology, Kernel Functions (Overview only), Types of Kernels (Monolithic kernel & Microkernel), Tasks/ Processes.	3
5.2	Introduction to RTOS: Real time tasks and Systems, RTOS basics, Comparison of General Purpose OS and Real Time OS	3
5.3	**Communication Protocols:** RS232, I2C, SPI & USB	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 206

Course Name: MICROCONTROLLERS AND EMBEDDED SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Which are different types of computer memory?	(3)
2	Difference between microprocessor and microcontroller Architecture.	(3)
3	Explain interrupt structure of 8051	(3)
4	Which are the registers used for timer programming in 8051?	(3)
5	Explain the distinct features of embedded systems	(3)
6	What is meant by hardware software co-design?	(3)
7	Briefly explain features of Arduino Uno board	(3)
8	What is an IDE? What are the features of Arduino IDE?	(3)
9	Differentiate between Monolithic kernel & Microkernel.	(3)
10	Why do we need RTOS?	(3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11	a)	With the help of Block Diagram explain architecture of a computer	(6)
	b)	Explain register organization of 8051 microcontroller	(8)
12	a)	Write an ALP program to Transfer a block of data from one internal memory location to another	(8)
	b)	Explain the different addressing modes of 8051.	(6)

MODULE II

13	a)	Write an ALP or Embedded C program to interface LCD with 8051	(10)
	b)	Explain the resisters used for serial port programming in 8051	(4)
14	a)	Explain with the help of a program how keyboard can be interfaced with 8051	(10)
	b)	Explain the structure of TMOD register.	(4)

MODULE III

15	a)	Compare embedded system with a general purpose computing system	(6)
	b)	Explain Embedded product development Life Cycle water fall model	(8)
16	a)	Explain the selection criteria of an embedded processor for an applications	(4)
	b)	What is the function of Assemblers, Compilers, linkers, Loaders and Debuggers	(10)

MODULE IV

17	a)	Explain the technical specifications of Arduino Uno.	(8)
	b)	Which are the general pin functions of Arduino Uno.?	(6)
18	a)	What does GPIO Stand for? What are its functions? How do you configure them?	(10)
	b)	Write a program for blinking of LED using Arduino Uno	(5)

MODULE V

19	a)	With the help of a diagram explain Functional layers in a computer system OS terminology	(8)
	b)	Compare General Purpose OS with Real Time OS	(6)
20	a)	Explain the important functions of OS kernel	(7)
	b)	Discuss the features of Communication Protocols RS23 and I2C	(7)

****

RAL 202	MANUFACTURING AND PROTOTYPING (LAB)	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

COURSE OUTCOMES

CO1. Get hands onvarious manual production machines and processes.
CO2. Identify the various operations and the required machines and attachments for prototyping the robotic components.
CO3. Preparing the CNC machines and programming them for machining robotic components.
CO4. Use CAD/CAM for generating CNC code for production machines to realise parts.
CO5.Understand the properties of 3D printed parts and use the rapid prototyping effectively to make prototypes.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											3
CO 2	3											3
CO 3	3				2							3
CO 4	3	2	2		3							3
CO 5	3	2	2		3							3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work (selection of tools,specifying machine settings etc) : 10 Marks
(b) Implementing the work/Conducting the experiment : 25 Marks
(c) Result (accuracy, surface finish, completion of the part) : 15 Marks
(d) Viva voce : 20 Marks
(e) Record : 5 Marks

LIST OF EXPERIMENTS

1. **Exercises on Milling Machine**: - Face milling, end milling – spur and helical gear cutting – milling of key ways, T slot cutting, Inspection of the work using measuring instruments
2. **Exercises on Centre Lathe**: - Facing, plain turning, step turning, taper turning and form turning, groove cutting, knurling and chamfering, multi-start thread, square thread and internal thread,Inspection of the work using measuring instruments
3. **Exercises on Grinding machine**: - Exercise on surface grinding, cylindrical grinding and tool grinding,Inspection of the work using measuring instruments
4. **Exercises on Welding**: - Exercises on arc and gas welding - butt welding and lap welding of M.S. sheets.
5. Preparation of program and Exercise on **CNC lathe including simulation**: -turning, step turning, taper turning, thread cutting, circular interpolation etc.
6. Preparation of program and Exercise on **CNC milling machine including simulation**: - surface milling, pocket milling, contour milling etc.
7. Use of CAM software for generation of CNC code from CAD data.
8. **Exercises on Rapid Prototyping**: - 3D printing - simple box, helix shape, U bracket

NB: At least one experiment from each section is mandatory.

RAL 204	MICROCONTROLLERS AND EMBEDDED SYSTEMS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Course Outcomes: After the completion of the course the student will be able to

CO 1	Program and test a microcontroller system.
CO 2	Interface a microcontroller system to user controls and other electronic systems.
CO 3	Design embedded systems for the required applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3			2			2	2	2	3
CO 2	3	3	3			2			2	2	2	3
CO 3	3	3	3			2			2	2	2	3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 Marks
(e) Record :5 Marks

LIST OF EXPERIMENTS

Part A: 8051 Assembly language Programming

The programs shall be written in assembly language. The interfacing modules may be developed using Embedded C.

(5 experiments mandatory)

- Arithmetic Operations-32 bit addition, subtraction
- Data Transfer-
- Sorting
- Multiplication by shift and add method
- Time delay generation and relay interface.
- ADC interface.
- DAC interface with wave form generation
- Display (LED/Seven segments/LCD) and keyboard interface.
- Stepper motor and DC motor interface

Part B: Arduino Programming using Arduino IDE

(5 experiments mandatory)

- Toggle the ON/OFF status of an LED with a Switch
- Turn a Relay ON and OFF
- Control the speed of a DC Motor
- Interfacing Stepper Motor
- Serial Communication Program
- Interfacing Seven Segment Display/ Alphanumeric Display
- ADC operation of Arduino using Potentiometer and Display

Part c: Project

Mini Project using at least one sensor and one actuator

Reference Books

1. Muhammad Ali Mazidi, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Pearson, 2nd Edition, 2007.
2. Michael McRoberts, "Beginning Arduino", Apress, 1e, 2011
3. Kenneth Ayala,"The 8051 Microcontroller", Cengage Learning, 3e, 2012
4. Raj Kamal, "Embedded Systems Architecture, programming and Design", Tata McGraw-Hill, 3e, 2013

SEMESTER -4

MINOR

RAT 282	INTRODUCTION TO INDUSTRIAL AUTOMATION	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basic concepts of automation methodologies and trends in manufacturing automation.
CO 2	Understand the working principle and applications of different types of sensors.
CO 3	Study the design aspects of modern CNC machines.
CO 4	Study the basic principles and operation of different types of material handling devices.
CO 5	Develop different pneumatic circuits based on their applications.
CO 6	Familiarize the basic concepts of PLC programming.
CO 7	Understand different automated inspection methods.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	2	2	1	2							3
CO 2	3	2	2	1	2	1						2
CO 3	3	2	2	2	2	1						3
CO 4	3	2	2	2	1	1						2
CO 5	3	3	2	2	2	1						2
CO 6	3	3	2	2	2							2
CO 7	3	3	2	2	2	2						2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	25	25	30
Apply	15	15	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Module 1

Automation methodologies: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines.

Trends in manufacturing – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.

Module 2

Sensors and actuators for automation: Classification of position and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.

Electrical, Hydraulic and pneumatic actuators and their comparison, Examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.

Module 3

Elements of CNC systems: servomotor and servo system design trends, stepper motors and controls, adaptive control, ball screws and guideways, spindle, bearings and mountings. Drive systems. Automated tool changers and pallet changers. Accessories, and selection of drives for CNC machines.

Material Handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.

Module 4

Pneumatic/Hydraulic Automation: control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems.

Electro pneumatic/electro hydraulic automation: Symbols: Basic electrical elements – relay, solenoid, timers, pneumatic – electrical converters, design of circuits and hands on models on material handling systems.

Module 5

Automation Control: Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming the PLC. Practical Examples on PLC ladder programming.

Inspection automation: Inspection automation, off-line and on-line inspections, computerized coordinate measuring machine – CMM construction, online inspection systems., laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems.

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.

References:

1. Computer Control of Manufacturing Systems‖ YoramKoren, Tata McGraw-Hill Edition 2005.
2. CNC Machines, Radhakrishnan P., New Central Book Agency, 1992.
3. Mechatronics: A Multidisciplinary Approach, 4/E‖, W. Bolton. Pearson Education India.
4. Mechatronics, HMT, Tata McGraw-Hill, 1998. 6. ―Pneumatic Control for Industrial Automation‖, Peter Rohner& Gordon Smith, John Wiley and Sons, 1987.
5. Standard Handbook of Industrial Automation, Onsidine D M C & Onsidine G D C, Chapman and Hall, NJ, 1986.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	**Automation methodologies**: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines.	4
1.2	**Trends in manufacturing** – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.	4
2	**MODULE 2**	
2.1	**Sensors and actuators for automation:** Classification of position and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.	4
2.2	Electrical, Hydraulic and pneumatic actuators and their comparison	2

3	**MODULE 3**	
3.1	**Elements of CNC systems:** servomotor and servo system design trends, stepper motors and controls, adaptive control, ball screws and guideways, spindle, bearings and mountings. Drive systems. Automated tool changers and pallet changers. Accessories, and selection of drives for CNC machines.	5
3.2	**Material Handling and Identification Technologies:** Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.	5
4	MODULE 4	
4.1	**Pneumatic/Hydraulic Automation:** control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems.	5
4.2	**Electro pneumatic/electro hydraulic automation**: Symbols: Basic electrical elements – relay, solenoid, timers, pneumatic – electrical converters, design of circuits and hands on models on material handling systems.	4
5	MODULE 5	
5.1	**Automation Control:** Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming the PLC. Practical Examples on PLC ladder programming.	6
5.2	**Inspection automation:** Inspection automation, off-line and on-line inspections, computerized coordinate measuring machine – CMM construction, online inspection systems., laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems.	6

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 282

Course Name: INTRODUCTION TO INDUSTRIAL AUTOMATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 Explain the concept of part family. (3)

2		Write short note on expert systems.	(3)
3		Explain the term sensitivity of a measuring instrument.	(3)
4		Differentiate between RTD and thermocouple.	(3)
5		Briefly explain the different functions of machine tool guide ways.	(3)
6		Explain the stick slip effect in friction guide ways.	(3)
7		Explain cushioning in pneumatic cylinders.	(3)
8		Draw the ISO symbol for single pilot operated spring offset 5/2 direction control valve.	(3)
9		What are the advantages of PLC over electromechanical relay control?	(3)
10		With suitable example explain latching in PLC Ladder logic.	(3)

PART B

Answer any one full question, each carries14 marks.

MODULE1

11	a)	With neat sketch explain different types of automated transfer lines used in an industry.	(7)
	b)	Discuss the nature and role of CIM elements.	(7)
12	a)	Explain the significance of group technology in present manufacturing scenario.	(6)
	b)	Explain different types of FMS layout.	(8)

MODULE II

13	a)	Explain the construction and working of LVDT.	(6)
	b)	Explain the working of eddy current and capacitance type proximity sensors.	(8)
14	a)	With neat sketches explain the working of i) resolver ii) Synchros.	(8)
	b)	Illustrate the configuration of gray coded absolute encoder.	(6)

MODULE III

15	a)	Explain the preloading of ball screws in recirculating ball screw mechanism.	(6)
	b)	With neat sketches explain adaptive control of machine tools.	(8)
16	a)	Explain the different types of industrial trucks used for material handling.	(8)

	b)	Explain the different types of conveyors used for automated material handling.	(6)

MODULE IV

17	a)	Design a pneumatic circuit for A+B+ B-A-.sequencing operation using Karnaugh-Veitch method.	(8)
	b)	With neat sketch explain basic components of a pneumatic system.	(6)
18	a)	With neat sketches explain the basic electrical devices used in electro pneumatic control.	(8)
	b)	With a neat sketch explain the use of an on delay timer in an electro pneumatic circuit.	(6)

MODULE V

19	a)	Design PLC ladder logic for operating two cylinders in the sequence A+B+A-B-.	(8)
	b)	Develop a PLC ladder program to glow three lights in sequence with a delay of 15 seconds in between. The circuit has only one switch to control the sequence.	(6)
20	a)	Briefly explain coordinate measuring machine.	(7)
	b)	Explain the scanning laser optical measurement system with a neat sketch.	(7)

****

SEMESTER -4
HONOURS

RAT 292	Sensors and Actuators for Robots	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze and select the most appropriate sensors and actuators for a robotic application
CO 2	Explain fundamental principle of working of sensors and actuators for robots
CO 3	Interpret typical manufacturer's data sheet of sensors and actuators and use them for selection in typical applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	**2**	**2**									3
CO 2	**3**	**2**	**2**									3
CO 3	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Module I

Requirement of sensors in robots used in industry, agriculture, medical field, transportation, military, space and undersea exploration, human-robot interactions, robot control, robot navigation, tele-operational robot etc.

Proprioceptive or Internal sensors Position sensors- encoders- linear, rotary, incremental linear encoder, absolute linear encoder, Incremental rotary encoder, absolute rotary encoder; potentiometers; LVDTs; velocity sensors-optical encoders, tacho generator, Hall effect sensor, , acceleration sensors,Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS, active optical and RF beacons, ultrasonic beacons, reflective beacons; Force sensors-strain gauge based and Piezo electric based, Torque sensors- Numerical Problems; Electronic skin, micro-cantilevers;Block schematic representations; Interpreting typical manufacturer's data sheet of internal sensors; Examples - the use of Proprioceptive sensors in robots.

ModuleII

Exteroceptive or External sensors-contact type, noncontact type;Tactile, proximity- detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor; Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light(2D), performance comparison range sensors; motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Block schematic representations; Numerical problems;Block schematic representations; Interpreting typical manufacturer's data sheet of external sensors;Examples - use of Exteroceptive sensors in robots.

Module III

Vision based sensors- Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system, CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor; Block schematic representations.

Criteria for selection of sensors- range, dynamic range, sensitivity, Linearity, response time, band width, accuracy, repeatability & precision, Resolution & threshold, type of output, size and weight, environmental conditions, interfacing.

Module IV

Requirement of actuators for robotic applications, Pneumatic and Hydraulic actuators, physical components, comparison of hydraulic and pneumatic systems- Components of electro hydraulic and pneumatic systems; hydraulic and pneumatic actuators with proportional control valves.

Electric actuators- advantages, DC motors, DC and AC servo motors,various types of Stepper motors; brushless DC motors ; PMSM; SRM; Motor characteristics, Selection of motors, block schematic of typical electric drive, closed loop speed and torque control.

Interpreting typical manufacturer's catalogue of actuators and using them for selection in typical applications.

Module V

Linear actuation mechanisms- Belt-driven and screw-driven actuators, Pneumatically and hydraulically driven linear actuators, Rack-and-pinion driven actuators, Linear motor driven actuators.

Transmission mechanisms-Cams and Cam followers, working principle. Gears and gear trains, ratchet and pawl, belt drive, advantages of belt drive, bearings classification and selection of bearings.

Electro thermal, electro-optical and electrochemical actuators, Piezo-actuators, pneumatic muscles

Micro-actuators- Electrostatic, Electromagnetic, Piezoelectric, Fluid, Thermal, Shape memory alloy, characteristics of microactuators- Stroke, Force/torque, Stiffness, Input energy, Efficiency, Linearity, Hysteresis, Response time, Drift, Bandwidth.

References

1. Robotics Engineering: An Integrated Approach, by Richard D. Klafter, Prentice Hall Inc.
2. Clarence W. de Silva, Sensors and Actuators: Control System Instrumentation, CRC Press 2007, ISBN-13: 978-1420044836
3. Introduction to Robotics, S K Saha, McGraw Hill Eduaction
4. D. Patranabis, “Sensors and Transducers”, PHI Learning Private Limited.
5. W. Bolton, “Mechatronics”, Pearson Education Limited.
6. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.
7. Pillai S. K. “A first course on electric drives”, Wieley Eastern Ltd, New Delhi
8. Journal of sensors, Special issue- Sensors for Robotics, Aiguo Song , Guangming Song, Daniela Constantinescu, Lei Wang, and Quanjun Song, Volume 2013
9. Mechatronics: Integrated mechanical electronic systems By K.P. Ramachandran, G.K. Vijayaraghavan, Wiley India
10. Linear Electric Actuators by I. Boldea
11. Piezoelectric Actuators (Electrical Engineering Developments), 2012, by Joshua E. Segel

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Proprioceptive or Internal sensors**	
1.1	Requirement of sensors in robots used in industry, agriculture, medical field, transportation, military, space and undersea exploration, human-robot interactions, robot control, robot navigation, tele-operational robot etc.	1
1.2	Position sensors- encoders- linear, rotary, incremental linear encoder, absolute linear encoder, Incremental rotary encoder, absolute rotary encoder; potentiometers; LVDTs.	2
1.3	velocity sensors-optical encoders, tacho generator, Hall effect sensor, acceleration sensors	2

1.4	Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS,	2
1.5	active optical and RF beacons, ultrasonic beacons, reflective beacons	1
1.6	Force sensors-strain gauge based and Piezo electric based, Torque sensors- Electronic skin, micro-cantilevers. Examples - use of Proprioceptive sensors in robots.	2
	Note- Block schematic representations, Interpretation of typical manufacturer's data sheet and Numerical problems of the above mentioned sensors are to be covered.	
2	**Exteroceptive or External sensors**	
2.1	contact type, noncontact type; Tactile, proximity- detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor;	3
2.2	Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light(2D), performance comparison range sensors;	3
2.3	Motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Numerical problems; Examples- use of Exteroceptive sensors in robots.	3
	Note- Block schematic representations, Interpretation of typical manufacturer's data sheet and Numerical problems of the above mentioned sensors are to be covered.	
3		
3.1	Vision based sensors - Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system	4
3.2	CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor.	3
3.3	Criteria for selection of sensors- range, dynamic range, sensitivity, Linearity, response time, band width, accuracy, repeatability & precision, Resolution & threshold, type of output, size and weight, environmental conditions, interfacing.	2
4	**Actuators for Robots**	
4.1	Requirement of actuators for robotic applications, Pneumatic and Hydraulic actuators, physical components, comparison of hydraulic and pneumatic systems- Components of electro hydraulic and pneumatic systems; hydraulic and pneumatic actuators with proportional control valves.	4
4.2	**Electric actuators**- advantages, DC motors, DC and AC servo motors, various types of Stepper motors ; brushless DC motors ; PMSM; SRM; Motor characteristics, Selection of motors, block schematic of typical electric drive, closed loop speed and torque control.	5
	Note: Interpreting typical manufacturer's catalogue of actuators and using them for selection in typical applications to be covered	

5		
5.1	Linear actuation mechanisms- Belt-driven and screw-driven actuators, Pneumatically and hydraulically driven linear actuators, Rack-and-pinion driven actuators, Linear motor driven actuators.	3
5.2	Transmission mechanisms-Cams and Cam followers, working principle. Gears and gear trains, ratchet and pawl, belt drive, advantages of belt drive, bearings classification and selection of bearings.	2
5.3	Electro thermal, electro-optical and electrochemical actuators, Piezo-actuators, pneumatic muscles	1
	Micro-actuators - Electrostatic, Electromagnetic, Piezoelectric, Fluid, Thermal, Shape memory alloy, characteristics of microactuators - Stroke, Force/torque, Stiffness, Input energy, Efficiency, Linearity, Hysteresis, Response time, Drift, Bandwidth.	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 292
Course Name: SENSORS AND ACTUATORS FOR ROBOTS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	How proprioceptive sensors differ fromexteroceptive sensors?	(3)
2	Mention the applications of force sensors.	(3)
3	A robot is moving in an environment amidst obstacles which are black in colour. Which sensor is preferred in this scenario for range measurement and obstacle avoidance? Justify your answer.	(3)
4	Explain the uses of tactile sensors.	(3)
5	Can we compute depth of an object using camera? Justify your answer.	(3)
6	What is visual servoing?	(3)
7	If the payload of a robotic manipulator is a car, which actuator is preferred? Justify your answer.	(3)
8	Which motors are generally used for position control applications?	(3)
9	Which are the commonly used linear actuating mechanisms for robots?	(3)
10	What are pneumatic muscles?	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	What is LVDT? What are the parameters that can be measured by this? Describe with a neat diagram the principle of operation and output characteristics of the same.	(10)
	b)	A robot'scontrol memory has 8 bit storage capacity; it has two rotational joints and one linear joint. The linear link can varyits length from as short as 0.2 meters to as long as 1.2 meters. Compute the control resolution for encoder of each joint.	(4)
12	a)	What is Gyroscope? Enumerate various sources of errors in Gyroscopes? How will you rectify them while gyroscopes are used in robotic applications?	(10)
	b)	Can we use GPS sensors in indoor environments? Justify your answer.	(4)
		MODULE II	
13	a)	Which are the sensors used to detect closeness of objects? And how will you compute the same?	(10)
	b)	How range is measured using optical triangulation method?	(4)
14		Consider a scenario where a surveillance vehicle chases a car which violated traffic rules. Which all sensors are to be used in the surveillance vehicle to compute the position and relative velocity of the target vehicle (car)? Explain the working of the sensors being used.	(14)
		MODULE III	
15	a)	Which are the elements of a vision sensor? How will you extract features using vision sensor?	(10)
	b)	What are the advantages of CMOS cameras?	(8)
16		Explain the criteria for selection of sensors for different applications	(14)
		MODULE IV	
17	a)	Compare hydraulic and pneumatic actuators?	(8)
	b)	What is FRL unit? What are its functions?	(6)
18	a)	With the help of neat diagram explain the working of stepper motor?	(8)
	b)	In which context Brushless DC motors are used for robotic applications? Mention one application for the same.	(3)
	c)	How much power is required to lift a 20Kg weight by a DC motor if the lifting speed is 0.2m/s?	(3)
		Module V	
19	a)	Explain the working of Rack-and-pinion driven actuator with the help a diagram.	(8)
	b)	Explain in detail about different transmission mechanisms.	(6)
20	a)	Compare electro thermal, electro-optical and electrochemical actuators.	(7)
	b)	Which are the characteristics of micro-actuators?	(7)

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SEMESTER V

RAT301	INTRODUCTION TO ROBOTICS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course helps the student to basic idea of Robots. Students are introduced to the basic design consideration of robots. Concepts like trajectory planning and obstacle avoidance and kinematics of robots are introduced. Discussion on various mobile robots and robotic manipulators are also included as part of the course to get an overall idea on robotics

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarise with anatomy, specificationsand types of Robots
CO 2	Obtain forward and inverse kinematic models of robotic manipulators
CO 3	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion
CO 4	Develop dynamic model and design the controller for robotic manipulators
CO 5	Choose appropriate Robotic configuration and list the technical specifications forrobots used in different applications
CO 6	Familiarise with different types of mobile robots, kinematic models, motion control and sensors for mobile robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1										3
CO 2	2	1										3
CO 3	2	1										3
CO 4	3	2	2									3
CO 5	3	2	2									3
CO 6	3	2	2									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Differentiate between open and closed kinematic chain with the help of examples.
2. What do you mean by degrees of freedom

Course Outcome 2 (CO2):

1. Differentiate between reachable and dexterous workspace.

Course Outcome 3 (CO3):

1. Differentiate between path and trajectory of a robotic manipulator.
2. What is cartesian space trajectory planning

Course Outcome 4 (CO4):

1. What is dynamic model of robotic manipulators.
2. What is robotic manipulators

Course Outcome 5 (CO5):

1. Characteristics of a spray painting robot.
2. Compare holonomic and non-holonomic robots.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 301

Course Name:Introduction to Robotics

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	What do you mean by degrees of freedom? How many degrees of freedom required for a robotic manipulator to achieve any position (for the end effector) in 3D space? And how many more DOF required for achieving any orientation as well.	(3)
2	Differentiate between open and closed kinematic chain with the help of examples	(3)
3	If a point$P = [3 \quad 0 \quad -1 \quad 1]^T$, find the new location of the point P, if it is rotated by π about z-axis of fixed frame and then translated by 3 units along y axis	(3)
4	Differentiate between reachable and dexterous workspace. For a 2 link planar manipulator, the first link length is equal to 2nd link length, i.e. L_1=L_2. Sketch the reachable and dexterous workspace	(3)
5	Differentiate between path and trajectory of a robotic manipulator. Which are the inputs fed to the typical trajectory planner of a robotic manipulator?	(3)
6	Compare Joint space and cartesian space trajectory planning.	(3)
7	How will you obtain dynamic model of robotic manipulators?	(3)
8	Are robotic manipulators nonlinear systems? Can we use linear control schemes for the control of robotic manipulators?	(3)
9	What the technical specifications / characteristics of a spray painting robot?	(3)
10	Compare holonomic and non-holonomic robots.	(3)

PART B

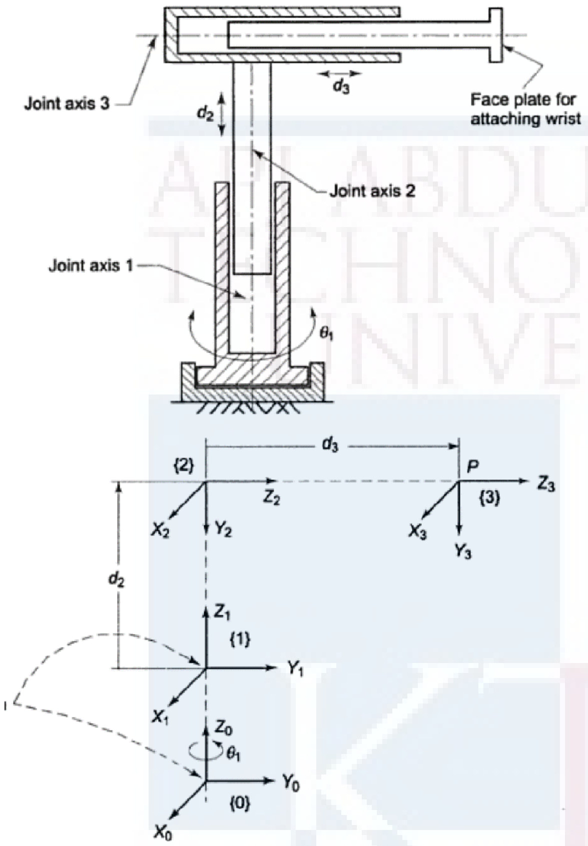
Answer any one full question from each module, each carries14 marks.

MODULE I

11	a)	How robotic manipulators are classified based on configurations? Explain with the help of diagrams.	(7)
	b)	How robots are classified based on motion control methods and drive technologies?	(7)
12	a)	Explain in detail the classification of end effectors.	(6)
	b)	Explain the general features of wheeled, legged and aerial robots.	(8)

MODULE II

13 a) For the following cylindrical robot arm, compute the position and orientation of the tool tip. (7)



b) Determine the joint angles θ1, θ2, θ3 of a 3 axis robot if the origin of {3} is located at $[0.707, 1.707, 0.000]^T$ and the orientation of {3} with respect to {0} is given by the rotation matrix $R = \begin{bmatrix} 0.5 & -0.866 & 0 \\ 0.866 & 0.5 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. (7)

Given $T_0^3 = \begin{bmatrix} C_{123} & -S_{123} & 0 & L_1C_1 + L_2C_{12} \\ S_{123} & C_{123} & 0 & L_1S_1 + L_2S_{12} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

14 a) Let $F = \{f^1, f^2, f^3\}$ and $M = \{m^1, m^2, m^3\}$ be the fixed and mobile co-ordinate frames. Given $[P]^F = A = [1 \quad 2 \quad 0 \quad 1]^T$. If the homogeneous transformation matrix which maps mobile co-ordinates to fixed co-ordinates is given by (7)

$T = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 2 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$. Find the homogeneous transformation which maps fixed frame to mobile frame. Also compute the co-ordinates of the point P with respect to mobile frame, $[P]^M$.

b) Explain how DH algorithm is used to obtain the forward kinematic model of a robotic manipulator. (7)

MODULE III

15 a) Which are the joint space trajectory planning methods? Explain in detail. (7)

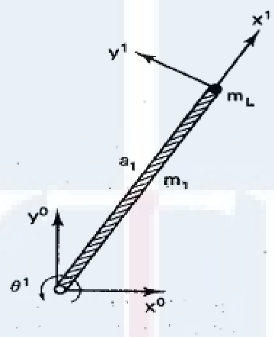
b) The second joint of a SCARA robot has to move from 15^0 to 45^0 in 3 sec. Find the coefficients of the cubic polynomial to interpolate a smooth trajectory.Also obtain the position, velocity and acceleration profiles (7)

16 a) How a circular trajectory is planned in cartesian space? (7)

b) Explain how artificial potential filed method is used for obstacle avoidance of robotic manipulators (7)

MODULE IV

17 a) Obtain the dynamic model of the following manipulator (6)



b) What is the need of a torque regulator in a typical robotic control system? Explain the working of the same with the help of block schematic. How will you choose Kp, KI and Kd values for single axis PID control of robotic manipulator? (8)

18 a) How will you compute the dynamic model of a 2 DOF planar manipulator? (7)

b) Explain in detail how computed torque control is implemented in robotic manipulators. (7)

MODULE V

19 a) Explain in detail how robotic manipulators are used for Material handling, welding and machining applications (8)

b) Obtain the kinematic model of a differential driven mobile robot. (6)

20 a) How will you choose robotic configuration for a pick and place task? (7)

b) Explain in detail different sensors used in mobile robots. (7)

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Syllabus

Module I (9 Hours)

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.

Module II (10 Hours)

Robot Kinematics

Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous co-ordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF)
Inverse kinematics- general properties of solutions, Problems (upto 3DOF)
Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only)
Tool configuration Jacobian, relation between joint and end effector velocities.

Module III(8 Hours)

Trajectory planning

Tasks Path planning Trajectory Planning. Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, Point to point vs continuous path planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms.

Module IV(9 Hours)

Manipulator Dynamics

Lagrange'sformulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots upto 2 DOF, modelling including motor and gearbox.

Robot Control

The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control.

Simulation of simple robot-control system-Matlab programming for control of robots(demonstration/assignment only)

Module V(9 Hours)

Industrial Applications-Material handling, welding, Spray painting, Machining. Case study-for robotic applications including robot selection considerations for a typical industrial application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment. foreg – the robotic configuration for pick and place robot, spot welding robot in a car manufacturing industry, peg in hole assembly. Applications in the medical, mining, space, defence, security, domestic, entertainment.

Field robotics

Locomotion, Key issues for locomotion, Legged Mobile Robots, Wheeled Mobile Robots. Aerial Mobile Robots.

Mobile Robot Kinematics (Differential Drive robot), simple Examples: Robot kinematic models and constraints, Mobile Robot Workspace- Degrees of freedom, Holonomic and nonholonomic robots.

Motion Control (Kinematic Control), Open loop control (trajectory-following), Feedback control.

Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, Representing uncertainty, Wheel/motor sensors, Heading sensors, Accelerometers, Inertial measurement unit (IMU), Ground beacons, Active ranging, Motion/speed sensors, Vision sensors.

Text Books

1. Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996.
2. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
3. Introduction to Robotics by S K Saha, Mc Graw Hill Education
4. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
5. AshitavaGhosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
6. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb
7. Introduction to Autonomous Mobile Robots, Siegwart, Roland, Cambridge, Mass. : MIT Press, 2nd ed.

Reference Books

1. Sicilliano, Khatib , "Handbook of Robotics", Springer
2. John J. Craig, Introduction to Robotics – Mechanics and Control
3. Kevin M. Lynch, Frank C. Park, Modern Robotics Mechanics, Planning and Control
4. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe OrioloRobotics Modelling, Planning and Control, Springer

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots;	2
1.2	Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom;	1.5
1.3	Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist	3
1.4	Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.	2.5
2	**MODULE 2**	
	Robot Kinematics	
2.1	Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous co-ordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations	3
2.2	Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF)	3
2.3	Inverse kinematics- general properties of solutions, Problems (upto 3DOF)	2
2.4	Tool configuration Jacobian, relation between joint and end effector velocities.	2
3	**MODULE 3**	
	Trajectory planning	
3.1	How to arrive at trajectory planning from task descriptions? Joint space vs cartesian space trajectory planning	0.5
3.2	Trajectory planning cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points;	2.5
3.3	Cartesian space planning-straight line and circular trajectories, Point to point vs continuous path planning	3
3.2	Obstacle avoidance methods- Artificial Potential field, A* algorithms.	2
4	MODULE 4	
	Manipulator Dynamics and Robot Control	

4.1	Lagrange's formulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots upto 2 DOF, modelling including motor and gearbox.	4.5
4.2	The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control. Simulation of simple robot-control system-Matlab programming for control of robots(demonstration/assignment only)	4.5
5	MODULE 5	
	Robot applications and Field Robotics	
5.1	Industrial Applications-Material handling, welding, Spray painting, Machining. Case study- for robotic applications including robot selection considerations for a typical industrial application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment. foreg – the robotic configuration for pick and place robot, spot welding robot in a car manufacturing industry, peg in hole assembly. Applications in the medical, mining, space, defence, security, domestic, entertainment.	5
5.2	**Basic concepts of Field Robotics** Locomotion, Key issues for locomotion, Legged Mobile Robots, Wheeled Mobile Robots. Aerial Mobile Robots. Mobile Robot Kinematics (Differential Drive robot), simple Examples: Robot kinematic models and constraints, Mobile Robot Workspace- Degrees of freedom, Holonomic and nonholonomic robots. Motion Control (Kinematic Control), Open loop control and Feedback control. Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, Representing uncertainty, Wheel/motor sensors, Heading sensors, Accelerometers, Inertial measurement unit (IMU), Ground beacons, Active ranging, Motion/speed sensors, Vision sensors.	4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT303	SOLID MECHANICS	PCC	3	1	0	4

Preamble: This course helps the students to understand the concept of stress and strain in different types of structure/machine under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion in circular, and non circular section, strain energy, different theories of failure, stress in thin cylinder thick cylinder and spheres due to external and internal pressure.

Prerequisite: ENGINEERING MECHANICS

Course Outcomes: After the completion of the course the student will be able to

CO 1	Determine the stresses, strains and displacements of structures by tensorial and graphical (Mohr's circle) approaches
CO 2	Analyse the strength of materials using stress-strain relationships for structural and thermal loading
CO 3	Perform basic design of circular shafts and thin walled structures subjected to torsional loading and analyse beams subjected to bending moments under different idealised loading conditions
CO 4	Determine the deformation of structures subjected to various loading conditions using strain energy methods
CO 5	Analyse column buckling and appreciate the theories of failures and its relevance in engineering design

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**	**1**										3
CO 2	**2**	**1**										3
CO 3	**2**	**1**										3
CO 4	**3**	**2**	**2**									3
CO 5	**3**	**2**	**2**									3
CO 6	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

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Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write down the Cauchy's strain displacement relationships.

Course Outcome 2 (CO2):

1. Explain the generalized Hooke's law for a Linear elastic isotropic material.

Course Outcome 3 (CO3):

1. What is the significance of flexural rigidity and section modulus in the analysis of beams.

Course Outcome 4 (CO4):

1. Discuss reciprocal relation for multiple loads on a structure.

Course Outcome 5 (CO5):

1. Discuss Saint-Venant's theory of failure.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code : RAT 303

Course Name : Solid Mechanics

Max. Marks : 100 Duration : 3 Hours

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Express the stress invariants in terms of Cartesian components of stress and principal stress.
2. Write down the Cauchy's strain displacement relationships.
3. Distinguish between the states of plane stress and plane strain.
4. Explain the generalized Hooke's law for a Linear elastic isotropic material.
5. List any three important assumptions in the theory of torsion.
6. Write the significance of flexural rigidity and section modulus in the analysis of beams.
7. Discuss reciprocal relation for multiple loads on a structure.
8. Express the strain energy for a cantilever beam subjected to a transverse point load at free end.
9. Discuss Saint-Venant's theory of failure.
10. Explain the term 'critical load' with reference to the buckling of slender columns.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – I

11 a) The state of stress at a point is given by σ_{xx} = 12.31 MPa, σ_{yy} = 8.96 MPa, σ_{zz} = 4.34 MPa, τ_{xy} =4.2 MPa, τ_{yz} = 5.27 MPa, τ_{xz} = 0.84 MPa. Determine the principal stresses. (7 marks)

b) The displacement field for a body is given by u= $(x^2 + y)i + (3 + z)\,j + (x^2 + 2y)k$. What is the deformed position of a point originally at (3,1,–2)? Write the strain tensor at the point (−3,−1,2) .(7 marks)

OR

12. a) The state of plane stress at a point is given by σ_{xx} = 40 MPa, σ_{yy} = 20 MPa and τ_{xy} = 16 MPa. Using Mohr's circle determine the i) principal stresses and principal planes and ii) maximum shear stress. (7 marks)

b) The state of stress at a point is given below. Find the resultant stress vector acting on a plane with direction cosines n_x=0.47, n_y=0.82 and n_z=0.33. Find the normal and tangential stresses acting on this plane. (7 marks)

$$\sigma_{ij} = \begin{bmatrix} 10 & 5 & -10 \\ 5 & 20 & -15 \\ -10 & -15 & -10 \end{bmatrix} MPa$$

MODULE – II

13. a) Calculate Modulus of Rigidity and Young's Modulus of a cylindrical bar of diameter 30 mm and of 1.5 m length if the longitudinal strain in a bar during a tensile stress is four times the lateral strain. Find the change in volume when the bar is subjected to a hydrostatic pressure of 100 N/mm2. Take E = 105 N/mm (9 marks)

b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mmdiameter for the remaining length. If the bar is subjected to an axial pull of 15 kN. Find themaximum axial stress produced and the total extension of the bar. Take E = 2x105 N/mm2 (5 marks)

OR

14. a) A brass bar 20mm diameter is enclosed in a steel tube of 25mm internal diameter and 50mm external diameter. Both bar and tube are of same length and fastened rigidly at their ends. The composite bar is free of stress at 20°C. To what temperature the assembly must be heated to generate a compressive stress of 48MPa in the brass bar? Also determine the stress in the steel tube. E_{steel} = 200GPa and E_{brass} = 84GPa, αsteel = 12 × 10−6 / °C and αbrass= 18 × 10−6 / °C. (9 marks)

b) Draw the stress-strain diagram for a ductile material and explain the salient points. (5 marks)

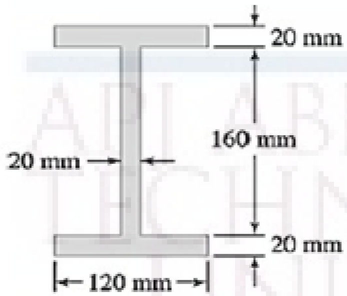
MODULE – III

15.a) Draw shear force and bending moment diagram for a simply supported beam of length 10 m carries a point load of 10N at a distance of 2 m from left support and a udl of 5N/m for the entire length. (9 marks)

b) Compare the strength of a hollow shaft of diameter ratio 0.75 to that of a solid shaft by considering the permissible shear stress. Both the shafts are of same material, of same length and weight. (5 marks)

OR

16. a) A simply supported beam of span of 10 m carries a UDL of 40 kN/m. The cross section is of **I** shape as given below. Calculate the maximum stress produced due to bending and plot the bending stress distribution. (9 marks)



b) The shear stress of a solid shaft is not to exceed 40 N/mm2 when the power transmitted is 20kW at 200 rpm. Determine the minimum diameter of the shaft.

(5 marks)

MODULE – IV

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at itsends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from thetwo ends respectively. Moment of inertia for the section of the girder is 16 × 108 mm4 and Es =210 kN/mm2. Calculate the deflection of the girder at points under the two loads and maximumdeflection using Macaulay's method. (8 marks)

b) Derive the expressions for elastic strain energy in terms of applied load/moment and materialproperty for the cases of a) Axial force b) Bending moment. (6 marks)

OR

18. a) Calculate the displacement at the load point due to the downward load P applied at a distance of L/3 from the left end for a simply supported beam of span L. (10 marks)

b) State Castigliano's second theorem and explain its significance. (4 marks)

MODULE – V

19. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula andRankine's constant as 1/7500 and σc = 335 N/mm2. Compare this load by crippling load given byEuler's formula. Take E = 110 GPa. (8 marks)

b) Explain the maximum normal stress theory, maximum strain energy theory and maximumshear stress theory of failure. (6 marks)

OR

20. a) The principal stresses at a point in an elastic material are 22 N/mm2(tensile), 110 N/mm^2(tensile) and 55 N/mm2 (compressive). If the elastic limit in simple tension is 210 N/mm^2, thendetermine whether the failure of material will occur or not according to Maximum principalstress theory, Maximum shear stress theory and maximum distortion energy theory . (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

SYLLABUS

Module I (10 Hours)

Deformation behavior of elastic solids in equilibrium under the action of a system of forces, method of sections. Stress vectors on Cartesian coordinate planes passing through a point, stress at a point in the form of a matrix. Equality of cross shear, Cauchy's equation. Displacement, gradient of displacement, Cartesian strain matrix, strain- displacement relations (small-strain only), Simple problems to find strain matrix.Stress tensor and strain tensor for plane stress and plane strain conditions. Principal planes and principal stress,meaning of stress invariants, maximum shear stress. Mohr’s circle for 2D 3D case.

Module II (9 Hours)

Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson’s ratio. Constitutive equations-generalized Hooke’s law, equations for linear elastic isotropic solids in terms of Young’s Modulus and Poisson’s ratio, Hooke’s law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required). Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar with different end conditions

Module III (9 Hours)

Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, torsion formula -no derivation .Torsional rigidity, Polar moment of inertia, basic design of transmission shafts. Simple problems to estimate the stress in solid and hollow shafts.Analysis of thin walled structures under torsional loading. Simple problems

Shear force and bending moment diagrams for cantilever,hinged and simply supported beams. Differential equations between load, shear force and bending moment-no derivation. Normal and shear stress in beams: Flexural formula-no derivation , section modulus, flexural rigidity, numerical problems to evaluate bending stress. Shear stress formula for beams-no derivation , shear stress distribution in rectangular,circular section.

Module IV (8 Hours)

Deflection of beams using Macauley’s method Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads.

Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Castigliano's second theorem, reciprocal relation-no proof required, reciprocal relation. Simple problems to find the deflections using Castigliano's theorem.

Module V (7 Hours)

Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler's buckling theory for long columns. Critical stress, slenderness ratio, Rankine's formula for short columns. Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy

Text Books

1. Mechanics of materials in S.I. Units, R .C. Hibbeler, Pearson Higher Education 2018
2. Mechanics Of Materials (In Si Units) , Ferdinand Beer, E. Russell Johnston, Jr, McGraw-Hill 2017.
3. Advanced Mechanics of Solids, L. S. Srinath, McGraw Hill Education 4
4. Design of Machine Elements, V. B Bhandari, McGraw Hill Education

Reference Books

1. Engineering Mechanics of Solids, Popov E., PHI 2002
2. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2ndEdition, 2015
3. Strength of Materials, Rattan, McGraw Hills 2011
4. Strength of Materials, Surendra Singh, S. K. Kataria& Sons

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1: Stress and Strain Analysis**	
1.1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe methods of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point and writing stress at a point in the form of a matrix.	2
1.2	Equality of cross shear (Derivation not required). Write Cauchy's equation	2

	(Derivation not required),Find resultant stress, Normal and shear stress on a plane given stress tensor and direction cosines (no questions for finding direction cosines).	
1.3	Displacement, gradient of displacement, Cartesian strain matrix, Write strain displacement relations (small-strain only), Simple problems to find strain matrix given displacement field (2D and 3D), write stress tensor and strain tensor for Plane stress and plane strain conditions.	2
1.4	Concepts of principal planes and principal stress, characteristic equation of stress matrix and evaluation of principal stresses and principal planes as an eigenvalue problem, meaning of stress invariants, maximum shear stress	2
1.5	Mohr's circle for 2D and 3D case: find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohr's circle	2
2	**Module 2: Stress - Strain Relationships**	
2.1	Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio	2
2.2	Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in terms of Young's Modulus and Poisson's ratio . Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required), Numerical problems. Calculation of stress, strain and change in length in axially loaded members with single and composite materials,	3
2.3	Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required), Numerical problems. Calculation of stress, strain and change in length in axially loaded members with single and composite materials,	2
2.4	Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed,pin joint and yielding supports. Numerical problems for axially loaded members.	2
3	**Module 3: Torsion , Shear Force-Bending Moment Diagrams and Pure bending**	
3.1	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, Torsional rigidity, Polar moment of inertia, comparison of solid and hollow shaft. Simple problems to estimate the stress in solid and hollow shafts .	2

3.2	Thin walled structures open and closed-calculating the shear stress distribution and overall angle of twist due to applied torque,simpleproblems,no derivation.	3
3.3	Shear force and bending moment diagrams for cantilever and simply supported beams subjected to point load, moment, UDL and linearly varying load ,Differential equations between load, shear force and bending moment.	2
3.4	Normal and shear stress in beams: section modulus, flexural rigidity, numerical problems to evaluate bending stress, Shear stress formula for beams: ,numerical problem to find shear stress distribution for rectangular,circular section	2
4	**Module 4: Deflection of beams, Strain energy**	
4.1	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macauley's method (procedure and problems with multiple loads)	3
4.2	Linear elastic loading, elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads (short derivations in terms of loads and deflections).	2
4.3	Castigliano's second theorem, reciprocal relation-proof. Simple problems to find the deflections subjected to point load,udl and moment using Castigliano's theorem.	3
5	**Module 5: Buckling and theories of failure**	
5.1	Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler's buckling theory for long columns. Critical stress, slenderness ratio, Rankine's formula for short columns	4
5.2	Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy.Simple problems under 2D stress conditions.	4

RAT305	INDUSTRIAL AUTOMATION	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The objective of this course is to provide the student with a general idea of the different automation technologies used in manufacturing environments. Course discusses on the various types of sensors and actuators that acts as the backbone of any automation systems. Study of material handling devices, pneumatic and hydraulic circuits are part of the course. It also provides insights on computerised control and PLC programming.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the basic concepts of automation methodologies and trends in manufacturing automation.
CO 2	Explain the working principle and applications of different types of sensors and actuators
CO 3	Discuss different automated inspection methods.
CO 4	Explain the design aspects of modern CNC machines.
CO 5	Explain the basic principles and operation of different types of material handling devices.
CO 6	Develop different pneumatic and hydraulic circuits based on their applications.
CO 7	Familiarize the basic concepts of PLC programming.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	2	2	1	2							3
CO 2	3	2	2	1	2	1						2
CO 3	3	2	2	2	2	1						3
CO 4	3	2	2	2	1	1						2
CO 5	3	3	2	2	2	1						2
CO 6	3	3	2	2	2							2
CO 7	3	3	2	2	2	2						2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	25	25	30
Apply	15	15	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare and contrast the Detroit type automation and Automated Flow line
2. Explain the advantages of Mechanization and Automation in manufacturing industry

Course Outcome 2 (CO2):

3. Explain the working principle of LVDT and RVDT
4. Discuss the need for calibration and explain any one method

Course Outcome 3 (CO3):

5. Explain the principle and working behind the use of laser interferometer for automatic inspection
6. What are the different automated thickness measurement systems? Explain.

Course Outcome 4 (CO4):

7. Discuss in detail about the different types of automated tool changers available in CNC machines
8. What is adaptive control? How is it used in the design of CNC machines? Explain.

Course Outcome 5 (CO5):

9. Discuss the major design consideration of Material handling systems.
10. Discuss any two automated storage and retrieval systems (ASRS)

Course Outcome 6 (CO6):

11. Design a pneumatic circuit for A+B+ B-A-. sequencing operation using Karnaugh-Veitch method.
12. Explain the functions of the following
    a. Solenoid
    b. Pneumatic-electrical converters

Course Outcome 7 (CO1):

13. Develop a PLC ladder program for the following sequence: Start a motor with push switch, and then after a delay of 90s, start a pump. When the motor is switched off, the pump will get switched off after a delay of 5s. Mention the logic used for each rung in the program to substantiate your answer.

14. Design PLC ladder logic for operating two cylinders in the sequence A+B+A-B-.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 305

Course Name: INDUSTRIAL AUTOMATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	What are the methods adopted to group parts in to part families?	(3)
2	Explain programmable Automation.	(3)
3	Explain the working of any one non-contact temperature measurement system.	(3)
4	Explain any two situations when pneumatic actuators are preferred over hydraulic ones.	(3)
5	Explain linear motion guideways. Explain any one application for the use of LM guideways.	(3)
6	Briefly explain carousal type automated storage system.	(3)
7	Explain the different actuation mechanisms in DCVs.	(3)
8	Draw the ISO symbol for the following i) Double pilot operated 5/2 direction control valve. ii) Shuttle valve.	(3)
9	Draw the ladder diagram for the following logic functions. (i) XOR (ii) NAND (iii) NOR	(3)
10	Illustrate the significance of Internal Relays in PLC program.	(3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11 a) With neat sketch explain different types of automated transfer lines used in an industry. (7)

	b)	Explain how group technology is used in designing manufacturing cells.	(7)
12	a)	An automated transfer line has 30 stations and an ideal cycle time of 2.0 min. Probability of a station failure is p=0.02, and the average downtime when a breakdown occurs is 15 min. Determine (a) average production rate Rp and (b) line efficiency E.	(6)
	b)	Explain different types of FMS layout.	(8)

MODULE II

13	a)	Explain the working of an optical absolute encoder. How the number of tracks and sectors of absolute encoder is related to the resolution of the encoder?	(6)
	b)	Explain the scanning laser optical measurement system with a neat sketch.	(8)
14	a)	With neat sketches explain the working of i) resolver ii) Synchros.	(8)
	b)	Design a hydraulic circuit to operate a winch fitted with a hydraulic motor. The motor should be run clockwise, counter clockwise and stopped. Use a manually operated valve.	(6)

MODULE III

15	a)	Sketch and explain working of an AC servomotor.	(6)
	b)	With neat sketches explain adaptive control of machine tools.	(8)
16	a)	Explain the different types of AGVs used for automated material handling.	(8)
	b)	Explain the different types of conveyors used for automated material handling.	(6)

MODULE IV

17	a)	Design a pneumatic circuit for A+B+ B-A-.sequencing operation using Karnaugh-Veitch method.	(8)
	b)	Components are to be stamped using stamping machine. A double acting cylinder is used to push the die attached down to a fixture one second after push button is pressed. The die is to return to the initial position upon reaching sufficient stamping pressure as sensed by a pressure switch. Develop an electro pneumatic control circuit to implement the control task for the stamping operation.	(6)
18	a)	With neat sketches explain the basic electrical devices used in electro pneumatic control.	(8)
	b)	Explain the design considerations of proportional control valve.	(6)

MODULE V

19 a) Design PLC ladder logic for operating two cylinders in the sequence A+B+A-B-. (8)

b) Two motors are to be controlled in a sequence. The second motor starts 30 seconds after the starting of first motor by a push switch. Develop a PLC ladder diagram for the following cases and describe the circuit. (6)
Case (A): Only one motor operates at a time.
Case (B): Both the motor gets off together after 50 seconds

20 a) Design PLC based automated car parking barrier system with suitable sensors and actuators. Design the ladder logic for the PLC so that the system collects coins for parking cars and the barrier prevents the entry of one vehicle for a single coin collection. (7)

b) Develop a PLC ladder program for the following sequence: Start a motor with push switch, and then after a delay of 90s, start a pump. When the motor is switched off, the pump will get switched off after a delay of 5s. Mention the logic used for each rung in the program to substantiate your answer. (7)

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SYLLABUS

Module I

Automation methodologies: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines. Trends in manufacturing – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.

Module II

Sensors and actuators for automation: Classification of position, proximity and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.
Electrical, Hydraulic, and pneumatic actuators and their comparison, Examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.
Sensor systems for automated inspection- online inspection systems, laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems.

Module III

Elements of CNC systems: servomotor and servo system design trends, stepper motors and controls, adaptive control, Drive systems. Automated tool changers and pallet changers-different types. Accessories, and selection of drives for CNC machines.

Material Handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, ASRS different types Overview of Automatic part Identification Methods, Automatic Guided Vehicles.

Module IV

Pneumatic/Hydraulic Automation: control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems.

Electro pneumatic/electrohydraulic automation: Symbols: Basic electrical elements – relay, solenoid, timers, pneumatic – electrical converters, design of circuits and hands on models on material handling systems. Proportional valves and their control.

Module V

Automation Control: Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming of PLC- analog and digital I/Os, timers, counters, function blocks. Case studies on PLC ladder programming. Motion controllers-VFD, MLD, external relays and contactors.

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.

References:

1. Computer Control of Manufacturing Systems YoramKoren, Tata McGraw-Hill Edition 2005.
2. CNC Machines, Radhakrishnan P., New Central Book Agency, 1992.
3. Mechatronics: A Multidisciplinary Approach, 4/E, W. Bolton. Pearson Education India.
4. Mechatronics, HMT, Tata McGraw-Hill, 1998.
5. Standard Handbook of Industrial Automation, Considine D M C & Considine G D C, Chapman and Hall, NJ, 1986.
6. Pneumatic Control for Industrial Automation‖, Peter Rohner& Gordon Smith, John Wiley and Sons, 1987.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	**Automation methodologies**: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines.	4
1.2	**Trends in manufacturing** – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.	4
2	**MODULE 2**	
2.1	**Sensors and actuators for automation:** Classification of position and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.	4
2.2	Electrical, Hydraulic and pneumatic actuators and their comparison, examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.	2
2.3	Sensor systems for automated inspection- online inspection systems, laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems.	3
3	**MODULE 3**	
3.1	**Elements of CNC systems:** servomotor and servo system design trends, stepper motors and controls, adaptive control, ball screws and guideways, spindle, bearings and mountings. Drive systems. Automated tool changers and pallet changers. Accessories and selection of drives for CNC machines.	5
3.2	**Material Handling and Identification Technologies:** Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.	4
4	**MODULE 4**	

4.1	**Pneumatic/Hydraulic Automation:** control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems.	5
4.2	**Electro pneumatic/electrohydraulic automation**: Symbols: Basic electrical elements – relay, solenoid, timers, pneumatic – electrical converters, design of circuits and hands on models on material handling systems.	5
5	**MODULE 5**	
5.1	**Automation Control:** Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming the PLC. Practical Examples on PLC ladder programming.	6
5.2	Motion controllers-VFD, MLD, external relays and contactors.	3

RAT307	CONTROL SYSTEMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble : This course provides the basic idea of modelling a complex physical system into a simple model for different kinds of analysis. The course provides the student with in-depth knowledge on time domain and frequency analysis of systems, determine the stability of a dynamic system, functions of controllers and compensators in a system. It also discussed on various methods used for the analysis of non-linear systems

Prerequisite: Mathematics course in differential equations and Laplace transform, and basic electrical network analysis.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Model the systems using transfer function approach as well as state space approach
CO 2	Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.
CO3	Compute the time domain and frequency domain specifications of a system
CO4	Analyse dynamic systems for their stability and performance using root locus and Bode plot
CO5	Identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system.
CO6	Analyse systems using state space approach
CO7	Explain a variety of methods for analysing nonlinear systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2									3
CO 2	3	2	2									3
CO 3	3	2	2									3
CO4	3	2	2									3
CO5	3	2	2									3
CO6	3	2	2									3
CO7	3	2	2									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

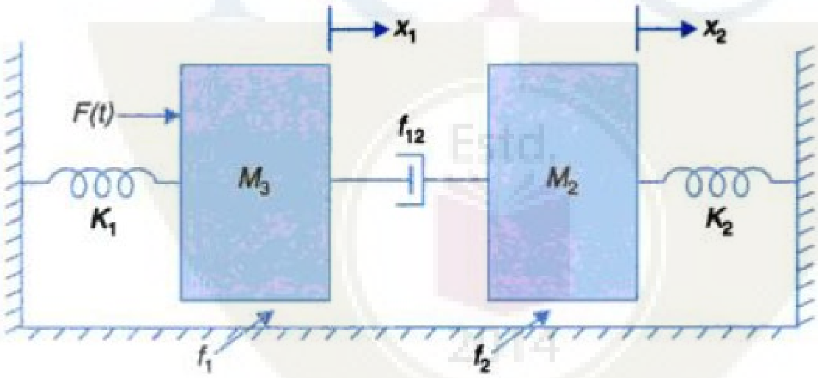
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Open Loop and Closed Loop Control Systems. Discuss the functionality of critical components of a control system
2. Determine the transfer function representation of the translational mechanical system shown in following figure. Take displacement x_2 as output and force F(t) as input.

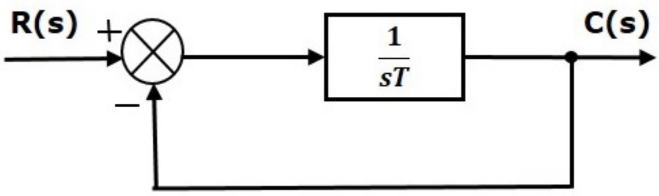


Course Outcome 2 (CO2):

3. Explain Static and Transient response of a system. List out the standard test signals and their characteristics
4. A unity feedback system has an open loop transfer function $\frac{20(s+3)}{(s+0.1)(s+5)}$. Determine steady state error for unit parabolic input?

Course Outcome 3 (CO3):

5. Determine the order of the system given below. Also find out the impulse response of the same.



6. Calculate the resonant peak, resonant frequency and bandwidth for a second order closed loop system given below.

$$T(s) = \frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\delta\omega_n s + \omega_n^2}$$

Course Outcome 4 (CO4):

7. Sketch the root locus for the unity feedback system whose open loop transfer function is given below

$$G(s)H(S) = \frac{K}{s(s+4)(s^2+4s+20)}.$$

8. Sketch the Bode diagram for the following transfer function and hence compute the gain margin and phase margin.

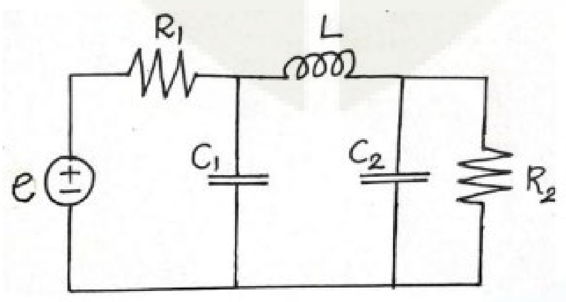
$$G(s) = \frac{75(1+0.2s)}{s(s^2+16s+100)}$$

Course Outcome 5 (CO5):

9. Describe the design procedure for a lag compensator
10. Explain in detail about the three different types of controllers.

Course Outcome 6 (CO6):

11. A system is defined by the transfer function $\frac{Y(s)}{U(s)} = \frac{10(s+4)}{s(S+2)(s+3)}$. Find the state and output equations of the system
12. Obtain the state space representation of the electrical system given below.



Course Outcome 7 (CO7):

13. Derive the Describing function of a Dead-zone nonlinearity.

14. Investigate the stability of the following non-linear system using Lyapunov direct method $\dot{x_1} = x_2 \dot{x_2} = -x_1 - x_1^2 x_2$

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 307

Course Name: Control Systems

Max. Marks: 100 | Duration: 3 Hours

PART A

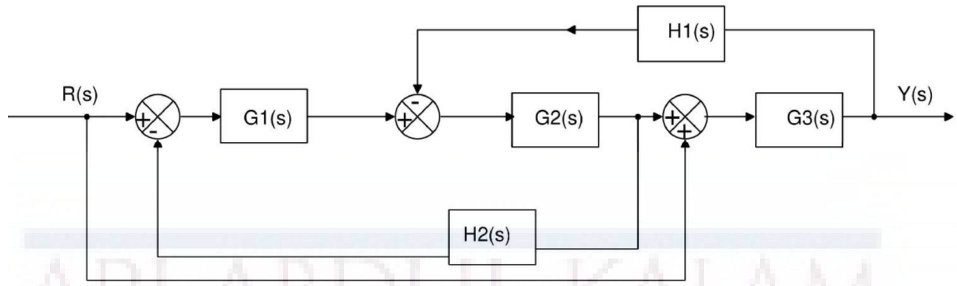
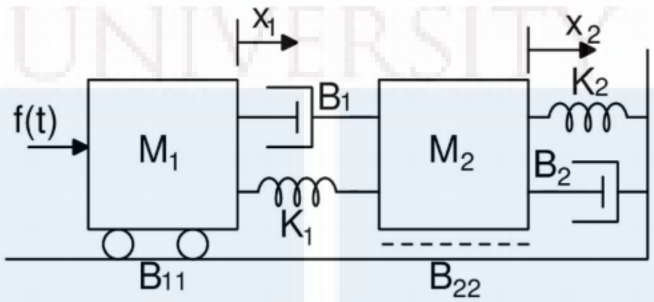
		Answer all questions, each carries 3 marks.	Marks
1		Derive the closed loop transfer function for a non-unity feedback system.	(3)
2		Draw the block schematic of a typical closed loop control system. Explain the components with respect to a robotic system.	(3)
3		Obtain the unit step response of $\frac{5}{s+3}$	(3)
4		A unity feedback system has an open loop transfer function $\frac{20(s+3)}{(s+0.1)(s+5)}$. Determine steady state error for unit parabolic input?	(3)
5		How do you determine the angle of departure of root locus branch from an open loop pole, using angle criterion?	(3)
6		What are frequency domain specifications?	(3)
7		Derive the transfer function of a PID Controller	(3)
8		Explain the terms (i) state (ii) state variables (iii) state vector	(3)
9		A robot is a linear or nonlinear system? Justify your answer. Can we use linear controllers in robots? If so how?	(3)
10		Define Describing function. What is the difference between stability analysis of linear and nonlinear systems?	(3)

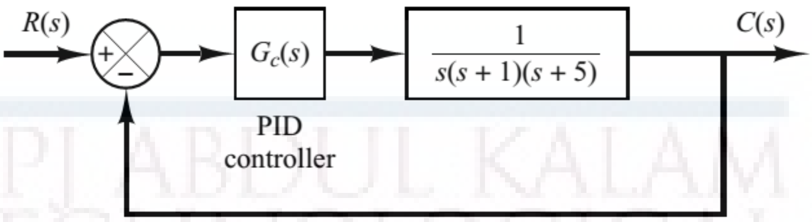
PART B

Answer any one full question from each module, each carries 14 marks.

MODULEI

11	a)	Explain in detail about different actuators and sensors used in a typical robotic control system	(5)
	b)	Analyse the effect of feedback block H(s) on the characteristic equation and pole-zero locations of the closed loop system having $G(s) = \frac{2}{s^2+4s+4}$ with (i) H(s)=$\frac{1}{s}$ $and\ (ii)\ H(s) = s$	(5)

		Derive the transfer function of an armature-controlled dc motor?	4
12	a)	Obtain the transfer function using block diagram reduction techniques  	(7)
	b)	Obtain the transfer function of  	(7)
MODULE II			
13	a)	Determine the unit step response for the system with transfer function $G(s) = \frac{2}{s^2+4s+5}$ Also determine peak overshoot (Mp) and peak time (tp).	(8)
	b)	Check the stability of the system given by the characteristic equation $Q(s)=S^5+3s^4+ 4s^3+ 8s^2+16s+36$	(6)
14	a)	Test the stability of the unity negative feedback system with $G(s) = \frac{16}{s(s^5+s^4+8s^3+6s^2+20s+8}$ using Routh's stability criterion. Hence identify the location of roots of the system	(8)
	b)	Explain how does the type of the system control the steady state error for a ramp and parabolic inputs?	(6)
MODULE III			
15	a)	Determine the stability of the closed loop system $G(s) = \frac{K(s+1)}{(s^2+4s+8}$ using Root locus plot. Hence, determine the value of K such that the damping factor is 0.866	(10)
	b)	Explain gain margin and phase margin of the system	(4)
16	a)	The open-loop transfer function of a unity feedback system is $\frac{K}{s(0.5s+!)(0.04s+1)}$. Use asymptotic approach to plot the bode diagram and determine the value of K for a gain margin of 10.5 dB	(10)
	b)	Discuss about the effect of addition of poles and zeros to the open-loop transfer	(4)

		function G(s) H(s) on the root locus.	
		MODULE IV	
17	a)	Design a PID controller for this system 	(8)
	b)	Obtain the state model of the system whose transfer function is given by $\frac{Y(s)}{U(s)} = \frac{10}{s^3+4s^{2+2s+1}}$	(6)
18	a)	Consider a linear system described by the transfer function $\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$. Design a feedback controller with a state feedback so that the closed loop poles are placed at -2, -1±j1.	(8)
	b)	A system is described by $X(\dot{t}) = \begin{bmatrix} 0 & 1 \\ -4 & -4 \end{bmatrix} X(t)$. Determine state transition matrix for the system Type equation here.	(6)
		MODULE V	
19	a)	Derive the Describing function of a Dead-zone nonlinearity.	(8)
	b)	Define Singular point. Explain the nature of Eigen values of system matrix for any five types of singular points.	(6)
20	a)	Discuss any three non linearities present in nature	(6)
	b)	Investigate the stability of the following non-linear system using Lyapunov direct method $\dot{x_1} = x_2\dot{x_2} = -x_1 - x_1^2 x_2$	(8)
		****	

SYLLABUS

Module I (9 Hours)

Control System- Definition, Open loop vs closed loop control systems- components of a typical control system- Necessity of a control system in a Robot, bird's eye view of typical actuators in robot control systems-hydraulic, pneumatic and electric actuators- over view of basic types-DC motors for speed control, DC and AC servo motors for position control, Brushless DC motors for speed control of quadcoptersand linear actuation mechanisms. Basic idea of feedbacks in robotic systems-sensors-eg. Linear and rotary encoders.

Linear time invariant Systems- Transfer function, Necessity of knowing the transfer function, Modelling -Mechanical and Electromechanical systems –block diagram representation - block diagram reduction, characteristic equation, signal flow graph, overview Mason's gain formula -

Module II (9 Hours)

Time domain analysis of control systems: Transient and steady state responses - time domain specifications - first and second order systems - step responses of first and second order systems.steady state error analysis - static error coefficient of type 0,1, 2 systems - Dynamic error coefficients.

Concept of stability: Time response for various pole locations - stability of feedback system - Routh's stability criterion.

Module III (10 Hours)

Root locus - General rules for constructing Root loci – stability from root loci - effect of addition of poles and zeros.

Frequency domain analysis: Frequency domain specifications- Analysis based on Bode plot - Log magnitude vs. phase plot.

Design of P, PI and PID controller using Ziegler-Nichols tuning method, Overview-Necessity of using Lag,lead and lag-lead compensators in Control Systems.

Module IV (9 Hours)

State space analysis of systems: Introduction to state concept - state equation of linear continuous time systems, matrix representation of state equations. Phase variable and canonical forms of state representation-controllable, observable, diagonal and Jordan canonical forms- solution of time invariant autonomous systems, forced system-state transition matrix, relationship between state equations and transfer function.State feedback controller design: Controllability &observability-Kalman's method. State feed-back design via pole placement technique.

Case study- Feedback control of a single link manipulator. (Assignment/demo only)

Module V (8 Hours)

Nonlinear systems: Introduction - characteristics of nonlinear systems. Types of nonlinearities. Determination of describing function of nonlinearities (relay, dead zone and saturation only) - application of describing function for stability analysis of autonomous system with single nonlinearity. Singular points – Classification of singular points. Definition of stability- asymptotic stability and instability, overview of Lyapunov methods to stability of linear and nonlinear, continuous time systems.

Case study-kinematic modelling of a differential drive robotand controlling the same to move to a point (Assignment/demo only)

TextBooks

1. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Pvt Ltd, 6/e.
2. Katsuhiko Ogata, "Modern Control Engineering", Pearson Education India, 5/e.
4. M. Gopal, "Control Systems Principles and Design", McGraw Hill Education (India) Pvt. Ltd., 4/e.
5. A. Anand Kumar, "Control Systems", PHI, 2/e.
6. D. Roy Choudhury, "Modern Control Engineering", PHI.
7. K. Alice Mary and P. Ramana, "Control Systems", Orient Black Swan
8. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer

References

1. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern, 2010.
2. Dorf R. C. and R. H. Bishop, Modern Control Systems, Pearson Education, 2011.
3. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002
4. Ashitava Ghosal, Robotics- Fundamental Concepts and Analysis, , Oxford University press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Control System- Definition, Open loop vs closed loop control systems- components of a typical control system- Necessity of a control system in a Robot	1
1.2	bird's eye view of typical actuators in robot control systems-hydraulic, pneumatic and electric actuators	1
1.3	Overview of use of Electric actuators like DC motors for speed control, DC and AC servo motors for position control, Brushless DC motors for speed control of quadcopters and linear actuation mechanisms	1
1.4	Basic idea of feedbacks in robotic systems-sensors-eg. Linear and rotary encoders.	1
1.5	Linear time invariant Systems- Transfer function, Necessity of knowing the transfer function of a system	1
1.6	Modelling -Mechanical and Electromechanical systems	2
1.7	Block diagram representation - block diagram reduction, characteristic	2

	equation, signal flow graph - overview of Mason's gain formula -	
2		
2.1	Time domain analysis of control systems: Transient and steady state responses	2
2.2	time domain specifications - first and second order systems - step responses of first and second order systems.steady state error analysis - static error coefficient of type 0,1, 2 systems - Dynamic error coefficients.	4
2.3	Concept of stability: Time response for various pole locations - stability of feedback system - Routh's stability criterion	3
3		
3.1	Root locus - General rules for constructing Root loci – stability from root loci - effect of addition of poles and zeros	4
3.2	Frequency domain analysis: Frequency domain specifications- Analysis based on Bode plot - Log magnitude vs. phase plot.	4
3.3	Design of P, PI and PID controller using Ziegler-Nichols tuning method, Overview-Necessity of using Lag,lead and lag-lead compensators in Control Systems.	2
4		
4.1	State space analysis of systems: Introduction to state concept - state equation of linear continuous time systems, matrix representation of state equations	2
4.2	Phase variable and canonical forms of state representation-controllable, observable, diagonal and Jordan canonical forms	2.5
4.3	solution of time invariant autonomous systems, forced system-state transition matrix, relationship between state equations and transfer function.	2.5
4.4	State feedback controller design: Controllability & observability-Kalman's method- State feed-back design via pole placement technique	1
4.5	Case study- Feedback control of a single link manipulator – refer Robotics- Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford University press	1
5		
5.1	Nonlinear systems: Introduction - characteristics of nonlinear systems. Types of nonlinearities.	2
5.2	Determination of describing function of nonlinearities (relay, dead zone and saturation only) -	2
5.3	application of describing function for stability analysis of autonomous system with single nonlinearity.	1
5.4	Singular points – Classification of singular points. Definition of stability- asymptotic stability and instability; overview of Lyapunov	2

	methods to stability of linear and nonlinear, continuous time systems.	
5.5	Case study-kinematic modelling of a differential drive robot and controlling the same to move to a point- refer Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke, Springer.	1

RAL331	AUTOMATION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The lab familiarize the student with the various tools that uses hydraulic, and pneumatic controls that can be used for automation. Exposure to simulation packages for automation is also part of the course.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design and develop various hydraulic and electro-hydraulic systems
CO 2	Design and develop various pneumatic and electro-pneumatic systems
CO 3	Familiarisation of ladder programming and testing of PLC circuits
CO 4	Familiarization of hydraulic, pneumatic, electrohydraulic, electropneumatic circuits in simulation package

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	2	2	2		2			2	2		3
CO 2	3	2	2	2		2			2	2		3
CO 3	3	2	2	2	3	2			2	2		3
CO 4	3	2	2	2	3	2			2	2		3

Assessment Pattern

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipment and trouble shooting) : 25 Marks
(d) Viva voce : 20 Marks
(e) Record : 5 Marks

General instructions: End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

List of Experiments(12 Experiments Mandatory)

1. Experiments using hydraulic actuators and study of their performance under various operating conditions.
2. Experiments using electro-hydraulic systems and study of their characteristics
3. Experiments to implement logic using electro-hydraulics.
4. Experiments using pneumatic actuators and study of their performance under various operating conditions.
5. Experiments in pneumatics logic
6. Experiments in electro-pneumatics
7. Experiments using proportional and servo hydraulic valves.
8. Experiments on PLC
9. Interfacing PLC with electro-hydraulics
10. Interfacing PLC with electro-pneumatics
11. Experiments on Motion Logic Drive
12. Experiments on Variable Frequency drive
13. Experiments on SCADA
14. Simulation of hydraulic, pneumatic circuits in simulation package (eg: Automation Studio)
15. Simulation of electrohydraulic, electro-pneumatic circuits in simulation package (eg: Automation Studio)

Text Books

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.
2. Computer Control of Manufacturing Systems YoramKoren, Tata McGraw-Hill Edition 2005.
3. CNC Machines, Radhakrishnan P., New Central Book Agency, 1992.
4. Mechatronics: A Multidisciplinary Approach, 4/E, W. Bolton. Pearson Education India.

5. Mechatronics, HMT, Tata McGraw-Hill, 1998.
6. Standard Handbook of Industrial Automation, Considine D M C &Considine G D C, Chapman and Hall, NJ, 1986.
7. Pneumatic Control for Industrial Automation‖, Peter Rohner& Gordon Smith, John Wiley and Sons, 1987.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAL 333	ROBOT OPERATING SYSTEM LAB	PCC	0	0	3	2

Preamble: The lab introduces the student to a Robot Operating System and familiarisation of few ROS tools

Pre-requisites

- ROS Installed Ubuntu System—UBUNTU 16.04LTS/18.04LTS
- Basic knowledge of Linux command line tools
- Basic programming in Python—2.7/3.5/3.6
- Robotics Basics
-

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the applications of ROS in real world complex scenarios
CO 2	Work with turtlesim, Gazebo, MoveIt and Rviz
CO 3	Familiarise about the concepts behind navigation
CO 4	Interface with hardware and analyse the issues in hardware interfacing

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	2	2	2	3	2			2	2		3
CO 2	3	2	2	2	3	2			2	2		3
CO 3	3	2	2	2	3	2			2	2		3
CO 4	3	2	2	2	3	2			2	2		3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks

Continuous Assessment : 30 marks

Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 Marks

(e) Record : 5 Marks

General instructions: End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

ROS Essentials

- Installing and Configuring Your ROS Environment—ROS Kinetic/Melodic/Compatible versions
- Familiarisation with ROS (Master, nodes, topics, messages, services, parameters and actions)
- Familiarisation with ROS Tools – Gazebo , Moveit , Rviz
- Creating Workspace and Package in ROS

List of Experiments

PART A

10 Experiments mandatory

1. Writing a Simple Publisher and Subscriber, Simple Service and Client,Recording and playing back data, Reading messages from a bag file(Python/C++)
2. Getting Started with Turtlesim
3. Familiarisation with Rviz -- Markers: Sending Basic Shapes -- use visualization_msgs/Marker messages to send basic shapes, to send points and lines (C++), Interactive Markers: Writing a Simple Interactive Marker Server, Basic Controls
4. Introduction to tf -- broadcast the state of a robot to tf, get access to frame transformations, Adding a frame, waitForTransform function, Setting up your robot using tf, publish the state of your robot to tf, using the robot state publisher.
5. Building a Visual Robot Model with URDF from Scratch, Building a Movable Robot Model with URDF, Adding Physical and Collision Properties to a URDF Model.
6. Familiarisation with Gazebo--How to get Gazebo up and running,Creating and Spawning Custom URDF Objects in Simulation, Gazebo ROS API for C-Turtle, Simulate a Spinning Top, Gazebo Plugin - how to create a gazebo plugin, Create a Gazebo Plugin that Talks to ROS
7. Create a Gazebo Custom World (Building Editor, Gazebo 3D Models), Add Sensor plugins like Laser, Kinect, etc. to URDF of mobile robot
8. Create a 3DOF robotic arm from scratch
9. Familiarisation with MoveIt through its RViz plugin, Motion Planning with the Panda or other robot models.
10. Create Moveit package for robotic arm simulation and add controllers,Plan a path for a 3DOF Robotic Arm and execute the same, Move the 3DOF arm to a desired goal point
11. Attach 2DOF gripper as the end effector of 3DOF arm and execute gripping operations, Execute Pick and Place Operation
12. Familiarisation with 2D navigation stack, Basic ROS Navigation, Start robots in simulation.
13. Execute SLAM Mapping (Lidar based) using a differentially driven mobile robot
14. Execute AMCL Navigation in a known environment using a differentially driven mobile robot.

PART B (Hardware experiments)
(2 experiments mandatory)

15. Familiarise ROS Serial Arduino for hardware interface.
16. Obstacle avoidance using a differentially driven mobile robot

Text Books:

1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018

2. Aaron Martinez, Enrique Fernández, “Learning ROS for Robotics Programming”, Packt Publishing

Ltd, 2013.

Reference Books:

1. Jason M O'Kane, “A Gentle Introduction to ROS”, CreateSpace, 2013.

2. AnisKoubaa, “Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.

3. Kumar Bipin, “Robot Operating System Cookbook”, Packt Publishing, 2018.

4. Wyatt Newman, “A Systematic Approach to learning Robot Programming with ROS”, CRC Press,

2017.

5. Patrick Gabriel, “ROS by Example: A do it yourself guide to Robot Operating System”, Lulu, 2012.

SEMESTER V

MINOR

RAT381	AI AND MACHINE LEARNING FOR ROBOTICS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Modern day robotic application are able to mimic some of the critical operations that a human being is capable of. This was possible mainly due to the integration of Artificial Intelligence into robotic application. Artificial Intelligence can be applied to a wide range of engineering application and is a topic of study by itself. This course provides an introduction to the areas of AI that can be used for robotic application which include computer vision, path planning, object recognition etc.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Appreciate the role of AI in solving problems in different domains and their evolution of AI
CO 2	Explain the different learning techniques used in Machine learning
CO3	Recognize the need for multilayer neural network for solving complex tasks
CO4	Understand the fundamental concepts of Image processing and its application in computer vision
CO5	Explain the different ways of perception of the environment by a robot and its use in path planning

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	2	2										2
CO 2	3	2	2									2
CO 3	3	2	2									2
CO 4	3	2	2									2
CO 5	3	2	2									2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20

Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the use of Machine learning technique for classifying objects
2. Elaborate on the various AI techniques that can be used in robotics applications

Course Outcome 2 (CO2):

3. Compare and contrast Supervised and Unsupervised Learning techniques
4. How is Stochastic Gradient Descent algorithm better compared to other traditional learning techniques

Course Outcome 3 (CO3):

5. Explain how Back propagation algorithm can be used for character recognition application
6. Explain the basic Recurrent Neural Network architecture and its applications

Course Outcome 4 (CO4):

7. Discuss the any two techniques used for Edge detection in image processing
8. What is segmentation and how is it used in Image processing applications

Course Outcome 5 (CO5):

9. Explain Robotic Perception and the challenges faced in robotic perception
10. How can AI be used in path planning for robotic applications

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT381

AI AND MACHINE LEARNING FOR ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

	Question	Marks
1	Explain the Turing Test approach for the definition of AI. What are the additional capabilities required by an AI system to completely satisfy the total Turing Test	(3)
2	How can AI be used in natural Language Processing?	(3)
3	“A machine learning algorithm is an algorithm that is able to learn from data” – What do we mean by the term ‘learn’ in the above statement	(3)
4	Explain the term ‘Feature’ under machine learning context	(3)
5	What is a multilayer feed forward Network?	(3)
6	What is the role of activation function in a neural network?	(3)
7	Define Sampling pitch for a digital camera. Explain its effect on the quality of the image	(3)
8	What is aliasing in a digital image? What is the use of PSF in aliasing?	(3)
9	Explain Robotic perception and discuss the challenges faced in robotic perception	(3)
10	Discuss the motion model for localization in robotics	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Explain the contribution of Mathematics in the development of AI	(8)
	b)	What are the different applications of AI in Natural Language Processing	(6)
12	a)	What are Expert Systems? What is the role of knowledge base and Inference Engine in a knowledge based System	(7)
	b)	What are the application areas of AI in a Robotics	(7)

MODULE II

13	a)	Explain the kind ofproblems that can be solved using Machine Learning techniques	(6)
	b)	Explain the gradient descent Algorithm used in Machine Learning	
14	a)	Explain Supervised and Unsupervised Learning techniques in machine learning. Discuss the advantages and disadvantages of each.	(14)

MODULE III

15	a)	With an example, explain the working of Back Propagation algorithm	(14)
16	a)	What is a Convolutional Neural Network? Explain the functionality of each layer	(14)

MODULE IV

17	a)	Explain the method of image segmentation using multilevel threshold	(7)
	b)	Explain the 'Snakes' method of detecting active contours	(7)
18	a)	Explain region splitting and merging algorithm for segmentation	(7)
	b)	What is the use of Edge Linking and how it is carried out?	(7)

Module V

19	a)	Explain the Monte-Carlo localization algorithm using a range scan sensor model	(14)
20	a)	Discuss in detail the role of Machine learning in Robotic perception	(14)

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SYLLABUS

Module 1 (9 Hours):

Artificial intelligence - Introduction, its importance, The Turing test, Foundations of artificial intelligence, A brief historical overview

Application areas of AI -natural language processing, vision and speech processing, robotics, expert systems -basic overview

Module 2 (9 Hours):

Learning - Forms of learning, Supervised Learning Algorithms, Unsupervised Learning Algorithms, Reinforcement based learning - overview with basic elements agent, environment, action, state, reward only; Stochastic Gradient Descent, Challenges Motivating Deep Learning

Module 3 (9 Hours):

Deep Feedforward Networks- Example: Learning XOR, Gradient-Based Learning, Hidden Units. Architecture Design, Back-Propagation and Other Differentiation Algorithms, Convolutional Networks -basic outline and functions of each layers only, Sequence Modeling: Recurrent and Recursive Nets -Need for sequence models, basic RNN architecture and types

Case study-line follower robot using CNN, Speech Recognition using RNN (overview only)

Module 4 (9 Hours):

Machine vision - Introduction, Computer vision - Introduction, Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. challenges in image detection, Image features optimization.

Case study- application of AI in ball Tracking in football game, crop monitoring using drones, traffic sign detection, pedestrian detection

Module 5 (9 Hours):

Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception, Application domains

Case study- Use of AI in typical pick and place task, localization of a differential drive robot

Textbooks:

1. Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press, 2016
2. Stuart J. Russell and Peter Norvig, Artificial Intelligence - A Modern Approach Third Edition, 2016
3. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
4. Berthold Klaus, Paul Horn "Robot vision" The MIT Press, 1987.
5. Richard Szeliski, "Computer Vision: Algorithms and Applications", 2010.
6. Grigorescu, Sorin, et al. "A survey of deep learning techniques for autonomous driving." *Journal of Field Robotics* 37.3 (2020): 362-386.

Reference Books:

1. Robin R. Murphy – Introduction to AI Robotics, The MIT Press
2. Chandra S.S.V, AnandHareendran S. - Artificial Intelligence and Machine Learning, PHI
3. *Simon J. D. Prince* - Computer Vision – Models, Learning and Inference Cambridge University Press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Artificial intelligence - Introduction, its importance, The Turing test, Foundations of artificial intelligence, A brief historical overview (Ref 2, chapter 1 section 1.3).	4
1.2	Application area of AI: natural language processing, vision and speech processing, robotics, expert systems--basic overview only	3
2		
2.1	Learning - Forms of learning, (Ref 2 Chapter 18 section 18.1.1),	2
2.2	Supervised Learning Algorithms, Unsupervised Learning Algorithms,Reinforcement based learning-- overview with basic elements agent, environment, action, state, reward only; (Ref 2, Chapter 20, section 20.1) Stochastic Gradient Descent, Challenges Motivating Deep Learning (Ref 1, chapter 5 sections 5.7 – 9 and 5.11,	7

	Ref 2 Chapter 18 section 18.2),).	
3		
3.1	Deep Feedforward Networks, Convolutional Networks-basic outline and functions of each layers only, Sequence Modeling: Recurrent and Recursive Nets - Need for sequence models, basic RNN architecture and types(Ref 1 chapter 6, 9, 10, Ref 3 - chapter 5). Case study-line follower robot using CNN, Speech Recognition using RNN overview	9
4		
4.1	Machine vision - Introduction (Ref **4**, chapter 1), Computer vision - Introduction (Ref **5** chapter 1, section 1.2),	2
4.2	Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. (Ref 4, 5) challenges in image detection, Image features optimization.	5
4.3	Case study- application of AI in ball Tracking in football game, crop monitoring using drones, traffic sign detection, pedestrian detection	2
5		
5.1	Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception, Application domains (Ref 2, chapter 25 sections 25.1, 25.3.1, 25.3.3, 25.8)	7
5.2	Case study- Use of AI in typical pick and place task, localization of a differential drive robot	2

SEMESTER V

HONOURS

RAT393	PLC AND SCADA	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Acquire the skill of PLC and SCADA programming

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the components of a PLC system and its working
CO 2	Design logic circuits to perform industrial control functions of medium complexity and realise the same using ladder logic
CO3	Demonstrate the use of different types of inputs/outputs and networking commonly used on PLC-based systems.
CO4	Familiarisation of SCADA architecture and communication in SCADA
CO5	Determine hardware and software requirements of SCADA and DCS

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									3
CO 2	3	3	2									3
CO 3	3	3	2									3
CO 4	3	3	2									3
CO 5	3	3	2									3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. With the help of a block diagram, explain the basic architecture of a PLC system. Discuss any three types of PLCs used in automation
2. What are the different methods used to reduce maximum off state current to the input module

Course Outcome 2 (CO2):

1. A Manual mixing operation is to be automated using sequential process control methods. The process composed of three steps.
   a. Filling a tank to a pre-determined level
   b. Agitating the liquid for 30 minutes
   c. Draining the tank for use in another part of process

   Draw the ladder logic schematic to perform the above functions properly
2. Elaborate on the Functional Block Diagram and Sequential Flow Chart programming techniques

Course Outcome 3 (CO3):

1. With appropriate diagrams, explain the CANOpen standard. List out its advantages and disadvantages.
2. An industrial automation system needs to produce rectangular metal pieces of fixed dimensions. Implement an automation system using PLC which will help to reject the pieces that do not match with the fixed length and width.

Course Outcome 4 (CO4):

1. What are the important components of a SCADA system? Explain how the control operations can be carried out at the different levels of a manufacturing process using a SCADA system
2. What do you mean by Alarm Logging and Tag Logging in a SCADA system? Explain a scenario where each of these techniques can be used.

Course Outcome 5 (CO5):

1. Differentiate between a proprietary and Open Protocols. List out the advantages and disadvantages of both schemes.
2. With diagram, explain the architecture of a Distributed Control Systems. Explain the mechanisms available to handle communication failures in the distributed control systems.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT393

Course Name: PLC and SCADA

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

		Marks
1	What is the need for isolators in PLC I/O modules? Draw a commonly used isolator arrangement.	(3)
2	Draw the block diagram of a PLC showing the main functional items and explain the functions of each block.	(3)
3	Implement the function, F (a, b, c) = Σ (0,1,3,4,6,7) using ladder logic program.	(3)
4	Write any math instruction in a PLC with an example.	(3)
5	What is the need for HMI in industrial automation?	(3)
6	What is CANopen? What is its use?	(3)
7	List the basic blocks involved in a pressure control process using PLC.	(3)
8	Explain supervisory control system with an example.	(3)
9	What are the design considerations for displays used with high level operator interfaces in DCS?	(3)
10	What is meant by OPC with regard to SCADA?	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Which are the different control elements of an industrial automation?	(4)

	b)	Explain IEC/ ISA Standards for the various control elements.	(5)
	c)	What are relays? With the help of diagrams explain any one use of a relay in an industrial process. Also write its relay logic program.	(5)
12	a)	Draw the block diagram of an analog output module and explain the parts.	(4)
	b)	With the help of diagrams, explain any two methods used to reduce maximum off state current to the input module.	(5)
	c)	Explain using suitable diagrams, how modularity is achieved in an input module	(5)

MODULE II

13	a)	Design a ladder logic program for following process: A temperature control system consists of three thermostats. The system operates two heating units. The thermostats are set on 70°C, 75°C and 80°C. Below 70°C, two heaters are on. The temperature between 70°C and 75°C causes one heater to be on. Above 80°C, there is safety shutoff for two heaters in case one stays on by mistake. A master switch turns the system on and off.	(8)
	b)	With a neat diagram and a ladder logic program, explain how a stepper motor can be controlled using a PLC.	(6)
14		A pump is to be used to fill two storage tanks. The pump is manually started by the operator from a start/stop station. When the first tank is full, the control logic must be able to automatically stop flow to the first tank and direct flow to the second tank through the use of sensors and electric solenoid valves. When the second tank is full, the pump must shut down automatically. Indicator lamps are to be included to signal when each tank is full. With a drawing of the process, prepare a PLC ladder logic program for this control process.	(14)

MODULE III

15	a)	Which are the different networking standards associated with a PLC?	(8)
	b)	Explain the different types of HMI used in an industrial automation system.	(6)
16	a)	With a block diagram, explain the working of PROFIBUS. Give its two advantages	(6)
	b)	How can HMI elements be interfaced with a PLC in a water level control system?	(8)

MODULE IV

17	a)	Show how the following units are interfaced in SCADA system and explain the functions of each unit: a) Human Machine Interface unit, b) Master Terminal unit, c) Remote Terminal unit	(8)
	b)	An industrial automation system produces bars of metal of fixed length, ‘L’. It is required to design a system to detect and reject metal bars which has a length other than the required value. How can such a system be implemented using PLC?	(6)
18	a)	Write notes on VB & C Scripts for SCADA applications	(8)
	b)	Describe the software and hardware architectures of SCADA.	(6)

Module V

19	a)	Write notes on interfacing of SCADA with PLCs and drives.	(7)

	b)	What is meant by DDE? What is it used for?	(7)
20	a)	Explain the various operator interface requirements in DCS.	(7)
	b)	Which are the different proprietary and open communication protocols of SCADA.	(7)

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SYLLABUS

Module I

Industrial Automation -review, Control elements of Industrial Automation-IEC/ ISA Standards for Control Elements, Selection criteria for control elements-Construction of relay logic circuits with different control elements-Need for PLC -PLC evolution.

PROGRAMMABLE LOGIC CONTROLLERS: Architecture of PLC -Types of PLC –PLC modules, Input and Output modules –Digital and Analog Input/Output- examples of Digital and Analog Inputs/Outputs- PLC Configuration -Scan cycle -Capabilities of PLC-Selection criteria for PLC –PLC Communication with PC and software-PLC Wiring-Installation of PLC and its modules.

Module II

PROGRAMMING OF PLC: – Ladder Programming –Realization of simple logic circuits, Timers and counters–arithmetic and logic functions- PTO / PWM generation-Programming examples- High Speed Counter –Analog Scaling –Encoder Interfacing-Servo drive control –Stepper Motor Control.

Other programming types:Functional Block Diagram FBD (most commonly used in industries) -Sequential Flow Chart SFC -Structured Text (Textual) -Instruction List (Textual)

Module III

NETWORKING: PLC Networking-Networking standards & IEEE Standards -Protocols –Ethernet- Process field bus (PROFIBUS)-CANopen, different methods of interfacing with a PLC

Case studies- PLC based traffic light system, stepper motor & servo motor control using PLC, Analog sensor interfacing with PLC, encoder interfacing with PLC.

HMI SYSTEMS: Need for HMI in Industrial Automation, Types of HMI –Configuration of HMI, Screen development and navigation, Configuration of HMI elements / objects and interfacing with PLC

Module IV

APPLICATIONS OF PLC: Case studies of manufacturing automation and process automation.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA):Overview –Developer and runtime packages –Architecture –Tools –Tags–Graphics -Alarm logging –Tag logging –Trends –History –Report generation, VB & C Scripts for SCADA application

Module V

COMMUNICATION PROTOCOLS OF SCADA:Proprietary and open Protocols –OLE/OPC –DDE –Server/Client Configuration –Messaging –Recipe –User administration –Interfacing of SCADA with PLC, drive, and other field devices.

DISTRIBUTED CONTROL SYSTEMS (DCS):DCS –architecture –local control unit-programming language - communication facilities -operator interface -engineering interfaces.

Case studies- Design of conveyor automation system using PLC, SCADA and Electrical drive; Design of inspection automation system using sensors, PLC, HMI/SCADA; Design of simple water management system using PLC, SCADA and Electrical drive.

Text Books:

1. Programmable Logic Devices and Logic Controllers, Enrique Mandado, Jorge Marcos, Serafin A. Peres, Prentice Hall, 1996.
2. Practical SCADA for industry, David Bailey, Edwin Bright, Newnes, Burlington, 2003.

Reference Books

3. Introduction to Programmable Logic Controllers, Gray Dunning, Delamar Thomson Learning, 1998.
4. Programmable Controllers- AnEngineers's Guide, 2nd Edition, E.A. Parr, Newnes, 1999.
5. Programmable controllers, Hardware, Software & Applications, George L. Batten Jr., McGrawHill, 2nd Edition, 1994.
6. Programmable logic controllers, W. Bolton, Elsevier Ltd, 2015.
7. Programmable logic controllers,Frank D Petruzella, McGraw-Hill, 2011.
8. Programmable Logic Controllers: Programming Methods and Applications. John R Hackworth and Fredrick D Hackworth Jr., Pearson Education, 2006.
9. Practical Modern SCADA Protocols: DNP3, 60870.5 and Related systems, Gordon Clarke, Deon Reyneders, Edwin Wright, Newnes Publishing, 2004.48
10. Designing SCADA Application Software, Stuart G McCrady, Elsevier, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Industrial Automation -review, Control elements of Industrial Automation-IEC/ ISA Standards for Control Elements, Selection criteria for control elements-Construction of relay logic circuits with different control elements-Need for PLC - PLC evolution.	3
1.2	PROGRAMMABLE LOGIC CONTROLLERS: Architecture of PLC - Types of PLC –PLC modules, Input and Output modules – Digital and Analog Input/Output- examples of Digital and Analog Inputs/Outputs	3
1.3	PLC Configuration -Scan cycle -Capabilities of PLC-Selection criteria for PLC – PLC Communication with PC and software-PLC Wiring-Installation of PLC and its modules	3
2		
2.1	PROGRAMMING OF PLC: – Ladder Programming – Realization of simple logic circuits, Timers and counters–arithmetic and logic functions- PTO / PWM generation	3
2.2	Programming examples- High Speed Counter –Analog Scaling – Encoder Interfacing-Servo drive control –Stepper Motor Control.	3
2.3	Other programming types: Functional Block Diagram FBD (most commonly used in industries) -Sequential Flow Chart SFC -Structured Text (Textual) -Instruction List (Textual)	3
3		
3.1	NETWORKING: PLC Networking-Networking standards & IEEE Standards -Protocols – Ethernet- Process field bus (PROFIBUS)- CAN open, different methods of interfacing with a PLC	3
3.2	**Case studies**- PLC based traffic light system, stepper motor & servo motor control using PLC, Analog sensor interfacing with PLC, encoder interfacing with PLC.	3
3.3	HMI SYSTEMS: Need for HMI in Industrial Automation, Types of HMI –Configuration of HMI, Screen development and navigation, Configuration of HMI elements / objects and interfacing with PLC	3
4		
4.1	APPLICATIONS OF PLC: Case studies of manufacturing automation and process automation.	3
4.2	SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA): Overview –Developer and runtime packages –Architecture –Tools –	6

	Tags–Graphics -Alarm logging –Tag logging –Trends –History –Report generation, VB & C Scripts for SCADA application	
5		
5.1	COMMUNICATION PROTOCOLS OF SCADA: Proprietary and open Protocols –OLE/OPC –DDE –Server/Client Configuration –Messaging –Recipe –User administration –Interfacing of SCADA with PLC, drive, and other field devices.	3
5.2	DISTRIBUTED CONTROL SYSTEMS (DCS): DCS –architecture –local control unit- programming language - communication facilities - operator interface - engineering interfaces.	3
5.3	**Case studies**- Design of conveyor automation system using PLC, SCADA and Electrical drive; Design of inspection automation system using sensors, PLC, HMI/SCADA; Design of simple water management system using PLC, SCADA and Electrical drive.	3

SEMESTER VI

RAT302	DESIGN OF MACHINE ELEMENTS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course helps students to apply the concepts of stress analysis, theories of failure and material science to analyse and design commonly used machine components. The course also provides an in-depth understanding on the design of different types of joints, gear drives, belt drives and bearings which are critical components of automation.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	To review concepts of statics and strength of materials.
CO 2	To introduce fundamental approaches to failure prevention of components.
CO 3	To provide knowledge in the design of common machine elements such as fasteners, shafts, springs and couplings.
CO 4	To provide knowledge in the design of welded joints and fillet joints in tension, torsion and bending.
CO 5	To provide basic design methods for gear drives, belt drives and bearings

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**	**1**										3
CO 2	**2**	**1**										3
CO 3	**2**	**1**										3
CO 4	**3**	**2**	**2**									3
CO 5	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

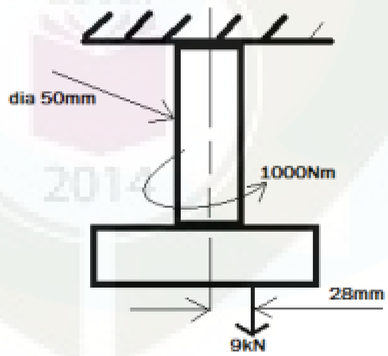
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is factor of safety? What are the factors to be considered in selection of factor of safety(FoS)?
2. What are the factors affecting the endurance strength
3. A load of 9kN is applied to the steel rod of 50mm diameter as shown in figure. If a torsional moment of 100 N-m is applied on it, Determine the maximum tensile stress and maximum shear stress.



Course Outcome 2 (CO2):

1. Explain the stresses acting on a screw fastener.
2. A cylinder head is fastened to the cylinder of a compressor using 6 bolts of M20 size. Bolt material is C20 steel. The Maximum fluid pressure is 3.5MPa, and the cylinder

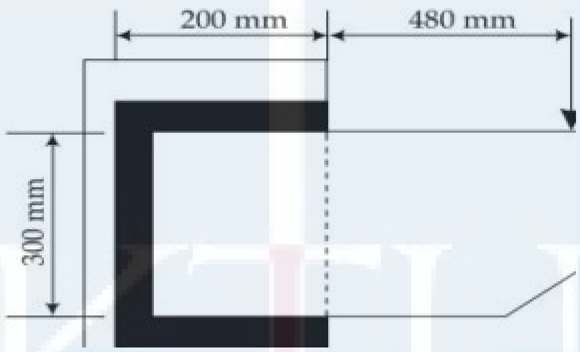
diameter is 75mm. A soft gasket is used. Assume the initial tension required in each bolt as 40kN.Determine the factor of safety.

Course Outcome 3 (CO3):

1. What is surging in springs?
2. Differentiate between torsional rigidity and lateral rigidity of shaft
3. Compare and Contrast rigid and flexible couplings List out any two application areas of rigid and flexible couplings

Course Outcome 4 (CO4):

1. Explain the stresses acting in Fillet and Butt Welds
2. Why do we design the weld joints based on throat area?
3. Determine the size of the weld for a bracket loaded as shown in the figure. The allowable stress in the weld is 60MPa.



Course Outcome 5 (CO5):

1. State and explain law of gearing with a neat sketch
2. Elaborate on the different modes of failure of gear tooth
3. Explain the advantages and limitations of V-Belt drive

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

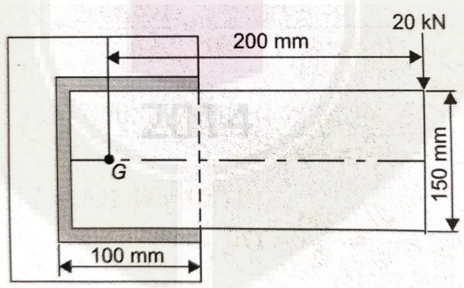
Course Code: RAT 302

Course Name: DESIGN OF MACHINE ELEMENTS

Max. Marks: 100 | Duration: 3 Hours

PART A

		Answer all questions, each carries 3 marks.	Marks
1		Distinguish between standards and codes	(3)
2		Explain the procedure to determine the endurance limit of a material	(3)
3		What is the role of washer in a bolted joint	(3)
4		What are the demerits of welded joints	(3)

5		Distinguish between rigid and flexible couplings	(3)
6		Explain shock and fatigue factor	(3)
7		Explain why dynamic factors need to be considered in the design of gears.	(3)
8		Enumerate the various types of flat belt drives.	(3)
9		Explain the mechanism of fluid film lubrication	(3)
10		Define equivalent bearing load	(3)
		PART B	
		Answer any one full question from each module, each carries14 marks.	
		MODULE1	
11	a)	Explain the steps involved in the design process.	(4)
	b)	A carbon steel rod of circular cross section is subjected to a bending moment which varies from 300 Nm to 500 Nm and an axial load which varies from 6 kN to 9 kN.Determine the diameter of the rod for a factor of safety of 3.Take σ_u= 600 MPa, σ_y=400 MPa	(10)
12	a)	Explain impact factor.	(2)
	b)	A 50 mm diameter steel shaft with a 20 mm transverse hole is simultaneously subjected to a bending stress which varies from + 100 MPa to – 70 MPa and a torsional stress which varies from + 80 MPa to -50 MPa. Find the factor of safety for infinite life assuming the following properties. Ultimate strength in tension 800MPa, Yield strength 550MPa. Surface correction factor = 0.85, size factor =0.85 and Notch sensitivity factor = 0.9. Use maximum distortion energytheory.	(12)
		MODULE II	
13	a)	What is meant by pre-tension in bolts? What is its significance?	(4)
	b)	The cylinder head is fastened to the cylinder of a compressor using 6 bolts (steel C 20) of M20 size. The maximum fluid pressure is 3.2 MPa, cylinder diameter is 70 mm. A soft copper gasket is used. Assume the initial tension required in each bolt as 40kN, Determine the factor of safety?	(10)
14	a)	What is weld reinforcement? Why is it done?	(2)
	b)	An eccentrically loaded bracket is welded to a support as shown in figure. The permissible shear stress for the weld material is 80 MPa. Determine the size of the weld. 	(12)
		MODULE III	
15		A railway wagon weighing 3 tons is moving with a velocity of 3 m/s. It is brought to rest by two buffer springs of diameter 200 mm. The maximum deflection allowed is 160 mm. The allowable shear stress in spring material is600 MPa. Take G=84 GPa. Design the spring.	(14)
16		Design a shaft to transmit power from an electric motor to a lathe head stock through a pulley by means of a belt drive. The pulley weighs 200 N and is located at 300 mm from the centre of the bearing. The diameter of the pulley is	(14)

		200 mm and the maximum power transmitted is 1 kW at 120 rpm. The angle of lap of the belt is 180^0 and the coefficient of friction between the belt and pulley is 0.3. The shock and fatigue factors for bending and twisting are 1.5 and 2.0.The allowable shear stress in the shaft may be taken as 35 MPa.	
		MODULE IV	
17		A motor shaft rotating at 1440 rpm has to transmit 15 kW power to a low speed shaft running at 500 {pm. A 200 pressure angle full depth involute system of geartooth is used. The pinion has 25 teeth. Both gear and pinion are made of cast ironhaving allowable static strength of 55 MPa. Design a suitable spur gear drive andcheck the design for dynamic load and wear.	(14)
18		It is required to select a V-belt drive to connect a 15 kW, 2880 rpm normaltorque A.C. motor to a centrifugal pump, runningat approximately 2400 rpm, for a service of 18hours per day. The centre distance should beapproximately 400 mm. Assume that the pitchdiameter of the driving pulley is 125 mm.	(14)
		MODULE V	
19	a)	What is Sommerfeld number?	(2)
	b)	Design a journal bearing to support a load of 6 kN at 750 rpm, using hardened steel journal and bronze backed babbit bearing. The oil has a specific gravity of 0.9 at 15.5°C and a viscosity of 9 centistokes at 82°C which may be taken as limiting temperature for oil. Assume clearance of 0.003mm/mm diameter.	(12)
20	a)	Define static and dynamic load carrying capacity of ball bearing.	(2)
	b)	A single row deep groove ball bearing has a dynamic load capacity of 40210 N and operates on the work cycle consists of radial load of 2000 N at 1000 rpm for 25 % of the time, radial load of 5000 N at 1500 rpm for 50 % of time, and radial load of 3000 N at 700 rpm for the remaining 25 % of time. Calculate theexpected life of the bearing in hours.	(12)
		****	

Syllabus

Module I (10 Hours)

Introduction to Design- Definition, steps in design process, preferred numbers, standards and codes in design.

Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, factor of safety

Module II (8 Hours)

Threaded Joints- Terminology, thread standards, Selection of threaded joints. Bolted joints- effect of initial tension, eccentric loading, design of bolts for static and fatigue loading, gasketed joints, power screws.

Design of welded joints- welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under bending, eccentrically loaded welds.

Module III (8 Hours)

Springs- classification, spring materials, stresses and deflection of helical springs, Selection of springs, concentric springs, end constructions

Design of shafts and couplings-Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity and critical speed, design for static and fatigue loads, repeated loading, reversed bending; Design of Coupling- selection, classification, rigid and flexible coupling, design of keys and pins

Module IV (10 Hours)

Gears- classification, Gear nomenclature, Tooth profiles, Materials of gears, virtual or formative number of teeth, gear tooth failures, Lewis equation, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, surface durability, heat dissipation – lubrication of gears, Merits and demerits of each type of gears. Design of spur gear.

Basic idea of flat belt- materials for belts

Selection of V-belt drives, Advantages and limitations of V-belt drive

Module V (9 Hours)

Rolling contact bearing- Types, Selection of a bearing type, bearing life, static and dynamic load capacity, axial and radial loads, equivalent bearing load, selection of bearing life

Sliding contact bearing- modes of lubrication, lubricants, viscosity, Petroff's equation, Journal bearings, hydrodynamic theory, Sommerfeld number, friction guideways and LM guideways selection

Text Books

1. J. E. Shigley, Mechanical Engineering Design, McGraw Hill,2003

2.Jalaludeen , Machine Dsign, Anuradha Publications, 2016

3.V.B.Bhandari, Design of Machine elements, McGraw Hill, 2016

4. R. L. Norton, Machine Design – An Integrated Approach, Pearson Education, 2001

Data books permitted for reference in the final examination

1. K. Mahadevan, K.Balaveera Reddy, Design Data Hand Book, CBS Publishers & Distributors, 2013

2. NarayanaIyengar B.R &Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984

3. PSG Design Data, DPV Printers, Coimbatore, 2012

References Books

1. Juvinall R.C &Marshek K.M., Fundamentals of Machine Component Design, John Wiley, 2011

2. M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 2006

3. RajendraKarwa, Machine Design , Laxmi Publications (P) LTD, New Delhi, 2006

4. Siegel, Maleev& Hartman, Mechanical Design of Machines, International Book Company, 1983

Course Contents and Lecture Schedule

Module	Contents	Hrs
1	Introduction to Design- Definition, steps in design process, preferred numbers, standards and codes in design.	4
	Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, factor of safety	6
2	Threaded Joints- Terminology, thread standards, Selection of threaded joints. Bolted joints- effect of initial tension, eccentric loading, design of bolts for static and fatigue loading, gasketed joints, power screws.	4
	Design of welded joints- welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.	4
3	Springs- classification, spring materials, stresses and deflection of helical springs, Selection of springs, concentric springs, end constructions	4
	Design of shafts and couplings-Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity and critical speed, design for static and fatigue loads, repeated loading, reversed bending; Design of Coupling- selection, classification, rigid and flexible coupling, design of keys andpins	4
4	Gears- classification, Gear nomenclature, Tooth profiles, Materials of gears, virtual or formative number of teeth, gear tooth failures, Lewis equation, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, surface durability, heat dissipation – lubrication of gears – Merits and demerits of each type of gears.	3
	Design of spur gear	3
	Basic idea of flat belt- materials for belts	1
	Selection of V-belt drives, Advantages and limitations of V-belt drive	3
5	Rolling contact bearing- Types, Selection of a bearing type, bearing life, static and dynamic load capacity, axial and radial loads, equivalent bearing load, selection of bearing life	2
	Design of Ball Bearings	2
	Sliding contact bearing- modes of lubrication, lubricants, viscosity, hydrodynamic theory, Petroff's equation, Journal bearings, Sommerfeld number	2
	Design of Journal bearings, Friction guideways and LM guideways selection	3

RAT304	ELECTRIC DRIVES AND CONTROL	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Robotics application span from very small mobile remote data collection equipment to large powerful robotic arms that can be used in production lines of huge manufacturing plants. Hence the design of motors and their associated drive mechanism used for the development of such robotsare quite challenging. This course provides sufficient exposure to students on the different types of robots and various drives that are used for the development of a robot.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the working of different types of motors commonly used in robotics and the need for Electric drives
CO 2	Recognize the different power semiconductor device and their working principles
CO3	Describe the working of SCR and the various techniques used for triggering SCR
CO4	Demonstrate design of various speed control techniques of DC motors
CO5	Explain the working of single phase and Three phase inverters
CO6	Explain the working of Position control and speed control of different types of motors

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1									2
CO 2	3	2										2
CO 3	3	3	2									2
CO4	3	3	3									2
CO5	3	2	1									2
CO6	3	2	1									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle and working of a Stepper Motor
2. Explain the working of a BLDC motor. How is it different from a normal DC motor and what are its advantages.
3. What are the different starting methods of DC motors
4. What are the factors that need to be considered in identifying a motor that meets the requirements of the load?
5. Why do we need Electric drives? With a block diagram, explain the important components and their roles of an electric drive

Course Outcome 2 (CO2):

1. Explain the working principle of IGBT. Discuss about an application where IGBT is used and state why IGBT is preferred over other power devices for that application
2. What is the need of isolation in electronic systems? Explain two commonly used isolation mechanisms used in electronic system design

Course Outcome 3 (CO3):

1. Draw the structure of an SCR and explain its working. Also discuss about the switching characteristics of an ACR.
2. Explain the different types of triggering circuits that can be used to trigger an SCR

Course Outcome 4 (CO4):

1. Explain the operation of a single phase fully controlled bridge rectifier in conduction modes

2. Explain how speed control of a DC motor can be achieved with the help of a chopper controlled DC drive
3. Explain the operation of a two quadrant speed control mechanism
4. What is a closed loop torque control? How do you choose between speed control and torque control during a system design

Course Outcome 5 (CO5):

1. Explain the operation of a 3-phase bridge inverter with a resistive load
2. Explain the different voltage control techniques used in single phase inverters
3. What is the impact of harmonics in an inverter? What are the ways in which harmonics can be removed from an inverter

Course Outcome 6 (CO6):

1. Differentiate between open loop and closed loop position control techniques of stepper motor
2. How is converter circuits used in speed control achieved in a BLDC motor. List out the different modes of operation of the same.
3. What is the principle behind sensorless control of motor speed ?
4. What is a self-controlled motor? How is self-control achieved in synchronous motors?

MODEL QUESTION PAPER			
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY **SIXTH SEMESTER B.TECH. DEGREE EXAMINATION**			
Course Code: RAT 304			
Course Name: ELECTRIC DRIVES AND CONTROL			
Max. Marks: 100			Duration: 3 Hours
PART A			

		Answer all questions, each carries 3 marks.	Marks
1		Compare and contrast the starting methods of DC motors.	(3)
2		Discuss the advantages of BLDC motors over conventional DC motors	(3)
3		Differentiate between latching current and holding current	(3)
4		Explain the role of opto-couplers in power drives with an example	(3)
5		Explain the condition where power may flow from load to source in chopper circuits.	(3)
6		Design a dc-dc converter with 15 V input and 200 V output at up to 50W. The ripple in the output voltage and input current should not exceed ±5% and ±20% respectively. Choose an appropriate switching device and frequency.	(3)
7		Compare methods to control output voltage of inverter.	(3)
8		What is the advantage of using DC Motor speed control using VFDs.	(3)
9		Sensorless control in BLDC used for high speed applications. Substantiate the	(3)

		statement.	
10		Write down the components of a servo system	(3)
		PART B	
		Answer any one full question from each module, each carries14 marks.	
		MODULE1	
11	a)	Investigate the torque-speed of the drive system during dynamic conditions	(6)
	b)	Explain about the speed-torque characteristics of a DC Shunt Motor with suitable graph and equations	(8)
12	a)	Explain the selection of different power rating for different loading conditions	(7)
	b)	Suitably compare conventional motors and stepper motors. Calculate the stepping angle of a three phase, 32 teeth,variable reluctance stepper motor.	(7)
		MODULE II	
13	a)	With schematics explain switching characteristics of power BJT and Explain any one drive circuit for power BJT	(10)
	b)	Describe the V-I characteristics of IGBT	(4)
14	a)	Compare Thyristor, Power MOSFET and IGBT on the basis of following parameters: i) Switching frequency ii) Voltage and current ratings iii) Applications (at least two)	(5)
	b)	Explain two quadrant and four quadrant choppers with its applications.	(9)
		MODULE III	
15	a)	Design an R-triggering circuit for a half wave controlled rectifier circuit for 24 V ac supply. The SCR to be used has the following data. Igmin = 0.1 mA, Igmax = 12 mA, Vgmin = 0.6V, Vgmax = 1.5 V	(10)
	b)	Discuss regenerative breaking and its advantages	(4)
16		Graphically explain the three phase fully controlled bridge converter circuit with R Load and firing angleα = $60^{0.}$ For what firing angle,α, the current through the load becomes discontinuous.	(14)
		MODULE IV	
17	a)	With necessary diagrams and equations explain 3-phase bridge inverter with R load and 120^{0} conduction mode.	(12)
	b)	Note down the advantages of single phase voltage source inverter.	(2)
18	a)	Briefly explain sinusoidal PWM.	(4)
	b)	What is the effect of blanking time in invert output? Suggest suitable methods to eliminate the effects of harmonics.	(10)
		MODULE V	
19	a)	Compare the full step and half step motor drive with applications. Also compare open loop and closed loop configurations	(14)
	b		
20	a)	Explain how position control is achieved in servo control system.	(4)
	b)	Explain how Hall sensors are used to achieve speed control in BLDC motors	(10)
		****	

SYLLABUS

Module I (9 Hrs)

Introduction to electric motors used for robotic applications.

DC Motor -Construction– principle of operation –Back emf–Torque - characteristics of shunt, series and compound motors - necessity of starters- starting methods of dc motors

Introduction to Special Electrical Machines- DC servo motor,AC servo motors, stepper motor- variable reluctance - permanent magnet- hybrid , BLDC, PMSM- Construction , working and principle of operation

Electric drives- Introduction – Block diagram – advantages of electric drives -Dynamics of motor load system, fundamental equations, and types of load – classification of load torque-matching motor and load- Selection of motors for typical applications based on speed torque characteristics.

Module II (8Hrs)

Introduction to Power semiconductor devices-Power diode, BJT, MOSFET, IGBT -static and dynamic characteristics

SCR – structure- working- V-I and switching characteristics- Turn on methods of SCR- Gate triggering circuits – R and RC triggering circuits, line synchronised triggering – natural and forced commutation (concept only). Protection of SCR. Requirements of isolation and synchronisation in gate drive circuits- Opto and pulse transformer based isolation.

Module III (10Hrs)

Controlled Rectifiers –single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – output voltage equation. Three phase fully controlled converter with RLE load

DC-DC converters – step down and step up choppers – control methods- two-quadrant & four quadrant chopper.

DC Motor drives- Solid state speed control of DC motors-Armature control and field control, Single phase fully controlled converter drives (Rectifier and inverter mode). Chopper controlled DC drives-Regenerative braking control- Four quadrant chopper drives. Closed loop speed and torque control.

Module IV (9 Hrs)

Inverters — 1-phase full bridge voltage source inverters inverter with R & RL loads- 3-phase bridge inverter with R load – 120° & 180° conduction mode. Voltage control in inverters– Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM-elimination of harmonics- Variable Voltage Variable Frequency Drive (Block diagram only).

Module V (9 Hrs)

Control of servomotors-Components of typical servo system-with DC and brushless DC servo motor**,** Feedback system -Sizing of servomotors

Position control of Stepper motor- Drive circuit – modes of excitation- open loop and closed loop control of Stepper Motor- applications
Permanent Magnet Motor drives- Speed control of BLDC motor- converter circuits, modes of operation - applications. Speed control of PMSM-Self control- Sensorless Control – Microcontroller based permanent magnet synchronous motor drives (schematic only)- applications

Text Books:

1. Ned Mohan, Tore m Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons.

2.Dubey G. K. "Power semiconductor control drives" Prentice Hall, Englewood Cliffs, New Jersey, 1989

3. E. G. Janardhanan, '*Special Electrical Machines*' PHI Learning Private Limited.

4. NAGARATH.I.J& KOTHARI .D.P,"Electrical machines", Tata McGraw-Hill.1998

References:

1. VEDAM SUBRAMANIAM "Electric drives (concepts and applications)", Tata McGraw-Hill.2001
2. R. Krishnan, '*Permanent magnet synchronous and Brushless DC motor Drives*', CRC Press.
3. Bimal K. Bose "Modern power electronics and AC drives" Pearson Education, Asia 2003
4. Irvin L. Kosow.'*Electrical Machinery and Transformers*', Oxford Science Publications.
5. T. J. E. Miller, '*Brushless PM and Reluctance Motor Drives*'.C.Larendon Press, Oxford.
6. Dr. P. S. Bimbra "Power electronics", Khanna publishers
7. VedamSubrahmanyam, "Electric Drives", MC Graw Hill Education, New Delhi
8. Pillai S. K. "A first course on electric drives", Wieley Eastern Ltd, New Delhi
9. Theodore Wildi, '*Electric Machines, Drives and Power Systems*', Prentice Hall India Ltd.
10. M.D. SINGH, K.B.KHANCHANDANI,"Power electronics," Tata McGraw-Hill.1998
11. N. K. De, P. K. Sen "Electric drives" Prentice Hall of India 2002

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Electric Drives (9 hours)**	
1.1	Introduction to electric motors used for robotic applications. DC Motor -Construction– principle of operation –Back emf	1
1.2	Torque – electrical and mechanical characteristics of shunt, series and compound motors	1
1.3	necessity of starters- starting methods of dc motors- three point starter	1
1.4	Introduction to Special Electrical Machine - DC servo motor,AC servo motors- Construction , working and principle of operation	1
1.5	stepper motor- different types -variable reluctance - permanent magnet-hybrid- Construction , working and principle of operation	2
1.6	BLDC, PMSM- Construction , working and principle of operation	1
1.7	Electric drives- Introduction – Block diagram – advantages of electric drives -Dynamics of motor load system, fundamental equations,	1
1.8	types of load – classification of load torque-matching motor and load-Selection of motors for typical applications based on speed torque characteristics.	1
2	**Introduction to Power semiconductor devices- (8 hours)**	
2.1	Power diode, BJT, MOSFET, IGBT -static and dynamic characteristics	2
2.2	**SCR** – structure- working- V-I and switching characteristics- Turn on methods of SCR	2
2.3	Gate triggering circuits – R and RC triggering circuits, line synchronised triggering –	2
2.4	natural and forced commutation (concept only), Protection of SCR.	1
2.5	Requirements of isolation and synchronisation in gate drive circuits- Opto and pulse transformer based isolation.	1
3	**DC Motor Drives(11 Hours)**	
3.1	**Controlled Rectifiers** –single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – output voltage equation.	2
3.2	Three phase fully controlled converter with RLE load	1
3.3	DC-DC converters – step down and step up choppers – control methods-	1
3.4	two-quadrant & four quadrant chopper- output voltage waveforms	2
3.5	DC Motor drives- Solid state speed control of DC motors-Armature	1

	control and field control	
3.6	Single phase fully controlled converter drives (Rectifier and inverter mode)	1
3.7	Chopper controlled DC drives-Regenerative braking control- Four quadrant chopper drives.	2
3.8	Closed loop speed and torque control.	1
4	**Inverters (8 Hours)**	
4.1	1-phase full bridge voltage source inverters inverter with R & RL loads	1
4.2	3-phase bridge inverter with R load – 120° & 180° conduction mode – output line voltage and phase voltage waveforms	3
4.3	Voltage control in inverters– Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM	2
4.4	Elimination of harmonics using PWM	1
4.5	Variable Voltage Variable Frequency Drive (Block diagram only).	1
5	**Control of servomotors - (9 Hours)**	
5.1	Control of servomotors- Components of typical servo system-with DC and brushless DC servo motor, Feedback system -Sizing of servomotors	2
5.2	Position control of Stepper motor- Drive circuit – modes of excitation- full step mode and half step mode-	2
5.3	open loop and closed loop control of Stepper Motor- applications	1
5.4	Permanent Magnet Motor drives- Speed control of BLDC motor- converter circuits, modes of operation - applications.	2
5.5	Speed control of PMSM-Self control- Sensorless Control – Microcontroller based permanent magnet synchronous motor drives (schematic only)- applications	2

RAT306	SIGNALS AND SYSTEMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Starting with the understanding of what a signal is and the different types of signals available in the real world, this course provides the student with deep insights into the representation of signals in various domains and the need for such representations. The course also helps students to gain knowledge on transforming a signal from one domain to another domain. The course also discusses about the use of filters in signal processing and use of DFT for the same.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarise with types of signals and systems
CO 2	Obtain the frequency domain representation of continuous signals
CO 3	Obtain frequency domain representation of discrete time signals
CO 4	Develop filtering methods based on DFT
CO 5	Computation of DFT

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1										3
CO 2	2	1										3
CO 3	2	1	2									3
CO 4	3	2	2									3
CO 5	3	2	2									3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

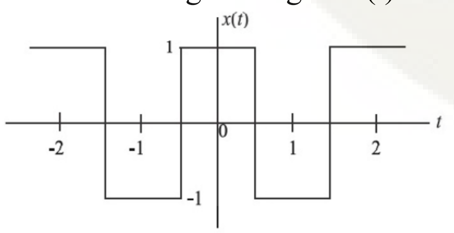
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions
Course Outcome 1 (CO1):
1. Compare and Contrast between a Continuous Time domain Signal and Discrete Time Domain Signal
2. How do you classify different systems in to CT and DT systems
3. Explain with an Example, how you will represent a discrete time system using difference equations

Course Outcome 2 (CO2):
1. With suitable examples, explain the properties of Continuous Fourier Series
2. State Sampling theorem and explain a mechanism to avoid aliasing
3. What do you mean by a response of a system? Explain the different types used in system design

Course Outcome 3 (CO3):
1. Find CTFS of the given signal x(t)



2. Derive the relationship between Fourier and Laplace transform
3. Determine the z-transform of $x(n)=(0.5)^n u(n)$

Course Outcome 4 (CO4):
1. Use linear convolution and find y(n)=x(n)*h(n),

2. where x(n)={0.5,2,-1.5,-,0,0.75,3,2,1.5,1,-.75,2} h(n)={1,2,-1}.
3. Solve it using the following two procedures a) Overlap-save method, (b) Overlap-add
4. How can we obtain Linear convolution using circular convolution
5. Explain Linear Filtering methods based on the DFT

Course Outcome 5 (CO5):

6. Find the 4-point DFT of x(n)={1,2,1,2}
7. Draw the basic butterfly diagram for DIT algorithm
8. Find the 8-point DFT of the sequence x(n)= {1,2,2,1,1,2,2,1} using DIF-FFT algorithm.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT306

Course Name: Signals and Systems

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

			Marks
1		Find the period of signal $x(n)=e^{j6\pi n}$.	(3)
2		Check the system is static or dynamic y(n)=x(2n)	(3)
3		What is Nyquist rate in sampling?	(3)
4		What is differentiation in Fourier Domain?	(3)
5		State the initial value theorem in z-transform	(3)
6		Determine the z-transform of $x(n)=(0.5)^n\ u(n)$	(3)
7		Find the 4-point DFT of x(n)={1,2,1,2}	(3)
8		What is time reversal property of DFT?	(3)
9		What is the basic operation in DIF algorithm?	(3)
10		What is signal flow diagram?	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

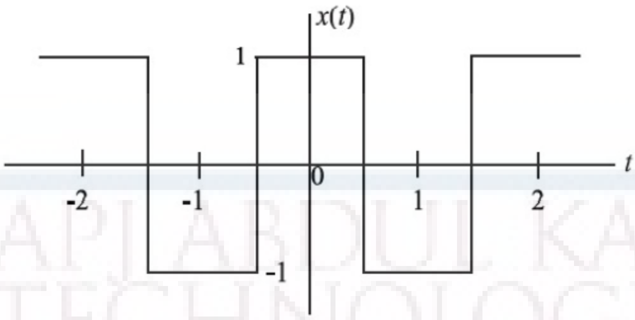
MODULE1

11	a)	Test if the following systems are causal or not (i)$y(n)=x(n)+x^2(n-1)$ (ii)y(n)=x(2n)	(5)
	b)	Determine power and energy of the following signals. Find whether the signals are power, energy or neither energy nor power signals (i) $x(n)=e^{2n}u(n)$ (ii) x(n)=sin(π/4.n) (iii)$x(n)=(1/3)^n u(n)$	(9)
12	a)	Determine the impulse response h(n) for the system described by difference equation y(n)+y(n-1)-2y(n-2)=x(n-1)+2x(n-2).	(8)
	b)	Compute convolution of the signals x(n)={3,2,1,2} and h(n)={1,2,1,2}.	(6)

MODULE II

13 a) State and Prove Parseval's theorem (4)

b) Find CTFS of the given signal x(t) (10)



14 a) What is sampling theorem? How can we avoid aliasing? (8)

b) Derive the relationship between Fourier and Laplace transform (6)

MODULE III

15 a) Determine the z-transform of the following (10)

(i) $x(n)= n^2u(n)$

(ii) $x(n)=(-1)^n\cos(\pi/3 \,.\, n)\, u(n)$

b) List out four properties of z-transform (4)

16 a) Consider an LTI-system critically at rest described by the difference equation $y(n)=0.25\, y(n-2)+x(n)$. Determine the impulse response of the system (10)

b) List out four properties of DTFS (4)

17 a) Use linear convolution find $y(n)=x(n)*h(n)$, where (14)

$x(n)=\{0.5,2,-1.5,-,0,0.75,3,2,1.5,1,-0.75,2\}$

$h(n)=\{1,2,-1\}$.

Solve it using the following two procedures

(a) Overlap-save method, (b) Overlap-add method

18 a) Find the circular convolution (6)

$x(n)=\{1,0,-1,0\}$ $h(n)=\{1,1,1\}$

b) Use the overlap-add method to find the step response of a filter with $h(n)=2^{-n}[u(n)-u(n-3)]$ and L=3. (8)

MODULE V

19 a) Find the 8-point DFT of the sequence $x(n)= \{1,2,2,1,1,2,2,1\}$ using DIF-FFT algorithm. (10)

b) What is the speed improvement factor in calculating 64-point DFT of a sequence using direct computation and FFT computation (4)

20 a) Draw the basic butterfly diagram for DIT algorithm (4)

b) Consider a causal linear time-invariant system whose system function is (10)

$H(z) = (1-0.5z^{-1})/(1-0.5z^{-1}+0.33z^{-2})(1+0.25z^{-1})$

****

Syllabus

Module I (7 Hours)

Elementary Signals, Classification and representation of continuous time and discrete time signals, Signal operations. Continuous time and discrete time systems – Classification. Representation of systems: Differential equation representation of continuous time systems. Difference equation representation of discrete systems.

Module II (11 Hours)

Frequency domain representation of continuous time signals- continuous time Fourier series and its properties. Continuous time Fourier transform and its properties. Relation between Fourier and Laplace transforms. Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, Frequency response, Magnitude and phase response Sampling of continuous time signals, Sampling theorem for low pass signals, aliasing

Module III (8 Hours)

Z transform, ROC, Inverse transform, properties, Unilateral transform. Frequency domain representation of discrete time signals, Discrete time Fourier series and its properties. Discrete time Fourier transform (DTFT) and its properties

Module IV (9 Hours)

The Discrete Fourier Transform-IDFT-Properties of DFT-Circular convolution - Linear Filtering methods based on the DFT- linear convolution using circular convolution, overlap save and overlap add methods

Module V (10 Hours)

Computation of DFT: Radix-2 Decimation in Time and Decimation in Frequency FFT - Algorithms - IDFT computation using Radix-2 FFT Algorithms.
FIR and IIR Filters.- FIR Filter Structures: Direct Form, Cascade Form
IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form (Design is not required)

Text Books

1. Alan V. Oppenheim and Alan Willsky, Signals and Systems, PHI, 2/e, 2009
2. Simon Haykin, Signals & Systems, John Wiley, 2/e, 2003R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
3. B P. Lathi, Priciples of Signal Processing & Linear systems, Oxford University PressAshitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
4. Oppenheim A. V., Schafer R. W. and Buck J. R., Discrete Time Signal Processing, 3/e, Prentice Hall, 2007.
5. Proakis J. G. and Manolakis D. G., Digital Signal Processing, 4/e, Pearson Education, 2007.

Reference Books

1. A.Papoulis, "Circuits and Systems: A Modern Approach", HW series in Electrical and Computer Engineering
2. Mahmood Nahvi, Signals and System, Mc Graw Hill (India),2015
3. H P Hsu, Signals And Systems, Schaum's Series – 3rd Edition
4. A Nagoor Kani, Signals and Systems, McGraw Hill Education.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Classification and representation of continuous time signals	1
1.2	Classification and representation of discrete time signals;	1
1.3	Signal operations	2
1.4	Continuous time and discrete time systems – Classification.	1
1.5	Differential equation representation of continuous time systems.	1
1.6	Difference equation representation of discrete systems.	1
2		
2.1	Frequency domain representation of continuous time signals-	1
2.2	Continuous time Fourier series and its properties	2
2.3	Continuous time Fourier transform and its properties	2
2.4	Relation between Fourier and Laplace transforms	2
2.5	Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, Frequency response, Magnitude and phase response	2
2.6	Sampling of continuous time signals, Sampling theorem for lowpass signals, aliasing	2
3		
3.1	Z transform, ROC, Inverse transform,	2
3.2	Properties, Unilateral transform.	2
3.3	Frequency domain representation of discrete time signals,	1
3.4	Discrete time Fourier series and its properties.	1.5
3.5	Discrete time Fourier transform (DTFT) and its properties	1.5
4		
4.1	The Discrete Fourier Transform-IDFT	1
4.2	Properties of DFT	2
4.3	Circular convolution -Linear Filtering methods based on the DFT	2
4.4	linear convolution using circular convolution,	2
4.5	Overlap save and overlap add methods	2

5		
5.1	Computation of DFT: Radix-2 Decimation in Time FFT Algorithm IDFT computation using Radix-2 FFT Algorithms.	3
5.2	FIR and IIR Filters.	1
5.3	FIR Filter Structures: Direct Form, Cascade Form	3
5.4	IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form (Design is not required)	3

RAT308	COMPREHENSIVE COURSE WORK	Category	L	T	P	Credit	Year of Introduction
		PCC	1	0	0	1	2019

Preamble: The course is designed to ensure that the students have firmly grasped the fundamental knowledge in Robotics & Automation Engineering familiar enough with the technological concepts. It provides an opportunity for the students to demonstrate their knowledge in various Robotics & Automation subjects.

Pre-requisite: Nil

Course outcomes: After the course, the student will able to:

CO1	Learn to prepare for a competitive examination
CO2	Comprehend the questions in Robotics & AutomationEngineering field and answer them with confidence
CO3	Communicate effectively with faculty in scholarly environments
CO4	Analyze the comprehensive knowledge gained in basic courses in the field of Robotics & AutomationEngineering

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO 4
CO1	3	1	1			2										
CO2	3	1				2				3			1	1	1	1
CO3	3	1			1	2				3						
CO4	3	3			1	2							1	1	1	1

Assessment pattern

Bloom's Category	End Semester Examination (Marks)
Remember	25
Understand	15
Apply	5
Analyze	5
Evaluate	
Create	

End Semester Examination Pattern:

A written examination will be conducted by the University at the end of the sixth semester.The written examination will be of objective type similar to the GATE examination.Syllabus for the comprehensive examination is based on the following five Robotics & Automation Engineering core courses.

RAT 202- Kinematics And Dynamics Of Mechanisms

RAT206- Microcontrollers and Embedded Systems

RAT307- Control Systems

RAT 301- Introduction to Robotics

RAT 305–Industrial Automation

The written test will be of 50 marks with 50 multiple choice questions (10 questions from each module) with 4 choices of 1 mark each covering all the five core courses. There will be no negative marking. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed above.

Written examination	:	50marks
Total	**:**	**50 marks**

Course Level Assessment and Sample Questions:

1) Which of the following conditions can be used to minimize undercutting in cam and follower mechanism?
   a. By using larger roller diameter
   b. By using internal cams
   c. By decreasing the size of the cam
   d. All of the above

2) A point is moving at the end of the link rotating with constant angular velocity ω, what will be the value of radial component of acceleration?
a) 0
b) $\omega^2 R$
c) Infinite
d) $\omega^2 R/2$

3) D' Alembert's principle is used for______________________?
   a) reducing the problem of kinetics to equivalent statics problem

b) determining stresses in the truss
c) stability of floating bodies
d) designing safe structures
e) solving kinematic problems

4) When the microcontroller executes some arithmetic operations, then the flag bits of which register are affected?.

a) PSW
b) SP
c) DPTR
d) PC

5) What is the width of the 8051 address bus?

a. 16-bit address bus
b. 8-bit address bus
c. 32-bit address bus
d. None of the above

6) Single-bit indicators that may be set or cleared to show the results of logical or arithmetic operations are the

a. Flags
b. Monitors
c. Registers
d. Decisions

7) What will be the nature of time response if the roots of the characteristic equation are located on the s-plane imaginary axis?

a) Oscillations
b) Damped oscillations
c) No oscillations
d) Under damped oscilaations

8) Consider a system with transfer function G(s) = s+6/Ks^2+s+6. Its damping ratio will be 0.5 when the values of k is:

a) 2/6
b) 3
c) 1/6
d) 6

9) The unit step response of a second order system is = 1-e^{-5t}-5te^{-5t} . Consider the following statements:
1. The under damped natural frequency is 5 rad/s.
2. The damping ratio is 1.
3. The impulse response is 25te^{-5t}.
Which of the statements given above are correct?
a) Only 1 and 2
b) Only 2 and 3

c) Only 1 and 3
d) 1,2 and 3

10) 9-Industrial Robots are generally designed to carry which of the following coordinate system(s).
(A) Cartesian coordinate systems
(B) Polar coordinate systems
(C) Cylindrical coordinate system
(D) All of the above

11) Which of the following work is done by General purpose robot?
(A) Part picking
(B) Welding
(C) Spray painting
(D) All of the above

12) Inverse kinematics problem of series manipulator with 6 DOF has
(a) a unique solution
(b) 2 solutions only
(c) 3 solutions only
(4) More than 6 solutions

13) In a PLC, the scan time refers to the amount of time in which
(A) the technician enters the program
(B) timers and counters are indexed by
(C) one "rung" of ladder logic takes to complete
(D) the entire program takes to execute
(E) transmitted data communications must finish

14) An OR function implemented in ladder logic uses
(A) Normally-closed contacts in series
(B) Normally-open contacts in series
(C) A single normally-closed contact
(D) Normally-open contacts in parallel
(E) Normally-closed contacts in parallel

15) LVDT windings are wound on
a) Steel sheets
b) Aluminium
c) Ferrite
d) Copper

Course Code: ICT 308

Comprehensive Course Work

MODULE I: Kinematics And Dynamics Of Mechanisms

Basics of mechanisms: Links, kinematic pairs, kinematic chain, mechanism and machine, common mechanisms like linkages, camsfollowermechanisms, gear trains, belt and chain, and multi-degrees of planar mechanisms in machines like earth moving machinery and planar versions of manipulators, mobility /degrees of freedom (DoF), Kutzbach's formula, determination of DoF of planar linkages and mechanisms with cam-follower pairs.position analysis, loop closure equations, fourbar, slider-crank,and multi DoF closed and open loop mechanisms, , exposure to graphical approach, inverse pose problem of an open loop 3R planar manipulator, and derivation of solution.Velocity analysis: forward and inverse velocity analysis of open loop 3R mechanism.Acceleration analysis: angular acceleration of a rigid link and relative acceleration of points,Corioli's acceleration.Static force analysis:nature of joint reaction forces, static force analysis,Euler's equation for rigid body rotation: moments of inertia, principal moments and principal axes, representation of relative orientation of reference frames using rotation matrices,properties of rotation matrices, transformation of moments of inertia matrices from one reference frame to another,

MODULE II: Microcontrollers & Embedded Systems

8051 microcontrollers-pin diagram; Architecture, I/O Port structure, Register organization - special function registers,-Memory organization- 8051 microcontrollers: Instruction set, Addressing modes - Simple Assembly language programs: Arithmetic (Addition, Subtraction, Multiplication & Division), -. Timers/Counters- Serial Communication, Interrupt structure-programming - Interfacing of peripherals – LED (ALP and embedded C programming). LCD, ADC, DAC, sensors, simple Switch and key board interfacing, 7 segment LED. Embedded System Architecture: HW - Processor, Controller, SoC, Memory, Peripherals; SW - Application, Middleware, OS, Device Drivers, Tool chain- Assembler, Interpreter, Compiler, Linker, Loader, Debugger Introduction to RTOS: Real time tasks and Systems, RTOS basics, Comparison of General Purpose OS and Real Time OS. Communication Protocols: RS232, I2C, SPI and USB

MODULE III: Control Systems

Feedback principles, signal flow graphs, transient response, time domain analysis of first and second order systems,step response of first and second order systems - steady-state-errors, static and dynamic error coefficients – Concept of stability – stability of feedback systems -, Routhstability criterion , root loci stability from root loci - ,effect of additional poles and zeros - Bode plot, log magnitude vs.phase plot phase and gain margins - Need of lead, lag and lead-lag compensators, state-space representation of systems; relationship between state equations and transfer functions - time-delay systems

MODULE IV: Introduction to Robotics

Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist; Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.Direct Kinematics-Rotations-Fundamental and composite Rotations, Homogeneous co-ordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF)Inverse kinematics- general properties of solutions, Problems (upto 3DOF) Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only)Tool configuration Jacobian, relation between joint and end effector velocities.Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, Point to point vs continuous path planning. Obstacle avoidance methods.

MODULE V:Industrial Automation

Classification of position, proximity and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors. Electrical, Hydraulic and pneumatic actuators and their comparison, Examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.Sensor systems for automated inspection- online inspection systems., laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems. Elements of CNC systems-Material Handling and Identification Technologies.

Pneumatic/Hydraulic Automation: control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems. Electro pneumatic/electro hydraulic automation- Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming of PLC- analog and digital I/Os, timers, counters, function blocksMotion controllers-VFD, MLD, external relays and contactors

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAL332	ROBOTICS LAB	PCC	0	0	3	2

Preamble: Robotics lab provides students with exposure to the common Robotic manipulators with atleast 3DOF and mobile robots. Students are also made to do experiments with sensors and feedback controls as well as object detection and tracking.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Test forward, inverse kinematic modelling and path planning of robotic manipulators
CO 2	Test basic control algorithms in mobile robots to move to a point, to follow a line, to follow a path and for obstacle avoidance.
CO 3	Familiarise about localisation of mobile robots
CO 4	Calibrate sensors used in robots
CO 5	Design and develop sensor-based systems in robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	2		2			2	2		3
CO 2	3	2	2	2		2			2	2		3
CO 3	3	2	2	2		2			2	2		3
CO 4	3	2	2	2		2			2	2		3
CO 5	3	2	2	2		2			2	2		3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 Marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS

All experiments from Part A, Part B and Part C are mandatory

Part A: Robotic Manipulators (3 DOF or greater) (All experiments mandatory)

1. Joint space and Cartesian space trajectory planning for a pick and place task
2. Obtain forward and inverse kinematic models (check end effector and joint positions with theoretical and actual values)
3. Point to point control and continuous path control

Part B: Mobile Robots

1. Control of mobile robot for moving to a point(xg, yg) , following a line (ax+by+c=0), moving to a specific target orientation (θ_g) (Closed loop control considering kinematic models)
2. Obstacle avoidance of a mobile robot while moving to a point.
3. Localization of a mobile robot using LIDAR

PART C: Sensor based experiments

1. Calibration of sensors-sonar, IR sensors and obtain the calibration curve
2. Object detection using any one standard algorithm
3. Object tracking and visual servoing
4. Following a moving target/ Object tracking from a moving vehicle

PART D: Mini Project (any one –compulsory)

1. Design and develop a servo controlled robotic manipulator (1 DOF) with visual feedback for pick and place task
2. Design and develop a mobile robot capable of obstacle avoidance and localisation
3. Assemble a quadcopter drone kit and make it hover.

Reference Books

1. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
2. Introduction to Robotics by S K Saha, Mc Graw Hill Education
3. R K Mittal and I J Nagrath, “Robotics and Control”, Tata McGraw Hill, New Delhi,2003.
4. Ashitava Ghosal, “Robotics-Fundamental concepts and analysis”, Oxford University press.
5. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb
6. Introduction to Autonomous Mobile Robots, Siegwart, Roland, Cambridge, Mass. : MIT Press, 2nd ed.
7. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke, Springer

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAD334	MINIPROJECT/ CORE LAB	PWS	0	0	3	2

Preamble: This course is designed for enabling the students to apply the knowledge to address the real-world situations/problems and find solutions. The course is also intended to estimate the ability of the students in transforming theoretical knowledge studied as part of the curriculum so far in to a working model. The students are expected to design and develop a software/hardware project to innovatively solve a real-world problem.

Prerequisites: Subjects studied up to sixth semester.

Course Outcomes: After the completion of the course the student will be able to

CO No.	Course Outcome (CO)	Bloom's Category Level
CO 1	Make use of acquired knowledge within the selected area of technology for project development.	Level 3: Apply
CO 2	Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.	Level 3: Apply
CO 3	Interpret, improve and refine technical aspects for engineering projects.	Level 3: Apply
CO 4	To exercise their creative and innovative qualities in a group project environment	Level 3: Apply
CO 5	Report effectively the project related activities and findings.	Level 2: Understand

Mapping of course outcomes with program outcomes

POs / COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	3	3	3	-	-	-	3
CO 2	3	3	3	3	3	-	2	3	-	3	2	3
CO 3	3	3	3	3	3	2	3	3	-	2	3	3
CO 4	3	3	2	2	-	-	-	3	3	3	3	3
CO 5	3	-	-	-	2	-	-	3	2	3	2	3

Assessment Pattern

The End Semester Evaluation (ESE) will be conducted as an internal evaluation based on the product/project, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, academic coordinator for that program and project guide/coordinator. The

Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement.

The Continuous Internal Evaluation (CIE) is conducted by evaluating the progress of the miniproject through minimum of TWO reviews. At the time of the 1st review, students are supposed to propose a new system/design/idea, after a thorough literature study of the existing systems under the chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution. The review committee should assess the extent to which the implementation reflects the proposed design. The final CIE mark is the average of 1st and 2nd review marks.

A zeroth review may be conducted before the beginning of the project to give a chance for the students to present their area of interest or problem domain or conduct open brain storming sessions for innovative ideas. Zeroth review will not be apart of the CIE evaluation process.

In the final review students are expected to demonstrate the product with its full specification along with a final report. A well coded, assembled and completely functional product is the expected output during the end of the semester.

Marks Distribution

Total Marks	CIE	ESE
150	75	75

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Marks awarded by Guide : 15 marks
Project Report: 10 marks
Evaluation by the Committee : 40 Marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks.
(a) Demonstration : 50 Marks
(b) Project report: 10 Marks
(d) Viva voce : 15marks

Course Plan

In this course, each group consisting of three/four members is expected to design and develop a moderately complex software/hardware system with practical applications. This should be a working model. The basic concept of product design may be taken into consideration.

Students should identify a topic of interest in consultation with Faculty-in-charge of miniproject/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews.

The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

SEMESTER VI

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT312	SENSORS AND TRANDUCERS	PEC	2	1	0	3

Preamble: It is through the various sensors and transducers that a robot interacts with the physical world. A thorough understanding of the working principle of these sensors and transducer are therefore necessary for a budding engineer to select appropriate components for the application. This course provide an exposure for the student to learn about various sensors, transducers and how they are selected by explaining the underlying theory followed by appropriate case studies.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze and select the most appropriate sensors and transducers for a robotic application
CO 2	Explain fundamental principle of working of sensors and transducers for robots
CO 3	Interpret typical manufacturer's data sheet of sensors and transducers and use them for selection in typical applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2									3
CO 2	3	2	2									3
CO 3	3	2	2									3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. List out the different sensor characteristics and their defintions
2. What is a LVDT? What is it used for?
3. What are the different types of Force sensors available? Under what condition will you chose a piezo electric based sensor over a strain gauge.
4. With example, explain the use of one Proprioceptive and exteroceptive sensor in a robotic application.

Course Outcome 2 (CO2):
1. Explain the working principle of real time differential GPS
2. Explain the working principle of Doppler based motion sensors. Discuss on the possible application of such sensors
3. Explain the various steps involved in an visual object detection process

Course Outcome 3 (CO3):
1. Discuss the important characteristics that need to be looked into while selecting a proximity sensor for obstacle avoidance application
2. List out the important properties to be looked into while selecting a CCD camera for object identifcation systems
3. Discuss the transducer performance characteristics based on the static and dynamic properties

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 312

Course Name: SENSORS AND TRANSDUCERS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		How proprioceptive sensors differ from exteroceptive sensors?	(3)
2		Mention the applications of force sensors.	(3)
3		A robot is moving in an environment amidst obstacles which are black in colour. Which sensor is preferred in this scenario for range measurement and obstacle avoidance? Justify your answer.	(3)
4		Explain the uses of tactile sensors.	(3)
5		Can we compute depth of an object using camera? Justify your answer.	(3)
6		What is visual servoing?	(3)
7		What's a force transducer?	(3)
8		Explain the performance characteristics of transducers.	(3)
9		Explain any two types of temperature transducer	(3)
10		How will you choose transducer for different robotic applications;	(3)

PART B

(Answer any one full question from each module, each carries 14 marks.)

MODULE1

11	a)	What is LVDT? What are the parameters that can be measured by this? Describe with a neat diagram the principle of operation and output characteristics of the same.	(10)
	b)	A robot'scontrol memory has 8 bit storage capacity; it has two rotational joints and one linear joint. The linear link can varyits length from as short as 0.2 meters to as long as 1.2 meters. Compute the control resolution for encoder of each joint.	(4)
12	a)	What is Gyroscope? Enumerate various sources of errors in Gyroscopes? How will you rectify them while gyroscopes are used in robotic applications?	(10)
	b)	Can we use GPS sensors in indoor environments? Justify your answer.	(4)

MODULE II

13	a)	Which are the sensors used to detect closeness of objects? And how will you compute the same?	(10)
	b)	How range is measured using optical triangulation method?	(4)
14		Consider a scenario where a surveillance vehicle chases a car which violated traffic rules. Which all sensors are to be used in the surveillance vehicle to compute the position and relative velocity of the target vehicle (car)? Explain the working of the sensors being used.	(14)

MODULE III

15 a) Which are the elements of a vision sensor? How will you extract features using vision sensor? (6)

b) What are the advantages of CMOS cameras? (8)

16 Explain the criteria for selection of sensors for different applications (14)

MODULE IV

17 a) 1. What are transducers ? What are it's classifications? (6)

b) Linear Resistance potentiometer is 50mm long & is uniformly wound with a wire having a resistance of 10,000Ω. Under normal conditions, the slider is at the center of the potentiometer. Find the linear displacement when the resistancesof the potentiometer as measured by Wheatstone bridge for two cases are (1)3850Ω (2)7560Ω. Are the two displacements in same direction. If it is possible to measure a minimum value of 10Ω resistancewith the bovearrangement, find the resolution (8)

18 a) With neat diagrams explain the following transducers (i) Position transducer (ii) Velocity transducer (iii)Force Transducer (6)

b) What are the two basic materials used for resistive strain gages? Which of these is most sensitive? Describe in your words what "sensitive" means. What is a disadvantage of the more sensitive strain gage material? (8)

MODULE V

19 a) With neat diagrams explain the following transducers (i) Temperature transducer (ii) Pressure transducer (iii)Flow Transducer (8)

b) What is the difference between a sensor and transducer ? Give some industrial applications of transducer. (6)

20 a) A pressure transducer uses a diaphragm as a pressure summing device. In application the diaphragm and fluid behave as a second-order, single-degree system. The static displacement is proportional to the applied force (pressure). If the natural undamped frequency of the system is 3600 Hz and the total viscous damping is 75% of critical, determine the frequency range(s) over which the ratio of dynamic amplitude to static amplitude (inherent error) deviates from unity by an amount no greater than 6%... (7)

b) Consider the pressure transducer from the previous problem to be damaged such that its viscous damping ratio becomes changed to some unknown value. If the transducer is subjected to a harmonic input of 2400 Hz, the phase angle between output and input is measured as 45 degrees. With this in mind, determine the inherent error (attenuation) of the transducer when used to measure a harmonic pressure signal of 1800 Hz. What will be the phase angle between the output and input at this frequency? (7)

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Syllabus

Module I (8 Hours)

Requirement of sensors in robots used in industry, agriculture, medical field, transportation, military, space and undersea exploration, human-robot interactions, robot control, robot navigation, tele-operational robot etc. **Sensor Characteristics**: Sensitivity, Linearity, Measurement/Dynamic range, Response Time, Accuracy, Repeatability & Precision, Resolution & Threshold, Bandwidth.

Proprioceptive or Internal sensors Position sensors- encoders- linear, rotary, incremental linear encoder, absolute linear encoder, Incremental rotary encoder, absolute rotary encoder; potentiometers; LVDTs; velocity sensors-optical encoders, tacho generator, Hall effect sensor, , acceleration sensors, Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS; Force sensors-strain gauge based and Piezo electric based, Torque sensors; Block schematic representations; Interpreting typical manufacturer's data sheet of internal sensors;

CaseStudy: Choosing the best internal sensors for autonomous navigation of a mobile robot

Module II (7 Hours)

Exteroceptive or External sensors-contact type, noncontact type;Tactile, proximity-detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor; Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light(2D), performance comparison range sensors; motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Block schematic representations; Numerical problems ;Block schematic representations; Interpreting typical manufacturer's data sheet of external sensors;Examples -use of Exteroceptive sensors in robots.

Case Study : Obstacle avoidance robot using IR sensor;

Module III (7 Hours)

Vision based sensors- Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system, CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor; Block schematic representations.

Choosing sensor for different robotic applications and application of sensors in flexible manufacturing

Case Study : Object Tracking robot using vision sensor

Module IV (7 Hours)

Introduction to transducers; Requirement of transducers in robots, medicine etc; Differences between Sensors and transducers; Transducer performance characteristics based on static and dynamic properties; Classification of transducers based on physical effect, physical quantity and source of energy- Active vs Passive, Principle of transduction, Analog and Digital transducer, Primary and Secondary transducer;Transducer and Inverse Transducer.

Position transducers, Displacement transducer – LVDT's,Captive Armatures, Unguided Armatures, Force-Extended Armatures; Velocity Transducers - LVT; Accelerometer- using potentiometer, Strain gage, Piezoelectric;Light transducers;, Force transducers; Piezoelectric transducer;

Block schematic representations; Advantages and Disadvantages; choosing transducer for different robotic applications; Numeric problems; Interpreting typical manufacturer's data sheet;

Case Study : Learn to calculate end effectors position of a robot using position transducer

Module V (6 Hours)

Temperature transducer – thermocouple, RTD- common errors, Thermistor, Integrated circuit; Pressure transducer - Bourdon tube, diaphragm, Capacitive Pressure transducer; Oscillator transducer; Flow transducer – Orifice Plate, venture, Defective type flow sensor, spin type flow sensor, Electromagnetic flow sensor; Level Transducer- Discrete Level, Level measurement by pressure sensor, differential pressure sensor, force sensor, capacitive level sensor; Inductive transducer; Ultrasonic transducer; LIDAR

Block schematic representations; Advantages and Disadvantages; choosing transducer for different robotic applications; Numeric problems; Interpreting typical manufacturer's data sheet.

Text Book

1. Robotics Engineering: An Integrated Approach, by Richard D. Klafter, Prentice Hall Inc.
2. D. Patranabis, "Sensors and Transducers", PHI Learning Private Limited.

References

3. Clarence W. de Silva, Sensors and Actuators: Control System Instrumentation, CRC Press 2007, ISBN-13: 978-1420044836
4. Introduction to Robotics, S K Saha, Mc Graw Hill Eduaction
5. W. Bolton, "Mechatronics", Pearson Education Limited.
6. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.
7. Pillai S. K. "A first course on electric drives", Wieley Eastern Ltd, New Delhi
8. Journal of sensors, Special issue- Sensors for Robotics, Aiguo Song , Guangming Song, Daniela Constantinescu, Lei Wang, and Quanjun Song, Volume 2013
9. Mechatronics: Integrated mechanical electronic systems By K.P. Ramachandran, G.K. Vijayaraghavan, Wiley India
10. Linear Electric Actuators by I. Boldea
11. Piezoelectric Actuators (Electrical Engineering Developments), 2012, by Joshua E. Segel

12. Morecki, Adam and Knapczyk, “Sensors and Transducers Used in Robots”, Basics of Robotics, Springer 1999, pp 275—304
13. Ruocco, S, “Robot sensors and transducers”, Springer Science \& Business Media, 2013.
14. Instrumentation, Measurement and Analysis, 2016, By Nakra & Chaudhary.
15. “HANDBOOK OF FORCE TRANSDUCERS” by Hardcover and Stefanescu
16. “Transducers and Instrumentation” by D V S Murthy

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Proprioceptive or Internal sensors**	
	Requirement of sensors in robots used in industry, agriculture, medical field, transportation, military, space and undersea exploration, human-robot interactions, robot control, robot navigation, tele-operational robot etc.**Sensor Characteristics**: Sensitivity, Linearity, Measurement/Dynamic range, Response Time, Accuracy, Repeatability & Precision, Resolution & Threshold, Bandwidth.	2.5
1.2	Position sensors- encoders- linear, rotary, incremental linear encoder, absolute linear encoder, Incremental rotary encoder, absolute rotary encoder; potentiometers; LVDTs.	2
1.3	velocity sensors-optical encoders, tacho generator, Hall effect sensor, acceleration, Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS	2
1.4	Force sensors-strain gauge based and Piezo electric based, Torque sensors	1.5
	Note- Block schematic representations, Interpretation of typical manufacturer’s data sheet and Numerical problems of the main sensors are to be covered.	
2	**Exteroceptive or External sensors**	
2.1	contact type, noncontact type; Tactile, proximity- detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor;	3
2.2	Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light(2D), performance comparison range sensors;	2
2.3	Motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Numerical problems	2
	Note- Block schematic representations, Interpretation of typical manufacturer’s data sheet and Numerical problems of the main sensors are to be covered.	
3	**Vision based sensors-**	
3.1	Vision based sensors - Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system	3

3.2	CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor.	3
3.3	Choosing sensor for different robotic applications and application of sensors in flexible manufacturing	1
4	**Introduction to transducers**;	
4.1	**Introduction to transducers**; Requirement of transducers in robots, medicine etc; Differences between Sensors and transducers; Transducer performance characteristics based on static and dynamic properties; Classification of transducers based on physical effect, physical quantity and source of energy- Active vs Passive, Principle of transduction, Analog and Digital transducer, Primary and Secondary transducer;Transducer and Inverse Transducer.	4
4.2	Position transducers, Displacement transducer – LVDT's,Captive Armatures, Unguided Armatures, Force-Extended Armatures; Velocity Transducers - LVT; Accelerometer- using potentiometer, Strain gage, Piezoelectric;Light transducers;, Force transducers;Piezoelectric transducer;	3
5		
5.1	Temperature transducer – thermocouple, RTD- common errors, Thermistor, Integrated circuit; Pressure transducer - Bourdon tube, diaphragm, Capacitive Pressure transducer; Oscillator transducer; Flow transducer – Orifice Plate, venture, Defective type flow sensor, spin type flow sensor,	3
5.2	Electromagnetic flow sensor; Level Transducer- Discrete Level, Level measurement by pressure sensor, differential pressure sensor, force sensor, capacitive level sensor; Inductive transducer; Ultrasonic transducer; LIDAR	3

RAT322	ROBOTIC CONTROL SYSTEMS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Control mechanisms are a crucial elements of any autonomous systems. This course provides the students an introduction to the various control mechanisms that can be used in the development of a robot.

Prerequisite: Basic course in Control Systems

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design linear controllers for robotic manipulators
CO 2	Familiarise about various nonlinear control schemes for robotic manipulators
CO 3	Acquaint with force control schemes of manipulators
CO 4	Familiarise about controllers for mobile robots
CO 5	Familiarise about vision-based control schemes for robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	1	2							3
CO 2	3	2	2	1	2	1						2
CO 3	3	2	2	2	2	1						3
CO 4	3	2	2	2	1	1						2
CO 5	3	3	2	2	2	1						2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	25	25	50
Apply	15	15	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. With block diagrams, explain the closed loop and feed forward Robotic Control Systems
2. With an example, explain a trajectory following control used for robots.
3. Explain PID control of a single link manipulator

Course Outcome 2 (CO2):

1. What is an adaptive Control mechanism? How can it be used in robotic controls?
2. Explain one non-linear control scheme of robotic manipulator

Course Outcome 3 (CO3):

1. Discuss the response of a mass-Spring system with a driving force
2. Elaborate on the hybrid position –force problem and its control scheme

Course Outcome 4 (CO4):

1. Differentiate between a steered robot and a differentially driven mobile robot. Explain the kinematic model of any one of them
2. How is a line follower different from a mechanism designed to follow a path

Course Outcome 5 (CO5):

1. What is stereo vision and how is it useful?
2. Explain the working of an image based visual servo mechanism
3. Explain the import factors to be considered for camera calibration in a visual based control scheme?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 322

Course Name: ROBOTIC CONTROL SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

		Marks
1	Typically robotic systems are linear or non-linear? Can we implement linear controllers for robots? Justify your answer.	(3)
2	Draw the block schematic for feedback control of robotic manipulator. Which is the commonly used sensor in the feedback loop for the position control of a manipulator?	(3)
3	Explain PD gravity control of a robotic manipulator.	(3)
4	Explain resolved motion rate control of robots.	(3)
5	What are the applications of industrial robots where force control may be needed?	(3)
6	What do you mean by natural and artificial constraints for tasks in partially constrained environments?	(3)
7	What is a differentially driven mobile robot? How it is different from steered robot?	(3)
8	If a controller is to be designed to move a differentially driven mobile robot to point, which all sensors may be needed? Explain with the help of block schematic.	(3)
9	What is visual servoing?	(3)
10	What is the necessity of camera calibration for visual servoing applications?	(3)

PART B

Answer any one full question, each carries14 marks.

MODULE I

11 a) Differentiate between closed loop and feed forward control, with the help of block diagrams (7)

b) Explain PID control of a single link manipulator (7)

12 a) What do you mean by control law partitioning? (6)

b) A researcher has proposed the following control scheme for a serial manipulator, where [kp] and [Kv] are positive definite gain matrices (8)

$$\begin{aligned}\boldsymbol{\tau} = [\mathbf{M}(\mathbf{q})]\ddot{\mathbf{q}}_d + \mathbf{C}(\mathbf{q}, \dot{\mathbf{q}}) + \mathbf{G}(\mathbf{q}) \\ +[K_p](\mathbf{q}_d - \mathbf{q}) + [K_v](\dot{\mathbf{q}}_d - \dot{\mathbf{q}})\end{aligned}$$

Draw the block schematic of the proposed controller and explain. What are the possible advantages of the scheme?

MODULE II

13 a) Explain any one non-linear control scheme of robotic manipulator. (7)

b) What the advantages and disadvantages of computed torque control? (7)

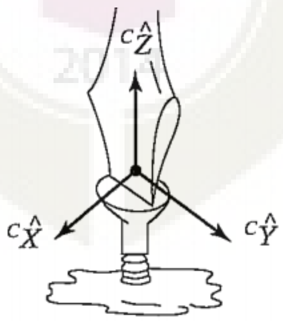
14 a) Explain about task space control schematic of robots (8)

b) Explain adaptive control of robotic manipulators (6)

MODULE III

15 a) Explain the assembly sequences used to put a round peg into a round hole (7)

b) Figure shows a manipulator tightening a screw. What are the natural and artificial constraints for this task? (7)



16 a) Explain the force control of a typical mass spring dashpot system (8)

b) Explain typical hybrid position/force control scheme with the help of block diagram (6)

MODULE IV

17	a)	Obtain the kinematic model of a differentially driven mobile robot.	(7)
	b)	With the help of block schematic explain how a differentially driven mobile robot is controlled to follow a line.	(7)
18		With the help of block schematic explain how a quadcopter can be controlled to track a trajectory?	(14)

MODULE V

19	a)	Explain the configuration of a vision system in a visual servoing scenario	(7)
	b)	How pose is estimated in a typical vision based control system?	(7)
20		Explain in detail position based visual servoing and Image based visual servoing	(14)

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Syllabus

Module I (8 Hours)

Review of dynamic modelling of robots: Introduction to robot control- Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control.
Linear control of manipulators - closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory-following control, Feedback control of single link manipulator
Case study- Matlab simulation-PID Control of single link manipulator and planar 2R manipulator , closed loop control of wall following robot- block schematic- sensor selection etc

Module II (7 Hours)

Nonlinear Control of manipulators- PD Gravity Control, Computed Torque Control, adaptive control
Task Space Control Schemes – resolved motion rate control and resolved motion acceleration control
Case study- resolved motion rate control of 2R manipulator

Module III (6 Hours)

Force control of manipulators- introduction, application of industrial robots to assembly tasks, force control of a mass—spring system, the hybrid position/force control problem, the hybrid position/force control scheme
Case study- force control of peg in hole assembly task, natural and artificial constraints

Module IV (7 Hours)

Kinematic model of steered robot and differentially driven mobile robot , Control of a mobile robot to move to a point, to follow a line, following a path, moving to a pose, Dynamic model of quadcopter, Controller design to track any desired trajectory.

Module V (8 Hours)

Vision based Control- configuration of a vision system, image segmentation, image interpretation, Pose estimation, Stereo vision, Camera Calibration, Position based visual servoing, Image based visual servoing, Hybrid visual servoing.

Text Books:

1. Introduction to Robotics Mechanics and Control, John J. Craig, 3e, Pearson
2. Robotics: Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford
3. Robotics- Modelling planning and control- Bruno Siciliano , Lorenzo Sciavicco Luigi Villani, Giuseppe Oriolo, Springer-Verlag London
4. Peter Corke, "Robotics, Vision and Control-Fundamental Algorithms in MATLAB", Springer Tracts in Advanced Robotics, volume 73.
5. The Robotics Primer-Maja J Matari´c, The MIT Press

References:

1. Probabilistic Robotics: Sebastian Thrun, Wolfram Burgard, Dieter Fox, MIT Press
2. Modern Robotics Mechanics, Planning and Control, Kevin M.Lynch, Frank C. Park, Cambridge University Press, 2017

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE I**	
1.1	Review of dynamic modelling of robots. Introduction to robot control- Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control. Linear control of manipulators- closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory-following control, Feedback control of single link manipulator (Ref 1 and 2)	7
1.2	Case study- Matlab simulation-PID Control of single link manipulator and planar 2R manipulator (Ref2)	0.5

	closed loop control of wall following robot- block schematic- sensor selection etc (Ref 5)	0.5
2	**MODULE II**	
2.1	**Nonlinear Control of manipulators-** PD Gravity Control, Computed Torque Control, adaptive control (Ref1)	3
2.2	**Task Space Control Schemes** – resolved motion rate control and resolved motion acceleration control (Ref1)	3
2.3	Case study- resolved motion rate control of 2R manipulator (Ref 1)	1
3	**MODULE III**	
3.1	Force control of manipulators- introduction, application of industrial robots to assembly tasks, force control of a mass—spring system, the hybrid position/force control problem, the hybrid position/force control scheme (Ref 1 and 2)	5
3.2	Case study- force control of peg in hole assembly task, natural and artificial constraints (Ref 2)	1
4	**MODULE IV**	
4.1	Kinematic model of steered robot and differentially driven mobile robot (Ref 4)	2
4.2	Control of a mobile robot to move to a point, to follow a line, following a path, moving to a pose (Ref 4)	3
4.3	Dynamic model of quadcopter, Controller design to track any desired trajectory(Ref 4)	2
5	**MODULE V**	
5.1	Vision based Control- configuration of a vision system, image segmentation, image interpretation, Pose estimation, Stereo vision, Camera Calibration (Ref 4)	3.5
5.2	Position based visual servoing, Image based visual servoing, Hybrid visual servoing (Ref 4)	3.5

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT332	FLUID POWER AUTOMATION	PEC	2	1	0	3

Preamble: Fluid power systems can transmit equivalent power within a much smaller space than mechanical or electrical drives can, especially when extremely high force or torque is required and hence plays an important role in automation applications in large industries. This course provides an understanding of the different pneumatic and hydraulic systems for various applications in automation.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basic concepts of different types of drives and their comparison.
CO 2	Understand the working principle and applications of different types of pumps and motors
CO 3	Study proportional and servo valves.
CO 4	Develop different pneumatic and hydraulic circuits based on their applications.
CO 5	Develop multi actuator circuits using different methods.
CO 6	Develop different electro pneumatic and electro hydraulic circuits based on their applications.
CO 7	Familiarize the basic concepts of interfacing hydraulic and pneumatic circuits with PLC.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	1	2							3
CO 2	3	2	2	1	2	1						2
CO 3	3	2	2	2	2	1						3
CO 4	3	2	2	2	1	1						2
CO 5	3	3	2	2	2	1						2
CO 6	3	3	2	2	2							2
CO 7	3	3	2	2	2	2						2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	25	25	30
Apply	15	15	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions
Course Outcome 1 (CO1):
1. Compare and contrast between pneumatic and electric drives
2. Discuss in detail the different components of a hydraulic system
3. Discuss the important criteria to be looked in to while choosing hydraulic drive for a automation system

Course Outcome 2 (CO2):
1. Explain in detail the working of a Vane motor
2. Explain the working of different types of piston pumps

3. What are the advantages of a pneumatic automation over hydraulic automation?

Course Outcome 3 (CO3):
1. Explain the working of a 4/3 tandem centre valve
2. What is the role of pressure relief valve in a hydraulic circuit
3. Explain the different types of direction control valves used in automation

Course Outcome 4 (CO4), Course Outcome 5 (CO5), Course Outcome 6 (CO6):
1. What is a regenerative type hydraulic circuit? Explain with an example
2. Design and draw hydraulic circuit for $A_1B_1B_0A_0$ sequencing operation using cascade method
3. Discuss the design steps involved in arriving at a hydraulic circuit for sequencing operation using Karnaugh-Veith method
4. Draw the displacement time diagram for the sequence $A_1B_1B_0A_0$
5. Explain the use of cylinder cushion
6. Explain the working of proportional solenoid operated flow control valve

Course Outcome 7 (CO7):
1. Differentiate between on timer delay and off timer delay with the help of a timing diagram
2. State the advantages of PLC systems over other conventional systems
3. State any one mechanism of interfacing a hydraulic circuit with PLC

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 332

Course Name: FLUID POWER AUTOMATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

		Marks
1	Draw the ISO symbol for pilot controlled 5/2 direction control valve.	(3)
2	What are the advantages and disadvantages of pneumatic automation over hydraulic automation?	(3)
3	Distinguish between 4/3 tandem centre valve and closed centre valve.	(3)

4		Name four different types of hydraulic cylinder mountings.	(3)
5		What is the purpose of a cylinder cushion?	(3)
6		Describe proportional solenoid operated flow control valve.	(3)
7		Draw the displacement time diagram for the sequence $A_1B_1A_0B_0$.	(3)
8		With suitable diagram explain meter in type speed control in a hydraulic circuit.	(3)
9		What are the basic electrical devices used in electro hydraulics.	(3)
10		With a neat sketch explain the use of a pressure switch in an electro pneumatic circuit.	(3)

PART B

Answer any one full question, each carries14 marks.

MODULE I

11	a)	Explain in detail the basic components of a hydraulic system.	(7)
	b)	With neat sketch explain the working of i) Swash plate axial piston pump ii) Vane Motor	(7)
12	a)	Briefly explain different types of piston pump.	(6)
	b)	Find the offset angle for an axial piston pump that delivers $0.0019m^3/s$ at 3000rpm. The pump has nine 16mm diameter pistons arranged on a 127mm piston circle diameter. The volumetric efficiency is 95%.	(8)

MODULE II

13	a)	Describe the working of three basic types of hydraulic accumulators.	(6)
	b)	With a neat sketch explain the use of pressure relief valve in a hydraulic circuit.	(4)
	c)	Explain in detail different types of flow control valves.	(4)
14	a)	Explain in detail different types of direction control valves.	(8)
	b)	Briefly explain different types of pressure control valves.	(6)

MODULE III

15	a)	Explain the differences between an ordinary DCV solenoid and a proportional	(6)

valve solenoid.

	b)	With a neat sketch explain the working of single stage (Flapper nozzle type) servo valve.	(8)
16	a)	Write short note on electro hydraulic servo valve and explain the components of closed loop electro hydraulic servo system.	(8)
	b)	Explain the design considerations of proportional control valve.	(6)

MODULE IV

17	a)	Explain in detail a regenerative type hydraulic circuit with a practical application.	(8)
	b)	With suitable diagram explain different types of speed control in a hydraulic circuit.	(6)
18	a)	Design and draw hydraulic circuit for $A_1B_1B_0A_0$ sequencing operation using cascade method.	(8)
	b)	Design and draw hydraulic circuit for $A_1A_0B_1B_0$ sequencing operation using Karnaugh-Veitch method.	(6)

MODULE V

19	a)	Components are to be stamped using stamping machine. A double acting cylinder is used to push the die attached down to a fixture when a push button is pressed. The die is to return to the initial position upon reaching sufficient stamping pressure as sensed by a pressure switch and one second delay. Develop an electro pneumatic control circuit to implement the control task for the stamping operation	(8)
	b)	Differentiate between on timer delay and off timer delay with the help of a timing diagram.	(6)
20	a)	What are the advantages of PLC over electromechanical relay control?	(6)
	b)	Double acting cylinder is used to perform to and fro operation. Cylinder has to move forward when PB1 button is pressed and continue to and fro motion till 10 cycles of operations is performed. Draw the pneumatic circuit, PLC wiring diagram and ladder diagram to implement this task.	(8)

SYLLABUS

Module I (7Hours)

Classification of drives-hydraulic, pneumatic and electric –comparison ISO symbols for their elements, Selection Criteria

Generating Elements- Hydraulic pumps and motor gears, vane, piston pumps, motors-selection and specification

Module II (7Hours)

Drive characteristics – Utilizing Elements-- Linear actuator – Types, mounting details, cushioning, power packs, accumulators

Control and regulation Elements—Direction, flow and pressure control Valves, Methods of actuation, types, sizing of ports. spool valves-operating characteristics

Module III (7Hours)

Proportional control of hydraulic systems, Electro hydraulic servo valves-Different types-characteristics and performance

Module IV (7Hours)

Typical Design methods of hydraulic and pneumatic circuits– sequencing circuits design combinational logic circuit design- cascade method-Karnaugh Veitch map method.

Module V (7Hours)

Electrical control of pneumatic and hydraulic circuits- use of relays, timers and counters.

Interfacing hydraulic and pneumatic circuits with PLCs .

Text Books:

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
2. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979

References:

1. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978
2. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
3. Dudbey. A. Peace, Basic Fluid Power, Prentice Hall Inc, 1967.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Classification of drives-hydraulic, pneumatic and electric – comparison ISO symbols for their elements, Selection Criteria	3
1.2	Generating Elements- Hydraulic pumps and motor, gear, vane, piston pumps, motors- selection and specification.	4
2	**MODULE 2**	
2.1	Drive characteristics – Utilizing elements-- Linear actuator – Types, mounting details, cushioning – power packs –accumulators	3
2.2	Control and regulation Elements— Direction, flow and pressure controlvalves-Methods of actuation, types, sizing of ports. spool valves-operating characteristics	4
3	**MODULE 3**	
3.1	Proportional control of hydraulic systems	3
3.2	Electro hydraulic servo valves-Different types-characteristics and performance.	4
4	**MODULE 4**	
4.1	Typical Design methods of hydraulic and pneumatic circuits-sequencing circuits design.	3
4.2	combinational logic circuit design, cascade method, Karnaugh veitch map method	4
5	**MODULE 5**	
5.1	Electrical control of pneumatic and hydraulic circuits- use of relays, timers and counters	4
5.2	Interfacing hydraulic and pneumatic circuits with PLCs	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT 342	MECHANICAL MEASUREMENTS AND METROLOGY	PEC	2	1	0	3

Preamble: Measurements and Measuring devices are key to any engineering design. This course introduces to the student on the various tools and methods for measuring different physical parameters. The course also given the basic concepts of metrology and use of standards for measurements

Course Outcomes: After the completion of the course the student will be able to

CO 1	Describe basic concepts of mechanical measurement and errors in measurements.
CO 2	Select linear, angular and taper measurement devices for measurement of various components
CO 3	Describe methods of measurement for various quantities like force, torque, power, displacement, velocity and acceleration
CO 4	Select appropriate temperature measuring device for various applications
CO 5	Describe basic concepts of Metrology. Discriminate between various screws by measuring their dimensions.
CO 6	Select suitable comparators and choose the method of surface roughness measurement.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1										3
CO 2	2	1										3
CO 3	2	1										3
CO 4	3	2	2									3
CO 5	3	2	2									3
CO 6	3	2	2									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

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Course Level Assessment Questions
Course Outcome 1 (CO1):

1. What are slip gauges? Explain their usage
2. What are the types of errors that can occur in measurements?
3. Explain any three angular measurement techniques

Course Outcome 2 (CO2):

1. What advantages does a Vernier calliper provide while taking linear measurements
2. Explain the working of clinometers
3. Discuss on the various static performance characteristics in measurement systems

Course Outcome 3 (CO3):

1. Explain the working of differential transformers to measure force
2. Explain the different techniques available to measure torque
3. Explain the bridge arrangement for strain measurement using strain gauges

Course Outcome 4 (CO4):

1. Explain the working of thermocouples to measure temperature
2. Explain the advantages and disadvantages of Electrical and Photoelectric Tachometers
3. What is a Seismic Accelerometer? Explain its working

Course Outcome 5 (CO5):

1. Explain the need of Inspection, Accuracy and Precision in modern day engineering
2. List out the various gear tooth terminologies used in industry
3. Explain the sources of Errors in the manufacturing of gears
4. What is the working principle of AutoCollimators and how are they useful in interferometry

Course Outcome 6 (CO6):

1. Explain the stylus system of measurement for surface roughness
2. Explain the working of Optical Comparator
3. Using pneumatic method, explain how surface roughness can be measured.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 342

Course Name: MECHANICAL MEASUREMENTS AND METROLOGY

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		Give the need of Mechanical measurement.	(3)
2		What are the characteristics of slip gauges?	(3)
3		Explain the working of load cells.	(3)
4		Explain the features of absorption dynamometer.	(3)
5		Explain the working of accelerometer.	(3)
6		Compare RTD and thermocouple.	(3)
7		Differentiate between accuracy and precision	(3)
8		Explain the principle of interferometry.	(3)
9		Define the terms surface texture, waviness and RMS value.	(3)
10		Give the functional requirements of comparators..	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Explain the static performance characteristics of measuring instruments .	(8)
	b)	Illustrate the use of slip gauges.	(6)
12	a)	Explain in detail the errors and types of errors in measurement	(10)
	b)	Give the significance of sine bar in angle measurement.	(4)

MODULE II

13	a)	Describe any one method for torque measurement.	(8)
	b)	Using electrical strain gauges how do we measure strain? explain	(6)
14	a)	Discuss the strain gauge materials.	(10)
	b)	What is temperature compensation?.	(4)

MODULE III

15		Explain the working of photoelectric tachometer. Also give the field of application.	(14)
16		List the type of thermocouples. Also explain the principle and working of any one type of thermocouple.	(14)

MODULE IV

17		Illustrate the use of gear tooth vernier to measure tooth thickness.	(14)

18 a) Explain the three wire method of measuring effective diameter of screw thread. (11)

b) Give the principle of working of optical flat. (3)

MODULE V

19 a) Describe the stylus system of measurement for surface roughness. (8)

b) Explain the working of an electronic comparator. (6)

20 a) Explain the characteristics of CMM. Also list the types (8)

b) Illustrate the working of Optical comparator (6)

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Syllabus

Module I (7 Hours)

Mechanical Measurement: Need of mechanical measurement, Basic definitions: Hysteresis, Linearity, Resolution of measuring instruments, Threshold, Drift, Zero stability, loading effect and system response. Measurement methods, Generalized Measurement system, Static performance characteristics, Errors and their classification. Linear Measurement Instruments, Vernier calliper, Micrometer, Interval measurements: Slip gauges, Checking of slip gauges for surface quality .Angular measurements using bevel protractors, spirit levels, clinometers, sine bar, angle gauges and optical dividing head.

Module II (7 Hours)

Measurement of Force, Torque and Strain: Force measurement: load cells, cantilever beams, differential transformers. Measurement of torque: Torsion bar dynamometer, servo controlled dynamometer, absorption dynamometers. Power Measurements. Measurement of strain: Mechanical strain gauges, electrical strain gauges, strain gauge: materials, gauge factors, theory of strain gauges and method of measurement, bridge arrangement, temperature compensation.

Module III (7 Hours)

Displacement, Velocity/Speed, and Acceleration, Measurement: Working principal of Resistive Potentiometer, Linear variable differential transducers, Mechanical, Electrical and Photoelectric Tachometers, Piezoelectric Accelerometer, Seismic Accelerometer. Temperature measurement: Temperature Measuring Devices: Thermocouples, Resistance Temperature Detectors(RTD), Thermistor, Pyrometer, Bimetallic strip.

Module IV (7 Hours)

Metrology: Basics of Metrology, Need for Inspection, Accuracy and Precision, Objectives, Standards of measurements. Metrology of Gears and screw threads: Gear tooth terminology, Sources of errors in manufacturing of gears, Measurement of major elements of screw threads and gears, gear tooth vernier caliper. Optical measuring instruments: Tool maker's microscope, Principle of interferometry-optical flat-Interferometers-Autocollimators.

Module V (7 Hours)

Metrology of Surface finish: Surface Metrology Concepts and terminology, Specification of surface Texture characteristics, and Method of measuring surface finish: Stylus system of measurement, other methods for measuring surface roughness: Pneumatic method, Light Interference microscopes. Comparators: Functional Requirements, Classification, Mechanical, optical, Pneumatic, Electrical and Electronic Comparators, Introduction to Coordinate measuring machine (CMM).

Text Book

1. Engineering Metrology and Measurement, N V Raghavendra and Krishnamurthy, Oxford University Press,
2. Engineering Metrology and Measurements, Bentley,

Reference Books:

3. A Text book of Engineering Metrology, I C Gupta, Dhanpat Rai Publications
4. A course in Mechanical Measurements and Instrumentation, A K Sawhney, Dhanpat Rai Publications
5. Mechanical Measurements and Instrumentations, Er. R K Rajput, Kataria Publication(KATSON)
6. Mechanical Measurement and Metrology by R K Jain, Khanna publishers.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Mechanical Measurement	
1.1	Need of mechanical measurement, Basic definitions: Hysteresis, Linearity, Resolution of measuring instruments, Threshold, Drift, Zero stability, loading effect and system response	2
1.2	Measurement methods, Generalized Measurement system, Static performance characteristics, Errors and their classification.	1

1.3	Linear Measurement Instruments, Vernier calliper, Micrometer, Interval measurements: Slip gauges, Checking of slip gauges for surface quality .Angular measurements using bevel protractors, spirit levels, clinometers, sine bar, angle gauges and optical dividing head.	4
2	Measurement of Force, Torque and Strain	
2.1	Force measurement: load cells, cantilever beams, differential transformers	1
2.2	Measurement of torque: Torsion bar dynamometer, servo controlled dynamometer, absorption dynamometers. Power Measurements	2
2.3	Measurement of strain: Mechanical strain gauges, electrical strain gauges, strain gauge: materials, gauge factors, theory of strain gauges and method of measurement, bridge arrangement, temperature compensation.	4
3		
3.1	Displacement, Velocity/Speed, and Acceleration, Measurement: Working principal of Resistive Potentiometer, Linear variable differential transducers, Mechanical, Electrical and Photoelectric Tachometers, Piezoelectric Accelerometer, Seismic Accelerometer.	4
3.2	Temperature measurement: Temperature Measuring Devices: Thermocouples, Resistance Temperature Detectors(RTD), Thermistor, Pyrometer, Bimetallic strip.	3
4		
4.1	Metrology: Basics of Metrology, Need for Inspection, Accuracy and Precision, Objectives, Standards of measurements	2
4.2	Metrology of Gears and screw threads: Gear tooth terminology, Sources of errors in manufacturing of gears, Measurement of major elements of screw threads and gears, gear tooth vernier caliper	3
4.3	Optical measuring instruments: Tool maker's microscope, Principle of interferometry-optical flat-Interferometers-Autocollimators.	2
5		
5.1	Metrology of Surface finish: Surface Metrology Concepts and terminology, Specification of surface Texture characteristics, and Method of measuring surface finish: Stylus system of measurement	2
5.2	other methods for measuring surface roughness: Pneumatic method, Light Interference microscopes	1
5.3	Comparators: Functional Requirements, Classification, Mechanical, optical, Pneumatic, Electrical and Electronic Comparators, Introduction to Coordinate measuring machine (CMM).	4

RAT352	ENGINEERING OPTIMIZATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Finding optimum solution for a given problem has a huge impact in any field of engineering. This paper introduces the student to the classical optimization techniques and various numerical methods of optimization. The course also provide the student with a basic knowledge in different evolutionary algorithms

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Formulate constrained and unconstrained optimisation problems
CO 2	Solve different Linear programming problems
CO 3	Solve nonlinear optimisation problems
CO 4	Choose the suitable method for the solution of the typical constrained or unconstrained optimisation problem

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1										3
CO 2	2	1										3
CO 3	2	1										3
CO 4	3	2	2									3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A farmer has a choice of planting barley, oats, rice, or wheat on his 200-acre farm. The labor, water, and fertilizer requirements, yields per acre, and selling prices are given in the following table:

Type of crop	Labor cost ($)	Water required (m^3)	Fertilizer required (lb)	Yield (lb)	Selling price ($/lb)
Barley	300	10 000	100	1 500	0.5
Oats	200	7 000	120	3 000	0.2
Rice	250	6 000	160	2 500	0.3
Wheat	360	8 000	200	2 000	0.4

The farmer can also give part or all of the land for lease, in which case he gets $200 per acre. The cost of water is $0.02/m3 and the cost of the fertilizer is $2/lb. Assume that the farmer has no money to start with and can get a maximum loan of $50 000 from the land mortgage bank at an interest of 8%. He can repay the loan after six months. The irrigation canal cannot supply more than 4 × 105 m3 of water. Formulate the problem of finding the planting schedule for maximizing the expected returns of the farmer.

Two copper-based alloys (brasses), A and B, are mixed to produce a new alloy, C. The composition of alloys A and B and the requirements of alloy C are given in the following table:

Alloy	Composition by weight			
	Copper	Zinc	Lead	Tin
A	80	10	6	4
B	60	20	18	2
C	≥ 75	≥ 15	≥ 16	≥ 3

If alloy B costs twice as much as alloy A, formulate the problem of determining the amounts of A and B to be mixed to produce alloy C at a minimum cost.

Course Outcome 2 (CO2):

1. A real estate company wants to construct a multistory apartment building on a 500 × 500-ft lot. It has been decided to have a total floor space of 8 × 105 ft2. The height of each story is required to be 12 ft, the maximum height of the building is to be restricted to 75 ft, and the parking area is required to be at least 10% of the total floor area according to the city zoning rules. If the cost of the building is estimated at \$(500,000h+2000F+500P), where h is the height in feet, F is the floor area in square feet, and P is the parking area in square feet. Find the minimum cost design of the building.

2. A manufacturer produces small refrigerators at a cost of \$60 per unit and sells them to a retailer in a lot consisting of a minimum of 100 units. The selling price is set at \$80 per unit if the retailer buys 100 units at a time. If the retailer buys more than 100 units at a time, the manufacturer agrees to reduce the price of all refrigerators by 10 cents for each unit bought over 100 units. Determine the number of units to be sold to the retailer to maximize the profit of the manufacturer.

Course Outcome 3 (CO3):

1. Solve the following nonlinear programming problem using Kuhn-Tucker conditions:

   Maximize $Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$

   subject to the constraints

   $x_1 + x_2 \le 4$

   $2x_1 + 3x_2 \le 12$

   $x_1, x_2 \ge 0$

2. Using Quadratic Programming, Minimize $f = -4X_1 + X_1^2 - 2X_1X_2 + 2X_2^2$

   subject to :

   $$2x_1 + x_2 \le 6$$
   $$x_1 - 4x_2 \le 0$$
   $$x_1 \ge 0, \quad x_2 \ge 0$$

Course Outcome 4 (CO4):

1. Explain how Genetic algorithm can be used to optimize trajectories of robot
2. How can Particle Swarm Optimization be used for robotic path planning
3. Discuss the different optimization algorithms that can be used for robotic trajectory optimization..

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 352

Course Name: Engineering Optimization

Max. Marks: 100 | Duration: 3 Hours

PART A

		Answer all questions, each carries 3 marks.	Marks
1		What is Degenerate solution in LPP?	(3)
2		Write the standard form of LPP maximize $Z = 2x_1 + 10x_2 + x_3$ subject to $5x_1 + 2x_2 + x_3 \geq -15$ $2x_1 + x_2 + 7x_3 \leq 20$ $x_1 + 3x_2 + 2x_3 \leq 25$ $x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$	(3)
3		Find the dual of following LPP maximize $Z = 6x_1 + 14x_2 + 13x_3$ subject to $x_1 + 4x_2 + 2x_3 \leq 48$ $x_1 + 2x_2 + 4x_3 \leq 60$ $x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$	(3)
4		Give an example for $0 - 1$ programming problem	(3)
5		Write the Lagrangian function for maximize $Z = f(x_1, x_2)$ subject to $g(x_1, x_2) = c$ $x_1 \geq 0, x_2 \geq 0$	(3)
6		What is integer linear programming problem	(3)
7		Explain the basic steps involved in solving a constrained optimization problem using Random Search Method?	(3)
8		Differentiate between local minima and global minima in search optimization problems. How are these related in the case of a convex programming problem	(3)

9		Consider the following two strings denoting the vectors $\mathbf{X}_1$ and $\mathbf{X}_2$ $\mathbf{X}_1$: {1 0 0 0 1 0 1 1 0 1} $\mathbf{X}_2$: {0 1 1 1 1 1 0 1 1 0} Find the result of crossover at location 2. Also, determine the decimal values of the variables before and after crossover if each string denotes a vector of two variables.	(3)
10		Explain the Roulette Wheel Selection Process	(3)
PART B			
Answer any one full question from each module, each carries 14 marks.			
MODULE1			
11	a)	Solve graphically, Minimize Z = 2x + 4y Subject to $x + 3y \geq 8$ $x + y \geq 4$ and $x \geq 0$, $y \geq 0$.	(5)
	b)	Suppose Z = cx + 4y. Find all values of c, such that the optimal solution of LPP remains same.	(9)
12	a)	Solve the following LPP by Big-M method: Minimize $Z = -3x_1 - 3x_2 + x_3$ subject to the constraints $x_1 + 3x_2 - 2x_3 \geq 5$ $-3x_1 - 2x_2 + x_3 \leq 4$ where x_1, x=, $x_3 \geq 0$	(14)
MODULE II			
13	a)	Solve the LPP by dual simplex method: Minimize $Z = 5x_1 + 3x_2 + x_3$ subject to the constraints $-x_1 + x_2 + x_3 \geq 1$ $3x_1 + x_2 - x_3 \geq 2$ where $x_1, x_2, x_3 \geq 0$	(14)
14	a)	Solve by branch and bound method: Maximize $Z = 500x_1 + 400x_2$ subject to constraints $8x_1 + 5x_2 \leq 42$ $3x_1 + 16x_2 \leq 60$ $x_1, x_2 \geq 0$, x_1, x_2 are integers	(14)
MODULE III			
15	a)	Solve the following nonlinear programming problem using Kuhn-Tucker conditions: Maximize $Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$ subject to the constraints	(14)

		$x_1 + x_2 \le 4$ $2x_1 + 3x_2 \le 12$ $x_1, x_2 \ge 0$	
16		Solve the following quadratic programming problem: Minimize $Z = x_1^2 - 2x_1x_2 + 2x_2^2 - 4x_1$ subject to the constraints $2x_1 + x_2 \le 6$ $x_1 - 4x_2 \le 0$ $x_1, x_2 \ge 0$	(14)
17	a)	Explain the algorithm of Sequential Linear Programming method for solving a non-linear programming problem. Discuss its advantages	(14)
18	a)	Explain the algorithm of gradient projection method for solving non-linear programming problems.	(9)
	b)	$$\text{Minimize } f(x_1, x_2) = x_1^2 + x_2^2 - 2x_1 - 4x_2$$ subject to $$g_1(x_1,x_2) = x_1 + 4x_2 - 5 \le 0$$ $$g_2(x_1,x_2) = 2x_1 + 3x_2 - 6 \le 0$$ $$g_3(x_1,x_2) = -x_1 \le 0$$ $$g_4(x_1,x_2) = -x_2 \le 0$$ starting from the point $\mathbf{X}_1 = \begin{Bmatrix} 1.0 \\ 1.0 \end{Bmatrix}$.	(5)
		MODULE V	
19	a)	Explain the steps involved in finding the optimum solution using Genetic Algorithm . Describe in detail the role of Genetic operators involved in the process	(14)
20	a)	Find the minimum of the function $f(x) = x^2 - 2x - 11$ in the range (0, 3) using the ACO method. Assume the number of ants is $N = 4$. Note that there is only one design variable in this example ($n = 1$). The permissible discrete values of $x = x_1$ are assumed, within the range of x_1, as ($p = 7$): $$x_{11} = 0.0, x_{12} = 0.5, x_{13} = 1.0, x_{14} = 1.5, x_{15} = 2.0, x_{16} = 2.5, x_{17} = 3.0$$ **Note:** A maximum of 3 iterations is sufficient, if the solution doesn't converge	(14)

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Syllabus

Module I (8 Hours)

Definition- Optimisation problem, Formulation of optimisation problems- examples

Linear programming: Statement and classification of optimization problems, standard form of linear programming problems- Convex set and Linear Programming Problem – Mathematical Formulation of LPP, Graphical solution of LPP, Basic feasible solutions, Degenerate solution, Slack variables and Surplus variables, Standard form of LPP, Simplex Method, Artificial variables in LPP, Big-M method

Module II (8 Hours)

Unbounded solutions of LPP, Two-phase method, Revised simplex method, Dual Simplex Method.
Integer linear programming- Gomory's Cutting plane method, Branch and Bound method , zero-one programming

Module III (6 Hours)
Constrained non-linear Optimization- examples-method of Lagrange multiplier, Necessary and sufficient conditions-Equality and inequality constraints, Kuhn Tucker conditions, Quadratic programming.

Module IV (7 Hours)
Direct search methods-Random search-pattern search -Descent Methods-Steepest descent, conjugate gradient.
Case studies- Finding the connected components of collision-free paths for a robot using random search, motion planning problems- optimising path length, execution time etc

Module V (6 Hours)
Recent developments in optimization techniques: Genetic Algorithm, Particle Swarm Optimization, Ant colony Optimization, Bees Algorithm, Tabu search and Simulated Annealing

Case studies- Genetic algorithm for optimizing robot trajectories, PSO based path planning of robots.

Text Books

1. Frederick S Hillier, Gerald J. Lieberman, Introduction to Operations Research, Seventh Edition, Tata McGraw-Hill, 2001
2. Singiresu S Rao, *Engineering Optimization Theory and Practice*,5/e, John Wiley&Sons 2020.

Reference Books

1. Ravindran, Philips, Solberg, *Operations Research: Principles and Practice,* Wiley student Edition,2/e, 2007
2. Kanti Swarup, P. K. Gupta, Man Mohan , Operations Research, Sultan chand & Sons
3. Pierre, D.A. 'Optimisation Theory with Applications' John Wiley & Sons, 1969

4. Fox, R.L., 'Optimisation method for Engineering Design', Addition Welsey,1971.
5. Hadely,G., 'Linear Programming', Addition Wesley, 1962.
6. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning. Reading, MA: Addison-Wesly, 1989.
7. Marco Dorigo, Vittorio Miniezza and Alberto Colorni "Ant System: Optimization by a colony of Cooperation Agents" IEEE transaction on system man and Cybernetics-Part B: cybernetics, Volume 26, No 1, pp. 29-41,1996.
8. Shi, Y. Eberhart, R.C., "A Modified Particle Swarm Optimizer", Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998

Course Contents and Lecture Schedule

Total 35 Hours

No	Topic	No. of Lectures
1		
1.1	Definition- Optimisation problem, Formulation of optimisation problems- examples	2
1.2	Linear programming: Statement and classification of optimization problems, standard form of linear programming problems- Convex set and Linear Programming Problem – Mathematical Formulation of LPP	3
1.3	Graphical solution of LPP, Basic feasible solutions, Degenerate solution, Slack variables and Surplus variables, Standard form of LPP, Simplex Method, Artificial variables in LPP	3
2		
2.1	Unbounded solutions of LPP, Two-phase method	2
2.2	Revised simplex method, Dual Simplex Method.	3
2.3	Integer linear programming- Gomory's Cutting plane method, Branch and Bound method , zero-one programming	3
3		
3.1	Constrained non-linear Optimization- examples-method of Lagrange multiplier, Necessary and sufficient conditions-Equality and inequality constraints, Kuhn Tucker conditions	4
3.2	Quadratic programming	2
4		
4.1	Direct search methods-Random search-pattern search -Descent Methods-Steepest descent, conjugate gradient.	4
4.2	Case studies- Finding the connected components of collision-free paths for a robot using random search, motion planning problems- optimising path length, execution time etc	3
5		
5.1	Recent developments in optimization techniques: Genetic Algorithm, Particle Swarm Optimization, Ant colony Optimization, Bees Algorithm, Tabu search and Simulated Annealing	4
5.2	Case studies- Genetic algorithm for optimizing robot trajectories, PSO based path planning of robots	2

RAT362	COMMUNICATIONS NETWORKS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Communication plays an important role in remote data acquisition as well as mobile robotics. This course gives the student a basic knowledge of communication elements and the processes involved between a sender and a receiver. Few common industry specific protocols popular among mobile robotics and remote data capture are discussed as part of the course

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basic concepts of wireless communication and techniques used for enhancing bandwidth
CO 2	Understand the process involved in the data transfer across a computer network and the different standards applicable
CO 3	Understand the various mechanisms used to address the different challenges in wireless networks
CO 4	Understand the working of two popular PAN protocols
CO 5	Understand the working of two popular low power PAN protocols

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1									2
CO 2	3	2	1									2
CO 3	3	2	2									2
CO 4	3	2	2									2
CO 5	3	2	1									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	30
Understand	30	30	70
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. State the advantages and disadvantages of wireless communication compared to wired communication.
2. Discuss the different Multiple Access Schemes used in communication
3. Explain the process involved in converting an analog signal to a digital signal

Course Outcome 2 (CO2):
1. What is the need of a protocol in data exchange between 2 devices
2. Explain the role of the lower 3 layers of ISO/OSI reference model
3. Explain the following media access protocols used in IEEE802 standards
    a. ALOHA b.) CSMA/CD

Course Outcome 3 (CO3):
1. What is CSMA/CA and how is it useful in wireless communication compared to CSMA/CD
2. What is an Adhoc wireless network? Explain the advantages and disadvantages of such a scheme
3. Discuss the issues involved in the design of a routing protocol for a Adhoc Wireless network

Course Outcome 4 (CO4):
1. Discuss the architecture of Bluetooth protocol
2. Using the state diagram, explain the working of Bluetooth protocol as the device goes through various stages
3. Discuss the architecture of Zigbee protocol stack in detail

Course Outcome 5 (CO5):

1. Discuss the features of 6LoWPAN and how it is useful for remote data collection
2. Explain the architecture of CoAP with diagram
3. How is GPS free positioning achieved in LoRaWAN.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 362
Course Name: Communications Networks

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all questions, each carries 3 marks. Marks

1		Why do we need modulation in a communication system? Is modulation of any use in wired communication? Justify your answer.	(3)
2		What are the characteristics of a wireless channel?	(3)
3		Why do we need layering in network protocols?	(3)
4		How is CSMA/CD better compared to CSMA?	(3)
5		What are the issues faced in an IEEE802.11 network compared to IEEE802.3 w.r.to media access?	(3)
6		How is an ad-hoc network different from a convention wireless lan?	(3)
7		What are the different states that a node can be in a Bluetooth network and explain the need for each state.	(3)
8		Compared to Bluetooth, How is zigbee useful in Robotics applications?	(3)
9		What is a LoPAN ? Why do we need LoPANS?	(3)
10		Explain the basic architecture of a LoRaWaN network?	(3)

PART B
Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Explain in detail the different digital modulation techniques used in communication networks	(7)
	b)	What are the different Multiple access techniques used in communication systems?	(7)
12	a)	What is the need of sampling and encoding in digital communication system? Explain with an example	(8)
	b)	Is digital communication better than analog communication? Justify your answer with appropriate reasons	(6)

MODULE II

13	a)	Discuss in detail the roles of different layers of OSI architecture.	(8)
	b)	Mention a scheme to solve the hidden terminal and exposed terminal problems in wireless networks.	(6)
14	a)	Explain in detail on the physical and data link layer of IEEE802.3 standard.	(8)
	b)	Discuss any two media access mechanisms that can be used in a wired network	(6)

MODULE III

15	a)	Discuss in detail the different design challenges of MAC layer in an Ad-hoc wireless network. Explain any one technique that can address these challenges	(9)
	b)	How is CSMA/CA different from CSMA/CD	(5)
16		Explain the challenges and design goals that need to be addressed while designing a routing protocol for an ad-hoc wireless network.	(14)

MODULE IV

17	a)	With appropriate diagram, Explain the different layers of Bluetooth protocol stack	(14)
18	a)	With appropriate diagram, Explain the different layers and functions of zigbee protocol stack	(14)

MODULE V

19	a)	Explain the architecture of CoAP with appropriate diagram	(8)
	b)	What is compression and Fragmentation in 6LowPAN	(6)
20	a)	Explain how adaptive Data rate and GPS free positioning implemented in LoRaWAN	(14)

****

Syllabus

Module I (7 Hours)

Communication Systems: Components of a communication system(Block diagram level) – Introduction to wireless communication - Radio propagation – Characteristics of the wireless channel – Analog Modulation – Digital Modulation – Multiple Access Techniques – FDMA, TDMA, CDMA, SDMA – Sampling - Encoding – Error Control

Module II (7 Hours)

Computer Network Architecture: The OSI Reference model The TCP/IP reference Model – The ATM reference Model – comparison

IEEE 802 Networking Standards – Physical layer – Data link Layer – LLC – MAC – ALOHA – CSMA – CSMA/CD – IEEE802.3 Standard – Physical Layer – Data Link Layer

Module III (7 Hours)

Wireless LAN: Design Considerations – Network Architecture - IEEE 802.11 Standard – Physical Layer – MAC layer mechanisms – CSMA/CA – Additional MAC layer Functions

Ad-hoc wireless networks – Applications and issues of ad-hoc wireless networks – MAC protocols for AD-HOC wireless networks – Design issues of MAC – Design Goals - Routing protocols for Ad-HOC Wireless Networks – issues in designing routing protocols – classification

Module IV (7 Hours)

WPAN: IEEE802.15 - Bluetooth – User scenarios – Architecture – Networking - Protocol Stack – Radio Layer – Baseband Layer – Link Manager protocol – L2CAP – Security – Service Discovery Protocol – Bluetooth Profiles - Transport Protocol Group – Middleware protocol Group

Zigbee – Protocol Stack – Network layer – Application layer – Reduced Function Device-Full Function Device – Network Coordinator – Frame Formats – Channel Access Mechanism – Types of Data transfer- Network formation roles of Network Coordinator – Parent device – Child device

Module V (7 Hours)

Low Power Communication Protocols: 6LoWPAN – IPV6 – IP over IEEE 802.15.4 – Compression – Fragmentation – Reassembly – Routing – Constrained Application Protocol(CoAP) (Architecture only) – RPL Routing Protocol

LoRaWAN – Architecture – MAC Layer – LoRaWAN Classes – Physical Message Format – MAC message format – Channel Access – Adaptive Data Rate – GPS free positioning

Text Books

1. Ad-Hoc Wireless Networks Architectures and Protocols, C Siva Ram Murthy, B.S.Manoj, Prentice Hall
2. Wireless Networking and Mobile Data Management, R.K.Gosh, Springer

3. Mobile Communications Jochen Schiller, Pearson Education
4. Data Communication and Networking, Behrouz.A.Forouzan, Sophia Chung Fegan,McGraw Hill

Reference Books

1. Wireless Communication Networks and Systems, Cory Beard & William Stallings, Pearson
2. Beginning LoRa Radio Networks with Arduino: Build Long Range, Low Power Wireless IoT Networks, Pradeeka Seneviratne, Apress
3. Future Internet – open access journal published by mdpi - https://www.mdpi.com/1999-5903/11/10/216/htm

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Communication Systems**	
1.1	Components of a communication system, Introduction to wireless communication	1
1.2	Radio propagation, Characteristics of the wireless channel, Analog & Digital Modulation	2
1.3	Multiple Access Techniques – FDMA, TDMA, CDMA, SDMA	2
1.4	Sampling - Encoding – Error Control	2
2	**Computer Network Architecture**	
2.1	The OSI Reference model	1
2.2	The TCP/IP reference Model – IP Addressing, IP4	2
2.3	The ATM reference Model – Comparison,	1
2.4	IEEE 802 Networking Standards – Physical layer – Data link Layer - LLC – MAC – ALOHA	1
2.5	CSMA – CSMA/CD - IEEE802.3 Standard – Physical Layer – Data Link Layer	2
3	**Wireless LAN**	
3.1	Design Considerations – Network Architecture - IEEE 802.11 Standard	1
3.2	Physical Layer – MAC layer mechanisms – CSMA/CA	1
3.3	Additional MAC layer Functions	1
3.4	Ad-hoc wireless networks – Applications and issues of ad-hoc wireless networks	1
3.5	MAC protocols for AD-HOC wireless networks – Design issues of MAC – Design Goals	2
3.6	Routing protocols for Ad-HOC Wireless Networks – issues in designing routing protocols – classification	1
4	**WPAN**	
4.1	IEEE802.15 - Bluetooth – User scenarios – Architecture	1
4.2	Networking - Protocol Stack – Radio Layer – Baseband Layer – Link	1

	Manager protocol	
4.3	Security – Service Discovery Protocol – Bluetooth Profiles	2
4.4	Zigbee – Protocol Stack – Network layer – Application layer – Reduced Function Device-Full Function Device – Network Coordinator	1
4.5	Frame Formats – Channel Access Mechanism – Types of Data transfer-Network formation roles of Network Coordinator – Parent device – Child device	2
5	**Low Power Communication Protocols**	
5.1	6LoWPAN – IPV6 – IP over IEEE 802.15.4 – Compression – Fragmentation – Reassembly – Routing	2
5.2	Constrained Application Protocol(CoAP) (Architecture only) – RPL Routing Protocol	2
5.3	LoRaWAN – Architecture – MAC Layer – LoRaWAN Classes – Physical Message Format – MAC message format	2
5.4	Channel Access – Adaptive Data Rate – GPS free positioning	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT 372	SOFT COMPUTING TECHNIQUES	PEC	2	1	0	3

Preamble: Soft computing techniques are gaining popularity in all domains of engineering application. This paper introduces the student to the basic mechanisms of finding solution to problems through the different soft computing techniques. This course explain in detail the 3 basic soft computing techniques namely - Neural networks, Fuzzy systems and Genetic Algorithms and how they can be applied to mimic the human mind

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand and design basic neural networks
CO 2	Develop the concepts of supervised/unsupervised learning
CO 3	Understand fuzzy based systems
CO 4	Apply Fuzzy logic for developing systems
CO 5	Understand the optimization techniques using Genetic Algorithm

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	1									2
CO 2	3	2	2									2
CO 3	2	2	1									2
CO 4	3	2	2									2
CO 5	2	2	1									2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. Differentiate between soft computing and Hard computing techniques
2. Explain the different types of learning techniques used in Neural networks
3. Describe the architecture of Back propagation networks

Course Outcome 2 (CO2):
1. What is an activation function in a neural network? What is its significance?
2. Explain the generalized Hebbian learning algorithm
3. Discuss on Self-organizing computation maps and its uses

Course Outcome 3 (CO3):
1. Differentiate between Crisp set and fuzzy set
2. Explain what is a Tolerance relation and Equivalence relation.
3. Explain the steps involved in developing a fuzzy rule based systems

Course Outcome 4 (CO4):
1. Explain the working of a fuzzy inference system using Mamdani approach
2. Explain the different defuzzification methods
3. Explain what is a Neuro-fuzzy systems

Course Outcome 5 (CO5):
1. What is the significance of Genetic algorithms in artificial intelligence
2. Explain the different stages of a GA implementation
3. What do you mean by convergence of a GA.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 372

Course Name: SOFT COMPUTING TECHNIQUES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

		Marks
1	Enumerate the difference between soft computing and hard computing.	(3)
2	Explain hypermeter tuning	(3)
3	What is Self Organizing maps	(3)
4	Write short notes on supervised and unsupervised learning methods.	(3)
5	Consider two fuzzy sets $A=\left\{\frac{0.2}{0},\frac{0.2}{1},\frac{1}{2},\frac{0.1}{3},\frac{0.5}{4}\right\}$ $B=\left\{\frac{0.1}{0},\frac{0.25}{1},\frac{0.9}{2},\frac{0.7}{3},\frac{0.3}{4}\right\}$ Find a. Algebraic Sum b. Bounded sum c. Bounded difference	(3)
6	What is tolerance and equivalence relations	(3)
7	Enlist the characteristics of Fuzzy Control Systems	(3)
8	Give the life cycle of a Genetic Algorithm	(3)
9	Compare Mamdani and Sugeno approaches	(3)
10	Explain fitness function in GA	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Explain the architecture and training algorithm of back propagation network.	(8)
	b)	compare different activation functions	(6)
12	a)	With suitable examples explain supervised, unsupervised and reinforcement learning.	(8)
	b)	What is meant by local minima problem? How it can be avoided	(6)

MODULE II

13	a)	Design a hebb network to realize AND gate	(8)
	b)	Explain a neural network as associative memory	(6)

14 a) Give the architecture of Boltzmann Machines (8)

b) With a neat functional diagram explain the Kohonen Self Organizing Maps. (6)

MODULE III

15 a) Compare and contrast between different Fuzzy decision making functions. (8)

b) Explain Fuzzy rule based systems (6)

16 a) Three elements of a medicinal search are given by (8)

$$A = \left\{ \frac{0.1}{2} + \frac{0.3}{4} + \frac{0.7}{6} + \frac{0.4}{8} + \frac{0.2}{10} \right\}$$

$$B = \left\{ \frac{0.1}{0.1} + \frac{0.3}{0.2} + \frac{0.3}{0.3} + \frac{0.4}{0.4} + \frac{0.5}{0.5} + \frac{0.2}{0.6} \right\}$$

$$C = \left\{ \frac{0.1}{0} + \frac{0.7}{0.5} + \frac{0.3}{1} \right\}$$

Find R= A X B, S = B x C,

$$M = R \circ S(\max - \min\ composition)$$

$$N = R \circ S(\max - productcomposition)$$

b) (6)

MODULE IV

17 a) Develop a Fuzzy inference System for controlling the temperature using air conditioner. (8)

b) Develop an ANFIS model with suitable example. (6)

18 a) Explain Mamdani and Sugeno approach with suitable examples (10)

b) Discuss the architecture and Operation of a Fuzzy logic Control system (4)

MODULE V

19 a) Illustrate the general architecture of Genetic Algorithm approach. (8)

b) State and explain theRoulette Wheel selection method (6)

20 a) How the cross over operation takes place for creating the operating. Explain the types of cross over in GA (8)

b) Write short notes on evolutionary algorithm (6)

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Syllabus

Module I (7 Hours)

Introduction to soft computing- soft computing Vs hard computing – applications of soft computing.

Neural Networks: Evolution- definition of neuron- artificial and biological neurons-supervised, unsupervised, reinforcement learning- examples- activation functions- McCulloch-Pits model-Single layer Perceptron-Multilayer Perceptron-Back Propagation networks-Architecture of Backpropagation(BP) Networks- Backpropagation Learning -variational back propagation– hyper parameters – learning rate – momentum factor- Radial basis function.

Module II (8 Hours)

Neural Networks as Associative Memories – architecture- Hopfield Networks, Bidirectional Associative Memory -activation functions. Unsupervised Learning: Hebbian Learning, Generalized Hebbian learning algorithm, Competitive learning, Self- Organizing Computational Maps: Kohonen Network. Introduction to Boltzmann Machines

Module III (7 Hours)

Fuzzy Systems: Fuzzy Set theory, Fuzzy versus Crisp set, operations on fuzzy sets-Fuzzy Relation- Min-Max Composition,- features of membership functions-Tolerance and equivalence function-Fuzzification, Fuzzy Logic, Fuzzy Rule based systems, Fuzzy Decision Making- types

Module IV (7 Hours)

Fuzzy Inference systems – Mamdani approach and Sugeno approach- Defuzzification Methods - Fuzzy Control Systems – characteristics- Fuzzy Classification.

Hybrid systems- Neuro-fuzzy systems- case studies- ANFIS model- case studies
Applications of Neural Networks and Fuzzy Systems.

Module V (6 Hours)

Evolutionary algorithms -Genetic algorithms: basic concepts, encoding, reproduction-Roulette wheel, tournament, rank, and steady state selections, cross over, mutation, fitness function, Convergence of GA, Applications of GA case studies. Introduction to genetic programming-basic concepts.

Text Books

1. R. Rajasekaran and G. A and Vijayalakshmi Pai, "*Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*," Prentice Hall of India
2. S.N Sivandam and S.N Deepa, " Principles of Soft Computing," Wiley Publications.

3. D. E. Goldberg, *Genetic Algorithms in Search, Optimisation, and Machine Learning*, Addison-Wesley
4. Timothy J Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill, 1997.
5. Eiben A. E. and Smith J. E., "Introduction to Evolutionary Computing", Second Edition, Springer, Natural Computing Series, 2007.
6.

References

1. N. K. Sinha and M. M. Gupta, Soft Computing & Intelligent Systems: Theory & Applications-Academic Press /Elsevier. 2009.
2. Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc.
3. R. Eberhart and Y. Shi, Computational Intelligence: Concepts to Implementation, Morgan Kaufman/Elsevier, 2007.
4. Ross T.J. , Fuzzy Logic with Engineering Applications- McGraw Hill.
5. Driankov D., Hellendoorn H. and Reinfrank M., An Introduction to Fuzzy Control- Narosa Pub.
6. Bart Kosko, Neural Network and Fuzzy Systems- Prentice Hall, Inc., Englewood Cliffs

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction**	
1.1	Introduction to soft computing- soft computing Vs hard computing- applications of soft computing.	1
1.2	Neural Networks: Evolution- artificial and biological neurons- supervised, unsupervised, reinforcement learning- examples	1
1.3	McCulloch-Pits model-Single layer Perceptron- Multilayer Perceptron	1
1.4	Back Propagation networks-Architecture of Backpropagation(BP) Networks	2
1.5	variational back propagation– hyper parameters – learning rate	2
1.6	Momentum factor- radial basis function	1
2	**Neural Networks**	
2.1	Neural Networks as Associative Memories – architecture- Hopfield Networks	1
2.2	Bidirectional Associative Memory -activation functions	1
2.3	Unsupervised Learning: Hebbian Learning, Generalized Hebbian learning algorithm	1
2.4	Competitive learning, Self- Organizing Computational Maps	2
2.5	Kohonen Network.	1
2.6	Introduction to Boltzmann Machines	1

3	**Fuzzy Systems:**	
3.1	Fuzzy Set theory, Fuzzy versus Crisp set theory, operations on Fuzzy sets, Fuzzy Relation, Min-Max Composition -	3
3.2	Tolerance and equivalence , Fuzzification,	2
3.3	Fuzzy Logic, Fuzzy Rule based systems	1
3.4	Fuzzy Decision Making- types	1
4		
4.1	Fuzzy Inference systems – Mamdani approach and Sugeno approach-Defuzzification Methods	2
4.2	Fuzzy Control Systems - Fuzzy Classification	1
4.3	Hybrid systems- Neuro-fuzzy systems- case studies- ANFIS model- case studies	2
4.4	Applications of Neural networks and Fuzzy systems	2
5	**Genetic Algorithms**	
5.1	Evolutionary algorithms.	1
5.2	Genetic algorithms: basic concepts, encoding, fitness function, reproduction-Roulette wheel, Boltzmann, tournament, rank, and steady state selections	2
5.3	Convergence of GA	1
5.4	Applications of GA case studies. Introduction to genetic programming-basic concepts.-	2

SEMESTER VI

MINOR

RAT 382	INTRODUCTION TO MOBILE ROBOTICS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Robotics has been widely used in industrial automation for quite some time. Interest on mobile robots are growing off-late as it enables human beings to physically reach places that were inaccessible earlier – be it a disaster site or a remote intelligence or distant planets. This course provides the basic knowledge on the various aspects of design, motion planning and control systems for intelligent mobile robots.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarise types of locomotion for mobile Robots
CO 2	Derive the kinematic and dynamic model of a mobile robot
CO 3	Choose appropriate Sensors for mobile robots
CO 4	Perform path planning for mobile robot
CO 5	Control the mobile robots to follow different paths
CO 6	Understand the various practical applications of mobile robot

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2										3
CO 2	2	2										3
CO 3	2	2	2									3
CO 4	3	2	2									3
CO 5	3	2	2									3
CO 6	3	2	2									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. What are the key design challenges for a mobile robot?
2. Compare and Contrast between Wheeled Robots and Legged Robots
3. Explain few applications of underwater robots

Course Outcome 2 (CO2):
1. Explain the concept of Degree of Freedom and manoeuvrability
2. Explain the kinematic model for a differential drive WMR
3. Explain the dynamic modelling of differential drive WMR using Newton-Euler method

Course Outcome 3 (CO3):
1. How are the sensors classified in mobile robotics
2. Explain the working of ground based beacon sensors
3. Explain the working of vision based sensors and their applications

Course Outcome 4 (CO4):
1. What are the challenges faced in localization during the design of a robot?
2. Explain the Kalman method of map based localization
3. Explain the Dijkstra's algorithm for path planning

Course Outcome 5 (CO5):
1. Explain the Bug algorithm used for obstacle avoidance in mobile robots
2. What is the dynamic window approach used for obstacle avoidance in mobile robots
3. Using the kinematic model, Explain any one method of control of a differential drive robot

Course Outcome 6 (CO6):

1. Explain the design considerations for the development of a differential drive robot moving to a specific point following a line
2. What are cooperative and collaborative robots
3. Write a brief note on mobile manipulators

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 382

Course Name:

INTRODUCTION TO MOBILE ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

		Marks
1	What are the key issues related to locomotion?	(3)
2	List three applications where mobile robots can be used?	(3)
3	What is degree of steerability for a mobile robot?	(3)
4	Briefly explain about different wheel configurations.	(3)
5	Which are the typical sensor characteristics?	(3)
6	What is the use of IMU in mobile robot?	(3)
8	What is SLAM?	(3)
8	Compare local and global path planning.	(3)
9	What are the applications of collaborative robots?	(3)
10	Briefly explain the Vector field histogram.	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Explain the different factors affecting the choice of wheel for wheeled locomotion.	(10)
	b)	Which are the four basic wheel types?	(4)
12	a)	In general, adding degrees of freedom to a robot leg increases the maneuverability of the robot. Explain with the help of examples	(10)
	b)	Explain how leg configuration affect stability	(4)

MODULE II

13	a)	Derive the Kinematic model of a differential drive mobile robot.	(9)
	b)	Explain the terms degree of freedom and manoeuvrability	(5)
14	a)	Derive the dynamic modelling differential drive WMR using Newton-Euler method	(10)
	b)	It is desired to construct a mecanum wheel with n rollers of angle α. Determine the roller length Dr and the thickness d of the wheel	(4)

MODULE III

15 a) Explain in detail various steps involved in robotic vision. (14)

16 a) Briefly explain various sensors used for finding robots orientation and inclination (9)

b) Explain various classification of sensors (5)

MODULE IV

17 a) Explain the Kalman filter based localization of mobile robots (8)

b) Explain various challenges in localization of mobile robots (6)

18 Explain in detail about different Map based path planning (14)

MODULE V

19 a) Explain the control of steered robot based on its kinematic model (14)

20 a) Implement a differential drive robot capable of moving to a point (10)

b) Discuss the dynamic window approach for obstacle avoidance in mobile robot (4)

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Syllabus

Module I (9 Hours)

Introduction, key issues for locomotion, Wheeled Mobile Robots, Wheeled locomotion: The design space, Wheeled locomotion: Case studies. Legged Mobile Robots- Leg configurations and stability, Examples of legged robot locomotion, aerial robots, underwater robots and surface water robots.

Module 2 (9 Hours)

Basic understanding of Differential-Drive WMR, Car-Like WMR, Three-Wheel Omnidirectional Mobile Robot, Four Mecanum-Wheel Omnidirectional Robot

Kinematic model of a differential drive and a steered mobile robot, degree of freedom and manoeuvrability, Degree of steerability, different wheel configurations, holonomic and non-holonomic robots. Omnidirectional Wheeled Mobile Robots.

Dynamic modelling of differential drive WMR: Lagrange and Newton-Euler methods

Module 3 (9 Hours)

Sensors for mobile robot navigation: Sensor classification, Characterizing sensor performance, Wheel /motor sensors, Heading sensors, Accelerometers, IMUs, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors.

Robot Vision: Sensing, Preprocessing, Segmentation, Description, Recognition, Interpretation, feature extraction

Module 4 (9 Hours)

How to find answers to Where am I? Where am I going? How do I get there? by a mobile robot.

Basics of reactive navigation; Robot Localization, Challenges in localization, An error model for odometric position estimation, Probabilistic map based localization (only Kalman method), Autonomous map building, Simultaneous localization and mapping (SLAM).

Path Planning- local vs global path planning, Graph search, Potential field based path planning; Map based path planning- Dijkstra' s algorithm, A*, D* algorithms

Module 5 (9 Hours)

Obstacle avoidance- Bug algorithm, Vector field histogram, Dynamic window approach

Control of mobile robots- Control of differential drive robot and steered robot based on its kinematic model, Case study- design and implementation of a differential drive robot capable of moving to a point, following a line and following a path.

Basics of Swarm robots, cooperative and collaborative robots, mobile manipulators.

Text Books

1. Introduction to Autonomous Mobile Robots , R Siegwart, IR Nourbakhsh, D Scaramuzza, , MIT Press, USA, 2011.
2. Introduction to Mobile Robot Control, Spyros G. Tzafestas , Elsevier, USA, 2014.
3. Sensors for mobile robot ,HR Everett, CRC Press

Reference Books

1. Mobile Robotics: Mathematics, Models and methods, A Kelly, Cambridge University Press, USA,2013
2. Computational Principles of Mobile Robotics, G Dudek, M Jenkin, Cambridge University Press, USA,2010
3. Principles of Robot Motion, Theory, Algorithms, and Implementation, Howie Choset, Kevin M. Lynch, Seth Hutchinson, George A Kantor, Wolfarm Burgard, Lydia E. Kavraki, Sebastian Thrun, MIT Press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Mobile robot locomotion**	
1.1	Introduction, key issues for locomotion	1
1.2	Wheeled Mobile Robots, Wheeled locomotion: The design space	2
1.3	Wheeled locomotion: Case studies.	2
1.4	Legged Mobile Robots- Leg configurations and stability, Examples of legged robot locomotion	2
1.5	aerial robots, underwater robots and surface water robots.	2
2	**Modelling of WMR**	
2.1	Basic understanding of Differential-Drive WMR, Car-Like WMR, Three-Wheel Omnidirectional Mobile Robot, Four Mecanum-Wheel Omnidirectional Robot	3
2.2	Kinematic model of a differential drive and a steered mobile robot	2

2.3	Degree of freedom and manoeuvrability, Degree of steerability, different wheel configurations	1
2.4	Holonomic and non-holonomic robots. Omnidirectional Wheeled Mobile Robots.	1
2.5	Dynamic modelling of differential drive WMR: Lagrange and Newton-Euler methods	2
3	**Sensors and robot vision**	
3.1	Sensors for mobile robot navigation: Sensor classification, Characterizing sensor performance.	3
3.2	Wheel /motor sensors, Heading sensors, Accelerometers, IMUs, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors.	3
3.3	Robot Vision: Sensing, Preprocessing, Segmentation, Description, Recognition, Interpretation, feature extraction	3
4	**Navigation and Motion Planning**	
4.1	How to find answers to Where am I? Where am I going? How do I get there? by a mobile robot.	1
4.2	Basics of reactive navigation; Robot Localization, Challenges in localization	2
4.3	An error model for odometric position estimation, Probabilistic map based localization (only Kalman method), Autonomous map building, Simultaneous localization and mapping (SLAM).	3
4.4	Path Planning- local vs global path planning, Graph search, Potential field based path planning; Map based path planning- Dijkstra' s algorithm, A*, D* algorithms	3
5	**Obstacle avoidance and Control of mobile Robots**	
5.1	Obstacle avoidance- Bug algorithm, Vector field histogram, Dynamic window approach	3
5.2	Control of mobile robots- Control of differential drive robot and steered robot based on its kinematic model.	2
5.3	Case study- design and implementation of a differential drive robot capable of moving to a point, following a line and following a path.	2
5.4	Basics of Swarm robots, cooperative and collaborative robots, mobile manipulators.	2

SEMESTER VI

HONOURS

RAT394	ADVANCED CONTROL FOR ROBOTICS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Control mechanisms plays a vital role in the design of robotic systems. With the application area of robots being very vast and divergent, design of appropriate control mechanisms is quite challenging. This course provides the students an introduction to the different control mechanisms that are specifically applicable to robot design.

Prerequisite: Basic course in Control Systems

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design linear controllers for robotic manipulators
CO 2	Interpret about various nonlinear control schemes for robotic manipulators
CO 3	Illustrate force control schemes of manipulators
CO 4	Design controllers for mobile robots
CO 5	Familiarise about vision-based control schemes for robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	1	2							3
CO 2	3	2	2	1	2	1						2
CO 3	3	2	2	2	2	1						3
CO 4	3	2	2	2	1	1						2
CO 5	3	3	2	2	2	1						2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	25	25	40
Apply	15	15	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. With block diagrams, explain the closed loop and feed forward Robotic Contorl Systems
2. With an example, explain a trajectory following control used for robots.
3. Explain the architecture of an industrial-robot controller with suitable diagrams

Course Outcome 2 (CO2):

1. What is a model-based manipulator control design approach? What are the different models used in the above design process?
2. Explain one non-linear control scheme of robotic manipulator

Course Outcome 3 (CO3):

1. Explain the role of industrial robots in assembly lines in a
2. Discuss the response of a mass-Spring system with a driving force

Course Outcome 4 (CO4):

1. State and derive the expression for Lya punov stability criterion
2. Explain the use of a computed torque control in robotic design

Course Outcome 5 (CO5):

1. What is Image Segmentation? Explain the role of segmentation in Image processing applications
2. What is stereo vision and how is it useful?
3. Discuss the working of a image based visual servo mechanism that can be used in robotic application

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION

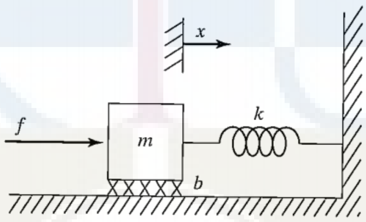
Course Code: RAT 394

Course Name: ADVANCED CONTROL FOR ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	What is the necessity of controllers in a robotic system?	(3)
2	 If m = 1, b = 1, and k = 1, find gains Kp and Kv for a position-regulation control law that results in the system's being critically damped with a closed-loop stiffness of 16.0.	(3)
3	Explain PD gravity control of a robotic manipulator.	(3)
4	Explain resolved motion rate control of robots.	(3)
5	What are the applications of industrial robots force control may be needed?	(3)
6	What do you mean by natural and artificial constraints for tasks in partially constrained environments?	(3)
7	A typical mobile robot is a linear or nonlinear system? Justify your answer.	(3)
8	Briefly explain Lyapunov Stability-Based Control Design of mobile robots.	(3)

9		What is visual servoing?	(3)
10		How pose is estimated using camera?	(3)

PART B

Answer any one full question, each carries14 marks.

MODULE I

11	a)	Explain control law partitioning with the help of an example.	(7)
	b)	Explain PID control of a single link manipulator	(7)
12	a)	Differentiate between continuous and discrete control	(6)
	b)	A researcher has proposed the following control scheme for a serial manipulator, where [kp] and [Kv] are positive definite gain matrices	(8)

$$\begin{aligned}\tau = {} & [\mathbf{M}(\mathbf{q})]\ddot{\mathbf{q}}_d + \mathbf{C}(\mathbf{q}, \dot{\mathbf{q}}) + \mathbf{G}(\mathbf{q}) \\ & + [K_p](\mathbf{q}_d - \mathbf{q}) + [K_v](\dot{\mathbf{q}}_d - \dot{\mathbf{q}})\end{aligned}$$

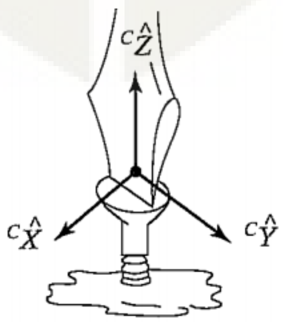
Draw the block schematic of the proposed controller and explain. What are the possible advantages of the scheme?

MODULE II

13	a)	Explain any one non-linear control scheme of robotic manipulator.	(7)
	b)	How will you design a Lyapunov based controller for a robotic system?	(7)
14	a)	Explain about task space control schematic of robots	(8)
	b)	Explain adaptive control of robotic manipulators	(6)

MODULE III

15	a)	Explain the assembly sequences used to put a round peg into a round hole	(7)
	b)	Figure shows a manipulator tightening a screw. What are the natural and artificial constraints for this task?	(7)



16	a)	Explain the force control of a typical mass spring dashpot system	(8)
	b)	A cartesian manipulator with 3 DOF is in touch with a contact surface. Explain the block schematic for a hybrid controller for a 3-DOF Cartesian arm	(6)

MODULE IV

17	a)	Obtain the kinematic model of a differentially driven mobile robot.	(8)
	b)	Check the stability of the following system using the Lyapunov method: $\dot{x} = -x$	(6)
18	a)	Explain state feedback control of robotic manipulators	(8)
	b)	Explain about computed torque control of mobile robots?	(6)

MODULE V

19	a)	Explain the configuration of a vision system in a visual servoing scenario	(7)
	b)	Explain position-based Visual Servoing using PD Control with Gravity Compensation	(7)
20	a)	Explain Image-based Visual Servoing using Resolved-velocity Control	(8)
	b)	Explain any two applications where visual servoing is employed.	(6)

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SYLLABUS

Module I (9 Hours)

Review of dynamic modelling of robots.
Introduction to robot control- Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control.
Linear control of manipulators- closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory-following control, disturbance rejection, continuous vs. discrete time control, Feedback control of single link manipulator, architecture of an industrial-robot controller

Case study- Matlab simulation-PID Control of single link manipulator and planar 2R manipulator, closed loop control of wall following robot- block schematic- sensor selection etc

Module II (9 Hours)

Nonlinear Control of manipulators- the control problem for manipulators- model-based manipulator control system -computed torque control, practical considerations, current industrial-robot control systems, PD Gravity control, Lyapunov stability analysis, adaptive control.
Task Space Control Schemes – resolved motion rate control and resolved motion acceleration control.
Case study- resolved motion rate control of 2R manipulator

Module III (9 Hours)

Force control of manipulators- introduction, application of industrial robots to assembly tasks, a framework for control in partially constrained tasks, the hybrid position/force control problem, force control of a mass—spring system, the hybrid position/force control scheme, current industrial-robot control schemes
Case study- force control of peg in hole assembly task, natural and artificial constraints

Module IV (9 Hours)
Mobile Robot Control : State space modelling- Lyapunov Stability, state feedback control, Proportional plus derivative control, Lyapunov function based control, Computed torque control, Resolved motion rate control , Resolved motion acceleration control

Module V (9 Hours)

Visual Servoing - Vision for Control -Configuration of the Visual System; Image Processing- Image Segmentation, Image Interpretation; Pose Estimation; Stereo Vision-Epipolar Geometry, Triangulation -Position-based Visual Servoing- PD Control with Gravity Compensation. Resolved-velocity Control; Image-based Visual Servoing, PD Control with Gravity Compensation, Resolved-velocity Control

Text Books:

1. Introduction to Robotics Mechanics and Control, John J. Craig, 3e, Pearson
2. Robotics: Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford
3. Robotics- Modelling planning and control- Bruno Siciliano , Lorenzo Sciavicco Luigi Villani, Giuseppe Oriolo, Springer-Verlag London
4. Introduction to Mobile Robot Control - S.G. Tzafestas, 2014, Elsevier
5. The Robotics Primer-Maja J Matari´c, The MIT Press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Review of dynamic modelling of robots	1
1.2	Introduction to robot control-Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control.	1
	Linear control of manipulators- closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory-following control, disturbance rejection, continuous vs. discrete time control	3
	Feedback control of single link manipulator, architecture of an industrial-robot controller	2
	Case study- Matlab simulation-PID Control of single link manipulator and planar 2R manipulator (Ref2), closed loop control of wall following robot- block schematic- sensor selection etc (Ref 5)	2
	Main reference books- Ref 1 and 2	
2	**MODULE 2**	
2.1	Nonlinear Control of manipulators-the control problem for manipulators	1
2.2	model-based manipulator control system -computed torque control, practical considerations, current industrial-robot control systems, PD Gravity control (ref1)	3
2.3	Lyapunov stability analysis, adaptive control (ref1)	3
2.4	Task Space Control Schemes – resolved motion rate control and resolved motion acceleration control (ref1)	1
2.5	Case study- resolved motion rate control of 2R manipulator (ref1)	1
3	**MODULE 3**	
3.1	Force control of manipulators- introduction, application of industrial robots to assembly tasks, a framework for control in partially constrained tasks, the hybrid position/force control problem, force control of a mass—spring system, the hybrid position/force control scheme, current industrial-robot control schemes (Ref 1 and 2)	7
3.2	Case study- force control of peg in hole assembly task, natural and artificial constraints (Ref 2)	2
4	**MODULE 4**	
4.1	Mobile Robot Control: State space modelling- Lyapunov Stability, state feedback control, Proportional plus derivative control,	9

	Lyapunov function based control, Computed torque control, Resolved motion rate control , Resolved motion acceleration control	
5	**MODULE 5**	
5.1	Visual Servoing - Vision for Control -Configuration of the Visual System; Image Processing- Image Segmentation, Image Interpretation; Pose Estimation; Stereo Vision- Epipolar Geometry, Triangulation -Position-based Visual Servoing- PD Control with Gravity Compensation. Resolved-velocity Control; Image-based Visual Servoing, PD Control with Gravity Compensation, Resolved-velocity Control (Ref 3)	9

SEMESTER III

MAT 203	DISCRETE MATHEMATICAL STRUCTURES	CATEGORY	L	T	P	CREDITS
		BSC	3	1	0	4

Preamble:

The purpose of this course is to create awareness in students about the basic terminologies used in advanced courses in Computer Science and develop rigorous logical thinking for solving different kinds of problems in Computer Science. This course helps the learner to apply the theory and applications of elementary Counting Principles, Propositional Logic, Predicate Logic, Lattices, Generating Functions, Recurrence Relations and Algebraic Structures eventually in practical applications.

Prerequisite: A sound background in higher secondary school Mathematics

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Check the validity of predicates in Propositional and Quantified Propositional Logic using truth tables, deductive reasoning and inference theory on Propositional Logic **(Cognitive Knowledge Level: Apply)**
CO2	Solve counting problems by applying the elementary counting techniques - Rule of Sum, Rule of Product, Permutation, Combination, Binomial Theorem, Pigeonhole Principle and Principle of Inclusion and Exclusion **(Cognitive Knowledge Level: Apply)**
CO3	Classify binary relations into various types and illustrate an application for each type of binary relation, in Computer Science (**Cognitive Knowledge Level: Understand)**
CO4	Illustrate an application for Partially Ordered Sets and Complete Lattices, in Computer Science **(Cognitive Knowledge Level: Apply)**
CO5	Explain Generating Functions and solve First Order and Second Order Linear Recurrence Relations with Constant Coefficients **(Cognitive Knowledge Level: Apply)**
CO6	Illustrate the abstract algebraic systems - Semigroups, Monoids, Groups, Homomorphism and Isomorphism of Monoids and Groups **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓		✓						✓
CO5	✓	✓	✓	✓								✓
CO6	✓	✓	✓	✓								✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance	**10 marks**
Continuous Assessment Tests (Average of Series Tests 1 & 2)	**25 marks**
Continuous Assessment Assignment	**15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module – 1 (Fundamentals of Logic)

Mathematical logic - Basic connectives and truth table, Statements, Logical Connectives, Tautology, Contradiction. Logical Equivalence - The Laws of Logic, The Principle of duality, Substitution Rules . The implication - The Contrapositive, The Converse,The Inverse.

Logical Implication - Rules of Inference. The use of Quantifiers - Open Statement, Quantifier. Logically Equivalent – Contrapositive, Converse , Inverse , Logical equivalences and implications for quantified statement, Implications , Negation .

Module - 2 (Fundamentals of Counting Theory)

The Rule of Sum – Extension of Sum Rule . The Rule of Product - Extension of Product Rule . Permutations. Combinations. The Binomial Theorem (without proof). Combination with Repetition. The Pigeon hole Principle. The Principle of Inclusion and Exclusion Theorem (Without Proof) - Generalization of the Principle. Derangements.

Module - 3 (Relations and Functions)

Cartesian Product - Binary Relation. Function – domain , range-one to one function, Image-restriction. Properties of Relations- Reachability Relations, Reflexive Relations, Symmetric Relations, Transitive relations, Anti-symmetric Relations, Partial Order relations, Equivalence Relations, Irreflexive relations.

Partially ordered Set – Hasse Diagram, Maximal-Minimal Element, Least upper bound (lub), Greatest Lower bound(glb) (Topological sorting Algorithm- excluded). Equivalence Relations and Partitions - Equivalence Class.

Lattice - Dual Lattice , Sub lattice , Properties of glb and lub , Properties of Lattice , Special Lattice , Complete Lattice, Bounded Lattice, Completed Lattice , Distributive Lattice.

Module - 4 (Generating Functions and Recurrence Relations)

Generating Function - Definition and Examples , Calculation techniques, Exponential generating function. First order linear recurrence relations with constant coefficients – homogeneous, non-homogeneous Solution. Second order linear recurrence relations with constant coefficients, homogeneous, non-homogeneous Solution.

Module - 5 (Algebraic Structures)

Algebraic system-properties- Homomorphism and Isomorphism. Semi group and monoid – cyclic monoid , sub semi group and sub monoid, Homomorphism and Isomorphism of Semi group and monoids. Group- Elementary properties, subgroup, symmetric group on three symbols ,The direct product of two groups, Group Homomorphism, Isomorphism of groups, Cyclicgroup. Rightcosets - Leftcosets. Lagrange's Theorem

Text Book

1. Discrete and Combinatorial Mathematics (An Applied Introduction), Ralph P Grimaldi, B V Ramana , 5th Edition, Pearson

Reference Books

1) Kenneth H. Rosen, Discrete Mathematics and Its Applications with Combinatorics and Graph Theory, Seventh Edition, MGH, 2011
2) Trembly J.P and Manohar R, "Discrete Mathematical Structures with Applications to Computer Science", Tata Mc Graw Hill Pub. Co. Ltd., New Delhi, 2003.
3) Bernard Kolman, Robert C. Busby, Sharan Cutler Ross, "Discrete Mathematical Structures", Pearson Education Pvt Ltd., New Delhi, 2003
4) Kenneth H .Rosen, "Discrete Mathematics and its Applications", 5/e, Tata Mc Graw Hill Pub. Co. Ltd, New Delhi 2003
5) Richard Johnsonbaugh, "Discrete Mathematics", 5/e, Pearson Education Asia, NewDelhi, 2002.
6) Joe L Mott, Abraham Kandel, Theodore P Baker,"Discrete Mathematics for Computer Scientists and Mathematicians", 2/e, Prentice-Hall India, 2009.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Show that $R \vee M$, $\neg R \vee S$, $\neg M$, $\neg S$ cannot exist simultaneously (without using truth table)
2. Represent the following statement in symbolic form "Not every city in Canada is clean".

Course Outcome 2 (CO2):

1. How many possible arrangements are there for the letters in MASSASAUGA in which 4 A' s are together?
2. Find the number of integers between 1 and 1000 inclusive, which are not divisible by 5, 6 or 8

Course Outcome 3 (CO3):

1. If A = {1, 2, 3, 4}, give an example of a relation R that is reflexive and symmetric but not transitive.
2. Let Z be the set of integers. R is a relation called "Congruence Modulo 3 " defined by R = { (x,y) /x ε Z,y ε Z, x - y is divisible by 3 } . Show that R is an equivalence relation.

Course Outcome 4 (CO4):

1. Assume A ={ a, b, c}. Let P(A) be its power set and '≤ ' be the subset relation on the power set. Draw the Hasse diagram of (P(A), ≤).
2. What is meant by Bounded Lattice ? Give an example.

Course Outcome 5 (CO5):

1. Solve $a_r - 3a_{r-1} - 4a_{r-2} = 3^r$ using Generating function method; Given $a_0 = 1$, $a_1 = 2$.
2. Find the generating function for the sequence 1, 3, 3^2, 3^3 …….

Course Outcome 6 (CO6):

1. Prove that the group { 1,-1, i, -i } is cyclic with generators i and –i.
2. State and prove Lagrange's Theorem.

Model Question Paper

QP CODE:

Reg No:_______________

Name :_______________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: MAT 203

Course Name: Discrete Mathematical Structures

Max.Marks :100 **Duration: 3 Hrs**

PART A

Answer all Questions. Each question carries 3 Marks

1. Show the following implication without constructing the truth table: (P ^ Q) => P→Q
2. Write the negation of the following statement. " If I drive, then I will not walk"
3. What is pigeon hole principle? Explain. If you select any five numbers from 1 to 8 then prove that at least two of them will add up to 9 .
4. In how many ways can the letters of the word ALLAHABAD be arranged ?
5. Show that the divisibility relation ' / ' is a partial ordering on the set Z^+.
6. Consider the functions given by $f(x) = 2x+3$ and $g(x) = x^2$. Find (g o f) and (f o g).
7. What is meant by exponential generating function? Explain.
8. Provide one example of linear homogeneous recurrence relation. Mention the degree also.
9. What is a monoid ? Explain.
10. Let (A, .) be a group. Show that $(ab)^{-1} = b^{-1}a^{-1}$

(10 x 3 = 30 Marks)

PART B

(Answer any one Question from each Module. Each question carries 14 Marks)

11.

(a) Show that $S \vee R$ is tautologically implied by $(P \vee Q) \wedge (P \rightarrow R) \wedge (Q \rightarrow S)$

(6 marks)

(b) Show that from

(ii) $(\exists x)(F(x) \wedge S(x)) \rightarrow (y)(M(y) \rightarrow W(y))$.

(iii) $(\exists y)(M(y) \wedge \neg W(y))$ the conclusion $(x)(F(x) \rightarrow \neg S(x))$ follows.

(8 marks)

OR

12.

(a) Show that $(x)(P(x) \vee Q(x)) \Rightarrow ((x)P(x) \vee (\exists x) Q(x))$ using indirect method of proof .

(6 marks)

(b) Discuss indirect method of proof . Show that the following premises are inconsistent

(i) If Jack misses many classes through illness, then he fails high school.

(ii) If Jack fails high school, then he is uneducated.

(iii) If Jack reads a lot of books, then he is not uneducated.

(iv) Jack misses many classes through illness and reads a lot of books.

(8 marks)

13.

(a) Explain binomial theorem. Determine the coefficient of x^9y^3 in the expansion of $(x+y)^{12}$, $(x+2y)^{12}$ and $(2x-3y)^{12}$ using binomial theorem.

(6 marks)

(b) How many 5 digit numbers can be formed from the digits 1,2,3,4,5 using the digits without repetition ?

(i) How many of them are even?

(ii) How many are even and greater than 30,000?

(8 marks)

OR

14.

(a) There are 8 guests in a party. Each guest brings a gift and receives another gift in return. No one is allowed to receive the gift they bought. How many ways are there to distribute the gifts?

(6 marks)

(b) Six papers are set in an examination of which two are mathematical. Only one examination will be conducted in a day. In how many different orders ,can the papers be arranged so that

(i) Two mathematical papers are consecutive?

(ii) Two mathematical papers are not consecutive?

(8 marks)

15.

(a) Let A = { 1,2,3,4,...11,12} and let R be the equivalence relation on A x A defined by (a,b) R (c,d) iff a+d = b+c. Prove that R is an equivalence relation and find the equivalence class of (2 ,5)

(8 marks)

(b) What is a chain lattice ? Explain. Also show that every chain is a distributive lattice.

(6 marks)

OR

16.

(a) Suppose f(x) = x+2 , g(x) = x-2, and h(x) = 3x for x ε R , where R is the set of real numbers. Find (g o f) , (f o g) , (f o f) and (g o g)

(8 marks)

(b) Let R and S be two relations on a set A . If R and S are symmetric, Prove that (R∩S) is also symmetric.

(6 marks)

17.

(a) Solve the recurrence relation $a_r - 7a_{r-1} + 10a_{r-2} = 0$ for $r \geq 2$; Given $a_0 = 0$; $a_1 = 41$ using generating functions

(8 marks)

(b) Solve the recurrence relation $a_r - 4a_{r-1} + 4a_{r-2} = (r+1)^2$ using generating function.

(6 marks)

OR

18.

(a) Solve $a_n - 3a_{n-1} + 2$; $a_0 = 1$ $n \geq 1$, using generating functions.

(8 marks)

(b) Use generating function to solve the following recurrence relation $a_n = 2a_{n-1} + 2^n$; with $a_0 = 2$.

(6 marks)

19.

(a) Prove that the set 'Q' of rational numbers other than 1 forms an abelian group with respect to the operation ' * ' defined by a * b = a+b -ab.

(8 Marks)

(b) Show that the direct product of two group is a group.

(6 Marks)

OR

20.

(a) Show that the subgroup of a cyclic group is cyclic.

(8 Marks)

(b) Let (A,*) be a group. Show that (A,*) is an abelian group if and only if $a^2 * b^2 = (a*b)^2$ for all ‘a’ and ‘b’ in A

(6 Marks)

TEACHING PLAN

No	Contents	No of Lecture Hrs
Module – 1 (Fundamentals of Logic) (9 hrs)		
1.1	Mathematical logic, Basic Connectives and Truth Table	1
1.2	Statements, Logical Connectives, Tautology, Contradiction	1
1.3	Logical Equivalence, The Laws of Logic	1
1.4	The Principle of duality, Substitution Rules	1
1.5	The implication, The Contrapositive, the Converse , the Inverse	1
1.6	Logical Implication,Rules of Inference, Logical Implication	1
1.7	The use of Quantifiers, Open Statement, Quantifier, Negation	1
1.8	Logically Equivalent, Contrapositive, The Converse, The Inverse	1
1.9	Logical Implications	1
Module - 2 (Fundamentals of Counting Theory) (9 hrs)		
2.1	The Pigeon-hole Principle	1
2.2	The Rule of Sum	1
2.3	Extension of Sum Rule	1
2.4	The Rule of Product	1
2.5	Extension of Product Rule , Permutations	1
2.6	Combinations, Combination with repetition	1
2.7	The Binomial Theorem	1
2.8	The Principle of Inclusion and Exclusion Theorem (Without Proof) Generalization of the Principle	1
2.9	Derangements	1
Module - 3 (Relations and Functions) (9 hrs)		
3.1	Cartesian Product, Binary Relation, Function, Domain, Range , One to One Function Image - Restriction	1
3.2	Properties, Reachability Relations, Reflexive Relations,Symmetric Relations,Transitive relations, Antisymmetric Relations.	1

3.3	Partial Order relations	1
3.4	Equivalence Relation, Irreflexive Relations.	1
3.5	Partially ordered Set, Hasse Diagram.	1
3.6	Maximal-Minimal Element, Least Upper bound, Greatest Lower Bound	1
3.7	Equivalence Relations and Partitions ,Equivalence Class	1
3.8	Lattice- Dual Lattice,sub lattice , Properties of glb and lub	1
3.9	Properties of Lattice , Special Lattice , Complete Lattice, Bounded Lattice, Completed Lattice, Distributive Lattice	1
Module - 4 (Generating Functions and Recurrence Relations) (9 hrs)		
4.1	Generating Function , Definition and Examples	1
4.2	Exponential Generating Function.	1
4.3	First Order Linear Recurrence Relations with Constant Coefficients (Lecture I)	1
4.4	First Order Linear Recurrence Relations with Constant Coefficients (Lecture II)	1
4.5	Homogeneous Solution	1
4.6	Non homogeneous Solution	1
4.7	Second order linear recurrence relations with constant coefficients	1
4.8	Homogeneous Solution	1
4.9	Non homogeneous Solution	1
Module - 5 (Algebraic Structures)(9 hrs)		
5.1	Algebraic System-Properties, Homomorphism and Isomorphism	1
5.2	Semi group , Monoid, Cyclic monoid	1

5.3	Sub semigroup and sub monoid	1
5.4	Homomorphism and Isomorphism of Semigroup, Monoids and Groups	1
5.5	Elementary Properties, Subgroup, Symmetric group on three symbols	1
5.6	The direct Product of two Groups	1
5.7	Group Homomorphism, Isomorphism, Cyclic group	1
5.8	Right coset, Left coset	1
5.9	Lagrange's Theorem	1

CST201	**DATA STRUCTURES**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**	**YEAR OF INTRODUCTION**
		PCC	**3**	**1**	**0**	**4**	**2019**

Preamble: This course aims at moulding the learner to understand the various data structures, their organization and operations. The course helps the learners to assess the applicability of different data structures and associated algorithms for solving real world problem which requires to compare and select appropriate data structures to solve the problem efficiently. This course introduces abstract concepts for data organization and manipulation using data structures such as stacks, queues, linked lists, binary trees, heaps and graphs for designing their own data structures to solve practical application problems in various fields of Computer Science.

Prerequisite: Topics covered under the course Programming in C (EST 102)

CO1	Design an algorithm for a computational task and calculate the time/space complexities of that algorithm **(Cognitive Knowledge Level: Apply)**
CO2	Identify the suitable data structure (array or linked list) to represent a data item required to be processed to solve a given computational problem and write an algorithm to find the solution of the computational problem **(Cognitive Knowledge Level: Apply)**
CO3	Write an algorithm to find the solution of a computational problem by selecting an appropriate data structure (binary tree/graph) to represent a data item to be processed **(Cognitive Knowledge Level: Apply)**
CO4	Store a given dataset using an appropriate Hash Function to enable efficient access of data in the given set **(Cognitive Knowledge Level: Apply)**
CO5	Select appropriate sorting algorithms to be used in specific circumstances (Cognitive Knowledge Level: **Analyze**)
CO6	Design and implement Data Structures for solving real world problems efficiently **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓						✓
CO2	✓	✓	✓	✓		✓						✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓		✓						✓
CO5	✓	✓	✓	✓		✓						✓
CO6	✓	✓	✓	✓		✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (Percentage)	Test2 (Percentage)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40

Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module 1

Basic Concepts of Data Structures

System Life Cycle, Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notation, Complexity Calculation of Simple Algorithms

Module 2

Arrays and Searching

Polynomial representation using Arrays, Sparse matrix, Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions

Linear Search and Binary Search

Module 3

Linked List and Memory Management

Self Referential Structures, Dynamic Memory Allocation, Singly Linked List-Operations on Linked List. Doubly Linked List, Circular Linked List, Stacks and Queues using Linked List, Polynomial representation using Linked List

Memory allocation and de-allocation-First-fit, Best-fit and Worst-fit allocation schemes

Module 4

Trees and Graphs

Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search Trees- Binary Search Tree Operations

Graphs, Representation of Graphs, Depth First Search and Breadth First Search on Graphs, Applications of Graphs

Module 5

Sorting and Hashing

Sorting Techniques – Selection Sort, Insertion Sort, Quick Sort, Merge Sort and Heap Sort

Hashing- Hashing Techniques, Collision Resolution, Overflow handling, Hashing functions – Mid square, Division, Folding, Digit Analysis

Text Book

1. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, Universities Press, Fundamentals of Data Structures in C

Reference Books

1. Samanta D., Classic Data Structures, Prentice Hall India.
2. Richard F. Gilberg, Behrouz A. Forouzan, Data Structures: A Pseudocode Approach with C, 2/e, Cengage Learning.
3. Aho A. V., J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pearson Publication.
4. Tremblay J. P. and P. G. Sorenson, Introduction to Data Structures with Applications, Tata McGraw Hill.
5. Peter Brass, Advanced Data Structures, Cambridge University Press.
6. Lipschuts S., Theory and Problems of Data Structures, Schaum's Series.
7. Wirth N., Algorithms + Data Structures = Programs, Prentice Hall.
8. Hugges J. K. and J. I. Michtm, A Structured Approach to Programming, PHI.
9. Martin Barrett, Clifford Wagner, C And Unix: Tools For Software Design, John Wiley.

Sample Course Level Assessment Questions

Course Outcome1(CO1): Write an algorithm for matrix multiplication and calculate its time complexity.

Course Outcome 2(CO2): How a linked list can be used to represent the polynomial $5x^4y^6+24x^3y^4-17x^2y^3+15xy^2+45$.Write an algorithm to add two Bivariate polynomials represented using linked list.

Course Outcome 3(CO3): Create a Binary search Tree with node representing the following sequence 14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2 and perform inorder, preorder and postorder traversals on the above tree and print the output.

Course Outcome 4(CO4): The size of a hash table is 7. The index of the hash table varies from 0 to 6. Consider the keys 89, 18, 49, 58, 25 in the order. Show how the keys are stored in the hash table using Linear probing.

Course Outcome 5(CO5): In what circumstances does Quick Sort perform over Merge sort.

Course Outcome 6(CO6): Design a reservation system for railways that include waiting list. If the reservation is full "Display reservation full" and put the passenger in in waiting list and give a waiting list number. If a passenger cancels the ticket, then the seat should be automatically allocated to the first passenger in the waiting list.

Model Question Paper

QP CODE: PAGES:3

Reg No:________________

Name:__________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 201

Course Name: DATA STRUCTURES

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Calculate the frequency count of the statement x = x+1; in the following code segment

   for (i = 0; i< n; i++)

   for (j = 0; j< n; j*=2)

   x = x + 1;

2. What is the relevance of verification in System Life Cycle?

3. Write an algorithm to insert a new element in a particular position of an array.

4. Convert the expression ((A/(B-D+E))*(F-G)*H) to postfix form. Show each step in the conversion including the stack contents

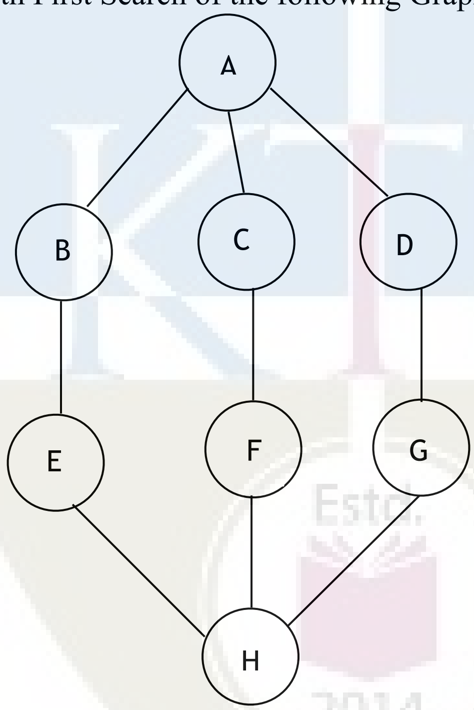
5. Write an algorithm to count the number of occurrences of a character in a linked list (each node contains only one character)

6. Write an algorithm for best-fit method of memory allocation

7. Draw the binary tree whose sequential representation is given below

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	C	-	D	E	-	-	-	-	F	G	-	-	-

8. Find the Depth First Search of the following Graph



9. Write an algorithm to arrange n numbers in nonincreasing order.

10. Let the size of a hash table is 10. The index of the hash table varies from 0 to 9. Assume the keys 73, 54, 15, 48, 89, 66, 37, 18, 41, 22, 62 are mapped using modulo operator. Show how the keys are distributed using chaining method.

Part B

Answer any one Question from each module. Each question carries 14 Marks

11. a) Explain the System Life Cycle in detail (10)

    b) How the performance of an algorithm is evaluated? (4)

OR

12. a) Write algorithms for Linear Search and Binary Search and Compare their time complexities (10)

    b) Between O(nlogn) and O(logn) which one is better and why? (4)

13. a) Write algorithms to insert and delete elements from a double ended queue. Demonstrate with examples (10)

    b) Compare and contrast Circular Queue with a Normal Queue (4)

OR

14. a) Write an algorithm to insert and delete elements from a Priority Queue (8)

    b) Discuss an algorithm to convert an infix expression to a prefix expression (6)

15. a) Write an algorithm to multiply two polynomials represented using linked list (10)

    b) How doubly linked list can be used to find palindromes ? (4)

OR

16. a) How is memory compaction (de-allocation) done in memory management ? (8)

    b) Discuss the advantages and disadvantages of First-fit, Best-fit and Worst-fit allocation schemes (6)

17. a) List the properties of Binary Search Tree. Write an algorithm to search an element from a Binary Search Tree (10)

b) Write an iterative algorithm for in-order traversal of a Binary Tree (4)

OR

18. a) Give algorithms for DFS and BFS of a graph and explain with examples (8)

b) How graphs can be represented in a Computer? (6)

19. a) Write algorithms for Merge sort and Quick Sort. (10)

b) Illustrate the working of Quick sort on the following input 38, 8, 0, 28, 45, -12, 89, 66, 42 (4)

OR

20. a) With examples discuss the different hash functions used for hashing (10)

b) Apply the hash function h(x) = x mod 7 for linear probing on the data 2341, 4234, 2839, 430, 22, 397, 3920 and show the resulting hash table (4)

Teaching Plan		
Module 1 :Basic Concepts of Data Structures		(5 hours)
1.1	System Life Cycle,	1 hour
1.2	Algorithms , Performance Analysis	1 hour
1.3	Space Complexity, Time Complexity	1 hour
1.4	Asymptotic Notation (Big O Notation)	1 hour
1.5	Complexity Calculation of Simple Algorithms	1hour
Module 2 :**Arrays and Searching**		(10 hours)
2.1	Polynomial representation using Arrays	1 hour
2.2	Sparse matrix (Lecture 1)	1 hour
2.3	Sparse matrix (Lecture 2)	1 hour

2.4	Stacks	1 hour
2.5	Queues, Circular Queues	1 hour
2.6	Priority Queues,	1 hour
2.7	Double Ended Queues,	1 hour
2.8	Conversion and Evaluation of Expressions (Lecture 1)	1 hour
2.9	Conversion and Evaluation of Expressions (Lecture 2)	1 hour
2.10	Linear Search and Binary Search	1 hour
Module 3 : **Linked List and Memory Management**		(12 hours)
3.1	Self Referential Structures	1 hour
3.2	Dynamic Memory Allocation	1 hour
3.3	Singly Linked List-Operations on Linked List,	1 hour
3.4	Doubly Linked List	1 hour
3.5	Circular Linked List	1 hour
3.6	Stacks using Linked List	1 hour
3.7	Queues using Linked List	1 hour
3.8	Polynomial representation using Linked List (Lecture 1)	1 hour
3.9	Polynomial representation using Linked List (Lecture2)	1 hour
3.10	Memory de-allocation	1 hour
3.11	Memory allocation-First-fit	1 hour
3.12	Best-fit and Worst-fit allocation schemes	1hour
Module 4 :**Trees and Graphs**		(8 hours)
4.1	Trees, Binary Trees	1hour
4.2	Tree Operations, Binary Tree Representation,	1hour
4.3	Tree Traversals	1hour
4.4	Binary Search Trees	1hour
4.5	Binary Search Tree Operations	1hour
4.6	Graphs, Representation of Graphs	1hour

4.7	Depth First Search and Breadth First Search on Graphs	1hour
4.8	Applications of Graphs	1hour
Module 5 : **Sorting and Hashing**		(10 hours)
5.1	Sorting Techniques – Selection Sort	1hour
5.2	Insertion Sort	1hour
5.3	Quick Sort	1hour
5.4	Merge Sort	1hour
5.5	Heap Sort	1hour
5.6	Hashing- Hashing Techniques	1hour
5.7	Collision Resolution	1hour
5.8	Overflow handling	1hour
5.9	Hashing functions – Mid square and Division methods	1hour
5.10	Folding and Digit Analysis methods	1hour

CST 203	LOGIC SYSTEM DESIGN	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble: The objective of the course is to familiarize learners with the basic concepts of Boolean algebra and digital systems. This course covers the design of simple combinational and sequential logic circuits, representation and arithmetic algorithms for Binary, BCD (Binary Coded Decimal) and Floating point numbers which in turn are helpful in understanding organization & design of a computer system and understanding how patterns of ones and zeros can be used to store information on computers, including multimedia data.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Illustrate decimal, binary, octal, hexadecimal and BCD number systems, perform conversions among them and do the operations - complementation, addition, subtraction, multiplication and division on binary numbers (**Cognitive Knowledge level: Understand**)
CO2	Simplify a given Boolean Function and design a combinational circuit to implement the simplified function using Digital Logic Gates (**Cognitive Knowledge level: Apply**)
CO3	Design combinational circuits - Adders, Code Convertors, Decoders, Magnitude Comparators, Parity Generator/Checker and design the Programmable Logic Devices - ROM and PLA. **(Cognitive Knowledge level: Apply)**
CO4	Design sequential circuits - Registers, Counters and Shift Registers. **(Cognitive Knowledge level: Apply)**
CO5	Use algorithms to perform addition and subtraction on binary, BCD and floating point numbers **(Cognitive Knowledge level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										✓
CO2	✓	✓	✓	✓		✓						✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓		✓						✓
CO5	✓	✓	✓									✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern:

Bloom's Category	Test 1 (%)	Test 2 (%)	End Semester Examination Marks (%)
Remember	20	20	20
Understand	35	35	35
Apply	45	45	45
Analyse			
Evaluate			
Create			

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module I

Number systems, Operations & Codes

Decimal, Binary, Octal and Hexadecimal Number Systems- Number Base Conversions. Addition, Subtraction, Multiplication and Division of binary numbers. Representation of negative numbers- Complements, Subtraction with complements. Addition and subtraction of BCD, Octal and Hexadecimal numbers. Binary codes- Decimal codes, Error detection codes, Reflected code, Character coding schemes – ASCII, EBCDIC.

Module II

Boolean Algebra

Postulates of Boolean Algebra. Basic theorems and Properties of Boolean Algebra. Boolean Functions - Canonical and Standard forms. Simplification of Boolean Functions- Using Karnaugh- Map Method (upto five variables), Don't care conditions, Product of sums simplification, Tabulation Method. Digital Logic Gates- Implementation of Boolean functions using basic and universal gates.

Module III

Combinational Logic Circuits

Design Procedure & Implementation of combinational logic circuits- Binary adders and subtractors, Binary Parallel adder, Carry look ahead adder, BCD adder, Code converter, Magnitude comparator, Decoder, Demultiplexer, Encoder, Multiplexer, Parity generator/ Checker.

Module IV

Sequential logic circuits:

Flip-flops- SR, JK, T and D. Triggering of flip-flops- Master slave flip- flops, Edge- triggered flip- flops. Excitation table and characteristic equation. Registers- register with parallel load. Counter design: Asynchronous counters- Binary and BCD counters, timing sequences and state diagrams. Synchronous counters- Binary Up- down counter, BCD counter.

Module V

Shift registers

Shift registers – Serial In Serial Out, Serial In Parallel Out, Bidirectional Shift Register with Parallel load. Ring counter. Johnson counter- timing sequences and state diagrams.

Arithmetic algorithms

Algorithms for addition and subtraction of binary numbers in signed magnitude and 2's complement representations. Algorithm for addition and subtraction of BCD numbers. Representation of floating point numbers, Algorithm for addition and subtraction of floating point numbers.

Programmable Logic devices

ROM. Programmable Logic Array(PLA)- Implementation of simple circuits using PLA.

Text Books:

1. M. Morris Mano, Digital Logic & Computer Design, 4/e, Pearson Education, 2013
2. Thomas L Floyd, Digital Fundamentals, 10/e, Pearson Education, 2009.
3. M. Morris Mano, Computer System Architecture, 3/e, Pearson Education, 2007.

Reference Books:

1. M. Morris Mano, Michael D Ciletti , Digital Design With An Introduction to the Verilog HDL, 5/e, Pearson Education, 2013.
2. Donald D Givone, Digital Principles and Design, Tata McGraw Hill, 2003

Sample Course Level Assessment Questions

Course Outcome1(CO1): Perform the following number base conversions:

a) $(250.55)_{10}$ to Hexadecimal b) $(357)_8$ to Decimal

Course Outcome 2(CO2): Given a Boolean function F and don't care conditions D, using Karnaugh map obtain the simplified expression in (i) SOP and (ii) POS:

$$F(A,B,C,D) = A'B'D' + A'CD + A'BC$$
$$D(A,B,C,D) = A'BC'D + ACD + AB'D$$

Course Outcome 3(CO3): Design a BCD to Excess-3 Code Convertor.

Course Outcome 4(CO4): Design a 4- bit binary ripple counter.

Course Outcome 5(CO5): Demonstrate floating-point addition algorithm.

Model Question Paper

QP CODE: PAGES: 2

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 203

Course name : LOGIC SYSTEM DESIGN

Max Marks: 100 **Duration: 3 Hours**

PART-A

(Answer All Questions. Each question carries 3 marks)

1. Represent the decimal numbers $(459)_{10}$ and $(859)_{10}$ in hexadecimal and perform addition of these hexadecimal numbers.
2. Subtract $(1101)_2$ from $(11010)_2$ using: i) $2's$ complement and ii) $1's$ complement arithmetic.
3. Find the dual and complement of the boolean function $F = AB' + B(A + B')$.
4. Using K-map, reduce the expression: $AB + ABC + ABC + BC$.
5. Design a half subtractor with NAND gates only.
6. Design a combinational circuit that multiplies an input decimal digit by 5 represented in BCD. The output is also in BCD. Show that the outputs can be obtained from the input lines without using any logic gates.
7. Differentiate between ripple counter and synchronous counter.
8. Construct D flip- flop using NAND gates. Also give its truth table.
9. Explain how a shift register is used for serial data transfer?
10. Write short notes on ROM.

PART-B

(Answer any one full question from each module) **(14X5=70)**

11. (a) Perform the following operations using 2's complement arithmetic: (8)

(i) $88_{10} + (-37)_{10}$ (ii) $(-20)_{10} + (-12)_{10}$

(b) Perform the following base conversions: (i) $(101011.11)_2$ to octal (6)
(ii) $(3F9B)_{16}$ to binary (iii) $(121)_{10}$ to binary (iv) $(3077)_8$ to binary

OR

12. (a) Find the 12 bit $2's$ complement representation of the following decimal numbers. (6)
(i) – 97 (ii) – 224 (iii) - 197.5

(b) Perform the following operations (8)
(i) $(520)_8 + (488)_8$ (ii) $(520)_{16} - (488)_{16}$

13. (a) Prove that (i) $AB + A(B + C) + B(B + C) = B + AC$ (4)
(ii) $AB + A(B + C) + B(B + D) = A$

(b) Using K-map, simplify the Boolean function F in sum of products form, using the don't care conditions d: (10

$$F(w, x, y, z) = w'(x'y + x'y' + xyz) + x'z'(y + w)$$
$$d(w, x, y, z) = w'x(y'z + yz') + wyz$$

OR

14. (a) Simplify the following expressions using Karnaugh- map method. (8)
(i) $F = \Sigma(0,2,4,6,9,11,13,15,17,21,25,27,29,31)$
(ii) $F = \Pi(0,2,5,7)$

(b) Convert the following to the other canonical form: (6)

(i) $F(x, y, z, a) = \sum(1,3,7)$

(ii) $F(x, y, z) = \Pi(0,3,6,7)$

(iii) $F(A, B, C, D) = \Pi(0,1,2,3,4,6,12)$

15. (a) Implement Full adder circuit using NAND gate only. (4)

(b) Design a code converter for converting BCD to Excess 3 code (10)

OR

16. (a) With a neat diagram explain 4-bit carry look-ahead adder. (6)

(b) Design a Gray to binary code converter using a 4x1 MUX. Draw the circuit diagram and explain. (8)

17. (a) Design a counter that count the states 0,3,5,6,0… using T flip- flops. (10)

(b) Write the characteristics equation, excitation table of JK, T and D flipflop. (4)

OR

18. (a) Explain race around condition and how it can be avoided. (6)

(b) Design a synchronous Binary Up-Down Counter. (8)

19. (a) With a neat diagram explain universal shift register. (8)

(b) Explain Johnson Counter with timing diagram. (6)

OR

20. (a) Write algorithm for floating point addition and subtraction. (8)

(b) Implement the functions $Y_1 = AB'C' + AB'C + ABC$ and $Y_2 = BC + AC$ using minimum gates Programmable Logic Array. (6)

Teaching Plan

Module 1: Number systems, Operations & Codes (No algorithms)		**(7 hours)**
1.1	**Number Systems**: Decimal, Binary, Octal and Hexadecimal number systems, Number Base Conversions.	**1 hour**
1.2	**Binary Arithmetic:** Addition, Subtraction, Multiplication & Division of Binary Numbers. (Lecture 1)	**1 hour**
1.3	Addition, Subtraction, Multiplication & Division of Binary Numbers. (Lecture 2)	**1 hour**
1.4	Representation of Negative Numbers- Complements, subtraction with complements.	**1 hour**
1.5	**BCD Arithmetic:** Addition and Subtraction of BCD Numbers	**1 hour**
1.6	**Octal and Hexadecimal Arithmetic**: Addition & Subtraction of Octal and Hexadecimal Numbers.	**1 hour**

1.7	**Binary Codes:** Decimal Codes, Error detection codes, Reflected code, Character Coding Schemes-ASCII, EBCDIC	**1 hour**
Module 2: Boolean Algebra		**(9 hours)**
2.1	**Introduction to Boolean Algebra:** Postulates of Boolean Algebra	**1 hour**
2.2	Basic theorems and Properties of Boolean Algebra	**1 hour**
2.3	**Boolean Functions:** Canonical and Standard Forms	**1 hour**
2.4	**Simplification of Boolean Functions**: Karnaugh -Map Method (upto five variables), Don't care conditions (Lecture 1)	**1 hour**
2.5	**Simplification of Boolean Functions**: Karnaugh -Map Method (upto five variables), Don't care conditions (Lecture 2)	**1 hour**
2.6	**Product of sums simplification**	**1 hour**
2.7	**Tabulation method**	**1 hour**
2.8	**Digital Logic Gates:** AND, OR, NOT, NAND, NOR, XOR, XNOR, Implementation of Boolean functions using basic and universal gates. (Lecture 1)	**1 hour**
2.9	**Digital Logic Gates:** AND, OR, NOT, NAND, NOR, XOR, XNOR, Implementation of Boolean functions using basic and universal gates. (Lecture 2)	**1 hour**
Module 3: Combinational Logic Circuits		**(9 hours)**
3.1	Design Procedure & Implementation of Combinational Circuits	**1 hour**
3.2	**Binary Adders:** Implementation of Half Adder, Full Adder	**1 hour**
3.3	**Binary Subtractors:** Implementation of Half Subtractor, Full Subtractor	**1 hour**
3.4	Implementation of Binary Parallel Adder ,Carry look ahead Adder, BCD Adder (Lecture 1)	**1 hour**
3.5	Implementation of Binary Parallel Adder ,Carry look ahead Adder, BCD Adder (Lecture 2)	**1 hour**

3.6	**Implementation of Various Combinational Circuits:** Code Converters, Magnitude Comparator	**1 hour**
3.7	Implementation of Decoder, Demultiplexer	**1 hour**
3.8	Implementation of Encoder, Multiplexer	**1 hour**
3.9	Implementation of Parity Generator/Checker	**1 hour**
Module 4: Sequential logic circuits:		**(9 hours)**
4.1	**Flip flops:** SR, JK, T and D flip- flops (Lecture 1)	**1 hour**
4.2	SR, JK, T and D flip- flops (Lecture 2)	**1 hour**
4.3	Triggering of flip-flops- Master slave flip- flop, Edge- triggered flip-flops (Lecture 1)	**1 hour**
4.4	Triggering of flip-flops- Master slave flip- flop, Edge- triggered flip-flops (Lecture 2)	**1 hour**
4.5	Excitation table and characteristic equations of flip- flops	**1 hour**
4.6	**Registers-** Register with parallel load	**1 hour**
4.7	**Counter Design:** Asynchronous counters- Binary and BCD counters- timing sequences and state diagrams. (Lecture 1)	**1 hour**
4.8	Asynchronous counters- Binary and BCD counters- timing sequences and state diagrams. (Lecture 2)	**1 hour**
4.9	Synchronous counters- Binary Up- down counter, BCD counter	**1 hour**
Module 5: Shift registers, Arithmetic algorithms & PLD's		**(11 hours)**
5.1	**Shift Registers** - Serial In Serial Out, Serial In Parallel Out.	**1 hour**
5.2	Bidirectional Shift Register with Parallel load	**1 hour**

5.3	**Shift register counters** - Ring Counter, Johnson Counter- timing sequences and state diagrams	**1 hour**
5.4	**Arithmetic Algorithms:** Algorithm for addition and subtraction of binary numbers in Signed magnitude and 2's complement representations (Lecture 1)	**1 hour**
5.5	Algorithm for addition and subtraction of binary numbers in Signed magnitude and 2's complement representations (Lecture 2)	**1 hour**
5.6	Algorithm for addition and subtraction of BCD numbers	**1 hour**
5.7	Representation of floating point numbers (IEEE Standard representations).	**1 hour**
5.8	Algorithms for floating point addition and subtraction	**1 hour**
5.9	**Programmable Logic devices** - ROM	**1 hour**
5.10	PLA, Implementation of simple circuits using PLA(Lecture 1)	**1 hour**
5.11	PLA, Implementation of simple circuits using PLA(Lecture 2)	**1 hour**

CST 205	OBJECT ORIENTED PROGRAMMING USING JAVA	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble: The purpose of this course is to enable learners to solve problems by breaking it down to object level while designing software and to implement it using Java. This course covers Object Oriented Principles, Object Oriented Programming in Java, Inheritance, Exception handling, Event handling, multithreaded programming and working with window-based graphics. This course helps the learners to develop Desktop GUI Applications, Mobile applications, Enterprise Applications, Scientific Applications and Web based Applications.

Prerequisite: Topics covered under the course PROGRAMMING IN C (EST 102)

Course Outcomes: After the completion of the course the student will be able to

CO1	Write Java programs using the object oriented concepts - classes, objects, constructors, data hiding, inheritance and polymorphism (Cognitive Knowledge Level: **Apply**)
CO2	Utilise datatypes, operators, control statements, built in packages & interfaces, Input/Output Streams and Files in Java to develop programs (Cognitive Knowledge Level: **Apply**)
CO3	Illustrate how robust programs can be written in Java using exception handling mechanism (Cognitive Knowledge Level: **Understand**)
CO4	Write application programs in Java using multithreading and database connectivity (Cognitive Knowledge Level: **Apply**)
CO5	Write Graphical User Interface based application programs by utilising event handling features and Swing in Java (Cognitive Knowledge Level: **Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓						✓		✓
CO4	✓	✓	✓	✓								✓
CO5	✓	✓	✓	✓								✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test1 (Marks %)	Test2 (Marks %)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

SYLLABUS

Object Oriented Programming Using Java

Module 1

Introduction:

Approaches to Software Design - Functional Oriented Design, Object Oriented Design, Case Study of Automated Fire Alarm System.

Object Modeling Using Unified Modeling Language (UML) – Basic Object Oriented concepts, UML diagrams, Use case model, Class diagram, Interaction diagram, Activity diagram, State chart diagram.

Introduction to Java **-** Java programming Environment and Runtime Environment, Development Platforms -Standard, Enterprise. Java Virtual Machine (JVM), Java compiler, Bytecode, Java applet, Java Buzzwords, Java program structure, Comments, Garbage Collection, Lexical Issues.

Module 2

Core Java Fundamentals:

Primitive Data types - Integers, Floating Point Types, Characters, Boolean. Literals, Type Conversion and Casting, Variables, Arrays, Strings, Vector class.

Operators **-** Arithmetic Operators, Bitwise Operators, Relational Operators, Boolean Logical Operators, Assignment Operator, Conditional (Ternary) Operator, Operator Precedence.

Control Statements - Selection Statements, Iteration Statements and Jump Statements.

Object Oriented Programming in Java - Class Fundamentals, Declaring Objects, Object Reference, Introduction to Methods, Constructors, ***this*** Keyword, Method Overloading, Using Objects as Parameters, Returning Objects, Recursion, Access Control, Static Members, Final Variables, Inner Classes, Command Line Arguments, Variable Length Arguments.

Inheritance - Super Class, Sub Class, The Keyword ***super***, protected Members, Calling Order of Constructors, Method Overriding, the Object class, Abstract Classes and Methods, using ***final*** with Inheritance.

Module 3

More features of Java:

Packages and Interfaces - Defining Package, CLASSPATH, Access Protection, Importing Packages, Interfaces.

Exception Handling **-** Checked Exceptions, Unchecked Exceptions, ***try*** Block and ***catch*** Clause, Multiple ***catch*** Clauses, Nested ***try*** Statements, ***throw***, ***throws*** and ***finally***.

Input/Output - I/O Basics, Reading Console Input, Writing Console Output, PrintWriter Class, Object Streams and Serialization, Working with Files.

Module 4

Advanced features of Java:

Java Library - String Handling – String Constructors, String Length, Special String Operations - Character Extraction, String Comparison, Searching Strings, Modifying Strings, using valueOf(), Comparison of StringBuffer and String.

Collections framework **-** Collections overview, Collections Interfaces- Collection Interface, List Interface.

Collections Class – ArrayList class. Accessing a Collection via an Iterator.

Event handling **-** Event Handling Mechanisms, Delegation Event Model, Event Classes, Sources of Events, Event Listener Interfaces, Using the Delegation Model.

Multithreaded Programming - The Java Thread Model, The Main Thread, Creating Thread, Creating Multiple Threads, Synchronization, Suspending, Resuming and Stopping Threads.

Module 5

Graphical User Interface and Database support of Java:

Swings fundamentals - Swing Key Features, Model View Controller (MVC), Swing Controls, Components and Containers, Swing Packages, Event Handling in Swings, Swing Layout Managers, Exploring Swings –JFrame, JLabel, The Swing Buttons, JTextField.

Java DataBase Connectivity (JDBC) **-** JDBC overview, Creating and Executing Queries – create table, delete, insert, select.

Text Books:

1. Herbert Schildt, Java: The Complete Reference, 8/e, Tata McGraw Hill, 2011.
2. Rajib Mall, Fundamentals of Software Engineering, 4th edition, PHI, 2014.
3. Paul Deitel, Harvey Deitel, Java How to Program, Early Objects 11th Edition, Pearson, 2018.

Reference Books:

1. Y. Daniel Liang, Introduction to Java Programming, 7/e, Pearson, 2013.
2. Nageswararao R., Core Java: An Integrated Approach, Dreamtech Press, 2008.
3. Flanagan D., Java in A Nutshell, 5/e, O'Reilly, 2005.
4. Barclay K., J. Savage, Object Oriented Design with UML and Java, Elsevier, 2004.
5. Sierra K., Head First Java, 2/e, O'Reilly, 2005.
6. Balagurusamy E., Programming JAVA a Primer, 5/e, McGraw Hill, 2014.

Sample Course Level Assessment Questions

Course Outcome1(CO1): For the following passage develop UML diagrams and then implement it as a Java program in accordance with your UML design.

Passage: College Office collects semester fee and college bus fee for each student. A clerk at the college office collects the fees from each student. The bus fee is calculated depending on the distance of the corresponding bus stop from the college. The semester fee varies depending upon the semester as well as branch of each student. Students are supposed to pay the fees in full. Economically backward students are eligible for 50% discount in semester fee. The consolidated fees receipt is issued to each student by the clerk, which contains the student name, admission number, semester and branch of student along with details of fees collected. Students can log in and view the details of fees remitted and dues if any. The system allows students and clerk level login to the system. Clerk is able to view reports of each class showing status of fees payment of each student.

Course Outcome 2(CO2): Write a Java program to evaluate a post fix expression containing two operands and a single operator using stack. Stack should be implemented as a separate entity so as to reflect OOP concepts.

Course Outcome 3(CO3): Write a program to demonstrate the start, run, sleep and join methods in Thread class.

Course Outcome 4(CO4): Write a GUI based program with separate buttons to add, delete and display student details i.e. name, student ID, current semester and branch of study based on student ID.

Course Outcome 5(CO5): Using Swing create a JFrame with a JLabel and two JButtons. Set the texts of JButtons as “Yes” and “No” respectively. Set the JLabel’s text to the text of the button currently being pressed. Initially the JLabel’s text is blank.

Model Question Paper

QP CODE: PAGES:3

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 205

Course Name: Object Oriented Programming using Java

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Briefly explain the portable, secure and robust features of Java.
2. Describe the concepts of object and class with a suitable Java program.
3. Explain the concept of method overriding with an example.
4. What is the use of the keyword ***final*** in Java?
5. Explain the concept of streams.
6. Explain any two applications of Serialization.
7. Distinguish the usage of "==" and ***equals()*** method when comparing String type?
8. What are Collections in Java? Explain any one Collection interface in Java.
9. Explain any two properties of Swing components in Java.
10. Explain JLabel component. With suitable examples explain any two of its constructors.

Part B

Answer any one question completely from each module

11.

(a) Describe in detail any three Object Oriented Programming principles. Illustrate with suitable examples.

(9)

(b) What is Java Runtime Environment? What is the role of Java Virtual Machine in it? (5)

OR

12.

(a) Compare and contrast Java standard edition and Java enterprise edition. (5)

(b) Why is Java considered to be platform independent? What is the role of Bytecode in making Java platform independent? (9)

13.

(a) Explain in detail the primitive data types in Java. (8)

(b) Explain automatic type conversion in Java with an example. What are the two conditions required for it? (6)

OR

14.

(a) Using a suitable Java program explain the difference between ***private*** and ***public*** members in the context of inheritance. (8)

(b) Is it possible to use the keyword ***super*** within a static method? Give justification for your answer. (6)

15.

(a) Explain in detail about byte streams and character streams with suitable code samples. (6)

(b) Describe in detail about exception handling, ***try*** block and ***catch*** clause with the help of a suitable Java program. (8)

OR

16.

(a) Explain object streams in Java. Explain the role of Serializable interface with a suitable code sample. (8)

(b) Explain ***throw***, ***throws*** and ***finally*** constructs with the help of a Java program. (6)

17.

(a) Describe in detail the creation of a thread using the Runnable interface and the Thread class with suitable examples. (10)

(b) Explain List Interface. Mention any two exceptions thrown by its methods. (4)

OR

18.

(a) Explain in detail the Delegation Event model for event handling in Java. (7)

(b) Write a simple program by extending appropriate class to demonstrate the working of threads in java. (7)

19.

(a) Write a Java program to demonstrate the use of JLabel and JButton by adding them to JFrame. (7)

(b) Explain step-by-step procedure of using Java DataBase Connectivity in Java programs. (7)

OR

20.

(a) Explain the class hierarchy of Java Swing components. (7)

(b) Write a Java Program to create a student table and to add student details to it using JDBC. (7)

Teaching Plan		
Module 1 : Introduction		(8 hours)
1.1	Approaches to Software Design- Functional Oriented Design, Object-Oriented Design, Case Study of Automated Fire Alarm System.	1 hour
1.2	Object Modeling Using UML – Basic object oriented concepts	1 hour
1.3	Basic object oriented concepts	1 hour
1.4	UML diagrams, Use case model	1hour
1.5	Class diagram, Interaction diagram	1hour
1.6	Activity diagram, State chart diagram	1hour
1.7	Java programming Environment and Runtime Environment, Development Platforms -Standard, Enterprise. JVM, Java compiler, Bytecode	1hour
1.8	Java applet, Java Buzzwords, Java program structure, Comments, Garbage Collection, Lexical Issues	1hour
Module 2: Core Java Fundamentals		(11 hours)
2.1	Core Java Fundamentals**:** Primitive Data types, Integers, Floating Point Types, Characters, Boolean	1 hour
2.2	Literals, Type Conversion and Casting, Variables, Arrays, Strings, Vector class.	1 hour
2.3	Operators: Arithmetic Operators, Bitwise Operators, Relational Operators, Boolean Logical Operators, Assignment Operator, Conditional (Ternary) Operator, Operator Precedence.	1 hour
2.4	Control Statements: Selection Statements, Iteration Statements and Jump Statements.	1 hour
2.5	Object Oriented Programming in Java**:** Class Fundamentals, Declaring Objects, Object Reference, Introduction to Methods	1 hour
2.6	Constructors, ***this*** Keyword, Method Overloading, Using Objects as Parameters	1 hour
2.7	Returning Objects, Recursion, Access Control, static Members	1 hour

2.8	Final Variables, Inner Classes, Command-Line Arguments, Variable Length Arguments	1 hour
2.9	Inheritance : Super class, Sub class, the keywords ***super***, ***protected*** Members,	1 hour
2.10	Calling Order of Constructors, Method Overriding, the Object class,	1 hour
2.11	Abstract Classes and Methods, Using ***final*** with Inheritance	1 hour
	Module 3: More features of Java	(8 hours)
3.1	Packages and Interfaces: Defining Package, CLASSPATH, Access Protection, Importing Packages	1 hour
3.2	Interfaces	1 hour
3.3	Input / Output: I/O Basics, Reading Console Input, Writing Console Output, PrintWriter Class	1 hour
3.4	Object Streams and Serialization	1 hour
3.5	Working with Files	1 hour
3.6	Exception Handling**:** Checked Exceptions, Unchecked Exceptions, ***try*** Block and ***catch*** Clause	1 hour
3.7	Multiple ***catch*** Clauses, Nested ***try*** Statements	1 hour
3.8	***throw***, ***throws*** and ***finally***	1 hour
	Module 4:Advanced features of Java	(10 hours)
4.1	Java Library: String Handling – String Constructors, String Length, Special String Operations	1hour
4.2	Character Extraction, String Comparison, Searching Strings, Modifying Strings Using valueOf( ), Comparison of String Buffer and String.	1hour
4.3	Collections framework – Collections overview, Collections Interfaces- Collection Interface	1hour
4.4	List Interface, Collections Class – ArrayList Class	1hour
4.5	Accessing Collections via an Iterator.	1hour
4.6	Event handling**:** Event Handling Mechanisms, Delegation Event Model	1hour
4.7	Delegation Event Model, Event Classes	1hour

4.8	Sources of Events, Event Listener Interfaces, Using the Delegation Model	1hour
4.9	Multithreaded Programming: The Java Thread Model, The Main Thread, Creating Thread	1hour
4.10	Creating Multiple Threads, Synchronization, Suspending, Resuming and Stopping Threads.	1hour
Module 5: Graphical User Interface and Database support of Java		(8 hours)
5.1	Swings fundamentals, Swing Key Features	1hour
5.2	MVC, Swing Controls, Components and Containers	1hour
5.3	Swing Packages, Event Handling in Swings.	1 hour
5.4	Swing Layout Managers	1hour
5.5	Exploring Swings –JFrame, JLabel, The Swing Buttons, JTextField.	1 hour
5.6	JDBC overview, Creating and Executing Queries – create table, delete, insert, select (Basics only, DBMS course is not a prerequisite).	1hour
5.7	Creating and Executing Queries – create table, delete, insert, select.	1 hour
5.8	Creating and Executing Queries – create table, delete, insert, select.	1 hour

<table>
<tr><td rowspan="2">CSL201</td><td rowspan="2">DATA STRUCTURES LAB</td><td>CATEGORY</td><td>L</td><td>T</td><td>P</td><td>CREDIT</td><td>YEAR OF INTRODUCTION</td></tr>
<tr><td>PCC</td><td>0</td><td>0</td><td>3</td><td>2</td><td>2019</td></tr>
</table>

Preamble: The aim of the Course is to give hands-on experience for Learners on creating and using different Data Structures. Data Structures are used to process data and arrange data in different formats for many applications. The most commonly performed operations on data structures are traversing, searching, inserting, deleting and few special operations like merging and sorting.

Prerequisite: Topics covered under the course Programming in C (EST 102)

CO1	Write a time/space efficient program using arrays/linked lists/trees/graphs to provide necessary functionalities meeting a given set of user requirements **(Cognitive Knowledge Level: Analyse)**
CO2	Write a time/space efficient program to sort a list of records based on a given key in the record (**Cognitive Knowledge Level: Apply**)
CO3	Examine a given Data Structure to determine its space complexity and time complexities of operations on it (**Cognitive Knowledge Level: Apply**)
CO4	Design and implement an efficient data structure to represent given data (**Cognitive Knowledge Level: Apply**)
CO5	Write a time/space efficient program to convert an arithmetic expression from one notation to another (**Cognitive Knowledge Level: Apply**)
CO6	Write a program using linked lists to simulate Memory Allocation and Garbage Collection (**Cognitive Knowledge Level: Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓		✓		✓		✓
CO2	✓	✓	✓	✓				✓		✓		✓
CO3	✓	✓	✓	✓				✓		✓		✓
CO4	✓	✓	✓	✓				✓		✓		✓
CO5	✓	✓	✓					✓		✓		✓
CO6	✓	✓	✓					✓		✓		✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Test (Internal Exam)*Percentage***	**End Semester Examination *Percentage***
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration**
150	**75**	**75**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance : 15 marks

Continuous Evaluation in Lab : 30 marks

Continuous Assessment Test : 15 marks

Viva-voce : 15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks will be converted out of 75 for End Semester Examination.

Operating System to Use in Lab **:** Linux

Compiler/Software to Use in Lab **:** gcc

Programming Language to Use in Lab **:** Ansi C

Fair Lab Record:

All Students attending the Data Structures Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record the right hand page should contain Experiment Heading, Experiment Number, Date of Experiment, Aim of Experiment, Data Structure used and the operations performed on them, Details of Experiment including algorithm and Result of Experiment. The left hand page should contain a print out of the code used for the experiment and sample output obtained for a set of input.

SYLLABUS

1. Implementation of Polynomials and Sparse matrices using arrays**
2. Implementation of Stack , Queues, Priority Queues, DEQUEUE and Circular Queues using arrays**
3. Application problems using stacks: Conversion of expression from one notation to another notation . **
4. Implementation of various linked list operations. **
5. Implementation of stack, queue and their applications using linked list.pression
6. Implementation of trees using linked list
7. Representation of polynomials using linked list, addition and multiplication of polynomials. **
8. Implementation of binary trees using linked lists and arrays- creations, insertion, deletion and traversal. **
9. Implementation of binary search trees – creation, insertion, deletion, search
10. Any application programs using trees
11. Implementation of sorting algorithms – bubble, insertion, selection, quick, merge sort

and heap sort.**

12. Implementation of searching algorithms – linear search, binary search.**

13. Representation of graphs and computing various parameters (in degree, out degree etc.) - adjacency list, adjacency matrix.

14. Implementation of BFS and DFS for each graph representations.**

15. Implementation of hash table using your own mapping functions and observe collisions and overflow resolving schemes.**

16. Simulation of first-fit, best-fit and worst-fit allocations.

17. Simulation of a basic memory allocator and garbage collector using doubly linked list.
    ** mandatory.

DATA STRUCTURES LAB - PRACTICE QUESTIONS

1. Write a program to read two polynomials and store them in an array. Calculate the sum of the two polynomials and display the first polynomial, second polynomial and the resultant polynomial.

2. C Write a program to enter two matrices in normal form . Write a function to convert two matrices to tuple form and display it. Also find the transpose of the two matrices represented in tuple form and display it. Find the sum of the two matrices in tuple form and display the sum in tuple form.

3. Write a program to enter two matrices in normal form . Write a function to convert two matrices to tuple form and display it. Also find the transpose of the two matrices represented in tuple form and display it. Find the sum of the two matrices in tuple form and display the sum in tuple form.

4. Implement a circular queue using arrays with the operations:
    4.1. Insert an element to the queue.
    4.2. Delete an elements from the queue.
    4.3. Display the contents of the queue after each operation.

5. Implement a Queue using arrays with the operations:

5.1. Insert elements to the Queue.
5.2. Delete elements from the Queue.
5.3. Display the contents of the Queue after each operation.

6. Implement a Stack using arrays with the operations:
   6.1. Pushing elements to the Stack.
   6.2. Popping elements from the Stack
   6.3. Display the contents of the Stack after each operation.

7. Implement a Priority Queue using arrays with the operations:
   7.1. Insert elements to the Priority Queue.
   7.2. Delete elements from the Priority Queue.
   7.3. Display the contents of the Priority Queue after each operation.

8. Implement a Double-Ended Queue (DEQUEUE) with the operations:
   8.1. Insert elements to the Front of the queue.
   8.2. Insert elements to the Rear of the queue
   8.3. Delete elements from the Front of the queue.
   8.4. Delete elements from the Rear of the queue.
   8.5. Display the queue after each operation.

9. Using stack convert an infix expression to a postfix expression and evaluate the postfix expression.

10. Write a program to convert an infix expression to a prefix expression using stacks.

11. Convert an infix expression to a postfix expression without using a stack

12. Write a menu driven program for performing the following operations on a Linked List:
    12.1. Display
    12.2. Insert at Beginning
    12.3. Insert at End
    12.4. Insert at a specified Position
    12.5. Delete from Beginning
    12.6. Delete from End
    12.7. Delete from a specified Position

13. Implement a stack using linked list with the operations:
    13.1. Push elements to the queue.
    13.2. Pop elements from the queue.
    13.3. Display the queue after each operation.

14. Implement a Queue using linked list with the operations:

14.1. Insert an elements to the queue.
14.2. Delete an elements from the queue.
14.3. Display the queue after each operation.

15. Write a program to reverse the content of queue using stack

16. Write a program to read two polynomials and store them using linked list. Calculate the sum of the two polynomials and display the first polynomial, second polynomial and the resultant polynomial.

17. Write a program to read two polynomials and store them using linked list. Find the product of two polynomials and store the result using linked list. Display the resultant polynomial.

18. Write a program for addition of polynomials containing two variables using linked list.

19. The details of students(number, name, total-mark) are to be stored in a linked list. Write functions for the following operations:
    19.1. Insert
    19.2. Delete
    19.3. Search
    19.4. Sort on the basis of number
    19.5. Display the resultant list after every operation

20. Create a Doubly Linked List from a string taking each character from the string. Check if the given string is palindrome in an efficient method.

21. Create a binary tree with the following operations
    21.1. Insert a new node
    21.2. Inorder traversal.
    21.3. Preorder traversal.
    21.4. Postorder traversal.
    21.5. Delete a node.

22. Write a program to create a binary search tree and find the number of leaf nodes

23. Create a binary search tree with the following operations:
    23.1. Insert a new node .
    23.2. Inorder traversal.
    23.3. Preorder traversal.
    23.4. Postorder traversal.
    23.5. Delete a node.

24. Write a program to sort a set of numbers using a binary tree.

25. Represent any given graph and
    25.1. Perform a depth first search .
    25.2. Perform a breadth first search

26. Create a text file containing the name, height, weight of the students in a class. Perform Quick sort and Merge sort on this data and store the resultant data in two separate files. Also write the time taken by the two sorting methods into the respective files.

Eg.	Sony Mathew	5.5	60
	Arun Sajeev	5.7	58
	Rajesh Kumar	6.1	70

27. Write a program to sort a set of numbers using Heap sort and find a particular number from the sorted set using Binary Search.

28. Implement a Hash table using Chaining method. Let the size of hash table be 10 so that the index varies from 0 to 9.

29. Implement a Hash table that uses Linear Probing for collision resolution

CSL 203	**OBJECT ORIENTED PROGRAMMING LAB (IN JAVA)**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**	**YEAR OF INTRODUCTION**
		PCC	**0**	**0**	**3**	**2**	**2019**

Preamble: The aim of the course is to provide hands-on experience to the learners on various object oriented concepts in Java Programming. This course helps the learners to enhance the capability to design and implement various Java applications for real world problems.

Prerequisite: Topics covered under the course Programming in C (EST 102)

Course Outcomes:

At the end of the course, the student should be able to

CO1	Implement the Object Oriented concepts - constructors, inheritance, method overloading & overriding and polymorphism in Java (Cognitive Knowledge Level: **Apply**)
CO2	Implement programs in Java which use datatypes, operators, control statements, built in packages & interfaces, Input/Output streams and Files (Cognitive Knowledge Level: **Apply**)
CO3	Implement robust application programs in Java using exception handling (Cognitive Knowledge Level: **Apply**)
CO4	Implement application programs in Java using multithreading and database connectivity (Cognitive Knowledge Level: **Apply**)
CO5	Implement Graphical User Interface based application programs by utilizing event handling features and Swing in Java (Cognitive Knowledge Level: **Apply**)

Mapping of course outcomes with program outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓			✓		✓		✓
CO2	✓	✓	✓	✓	✓			✓		✓		✓
CO3	✓	✓	✓	✓	✓			✓		✓		✓
CO4	✓	✓	✓	✓	✓			✓		✓		✓
CO5	✓	✓	✓	✓	✓			✓		✓		✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Test - Internal Exam (Percentage)	End Semester Examination (Percentage)
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 15 marks
Continuous Evaluation in Lab	: 30 marks
Continuous Assessment Test	: 15 marks
Viva-voce	: 15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks will be converted out of 75 for End Semester Examination.

Operating System to Use in Lab **:** Linux

Compiler/Software to Use in Lab **:** gcc, javac, jdk, jre, Eclipse, NetBeans, MySQL / PostgreSQL.

Programming Language to Use in Lab **:** Java

Fair Lab Record:
All Students attending the Object Oriented Programming Lab (in Java) should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record the right hand page should contain Experiment Heading, Experiment Number, Date of Experiment, Aim of Experiment, Operations Performed, Details of Experiment including algorithm and Result of Experiment. The left hand page should contain a print out of the code used for the experiment and sample output obtained for a set of input.

SYLLABUS

The syllabus contains six sessions (A, B, C, D, E, F). Each session consists of three concrete Java exercises, out of which at least two questions are mandatory.

(A) Basic programs using datatypes, operators, and control statements in Java.

1) Write a Java program that checks whether a given string is a palindrome or not.
   Ex: MALAYALAM is palindrome.
2) Write a Java Program to find the frequency of a given character in a string. **
3) Write a Java program to multiply two given matrices. **

(B) Object Oriented Programming Concepts: Problem on the use of constructors, inheritance, method overloading & overriding, polymorphism and garbage collection:

4) Write a Java program which creates a class named 'Employee' having the following members: Name, Age, Phone number, Address, Salary. It also has a method named 'print-Salary( )' which prints the salary of the Employee. Two classes 'Officer' and 'Manager' inherits the 'Employee' class. The 'Officer' and 'Manager' classes have data members 'spe-cialization' and 'department' respectively. Now, assign name, age, phone number, address and salary to an officer and a manager by making an object of both of these classes and print the same. (Exercise to understand inheritance). **
5) Write a java program to create an abstract class named Shape that contains an empty method named numberOfSides( ). Provide three classes named Rectangle, Triangle and Hexagon such that each one of the classes extends the class Shape. Each one of the class-es contains only the method numberOfSides( ) that shows the number of sides in the giv-en geometrical structures. (Exercise to understand polymorphism). **
6) Write a Java program to demonstrate the use of garbage collector.

(C) Handling different types of files as well as input and output management methods:

7) Write a file handling program in Java with reader/writer.
8) Write a Java program that read from a file and write to file by handling all file related ex-ceptions. **
9) Write a Java program that reads a line of integers, and then displays each integer, and the sum of all the integers (Use String Tokenizer class of java.util). **

(D) Exception handling and multi-threading applications:

10) Write a Java program that shows the usage of try, catch, throws and finally. **
11) Write a Java program that implements a multi-threaded program which has three threads. First thread generates a random integer every 1 second. If the value is even, second thread computes the square of the number and prints. If the value is odd the third thread will print the value of cube of the number.
12) Write a Java program that shows thread synchronization. **

(E) Graphics Programming:

13) Write a Java program that works as a simple calculator. Arrange Buttons for digits and the + - * % operations properly. Add a text field to display the result. Handle any possible exceptions like divide by zero. Use Java Swing. **
14) Write a Java program that simulates a traffic light. The program lets the user select one of three lights: red, yellow, or green. When a radio button is selected, the light is turned on, and only one light can be on at a time. No light is on when the program starts. **
15) Write a Java program to display all records from a table using Java Database Connectivity (JDBC).

(F) Standard Searching and Sorting Algorithms using data structures and algorithms learned from course Data Structures (**CST 201**):

16) Write a Java program for the following: **
    1) Create a doubly linked list of elements.
    2) Delete a given element from the above list.
    3) Display the contents of the list after deletion.
17) Write a Java program that implements Quick sort algorithm for sorting a list of names in ascending order. **
18) Write a Java program that implements the binary search algorithm.

** Mandatory

PRACTICE QUESTIONS

1) Write a Java program to reverse an given string.
2) Write a Java program to display the transpose of a given matrix.
3) Write a Java program to find the second smallest element in an array.
4) Write a Java program to check whether a given number is prime or not.
5) Write a Java program to calculate the area of different shapes namely circle, rectangle, and triangle using the concept of method overloading.
6) Write two Java classes Employee and Engineer. Engineer should inherit from Employee class. Employee class to have two methods display() and calcSalary(). Write a program to display the engineer salary and to display from Employee class using a single object instantiation (i.e., only one object creation is allowed).
   - display() only prints the name of the class and does not return any value. Ex. " Name of class is Employee."
   - calcSalary() in Employee displays "Salary of employee is 10000" and calcSalary() in Engineer displays "Salary of employee is 20000."
7) Write a Java program to illustrate Interface inheritance.
8) Write a Java program that shows how to create a user-defined exception.
9) Write a Java program to create two threads: One for displaying all odd number between 1 and 100 and second thread for displaying all even numbers between 1 and 100.
10) Write a Java program that shows thread priorities.
11) Write a Java program that reads a file and displays the file on the screen, with a line number before each line.
12) Write a Java program that displays the number of characters, lines and words in a text file.
13) Write a Java program for handling mouse events.
14) Write a Java program for handling key events using Adapter classes (general).
15) Write a Java program that allows the user to draw lines, rectangles and ovals.
16) Write a Java Swing program to print a wave form on the output screen.
17) Write a program to accept rollno, name, CGPA of "n" students and store the data to a database using JDBC connectivity. Display the list of students having CGPA greater than 7. (Use MySQL /PostgreSQL).
18) Write a Java program to implement Heap sort algorithm using array.

SEMESTER IV

MAT256	PROBABILITY AND STATISTICAL MODELLING	Category	L	T	P	Credit	Year of Introduction
		BSC	3	1	0	4	2019

Preamble: Study of this course provides the learners a clear understanding of fundamental concepts in probability and statistics. This course covers the modern theory of probability and statistics, important models of sampling, techniques of hypothesis testing and correlation & regression. The course helps the learners to find varied applications in engineering and science like disease modelling, climate prediction and computer networks.

Prerequisite: A sound knowledge in Calculus.

Mapping of course outcomes with program outcomes

CO1	Explain the concept, properties and important models of discrete random variables and use them to analyze suitable random phenomena**(Cognitive Knowledge Level: Apply)**
CO2	Summarize the properties and relevant models of continuous random variables and use them to analyze suitable random phenomena**(Cognitive Knowledge Level: Apply)**
CO3	Make use of concepts of sampling and theory of estimation to solve application level problems **(Cognitive Knowledge Level: Apply)**
CO4	Organize the basic concepts in hypothesis testing and develop decision procedures for the most frequently encountered testing problems**(Cognitive Knowledge Level: Apply)**
CO5	Build statistical methods like correlation and regression analysis to interpret experimental data **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔								✔
CO2	✔	✔	✔	✔								✔
CO3	✔	✔	✔	✔								✔
CO4	✔	✔	✔	✔								✔
CO5	✔	✔	✔	✔								✔
CO6	✔	✔	✔	✔								✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance	**10 marks**
Continuous Assessment Tests(Average of Internal Tests1&2)	**25 marks**
Continuous Assessment Assignment	**15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module-1 (Discrete probability distributions)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation ,multiple random variables.

Module - 2(Continuous probability distributions)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential and normal distributions, Continuous bivariate distributions, marginal distributions, Independent random variables. Expectation-multiple random variables, independent and identically distributed (i.i.d) random variables and Central limit theorem (Proof not required).

Module - 3(Sampling Techniques)

Need for Sampling, Some Fundamental Definitions, Important Sampling Distributions, Sampling Theory, Sandler's A-test, Concept of Standard Error, Estimation, Estimating the Population Mean(μ), Estimating Population Proportion, Sample Size and its Determination, Determination of

Sample Size through the Approach Based on Precision Rate and Confidence Level, Determination of Sample Size through the Approach Based on Bayesian Statistics

Module– 4**(Testing of Hypothesis)**

Hypothesis and Test Procedures, Tests about a population mean, Tests concerning a population proportion, p-values, Single factor ANOVA, F-test, Multiple comparisons in ANOVA, Two factor ANOVA

Module - 5 (Correlation and Regression Analysis)

Simple Linear Regression Model, Estimating model parameters, Correlation, Non-Linear and multiple regression, Assessing Model Adequacy, Regression with transformed values, Polynomial Regression, Multiple Regression Analysis

Text Books

1. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 8th edition, Cengage, 2012
2. Research Methodology: Methods and Techniques: C.R. Kothari, New Age International Publishers

Reference Books

1. HosseinPishro-Nik, Introduction to Probability, Statistics and Random Processes, Kappa Research, 2014 (Also available online at www.probabilitycourse.com)
2. Sheldon M. Ross, Introduction to probability and statistics for engineers and scientists, 4th edition, Elsevier, 2009.
3. T. VeeraRajan, Probability, Statistics and Random processes, Tata McGraw-Hill,2008
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010
5. Levin R.I. and Rubin D.S., Statistics for Management, 7th edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2001.
6. Srivastava TN, Shailaja Rego, Statistics for Management, Tata McGraw Hill, 2008.
7. Anand Sharma, Statistics for Management, Himalaya Publishing House, Second Revised edition, 2008.
8. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
9. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edition.), Pearson Education, Asia.
10. Sampling of Populations: Methods and Applications (2008): Paul S. Levy , Stanley Lemeshow (Fourth Edition), John Wiley &Sons

Course Level Assessment Questions

Course Outcome1 (CO1):

1. Organizers of a concert are limiting tickets sales to a maximum of 4 tickets per customer. Let T be the number of tickets purchased by a random customer. Here is the probability distribution of T:

T=#of tickets	1	2	3	4
P(T)	0.1	0.3	0.2	0.4

Calculate the expected value of T.

2. X is a binomial random variable B (n, p) with n = 100 and p= 0.1. How would you approximate it by a Poisson random variable?
3. Three balls are drawn at random without replacement from a box containing 2 white,3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X, Y).

Course Outcome 2(CO2):

1. What can you say about P(X = a) for any real number a when X is a (i) discrete random variable? (ii) continuous random variable?
2. Let X be a random variable with PDF given by

$$f_X(x) = \begin{cases} \mathbf{cx^2} & \mathbf{|x| \le 1} \\ \mathbf{0} & \text{Otherwise} \end{cases}$$

   a. Find the constant c.
   b. Find E(X) and Var(X).
   c. Find P(X≥1/2).

3. A string, 1 meter long, is cut into two pieces at a random point between its ends. What is the probability that the length of one piece is at least twice the length of the other?

Course Outcome 3(CO3):

1. In a random selection of 64 of the 2400 intersections in a small city, the mean number of scooter accidents per year was 3.2 and the sample standard deviation was 0.8.
   (a) Make an estimate of the standard deviation of the population from the sample standard deviation.
   (b) Work out the standard error of mean for this finite population.
   (c) If the desired confidence level is 0.90, what will be the upper and lower limits of the confidence interval for the mean number of accidents per intersection per year?

2. Suppose a certain hotel management is interested in determining the percentage of the hotel's guests who stay for more than 3 days. The reservation manager wants to be 95 per cent confident that the percentage has been estimated to be within ± 3% of the true value. What is the most conservative sample size needed for this problem?
3. 500 articles were selected at random out of a batch containing 10000 articles and 30 were found defective. How many defective articles would you reasonably expect to find in the whole batch?

Course Outcome 4(CO4):

1. A manufacturer of sprinkler systems used for fire protection in office buildings claims that the true average system-activation temperature is 130°F. A sample of n=9 systems, when tested, yields a sample average activation temperature of 131.08°F. If the distribution of activation times is normal with standard deviation 1.5°F, does the data contradict the manufacturer's claim at significance level α=0.01?
2. Let m denote the true average radioactivity level (picocuries per liter). The value 5 pCi/L is considered the dividing line between safe and unsafe water. Would you recommend testing H_0: μ =5 versus H_a: μ >5 or H_0: μ =5 versus H_a: μ <5 ? Explain your reasoning.
3. Pairs of P-values and significance levels, a, are given. For each pair, state whether the observed *P*-value would lead to rejection of H_0 at the given significance level.
   a. P-value=0.084, α=0.05
   b. P-value=0.003, α=0.001

Course Outcome 5 (CO5):

1.Calculate and interpret the correlation coefficient of the two variables below.

Person	Hand	Height
A	17	150
B	15	154
C	19	169
D	17	172
E	21	175

2. You are told that a 95% CI for expected lead content when traffic flow is 15, based on a sample of n=10 observations is (462.1, 597.7). Calculate a CI with confidence level 99% for expected lead content when traffic flow is 15.
3. A trucking company considered a multiple regression model for relating the dependent variable y=total daily travel time for one of its drivers (hours) to the predictors x_1=distance travelled (miles) and x_2=the number of deliveries made. Suppose that the model equation is $Y = \mathbf{-0.800 + 0.060\, x_1 + 0.900 x_2 + \varepsilon}$. What is the mean value of travel time when distance traveled is 50 miles and three deliveries are made?

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: MAT256

Course Name: Probability and Statistical Modelling

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Let X denote the number that shows up when an unfair die is tossed. Faces 1 to 5 of the die are equally likely, while face 6 is twice as likely as any other. Find the probability distribution, mean and variance of X.

2. An equipment consists of 5 components each of which may fail independently with probability 0.15. If the equipment is able to function properly when at least 3 of the components are operational, what is the probability that it functions properly?

3. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?

4. X and Y are independent random variables with X following an exponential distribution with parameter μ and Y following and exponential distribution with parameterλ. Find P (X+ Y$\leqslant$ 1).

5. Discuss the difference between F-distribution and Chi-square distribution.

6. From a random sample of 36 New Delhi civil service personnel, the mean age and the sample standard deviation were found to be 40 years and 4.5 years

respectively. Construct a 95 per cent confidence interval for the mean age of civil servants in New Delhi.

7. A sample of 50 lenses used in eyeglasses yields a sample mean thickness of 3.05 mm and a sample standard deviation of .34 mm. The desired true average thickness of such lenses is 3.20 mm. Does the data strongly suggest that the true average thickness of such lenses is something other than what is desired? Test using α=0.05.

8. A random sample of 110 lightning flashes in a certain region resulted in a sample average radar echo duration of 0.81 sec and a sample standard deviation of 0.34 sec. Calculate a 99% (two-sided) confidence interval for the true average echo duration m, and interpret the resulting interval.

9. Let the test statistic T have a t distribution when H_0 is true. Give the significance level for the following situation H_a: $\mu > \mu_0$, df=15, rejection region $t \geq 3.733$.

10. Calculate the regression coefficient and obtain the lines of regression for the following data

X	1	2	3	4	5	6	7
Y	9	8	10	12	11	13	14

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) The probability mass function of a discrete random variable is P(x) = kx ; x = 1,2,3 where k is positive constant. Find (i) the value of k (ii) P(X ≤2) (iii) E[X] (iv) var(1-X). **(7)**

(b) Find the mean and variance of a binomial random variable **(7)**

OR

12. (a) Accidents occur at an intersection at a Poisson rate of 2 per day. What is the probability that there would be no accidents on a given day? What is the probability that in January there are at least 3 days (not necessarily consecutive) without any accidents? **(7)**

(b) One fair die is rolled. Let X denote the number on the die and Y = 0 or 1, according as the die shows an even number or odd number. Find (i) the joint probability distribution of X and Y, (ii) the marginal distributions. (iii) Are X and Y independent? **(7)**

13. (a) The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130. **(7)**

(b) A continuous random variable X is uniformly distributed with mean 1 and variance 4/3. Find P(X < 0)? **(7)**

OR

14. (a) The joint density function of random variables X and Y is given by **(7)**

$$\mathbf{f(x, y)} = \begin{cases} e^{-(x+y)}, & x>0,\ y>0 \\ 0 & \text{otherwise} \end{cases}$$

Find $P(X + Y \leq 1)$. Are X and Y independent? Justify

(b) The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time. **(7)**

15. (a) A market research survey in which 64 consumers were contacted and states that 64 percent of all consumers of a certain product were motivated by the product's advertising. Find the confidence limits for the proportion of consumers motivated by advertising in the population, given a confidence level equal to 0.95. **(7)**

(b) Determine the size of the sample for estimating the true weight of the cereal containers for the universe with N = 5000 on the basis of the following information: **(7)**

(i) the variance of weight = 4 ounces on the basis of past records.

(ii) estimate should be within 0.8 ounces of the true average weight with 99% probability.

OR

16. (a) The foreman of *ABC* mining company has estimated the average quantity of iron ore extracted to be 36.8 tons per shift and the sample standard deviation to be 2.8 tons per shift, based upon a random selection of 4 shifts. Construct a 90 percent confidence interval around this estimate. **(7)**

(b) What should be the size of the sample if a simple random sample from a population of 4000 items is to be drawn to estimate the percent defective within 2 per cent of the true value with 95.5 per cent probability? What would be the size of the sample if the population is assumed to be infinite in the given case? **(7)**

17. The calibration of a scale is to be checked by weighing a10-kg test specimen 25 times. Suppose that the results of different weighings are independent of one another and that the weight on each trial is normally distributed with σ =0.200kg. Let μ denote the true average weight reading on the scale.

(a)What hypotheses should be tested? **(7)**

(b)Suppose the scale is to be recalibrated if either $\bar{x} \geq 10.1032$ or $\bar{x} \leq 0$ .8968. What is the probability that recalibration is carried out when it is actually unnecessary? **(7)**

OR

18. (a) Lightbulbs of a certain type are advertised as having an average lifetime of 750 hours. The price of these bulbs is very favorable, so a potential customer has decided to go ahead with a purchase arrangement unless it can be conclusively demonstrated that the true average lifetime is smaller than what is advertised. A random sample of 50 bulbs was selected, the lifetime of each bulb determined, and the appropriate hypotheses were tested using Minitab, resulting in the accompanying output.

Variable	N	Mean	StDev	SEMean	Z	P-Value
lifetime	50	738.44	38.20	5.40	-2.14	0

What conclusion would be appropriate for a significance level of 0.05? A significance level of 0.01? What significance level and conclusion would you recommend**?** **(7)**

(b) The recommended daily dietary allowance for zinc among males older than age 50 years is 15 mg/day. The article "Nutrient Intakes and Dietary Patterns of Older Americans: A National Study" reports the following summary data on intake for a sample of males age 65–74 years: n=115, $\bar{x}$ =11.3, and s=6.43. Does this data indicate that average daily zinc intake in the population of all males ages 65–74 falls below the recommended allowance? **(7)**

19. The flow rate y (m^3/min) in a device used for air-quality measurement depends on the pressure drop x (inches of water) across the device's filter. Suppose that for x values between 5 and 20, the two variables are related according to the simple linear regression model with true regression line

$y = -0.12 + 0.095x$

(a)What is the expected change in flow rate associated with a 1 inch increase in pressure drop? Explain. **(7)**

(b)What change in flow rate can be expected when pressure drop decreases by 5 inches? **(7)**

OR

20. Suppose that in a certain chemical process the reaction time y (hr) is related to the temperature (°F) in the chamber in which the reaction takes place according to the simple linear regression model with equation $y = 5.00 - 0.01x$ and $\sigma = 0.075$

(a)What is the expected change in reaction time for a 1°F increase and 10°F increase in temperature? **(7)**

(b)What is the expected reaction time when temperature is 200°F and 250°F? **(7)**

Teaching Plan

No	Contents	No. of Lecture Hours (45 hrs)
Module 1- (Discrete Probability distributions) (9 hours)		
1.1	Discrete random variables	1 hour
1.2	Probability Distributions	1 hour
1.3	Expectation, mean and variance	1 hour
1.4	Binomial distribution	1 hour
1.5	Poisson distribution	1 hour
1.6	Poisson approximation to binomial Distribution	1 hour
1.7	Discrete bivariate distributions	1 hour
1.8	Marginal distributions, Independent Random variables	1 hour
1.9	Expectation-multiple random variables	1 hour
Module-2 Continuous Probability distributions(9 hours)		
2.1	Continuous random variables and probability distributions	1 hour

2.2	Expectation, mean and variance	1 hour
2.3	Uniform distributions	1 hour
2.4	Exponential Distribution	1 hour
2.5	Normal distribution	1 hour
2.6	Continuous Bivariate distributions	1 hour
2.7	Marginal distributions, Independent random variables	1 hour
2.8	Expectation-multiple random variables, i.i.d random variables	1 hour
2.9	Central limit theorem.	1 hour
Module-3 (Sampling Techniques) (9 hours)		
3.1	Need for Sampling	1 hour
3.2	Some fundamental Definitions, Important Sampling Distributions	1 hour
3.3	Sampling Theory, Sandler's A-test	1 hour
3.4	Concept of Standard Error, Estimation , Estimating the Population Mean(μ)	1 hour
3.5	Estimating Population Proportion	1 hour
3.6	Sample Size and its Determination	1 hour
3.7	Determination of Sample Size through the Approach Based on Precision Rate and Confidence Level	1 hour
3.8	Determination of Sample Size through the Approach Based on Bayesian Statistics	1 hour
3.9	Determination of Sample Size through the Approach Based on Bayesian Statistics(continued)	1 hour
Module-4 (Testing of Hypothesis) (9 hours)		
4.1	Null and alternate Hypothesis	1 hour
4.2	Test Procedures	1 hour
4.3	Test Tests about a population mean	1 hour
4.4	Tests concerning a population proportion	1 hour
4.5	p-values	1 hour

4.6	Single factor ANOVA	1 hour
4.7	F-Test	1 hour
4.8	Multiple comparisons in ANOVA	1 hour
4.9	Two factor ANOVA	1 hour
Module-5 (Correlation and Regression Analysis) (9 hours)		
5.1	Simple Linear Regression Model(Lecture 1)	1 hour
5.2	Simple Linear Regression Model(Lecture 2)	1 hour
5.3	Estimating model parameters	1 hour
5.4	Correlation	1 hour
5.5	Non-Linear and multiple regression	1 hour
5.6	Assessing Model Adequacy	1 hour
5.7	Regression with transformed values	1 hour
5.8	Polynomial Regression	1 hour
5.9	Multiple Regression Analysis	1 hour

CST202	COMPUTER ORGANISATION AND ARCHITECTURE	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble:

The course is prepared with the view of enabling the learners capable of understanding the fundamental architecture of a digital computer. Study of Computer Organization and Architecture is essential to understand the hardware behind the code and its execution at physical level by interacting with existing memory and I/O structure. It helps the learners to understand the fundamentals about computer system design so that they can extend the features of computer organization to detect and solve problems occurring in computer architecture.

Prerequisite : Topics covered under the course Logic System Design (CST 203)

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Recognize and express the relevance of basic components, I/O organization and pipelining schemes in a digital computer **(Cognitive knowledge: Understand)**
CO2	Explain the types of memory systems and mapping functions used in memory systems **(Cognitive Knowledge Level: Understand)**
CO3	Demonstrate the control signals required for the execution of a given instruction **(Cognitive Knowledge Level: Apply)**)
CO4	Illustrate the design of Arithmetic Logic Unit and explain the usage of registers in it (**Cognitive Knowledge Level: Apply**)
CO5	Explain the implementation aspects of arithmetic algorithms in a digital computer **(Cognitive Knowledge Level:Apply)**
CO6	Develop the control logic for a given arithmetic problem (**Cognitive Knowledge Level: Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓						✓		✓
CO3	✓	✓	✓	✓						✓		✓
CO4	✓	✓	✓	✓						✓		✓
CO5	✓	✓	✓							✓		✓
CO6	✓	✓	✓	✓								✓

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PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
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PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

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Analyze			

Evaluate			
Create			

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Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

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Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module 1

Basic Structure of computers – functional units - basic operational concepts - bus structures. Memory locations and addresses - memory operations,Instructions and instruction sequencing , addressing modes.

Basic processing unit – fundamental concepts – instruction cycle – execution of a complete instruction - single bus and multiple bus organization

Module 2

Register transfer logic: inter register transfer – arithmetic, logic and shift micro operations.

Processor logic design: - processor organization – Arithmetic logic unit - design of arithmetic circuit - design of logic circuit - Design of arithmetic logic unit - status register – design of shifter - processor unit – design of accumulator.

Module 3

Arithmetic algorithms: Algorithms for multiplication and division (restoring method) of binary numbers. Array multiplier , Booth's multiplication algorithm.

Pipelining: Basic principles**,** classification of pipeline processors, instruction and arithmetic pipelines (Design examples not required), hazard detection and resolution.

Module 4

Control Logic Design: Control organization – Hard_wired control-microprogram control – control of processor unit - Microprogram sequencer,micro programmed CPU organization - horizontal and vertical micro instructions.

Module 5

I/O organization: accessing of I/O devices – interrupts, interrupt hardware -Direct memory access.

Memory system: basic concepts – semiconductor RAMs. memory system considerations – ROMs, Content addressable memory, cache memories - mapping functions.

Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, Computer Organization ,5/e, McGraw Hill, 2011
2. Mano M. M., Digital Logic & Computer Design, PHI, 2004
3. KaiHwang, Faye Alye Briggs, Computer architecture and parallel processing McGraw-Hill, 1984

Reference Books

1. Mano M. M., Digital Logic & Computer Design, 3/e, Pearson Education, 2013.
2. Patterson D.A. and J. L. Hennessy, Computer Organization and Design, 5/e, Morgan Kaufmann Publishers, 2013.
3. William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 9/e, 2013.
4. Chaudhuri P., Computer Organization and Design, 2/e, Prentice Hall, 2008.
5. Rajaraman V. and T. Radhakrishnan, Computer Organization and Architecture, Prentice Hall, 2011

Sample Course Level Assessment Questions

Course Outcome1(CO1): Which are the registers involved in a memory access operation and how are they involved in it?

Course Outcome 2(CO2): Explain the steps taken by the system to handle a write miss condition inside the cache memory.

Course Outcome 3(CO3): Generate the sequence of control signals required for the execution of the instruction MOV [R1],R2 in a threebus organization.

Course Outcome 4(CO4): Design a 4-bit combinational logic shifter with 2 control signals H0 and H1 that perform the following operations :

H1	H0	Operation
0	0	Transfer 1's to all output line
0	1	No shift operation
1	0	Shift left
1	1	Shift right

Course Outcome 5(CO5): Explain the restoring algorithm for binary division. Also trace the algorithm to divide $(1001)_2$ by $(11)_2$

Course Outcome 6(CO6): Design a software control logic based on microprogramed control to perform the addition of 2 signed numbers represented in sign magnitude form.

Model Question Paper

QP CODE: PAGES:2

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 202

Course Name: Computer organisation and architecture

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Give the significance of instruction cycle.
2. Distinguish between big endian and little endian notations. Also give the significance of these notations.
3. Compare I/O mapped I/O and memory mapped I/O.
4. Give the importance of interrupts in I/O interconnection.
5. Justify the significance of status register.
6. How does the arithmetic circuitry perform logical operations in an ALU.
7. Illustrate divide overflow with an example.
8. Write notes on arithmetic pipeline.
9. Briefly explain the role of micro program sequence.
10. Differentiate between horizontal and vertical micro instructions.

Part B

Answer any one Question from each module. Each question carries 14 Marks

11.

11.(a) What is the significance of addressing modes in computer architecture.

(4)

11.(b) Write the control sequence for the instruction DIV R1,[R2] in a three bus structure.
(10)

OR

12. Explain the concept of a single bus organization with help of a diagram. Write the control sequence for the instruction ADD [R1],[R2].

(14)

13. Explain various register transfer logics.

(14)

OR

14.

14.(a) Design a 4 bit combinational logic shifter with 2 control signals H1 and H2 that perform the following operations (bit values given in parenthesis are the values of control variable H1 and H2 respectively.) : Transfer of 0's to S (00), shift right (01), shift left (10), no shift (11).

(5)

14.(b) Design an ALU unit which will perform arithmetic and logic operation with a given binary adder.

(9)

15.

15.(a) Give the logic used behind Booth's multiplication algorithm.

(4)

15.(b) Identify the appropriate algorithm available inside the system to perform the multiplication between -14 and -9. Also trace the algorithm for the above input.

(10)

OR

16.

16.(a) List and explain the different pipeline hazards and their possible solutions

(10)

16.(b) Design a combinational circuit for 3x2 multiplication.

(4)

17. Design a hardwared control unit used to perform addition/subtraction of 2 numbers represented in sign magnitude form.

(14)

OR

18. Give the structure of the micro program sequencer and its role in sequencing the micro instructions.

(14)

19.

19.(a) Explain the different ways in which interrupt priority schemes can be implemented

(10)

19.(b) Give the structure of SRAM cell.

(4)

OR

20.

20.(a) Explain the various mapping functions available in cache memory.

(9)

20.(b) Briefly explain content addressable memory.

(5)

TEACHING PLAN		
No	**Contents**	**No of Lecture Hrs**
Module 1 : (Basic Structure of computers) (9 hours)		
1.1	Functional units,basic operational concepts,bus structures (introduction)	1
1.2	Memory locations and addresses , memory operations	1
1.3	Instructions and instruction sequencing	1
1.4	Addressing modes	1
1.5	Fundamental concepts of instruction execution, instruction cycle	1
1.6	Execution of a complete instruction - single bus organization (Lecture 1)	1
1.7	Execution of a complete instruction - single bus organization (Lecture 2)	1
1.8	Execution of a complete instruction - multiple bus organization (Lecture 1)	1
1.9	Execution of a complete instruction - multiple bus organization (Lecture 2)	1
Module 2 :(Register transfer logic and Processor logic design) (10 hours)		
2.1	Inter register transfer – arithmetic micro operations	1
2.2	Inter register transfer – logic and shift micro operations	1
2.3	Processor organization	1
2.4	Design of arithmetic circuit	1
2.5	Design of logic circuit	1
2.6	Design of arithmetic logic unit	1
2.7	Design of status register	1
2.8	Design of shifter - processor unit	1

2.9	Design of accumulator (Lecture 1)	1
2.10	Design of accumulator (Lecture 2)	1
Module 3 : (Arithmetic algorithms and Pipelining) (9 hours)		
3.1	Algorithm for multiplication of binary numbers	1
3.2	Algorithm for division (restoring method) of binary numbers	1
3.3	Array multiplier	1
3.4	Booth's multiplication algorithm	1
3.5	Pipelining: Basic principles	1
3.6	Classification of pipeline processors (Lecture 1)	1
3.7	Classification of pipeline processors (Lecture 2)	1
3.8	Instruction and arithmetic pipelines (Design examples not required)	1
3.9	Hazard detection and resolution	1
Module 4 :(Control Logic Design) (9 hours)		
4.1	Control organization –design of hardwired control logic (Lecture 1)	1
4.2	Control organization –design of hardwired control logic (Lecture 2)	1
4.3	Control organization –design of hardwired control logic (Lecture 3)	1
4.4	Design of microprogram control logic–control of processor unit (Lecture1)	1
4.5	Design of microprogram control logic–control of processor unit (Lecture2)	1
4.6	Design of microprogram control logic–control of processor unit (Lecture3)	1
4.7	Microprogram sequencer	1
4.8	Micro programmed CPU organization	1
4.9	Microinstructions –horizontal and vertical micro instructions	1
Module 5 : (Basic processing units, I/O and memory) (8 hours)		
5.1	Accessing of I/O devices –interrupts	1
5.2	Interrupt hardware	1

5.3	Direct memory access	1
5.4	Memory system: basic concepts –semiconductor RAMs	1
5.5	Memory system considerations – ROMs	1
5.6	Content addressable memory	1
5.7	Cache memories -mapping functions (Lecture 1)	1
5.8	Cache memories -mapping functions (Lecture 2)	1

CST 204	DATABASE MANAGEMENT SYSTEMS	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble: This course provides a clear understanding of fundamental principles of Database Management Systems (DBMS) with special focus on relational databases to the learners. The topics covered in this course are basic concepts of DBMS, Entity Relationship (ER) model, Relational Database principles, Relational Algebra, Structured Query Language (SQL), Physical Data Organization, Normalization and Transaction Processing Concepts. The course also gives a glimpse of the alternative data management model, NoSQL. This course helps the learners to manage data efficiently by identifying suitable structures to maintain data assets of organizations and to develop applications that utilize database technologies.

Prerequisite: Topics covered under the course Data Structures (CST 201), Exposure to a High Level Language like C/python.

Course Outcomes: After the completion of the course the student will be able to

CO1	Summarize and exemplify fundamental nature and characteristics of database systems (**Cognitive Knowledge Level: Understand)**
CO2	Model real word scenarios given as informal descriptions, using Entity Relationship diagrams. **(Cognitive Knowledge Level: Apply**)
CO3	Model and design solutions for efficiently representing and querying data using relational model (**Cognitive Knowledge Level: Analyze**)
CO4	Demonstrate the features of indexing and hashing in database applications **(Cognitive Knowledge Level: Apply**)
CO5	Discuss and compare the aspects of Concurrency Control and Recovery in Database systems **(Cognitive Knowledge Level: Apply**)
CO6	Explain various types of NoSQL databases (**Cognitive Knowledge Level: Understand**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓									✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓								✓
CO4	✓	✓	✓							✓		✓
CO5	✓	✓	✓							✓		✓
CO6	✓	✓	✓		✓					✓		✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom’s Category	**Continuous Assessment Tests**		**End Semester Examination Marks (%)**
	Test1 (%)	**Test2 (%)**	
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30

Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module 1: Introduction & Entity Relationship (ER) Model

Concept & Overview of Database Management Systems (DBMS) - Characteristics of Database system, Database Users, structured, semi-structured and unstructured data. Data Models and Schema - Three Schema architecture. Database Languages, Database architectures and classification.

ER model **-** Basic concepts, entity set & attributes, notations, Relationships and constraints, cardinality, participation, notations, weak entities, relationships of degree 3.

Module 2: Relational Model

Structure of Relational Databases - Integrity Constraints, Synthesizing ER diagram to relational schema

Introduction to Relational Algebra - select, project, cartesian product operations, join - Equi-join, natural join. query examples, introduction to Structured Query Language (SQL), Data Definition Language (DDL), Table definitions and operations – CREATE, DROP, ALTER, INSERT, DELETE, UPDATE.

Module 3: SQL DML (Data Manipulation Language), Physical Data Organization

SQL DML (Data Manipulation Language) - SQL queries on single and multiple tables, Nested queries (correlated and non-correlated), Aggregation and grouping, Views, assertions, Triggers, SQL data types.

Physical Data Organization - Review of terms: physical and logical records, blocking factor, pinned and unpinned organization. Heap files, Indexing, Singe level indices, numerical examples, Multi-level-indices, numerical examples, B-Trees & B+-Trees (structure only, algorithms not required), Extendible Hashing, Indexing on multiple keys – grid files.

Module 4: Normalization

Different anomalies in designing a database, The idea of normalization, Functional dependency, Armstrong's Axioms (proofs not required), Closures and their computation, Equivalence of Functional Dependencies (FD), Minimal Cover (proofs not required). First Normal Form (1NF), Second Normal Form (2NF), Third Normal Form (3NF), Boyce Codd Normal Form (BCNF), Lossless join and dependency preserving decomposition, Algorithms for checking Lossless Join (LJ) and Dependency Preserving (DP) properties.

Module 5: Transactions, Concurrency and Recovery, Recent Topics

Transaction Processing Concepts - overview of concurrency control, Transaction Model, Significance of concurrency Control & Recovery, Transaction States, System Log, Desirable Properties of transactions.

Serial schedules, Concurrent and Serializable Schedules, Conflict equivalence and conflict serializability, Recoverable and cascade-less schedules, Locking, Two-phase locking and its variations. Log-based recovery, Deferred database modification, check-pointing.

Introduction to NoSQL Databases, Main characteristics of Key-value DB (examples from: Redis), Document DB (examples from: MongoDB)

Main characteristics of Column - Family DB (examples from: Cassandra) and Graph DB (examples from : ArangoDB)

Text Books

1. Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education, 2013.
2. Sliberschatz A., H. F. Korth and S. Sudarshan, Database System Concepts, 6/e, McGraw Hill, 2011.

Reference Books:

1. Adam Fowler, NoSQL for Dummies, John Wiley & Sons, 2015
2. NoSQL Data Models: Trends and Challenges (Computer Engineering: Databases and Big Data), Wiley, 2018
3. Web Resource: https://www.w3resource.com/redis/
4. web Resource: https://www.w3schools.in/category/mongodb/
5. Web Resource: https://www.tutorialspoint.com/cassandra/cassandra_introduction.htm
6. Web Resource : https://www.tutorialspoint.com/arangodb/index.htm

Sample Course Level Assessment Questions

Course Outcome1 (CO1):

1. List out any three salient features of database systems, which distinguish it from a file system.
2. Give one example each for logical and physical data independence.

Course Outcome 2(CO2):

1. What facts about the relationships between entities EMPLOYEE and PROJECT are conveyed by the following ER diagram?

1. Design an ER diagram for the following scenario:
   There is a set of teams, each team has an ID (unique identifier), name, main stadium, and to which city this team belongs. Each team has many players, and each player belongs to one team. Each player has a number (unique identifier), name, DoB, start year, and shirt number that he uses. Teams play matches, in each match there is a host team and a guest team.

Course Outcome 3(CO3):

1. For the SQL query, SELECT *A, B FROM R WHERE B='apple' AND C = 'orange'* on the table R(A, B, C, D), where A is a key, write any three equivalent relational algebra expressions.
2. Given the FDs P→Q, P→R, QR→S, Q→T, QR→U, PR→U, write the sequence of *Armstrong's Axioms* needed to arrive at the following FDs: (a) P → T (b) PR → S (c) QR → SU
3. Consider a relation PLAYER (PLAYER-NO, PLAYER-NAME, PLAYER-POSN, TEAM, TEAM-COLOR, COACH-NO, COACH-NAME, TEAM-CAPTAIN). Assume that PLAYER-NO is the *only* key of the relation and that the following dependencies hold:

   TEAM→{TEAM-COLOR, COACH-NO, TEAM-CAPTAIN}
   COACH-NO→COACH-NAME.

   i. Is the relation in 2NF? If not, decompose to 2NF.
   ii. Is the relation in 3NF? If not, decompose to 3NF.

4. In the following tables foreign keys have the same name as primary keys except DIRECTED-BY, which refers to the primary key ARTIST-ID. Consider only *single-director* movies.
   MOVIES(<u>MOVIE-ID</u>, MNAME, GENRE, LENGTH, DIRECTED-BY)
   ARTIST(<u>ARTIST-ID</u>, ANAME)
   ACTING(<u>ARTIST-ID, MOVIE-ID</u>)
   Write SQL expressions for the following queries:
   (a) *Name(s) and director name(s) of movie(s) acted by 'Jenny'.*
   (b) *Names of actors who have <u>never</u> acted with 'Rony'*
   (c) *Count of movies genre-wise.*
   (d) *Name(s) of movies with maximum length.*

Course Outcome 4(CO4):

1. Consider an EMPLOYEE file with 10000 records where each record is of size 80 bytes. The file is sorted on employee number (15 bytes long), which is the primary key. Assuming un-spanned organization, block size of 512 bytes and block pointer size of 5 bytes. Compute the number of block accesses needed for retrieving an employee record based on employee number if (i) No index is used (ii) Multi-level primary index is used.

Course Outcome 5(CO5):

1. Determine if the following schedule is *recoverable*. Is the schedule *cascade-less*? Justify your answer. *r1(X), r2(Z), r1(Z), r3(X), r3(Y), w1(X), c1, w3(Y), c3, r2(Y), w2(Z), w2(Y), c2*. (*Note: ri(X)/wi(X)* means transaction *Ti* issues read/write on item X; *ci* means transaction *Ti* commits.)
2. Two-phase locking protocol ensures serializability. Justify.

Course Outcome 6(CO6):

1. List out any three salient features of NoSQL databases. Give example of a document in MongoDB.

Model Question paper

QPCODE

Reg No:__________________

Name:____________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 204

Course Name: **Database Management Systems**

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1 List out any three salient features of a database systems.

2 When is multi-valued composite attribute used in ER modelling?

3 For the SQL query, SELECT *A, B FROM R WHERE B='apple' AND C = 'orange'* on the table R(A, B, C, D), where A is a key, write any two equivalent relational algebra expressions.

4 Outline the concept of *theta*-join.

5 How is the purpose of *where* clause is different from that of having clause?

6 What is the use of a trigger?

7 When do you say that a relation is not in 1NF?

8 Given the FDs $P \rightarrow Q$, $P \rightarrow R$, $QR \rightarrow S$, $Q \rightarrow T$, $QR \rightarrow U$, $PR \rightarrow U$, write the sequence of Armstrong's Axioms needed to arrive at a. $P \rightarrow T$ b. $PR \rightarrow S$

9 What is meant by the lost update problem?

10 What is meant by check pointing?

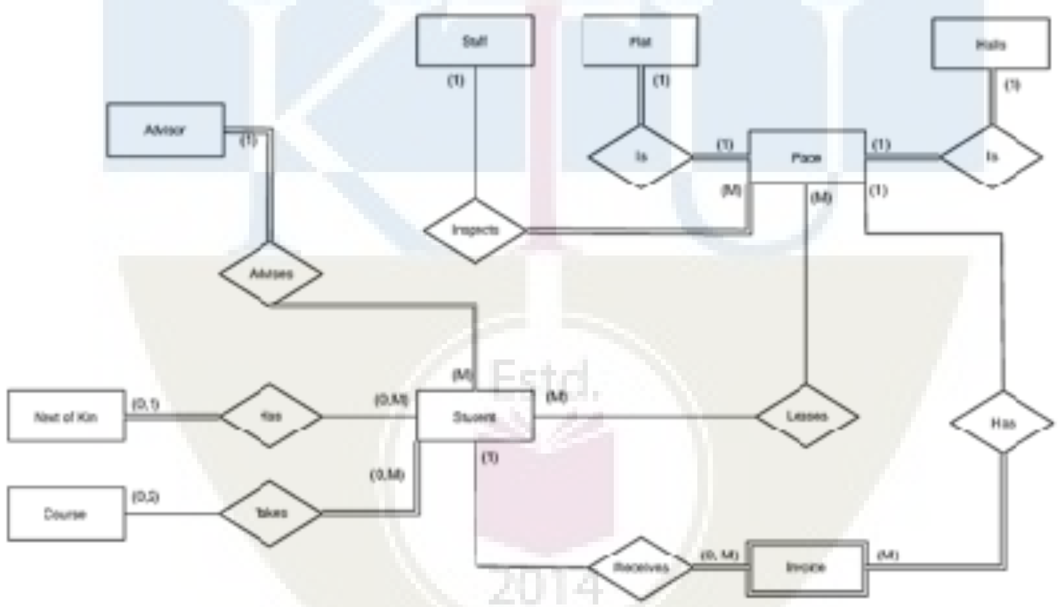
PART B

Answer any one Question from each module. Each question carries 14 Marks

11 a. Design an ER diagram for the following scenario: There is a set of teams, each team has an ID (unique identifier), name, main stadium, and to which city this team belongs. Each team has many players, and each player belongs to one team. Each player has a number (unique identifier), name, DoB, start year, and shirt number that he uses. Teams play matches, in each match there is a host team and a guest team. The match takes place in the stadium of the host team. For each match we need to keep track of the following: The date on which the game is played The final result of the match. The players participated in the match. For each player, how many goals he scored, whether or not he took yellow card, and whether or not he took red card. During the match, one player may substitute another player. We want to capture this substitution and the time at which it took place. Each match has exactly three referees. For each referee we have an ID (unique identifier), name, DoB, years of experience. One referee is the main referee and the other two are assistant referee. (14)

OR

12 a. Interpret the the following ER diagram. (8)



b. Distinguish between physical data independence and logical data independence with suitable examples. (6)

13 **EMPLOYEE(<u>ENO</u>, NAME, ADDRESS, DOB, AGE, GENDER, SALARY, DNUM, SUPERENO)** (14)
DEPARTMENT(<u>DNO</u>, DNAME, DLOCATION, DPHONE, MGRENO)
PROJECT(<u>PNO</u>, PNAME, PLOCATION, PCOST, CDNO)

DNUM is a foreign key that identifies the department to which an employee belongs. MGRENO is a foreign key identifying the employee who manages the department. CDNO is a foreign key identifying the department that controls the project. SUPERENO is a foreign key identifying the supervisor of each employee.

Write relational algebra expressions for the following queries:-

(a) Names of female employees whose salary is more than 20000.
(b) Salaries of employee from ‘Accounts’ department
(c) Names of employees along with his/her superviser’s name
(d) For each employee return name of the employee along with his department name and the names of projects in which he/she works
(e) Names of employees working in all the departments

OR

14 a. Write SQL DDL statements for the the following (Assume suitable domain types): (10)

i. Create the tables STUDENT(<u>ROLLNO</u>, NAME, CLASS, SEM, ADVISER), FACULTY(<u>FID</u>, NAME, SALARY, DEPT). Assume that ADVISER is a foreign key referring FACUTY table.

ii. Delete department with name ‘CS’ and all employees of the department.

iii. Increment salary of every faculty by 10%.

b. Illustrate foreign key constraint with a typical example. (4)

15 For the relation schema below, give an expression in SQL for each of the queries that follows: (14)

employee(<u>employee-name</u>, street, city)
works(<u>employee-name, company-name</u>, salary)
company(<u>company-name</u>, city)
manages(<u>employee-name, manager-name</u>)

a) Find the names, street address, and cities of residence for all employees who work for the Company 'RIL Inc.' and earn more than $10,000.
b) Find the names of all employees who live in the same cities as the companies for which they work.
c) Find the names of all employees who do not work for 'KYS Inc.'. Assume that all people work for exactly one company.
d) Find the names of all employees who earn more than every employee of 'SB Corporation'. Assume that all people work for at most one company.
e) List out number of employees company-wise in the decreasing order of number of employees.

OR

16 a. Consider an EMPLOYEE file with 10000 records where each record is of size 80 bytes. The file is sorted on employee number (15 bytes long), which is the primary key. Assuming un-spanned organization and block size of 512 bytes compute the number of block accesses needed for selecting records based on employee number if, (9)

i. No index is used
ii. Single level primary index is used
iii. Multi-level primary index is used

Assume a block pointer size of 6 bytes.

b. Illustrate correlated and non-correlated nested queries with real examples. (5)

17 a. Illstrate3NF and BCNF with suitable real examples. (6)

b. Given a relation R(A1,A2,A3,A4,A5) with functional dependencies A1→A2A4 and A4→A5, check if the decomposition R1(A1,A2,A3), R2(A1,A4), R3(A2,A4,A5) is lossless. (8)

OR

18 a. Consider the un-normalized relation R(A, B, C, D, E, F, G) with the FDs A→B , AC→G, AD→EF, EF→G, CDE→AB. Trace the normalization process to reach 3NF relations. (7)

	b.	Illustrate Lossless Join Decomposition and Dependency Preserving Decomposition with typical examples.	(7)
19	a.	Discuss the four ACID properties and their importance.	(7)
	b.	Determine if the following schedule is conflict serializable. Is the schedule recoverable? Is the schedule cascade-less? Justify your answers. r1(X), r2(Z), r1(Z), r3(X), r3(Y), w1(X), c1, w3(Y), c3, r2(Y), w2(Z), w2(Y), c2 (Note: ri(X)/wi(X) means transaction Ti issues read/write on item X; ci means transaction Ti commits.)	(7)

OR

20	a.	Discuss the main characteristics of Key-value DB and Graph DB.	(7)
	b.	Illustrate two-phase locking with a schedule containing three transactions. Argue that 2PL ensures serializability. Also argue that 2Pl can lead to deadlock.	(7)

Teaching Plan

	Course Name	Hours (48)
	Module 1: Introduction & ER Model	**8**
1.1	Concept & Overview of DBMS, Characteristics of DB system, Database Users.	1
1.2	Structured, semi-structured and unstructured data. Data Models and Schema	1
1.3	Three-Schema-architecture. Database Languages	1
1.4	Database architectures and classification	1
1.5	ER model: basic concepts, entity set & attributes, notations	1
1.6	Relationships and constraints – cardinality, participation, notations	1
1.7	Weak entities, relationships of degree 3	1
1.8	ER diagram – exercises	1
	Module 2: Relational Model	**7**
2.1	Structure of relational Databases, Integrity Constraints	1
2.2	Synthesizing ER diagram to relational schema, Introduction to relational algebra.	1
2.3	Relational algebra: select, project, Cartesian product operations	1
2.4	Relational Algebra: join - Equi-join, Natural join	1
2.5	Query examples	1
2.6	Introduction to SQL, important data types	1
2.7	DDL, Table definitions and operations – CREATE, DROP, ALTER, INSERT, DELETE, UPDATE	1
	Module 3: SQL DML, Physical Data Organization	**11**
3.1	SQL DML, SQL queries on single and multiple tables	1
3.2	Nested queries (correlated and non-correlated)	1
3.3	Aggregation and grouping	1

	Course Name	Hours (48)
3.4	Views, assertions (with examples)	1
3.5	Triggers (with examples), SQL data types	1
3.6	Review of terms: physical and logical records, blocking factor, pinned and unpinned organization. Heap files, Indexing	1
3.7	Singe level indices, numerical examples	1
3.8	Multi-level-indices, numerical examples	1
3.9	B-Trees and B+Trees (structure only, algorithms not required)	1
3.10	Extendible Hashing	1
3.11	Indexing on multiple keys – grid files	1
	Module 4: Normalization	**8**
4.1	Different anomalies in designing a database, The idea of normalization	1
4.2	Functional dependency, Armstrong's Axioms (proofs not required)	1
4.3	Closures and their computation, Equivalence of FDs, minimal Cover (proofs not required).	1
4.4	1NF, 2NF	1
4.5	3NF, BCNF	1
4.6	Lossless join and dependency preserving decomposition	1
4.7	Algorithms for checking Lossless Join and Dependency preserving properties (Lecture 1)	1
4.8	Algorithms for checking Lossless Join and Dependency preserving properties (Lecture 2)	1
	Module 5: Transactions, Concurrency and Recovery, Recent Topics	**14**
5.1	Transaction Processing Concepts: Transaction Model	1
5.2	Overview of concurrency control, Significance of concurrency Control & Recovery	1
5.3	Transaction States, System Log	1

	Course Name	Hours (48)
5.4	Desirable Properties of transactions, Serial schedules	1
5.5	Concurrent and Serializable Schedules	1
5.6	Conflict equivalence and conflict serializability	1
5.7	Recoverable and cascade-less schedules	1
5.8	Locking, Two-phase locking, strict 2PL.	1
5.9	Log-based recovery	1
5.10	Deferred database modification (serial schedule), example	1
5.11	Deferred database modification (concurrent schedule) example, check-pointing	1
5.12	Introduction to NoSQL Databases	1
5.13	Main characteristics of Key-value DB (examples from: Redis), Document DB (examples from: MongoDB) [detailed study not expected]	1
5.14	Main characteristics of Column-Family DB (examples from: Cassandra) and Graph DB (examples from : ArangoDB) [detailed study not expected]	1

CST 206	OPERATING SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble: Study of operating system is an essential to understand the overall working of computer system, tradeoffs between performance and functionality and the division of jobs between hardware and software. This course introduces the concepts of memory management, device management, process management, file management and security & protection mechanisms available in an operating system. The course helps the learner to understand the fundamentals about any operating system design so that they can extend the features of operating system to detect and solve many problems occurring in operating system and to manage the computer resources appropriately.

Prerequisite: Topics covered in the courses are **Data Structures (CST 201)** and **Programming in C (EST 102)**

Course Outcomes: After the completion of the course the student will be able to

CO1	Explain the relevance, structure and functions of Operating Systems in computing devices. (**Cognitive knowledge: Understand**)
CO2	Illustrate the concepts of process management and process scheduling mechanisms employed in Operating Systems. (**Cognitive knowledge: Understand**)
CO3	Explain process synchronization in Operating Systems and illustrate process synchronization mechanisms using Mutex Locks, Semaphores and Monitors (**Cognitive knowledge: Understand**)
CO4	Explain any one method for detection, prevention, avoidance and recovery for managing deadlocks in Operating Systems. (**Cognitive knowledge: Understand**)
CO5	Explain the memory management algorithms in Operating Systems. (**Cognitive knowledge: Understand**)
CO6	Explain the security aspects and algorithms for file and storage management in Operating Systems. **(Cognitive knowledge: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔							✔		✔
CO2	✔	✔	✔	✔						✔		✔
CO3	✔	✔	✔	✔						✔		✔
CO4	✔	✔	✔	✔						✔		✔
CO5	✔	✔	✔	✔						✔		✔
CO6	✔	✔	✔	✔						✔		✔

Abstract POs defined by National Board of Accreditation			
PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	Test 1 (Marks in percentage)	Test 2 (Marks in percentage)	End Semester Examination (Marks in percentage)
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test : 25 marks
Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module I

Introduction: Operating system overview – Operations, Functions, Service – System calls, Types – Operating System structure - Simple structure, Layered approach, Microkernel, Modules – System boot process.

Module II

Processes - Process states, Process control block, threads, scheduling, Operations on processes - process creation and termination – Inter-process communication - shared memory systems, Message passing systems.

Process Scheduling – Basic concepts- Scheduling criteria -scheduling algorithms- First come First Served, Shortest Job Firs, Priority scheduling, Round robin scheduling

Module III

Process synchronization- Race conditions – Critical section problem – Peterson's solution, Synchronization hardware, Mutex Locks, Semaphores, Monitors – Synchronization problems - Producer Consumer, Dining Philosophers and Readers-Writers.

Deadlocks: Necessary conditions, Resource allocation graphs, Deadlock prevention, Deadlock avoidance – Banker's algorithms, Deadlock detection, Recovery from deadlock.

Module IV

Memory Management: Concept of address spaces, Swapping, Contiguous memory allocation, fixed and variable partitions, Segmentation, Paging. Virtual memory, Demand paging, Page replacement algorithms.

Module V

File System: File concept - Attributes, Operations, types, structure – Access methods, Protection. File-system implementation, Directory implementation. Allocation methods.
Storage Management: Magnetic disks, Solid-state disks, Disk Structure, Disk scheduling, Disk formatting.

Text Book

Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, ' Operating System Concepts' 9th Edition, Wiley India 2015.

Reference Books:

1. Andrew S Tanenbaum, "Modern Operating Systems" , 4th Edition, Prentice Hall, 2015.
2. William Stallings, "Operating systems", 6th Edition, Pearson, Global Edition, 2015.
3. Garry Nutt, Nabendu Chaki, Sarmistha Neogy, "Operating Systems", 3rd Edition, Pearson Education.
4. D.M.Dhamdhere, "Operating Systems", 2nd Edition, Tata McGraw Hill, 2011.
5. Sibsankar Haldar, Alex A Aravind, "Operating Systems", Pearson Education.

Sample Course Level Assessment Questions

Course Outcome1 (CO1): What is the main advantage of the micro kernel approach to system design? How do user program and system program interact in a microkernel architecture?

Course Outcome 2 (CO2): Define process. With the help of a neat diagram explain different states of process.

Course Outcome 3 (CO3): What do you mean by binary semaphore and counting semaphore? With C, explain implementation of wait () and signal().

Course Outcome 4 (CO4): Describe resource allocation graph for the following. a) with a deadlock b) with a cycle but no deadlock.

Course Outcome 5 (CO5): Consider the following page reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. Find out the number of page faults if there are 4 page frames, using the following page replacement algorithms. i) LRU ii) FIFO iii) Optimal

Course Outcome 6 (CO6): Explain the different file allocation methods with advantages and disadvantages.

Model Question Paper

QP CODE: PAGES: ___

Reg No:_______________
Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 206

Course name : OPERATING SYSTEMS

Max Marks: 100 **Duration: 3 Hours**

PART-A

(Answer All Questions. Each question carries 3 marks)

1. How does hardware find the Operating System kernel after system switch-on?
2. What is the purpose of system call in operating system?
3. Why is context switching considered as an overhead to the system?

4. How is inter process communication implement using shared memory?

5. Describe resource allocation graph for the following.

   a) with a deadlock b)with a cycle but no deadlock.

6. What is critical section? What requirement should be satisfied by a solution to the critical section problem?

7. Consider the reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. How many page faults occur while using FCFS for the following cases.

   a) frame=2 b)frame=3

8. Differentiate between internal and external fragmentations.

9. Compare sequential access and direct access methods of storage devices.

10. Define the terms (i) Disk bandwidth (ii) Seek time.

PART-B(Answer any one question from each module)

11. a) Explain the following structures of operating system (i) Monolithic systems (ii) Layered Systems (iii) Micro Kernel (iv) Modular approach. **(12)**

    b) Under what circumstances would a user be better of using a time sharing system than a PC or a single user workstation? **(2)**

OR

12. a) What is the main advantage of the micro kernel approach to system design? How do user program and system program interact in a microkernel architecture? **(8)**

    b) Describe the differences between symmetric and asymmetric multiprocessing? What are the advantages and disadvantages of multiprocessor systems? **(6)**

13. a) Define process. With the help of a neat diagram explain different states of process. **(8)**

    b) Explain how a new process can be created in Unix using fork system call. **(6)**

OR

14 a) Find the average waiting time and average turnaround time for the processes given in the table below using:- i) SRT scheduling algorithm ii) Priority scheduling algorithm **(9)**

Process	Arrival Time (ms)	CPU Burst Time (ms)	Priority
P1	0	5	3
P2	2	4	1
P3	3	1	2
P4	5	2	4

b) What is a Process Control Block? Explain the fields used in a Process Control Block. **(5)**

15. Consider a system with five processes P_0 through P_4 and three resources of type A, B, C. Resource type A has 10 instances, B has 5 instances and C has 7 instances. Suppose at time t_0 following snapshot of the system has been taken:

Process	Allocation	Max	Available
	A B C	A B C	A B C
P_0	0 1 0	7 5 3	3 3 2
P_1	2 0 0	3 2 2	
P_2	3 0 2	9 0 2	
P_3	2 1 1	2 2 2	
P_4	0 0 2	4 3 3	

i) What will be the content of the Need matrix? Is the system in a safe state? If Yes, then what is the safe sequence? **(8)**

iii)What will happen if process P_1 requests one additional instance of resource type A and two instances of resource type C? **(6)**

OR

16. a) State dining philosopher's problem and give a solution using semaphores. **(7)**

b) What do you mean by binary semaphore and counting semaphore? With C struct, explain implementation of wait () and signal() **(7)**

17. a) Consider the following page reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. Find out the number of page faults if there are 4 page frames, using the following page replacement algorithms i) LRU ii) FIFO iii) Optimal **(9)**

b) Explain the steps involved in handling a page fault. **(5)**

OR

18. a) With a diagram, explain how paging is done with TLB. **(5)**

b) Memory partitions of sizes 100 kb, 500 kb, 200 kb, 300 kb, 600 kb are available, how would best ,worst and first fit algorithms place processes of size 212 kb, 417 kb, 112 kb, 426 kb in order. Rank the algorithms in terms of how efficiently they uses memory. **(9)**

19. a) Suppose that a disk drive has 5000 cylinders, numbered 0 to 4999. the drive currently services a request at cylinder 143, and the previous request was at cylinder 125. the queue of pending request in FIFO order is 86, 1470, 913, 1774, 948, 1509, 1022, 1750, 130. Starting from the current position, what is the total distance (in cylinders) that the disk arm moves to satisfy all pending requests for each of the following algorithms

i) FCFS ii) SSFT iii) SCAN iv) LOOK v) C-SCAN **(10)**

b) What is the use of access matrix in protection mechanism? **(4)**

OR

20. a) Explain the different file allocation operations with advantages and disadvantages. **(8)**

b) Explain the following i) file types ii) file operation iii) file attributes **(6)**

Teaching Plan

	Module 1 - Introduction	**5 Hours**
1.1	Introduction to Operating System	1
1.2	Operating System operations, functions, service	1
1.3	System calls, Types	1
1.4	Operating System Structure: Simple, Layered, Microkernel, Modules	1
1.5	System Boot Process	1
	Module 2 – Processes and Process Scheduling	**9 Hours**
2.1	Processes, Process states	1
2.2	Process Control Block, Threads	1

2.3	Scheduling	1
2.4	Operations on processes: process creation and termination	1
2.5	Inter-process communication: Shared memory systems, Message Passing	1
2.6	Process Scheduling – Basic concepts, Scheduling Criteria	1
2.7	Scheduling algorithms - Basics	1
2.8	First come First Served, Shortest Job First	1
2.9	Priority scheduling, Round Robin Scheduling	1
	Module 3 - Process synchronization and Dead locks	**13 Hours**
3.1	Process synchronization, Race conditions	1
3.2	Critical Section problem, Peterson's solution	1
3.3	Synchronization hardware, Mutex Locks	1
3.4	Semaphores	1
3.5	Monitors	1
3.6	Synchronization problem examples (Lecture 1)	1
3.7	Synchronization problem examples (Lecture 2)	1
3.8	Deadlocks: Necessary conditions, Resource Allocation Graphs	1
3.9	Deadlock prevention	1
3.10	Deadlock avoidance	1
3.11	Banker's algorithm	1
3.12	Deadlock detection	1
3.13	Deadlock recovery	1
	Module 4 - Memory Management	**9 Hours**
4.1	Memory Management: Concept of Address spaces	1
4.2	Swapping	1
4.3	Contiguous memory allocation, fixed and variable partitions	1
4.4	Segmentation.	1
4.5	Paging (Lecture 1)	1
4.6	Paging (Lecture 2)	1
4.7	Virtual memory, Demand Paging	1

4.8	Page replacement algorithms (Lecture 1)	1
4.9	Page replacement algorithms (Lecture 2)	1
	Module 5 - File and Disk management	**9 Hours**
5.1	File concept, Attributes, Operations, types, structure	1
5.2	Access methods	1
5.3	Protection	1
5.4	File-System implementation	1
5.5	Directory implementation	1
5.6	Allocation methods	1
5.7	Magnetic disks, Solid-state disks, Disk structure	1
5.8	Disk scheduling	1
5.9	Disk formatting	1

ADL202	PYTHON AND STATISTICAL MODELLING LAB	Category	L	T	P	Credits	Year of introduction
		PCC	0	0	3	2	2019

Preamble: The Python and Statistical modelling course is intended to impart the elementary concepts of Python and apply various statistical techniques to a variety of data. This course provides the learners with hands-on experience in Python and statistical processes like measures of central tendency, measures of dispersion, probability distributions, graphical analysis, correlation analysis and use of statistical analysis software. The course enables the students to get an exposure to Python programming and use proper methods to analyze and interpret data effectively.

Prerequisite: A basic knowledge of Probability and Statistical Modelling.

Course Outcomes: After the completion of the course the student will be able to

CO#	Course Outcomes
CO 1	Experiment with concepts of iteration, function, string and list **(Cognitive Knowledge Level: Apply)**
CO 2	Identify the importance of tuples, dictionary traversal, dictionary methods, files and operations **(Cognitive Knowledge Level: Apply)**
CO 3	Model graphical representation of data, measures of central tendency and measures of dispersion **(Cognitive Knowledge Level: Apply)**
CO 4	Solve problems based on Binomial distribution, Poisson distribution, sampling and regression analysis **(Cognitive Knowledge Level: Apply)**
CO 5	Make use of various correlation tests and utilize statistical analysis software **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓					✓				✓
CO2	✓	✓	✓	✓				✓				✓
CO3	✓	✓	✓	✓				✓				✓
CO4	✓	✓	✓	✓				✓				✓
CO5	✓	✓	✓	✓	✓			✓				✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests	End Semester Examination (Percentage)
Remember	20	20
Understand	20	20
Apply	60	60
Analyze		
Evaluate		
Create		

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Evaluation in Lab : 30 marks
Continuous Assessment Test : 15 marks
Viva Voce : 15 marks

Internal Examination Pattern:

The marks will be distributed as Design/Algorithm 30 marks, Implementation/Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern:
The marks will be distributed as Design/Algorithm 30 marks, Implementation/Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks will be converted out of 75 for End Semester Examination.

Fair Lab Record:
All Students attending the Statistical Modelling Using Python Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record, the right-hand page should contain Experiment Heading, Experiment Number, Date of experiment, Aim of the Experiment and the operations performed on them, Details of experiment including algorithm and result of Experiment. The left-hand page should contain a print out of the code used for experiment and sample output obtained for a set of input.

SYLLABUS

PYTHON AND STATISTICAL MODELLING LAB

1. Familiarization of expressions, conditional and iteration statements.
2. Problems on function and function calls. **
3. String traversal and other important string methods. **
4. List traversal and list operations. **
5. Tuples, dictionary traversal and dictionary methods. **
6. Problems based on files and operations. **
7. Problems on graphical representation of data. **
8. Problems based on measures of central tendency and measures of dispersion using raw data and grouped data. **
9. Application problems based on Binomial and Poisson distribution. **
10. Implement Chi-square test for goodness of fit. **
11. Perform t-test for difference of means. **
12. Implement Correlation tests. (Karl Pearson correlation coefficient and Spearman rank correlation coefficient).
13. Estimation of gain in precision due to stratification. **
14. Analysis of a one way/ two-way ANOVA.
15. Problems on Lines of regression, regression coefficients, angle between regression lines.
16. Familiarization with statistical analysis software. (SPSS or similar) **

**mandatory

PYTHON AND STATISTICAL MODELLING LAB – Practice Questions

1. Write a program to find the largest of three numbers.
2. Write a program to print the multiplication table of a number n.
3. Write a program to find Surface area and volume of a cylinder using function.
4. Write a program to replace a word by another word in a sentence.
5. Write a program to confirm the validity of an email id by verifying its format.
6. Write a program to remove every occurrence of a number from a list.
7. Write a program to add two matrices.
8. Write a program to read a tuple of numbers and print even tuple and odd tuple.
9. Create a dictionary with a set of book title and corresponding stock. Write a program to update the stock and to add or delete books.
10. A set of numbers are stored in a file. Write a program to print the prime numbers among them.
11. Write a program to count the number of words, sentences, upper case letters, lowercase letters and special symbols in a text stored in file.
12. Plot a graph y = f(x).
13. The areas of the various continents of the world (in millions of square miles) are as follows:11.7 for Africa; 10.4 for Asia; 1.9 for Europe; 9.4 for North America; 3.3 Oceania; 6.9 South America; 7.9 Soviet Union. Draw a bar chart representing the given data.
14. Draw the histogram of the following data:

Height of student(m)	135 - 140	140 - 145	145 - 150	150 - 155
No. of students	4	12	16	8

15. Table contains population and murder rates (in units of murders per 100,000 people per year) for different states. Compute the mean, median and variance for the population.

State	**Population**	**Murder**
Alabama	4,779,736	5.7
Alaska	710,231	5.6
Arizona	6,392,017	4.7
Arkansas	2,915,918	5.6
California	37,253,956	4.4
Colorado	5,029,196	2.8
Connecticut	3,574,097	2.4
Delaware	897,934	5.8

16. Calculate the S.D. and coefficient of variation (C.V.) for the following table:

Class:	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
Frequency:	5	10	20	40	30	20	10	5

17. If X is binomially distributed with 6 trials and a probability of success equal to 0.25 at each attempt, what is the probability of:
    a) exactly 4 successes   b) at least one success
18. If the random variable X follows a Poisson distribution with mean 3.4, find P(X=6).
19. A random sample of 395 people were surveyed and each person was asked to report the highest education level they obtained. The data that resulted from the survey is summarized in the following table. Are gender and education level dependent at 5% level of significance?

	High School	**Bachelors**	**Masters**	**Ph.D.**	**Total**
Female	60	54	46	41	201
Male	40	44	53	57	194
Total	100	98	99	98	395

20. Calculate the correlation coefficient of the two variables shown in the table below.

Person	**Hand**	**Height**
A	17	150
B	15	154
C	19	169
D	17	172
E	21	175

21. Suppose a sample of 16 light trucks is randomly selected off the assembly line. The trucks are driven 1000 miles and the fuel mileage (MPG) of each truck is recorded. It is found that the mean MPG is 22 with a SD equal to 3. The previous model of the light truck got 20 MPG. Conduct a t- test of the null hypothesis at p = 0.05

22. The mean productivity rating for all employees at a company was 3.8 on a five-point scale last year. This year you get ratings from a representative sample of fifteen employees from the Human Research Management. Do the data from this sample provide evidence that employee productivity in the department of Human Resource Management is significantly higher than in the company as a whole? Write the null and alternative hypotheses for this problem. Use statistical analysis software to test the null hypothesis stated above.

23. Obtain the regression equation for predicting systolic blood pressure from job satisfaction with reference to the given data using statistical analysis software. If one knows that a subject in the future has a score on job satisfaction of 15, what is their systolic blood pressure predicted to be? What is the standard error of estimate?

Job Satisfaction	Systolic BP
34	124
23	128
19	157
43	133
56	116
47	125
32	147
16	167
55	110
25	156

<table>
<tr><td rowspan="3">CSL204</td><td rowspan="3">OPERATING SYSTEMS LAB</td><td rowspan="2">CATEGORY</td><td rowspan="2">L</td><td rowspan="2">T</td><td rowspan="2">P</td><td rowspan="2">CREDIT</td><td>YEAR OF</td></tr>
<tr><td>INTRODUCTION</td></tr>
<tr><td>PCC</td><td>0</td><td>0</td><td>3</td><td>2</td><td>2019</td></tr>
</table>

Preamble: The course aims to offer students a hands-on experience on Operating System concepts using a constructivist approach and problem-oriented learning. Operating systems are the fundamental part of every computing device to run any type of software.

Prerequisite: Topics covered in the courses are **Data Structures (CST 201)** and **Programming in C (EST 102)**

Course Outcomes:

At the end of the course, the student should be able to

CO1	Illustrate the use of systems calls in Operating Systems. **(Cognitive knowledge: Understand)**
CO2	Implement Process Creation and Inter Process Communication in Operating Systems. **(Cognitive knowledge: Apply)**
CO3	Implement Fist Come First Served, Shortest Job First, Round Robin and Priority-based CPU Scheduling Algorithms. **(Cognitive knowledge: Apply)**
CO4	Illustrate the performance of First In First Out, Least Recently Used and Least Frequently Used Page Replacement Algorithms. **(Cognitive knowledge: Apply)**
CO5	Implement modules for Deadlock Detection and Deadlock Avoidance in Operating Systems. **(Cognitive knowledge: Apply)**
CO6	Implement modules for Storage Management and Disk Scheduling in Operating Systems. **(Cognitive knowledge: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓					✓		✓		✓
CO2	✓	✓	✓					✓		✓		✓
CO3	✓	✓	✓	✓				✓		✓		✓
CO4	✓	✓	✓	✓				✓		✓		✓
CO5	✓	✓	✓	✓				✓		✓		✓
CO6	✓	✓	✓	✓				✓		✓		✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern:

Bloom's Category	**Continuous Assessment Test (Internal Exam) Marks in percentage**	**End Semester Examination Marks in percentage**
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Evaluation in Lab	:	30 marks
Continuous Assessment Test	:	15 marks
Viva Voce	:	15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern: The percentage of marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 75 marks.

Operating System to Use in Lab : Linux

Compiler/Software to Use in Lab : gcc

Progamming Language to Use in Lab : Ansi C

Fair Lab Record:

All Students attending the Operating System Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record, the right hand page should contain Experiment Heading, Experiment Number, Date of experiment, Aim of the Experiment and the operations performed on them, Details of experiment including algorithm and result of Experiment. The left hand page should contain a print out of the code used for experiment and sample output obtained for a set of input.

SYLLABUS

OPERATING SYSTEMS LAB

* mandatory

1. Basic Linux commands
2. Shell programming
   -Command syntax
   -Write simple functions with basic tests, loops, patterns
3. System calls of Linux operating system:*
   fork, exec, getpid, exit, wait, close, stat, opendir, readdir
4. Write programs using the I/O system calls of Linux operating system (open, read, write)
5. Implement programs for Inter Process Communication using Shared Memory *
6. Implement Semaphores*
7. Implementation of CPU scheduling algorithms. a) Round Robin b) SJF c) FCFS d) Priority *
8. Implementation of the Memory Allocation Methods for fixed partition*
   a) First Fit b) Worst Fit c) Best Fit
9. Implement l page replacement algorithms a) FIFO b) LRU c) LFU*
10. Implement the banker's algorithm for deadlock avoidance. *
11. Implementation of Deadlock detection algorithm
12. Simulate file allocation strategies.
    b) Sequential b) Indexed c) Linked
13. Simulate disk scheduling algorithms. *
    c) FCFS b)SCAN c) C-SCAN

OPERATING SYSTEMS LAB - PRACTICE QUESTIONS

1. Write a program to create a process in linux.
2. Write programs using the following system calls of Linux operating system:
   fork, exec, getpid, exit, wait, close, stat, opendir, readdir
3. Write programs using the I/O system calls of Linux operating system (open, read, write)

4. Given the list of processes, their CPU burst times and arrival times, display/print the Gantt chart for FCFS and SJF. For each of the scheduling policies, compute and print the average waiting time and average turnaround time
5. Write a C program to simulate following non-preemptive CPU scheduling algorithms to find turnaround time and waiting time.

   a)FCFS b) SJF c) Round Robin (pre-emptive) d) Priority
6. Write a C program to simulate following contiguous memory allocation techniques

   a) Worst-fit b) Best-fit c) First-fit
7. Write a C program to simulate paging technique of memory management.
8. Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.
9. Write a C program to simulate disk scheduling algorithms a) FCFS b) SCAN c) C-SCAN
10. Write a C program to simulate page replacement algorithms a) FIFO b) LRU c) LFU
11. Write a C program to simulate producer-consumer problem using semaphores.
12. Write a program for file manipulation for display a file and directory in memory.
13. Write a program to simulate algorithm for deadlock prevention.
14. Write a C program to simulate following file allocation strategies.

    a)Sequential b) Indexed c) Linked

SEMESTER IV

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT	Year of Introduction
CST292	NUMBER THEORY	VAC	4	0	0	4	2019

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Engineering with specialization in ***Security in Computing***. The purpose of this course is to create awareness among learners about the important areas of number theory used in computer science. This course covers Divisibility & Modular Arithmetic, Primes & Congruences, Euler's Function, Quadratic Residues and Arithmetic Functions, Sum of Squares and Continued fractions. Concepts in Number Theory help the learner to apply them eventually in practical applications in Computer organization & Security, Coding & Cryptography, Random number generation, Hash functions and Graphics.

Prerequisite: A sound background in Higher Secondary School Mathematics

Course Outcomes: After the completion of the course the student will be able to

CO1	Illustrate modular arithmetic operations, methods and techniques **(Cognitive Knowledge Level:Understand)**
CO2	Use the methods - Induction, Contraposition or Contradiction to verify the correctness of mathematical assertions **(Cognitive Knowledge Level: Apply)**
CO3	Utilize theorems and results about prime numbers, congruences, quadratic residues and integer factorization for ensuring security in computing systems **(Cognitive Knowledge Level: Analyse)**
CO4	Illustrate uses of Chinese Remainder Theorem & Euclidean algorithm in Cryptography and Security **(Cognitive Knowledge Level: Apply)**
CO5	Explain applications of arithmetic functions in Computer Science **(Cognitive Knowledge Level:Understand)**
CO6	Implement Number Theoretic Algorithms using a programming language **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓						✓		✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓		✓						✓
CO5	✓	✓	✓	✓						✓		✓
CO6	✓	✓	✓	✓	✓			✓				✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (Percentage)
	Test1 (Percentage)	Test2 (Percentage)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module 1

Divisibility and Modular Arithmetic:

Finite Fields – Groups, Rings and Fields.

Divisibility - Divisibility and Division Algorithms, Well ordering Principle,Bezout's Identity.

Modular Arithmetic- Properties, Euclid's algorithm for the greatest common divisor, Extended Euclid's Algorithm, Least Common multiple, Solving Linear Diophantine Equations, Modular Division.

Module 2

Primes and Congruences:

Prime Numbers-Prime Numbers andprime-powerfactorization, Fermat and Mersenne primes., Primality testing and factorization.

Congruences-Linear congruences, Simultaneous linear congruences, Chinese Remainder Theorem, Fermat's little theorem, Wilson's theorem.

Module 3

Congruences with a Prime-Power Modulus&Euler's Function:

Congruences with a Prime-Power Modulus-Arithmetic modulo p, Pseudoprimes and Carmichael numbers, Solving congruences modulo prime powers.

Euler's Function-Euler's Totient function, Applications of Euler's Totient function, Traditional Cryptosystem, Limitations.

The Group of units- The group U_n,Primitive roots, Existence of primitive roots, Applications of primitive roots.

Module 4

Quadratic Residues & Arithmetic Functions :

Quadratic Residues- Quadratic Congruences, The group of Quadratic residues, Legendre symbol, Jacobi Symbol, Quadratic reciprocity.

Arithmetic Functions- Definition and examples, Perfect numbers, Mobius function and its properties, Mobius inversion formula, The Dirichlet Products.

Module 5

Sum of Squares and Continued Fractions:

Sum of Squares- Sum of two squares, The Gaussian Integers, Sum of three squares, Sum of four squares.

Continued Fractions -Finite continued fractions, Infinite continued fractions, Pell's Equation, Solution of Pell's equation by continued fractions.

Text Books

1. G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007.

2. Joseph Silverman, A Friendly introduction to Number Theory, Pearson Ed. 2009.

Reference Books

1. William Stallings, Cryptography and Network Security Principles and Practice, Pearson Ed.

2. Tom M.Apostol, ‘Introduction to Analytic Number Theory’, Narosa Publishing House Pvt. Ltd, New Delhi, (1996).

3. Neal Koblitz, A course in Number Theory and Cryptography, 2nd Edition, Springer ,2004.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Describe the properties of modular arithmetic and modulo operator.

Course Outcome 2 (CO2): Prove that the equation $y^2 = x^3 - 2$ has only the integer solution $(3, \pm 5)$.

Course Outcome 3 (CO3): State the law of reciprocity for Jacobi symbols and use it to determine whether 888 is a quadratic residue or non residue of the prime 1999.

Course Outcome 4 (CO4): Using Chinese remainder theorem, solve the system of congruence $x \equiv 2 \pmod 3$, $x \equiv 3 \pmod 5$, $x \equiv 2 \pmod 7$

Course Outcome 5(CO5): State and prove Dirichlet product.

Course Outcome 6 (CO6): Use extended Euclid's algorithm to solve Diophantine equations efficiently. Given three numbers $a>0$, $b>0$, and c, the algorithm should return some x and y such that $a x + b y = c$.

Model Question Paper

QP CODE: PAGES: 03

RegNo : …............................... Name :………..……………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER BTECH (HONOURS) DEGREE EXAMINATION, MONTH &YEAR

Course Code:CST 292 Course
Name: Number Theory

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks (10x3=30)

1. State and prove well ordering principle.
2. Find gcd d of x=525 and y=231 and express d as ax + by where a and b are integers.
3. Solve the congruence equation 103 x≡ 57 (mod 211).
4. Use Fermat's Little theorem to show that 91 is not a prime.
5. If m is relatively prime to n , show that $\Phi(mn) = \Phi(m)\ \Phi(n)$.
6. Explain how public key cryptography can be used for digital signatures.
7. Define Mobius function and prove Mobius function is a multiplicative.
8. State and prove Dirichlet product.
9. Show that every prime of the form 4k+1 canbe represented uniquely as the sum of two squares.
10. Find the continued fraction representation of the rational number 55/89.

Part B

Answer any one Question from each module.
Each question carries 14 Marks

11. (a) State the Euclidean algorithm and its extension with an example. (7)

(b) Find all the solutions of 24x + 34 y = 6. (7)

OR

12. (a) Describe the properties of modular arithmetic and modulo operator. (7)

(b) Explain Extended Euclidean algorithm. Using the algorithm find the multiplicative inverse of 135 mod 61 (7)

13. (a) State and prove Wilson's theorem . (7)

(b) Explain Fermat's factorization method and use it to factor 809009 (7)

OR

14. (a) Using Chinese remainder theorem, solve the system of congruences, $x \equiv 2 (\bmod 3)$, $x \equiv 3 (\bmod 5)$, $x \equiv 2 (\bmod 7)$ (7)

(b) Define Fermat primes. Show that any two distinct Fermat numbers are Relatively prime. (7)

15. (a) Distinguish between public key and private key encryption techniques. Also point out the merits and demerits of both. (7)

(b) Define Carmichael number and show that a Carmichael number must be the product of at least three distinct primes. (7)

OR

16. (a)Define a pseudo prime to a base and find all non trivial bases for which 15 is a pseudo prime. (6)

(b) Find an element of

i) order 5 modulo 11 ii) order 4 modulo 13

iii) order 8 modulo 17 iv) order 6 modulo 19 (8)

17. (a) Determine the quadratic residues and non residues modulo 17. Also determine whether 219 is a quadratic residue or non residue of the prime 383. (8)

(b) State the law of quadratic reciprocity. Determine those odd primes p for which 3 is a quadratic residue and those for which it is a non residue. (6)

OR

18. (a) State and prove properties of Legendre's symbol. (7)

(b) State the law of reciprocity for Jacobi symbols and using it determine whether 888 is a quadratic residue or non residue of the prime 1999. (7)

19. (a) Prove that the equation $y^2 = x^3 - 2$ has only the integer solution $(3, \pm 5)$. (7)

(b) Define a Gaussian integer. Factorize the Gaussian integer 440 − 55i. (7)

OR

20. (a) If *m*, and *n* can be expressed as sum of four squares, then show that *mn* can also be expressed the sum of four squares. (7)

(b) Find all the solutions of the Diophantine equation $x^2 - 6y^2 = 1$. (7)

Teaching Plan

Module 1: Divisibility and Euclidean Algorithm		**9 hours**
1.1	Finite Fields – Groups and Rings.	1 hour
1.2	Finite Fields – Fields.	1 hour
1.3	Divisibility and Division Algorithms, Well ordering Principle.	1 hour
1.4	Decimal Expansion of a positive Integer, Greatest Common Divisor, Bezout's Theorem.	1 hour
1.5	Modular Arithmetic- Properties of congruences, Modular Arithmetic Operations, Properties of Modular Arithmetic.	1 hour
1.6	Euclid's algorithm for the greatest common divisor, Extended Euclid's Algorithm.	1 hour
1.7	Solving Linear Diophantine Equations.	1 hour
1.8	Least Common multiple and Modular Division.	1 hour
1.9	Implementation of Euclid's algorithm, Extended Euclid's Algorithm and solution of Linear Diophantine Equations.	1 hour
Module 2: Primes and Congruences		**9 hours**
2.1	Prime Numbersand prime-powerFactorization.	1 hour
2.2	Fermat and Mersenne primes.	1 hour
2.3	Primality testing and factorization, Miller -Rabin Test for Primality.	1 hour
2.4	Pollard's Rho Method for Factorization, Fermat's Factorization.	1 hour

2.5	Linear congruences, Simultaneous linear congruences.	1 hour
2.6	Chinese Remainder Theorem.	1 hour
2.7	Implementation of Chinese Remainder Theorem.	1 hour
2.8	Fermat's little theorem.	1 hour
2.9	Wilson's theorem.	1 hour
Module 3: Congruences with a Prime-Power Modulus &Euler's Function		**9 hours**
3.1	Congruences with a Prime-Power Modulus, Arithmetic modulo p.	1 hour
3.2	Pseudo-primes and Carmichael numbers.	1 hour
3.3	Solving congruences modulo prime powers.	1 hour
3.4	Definition of Euler Totient function, Examples and properties.	1 hour
3.5	Multiplicativity of Euler's Totient function.	1 hour
3.6	Applications of Euler’s function, Euler’s Theorem.	1 hour
3.7	Traditional Cryptosystem, Limitations, Public Key Cryptography.	1 hour
3.8	The Group of Units, Primitive Roots.	1 hour
3.9	Existence of primitive roots for Primes, Applications of primitive roots.	1 hour
Module 4: Quadratic Residues and Arithmetic Functions		**9 hours**
4.1	Quadratic congruences, The group of Quadratic Residues.	1 hour
4.2	Legendre symbol, Jacobi Symbol.	1 hour
4.3	Quadratic reciprocity.	1 hour
4.4	Quadratic residues for prime-power moduli.	1 hour
4.5	Arithmetic Functions: Definition and examples.	1 hour

4.6	Perfect numbers, Definition and proposition.	1 hour
4.7	Mobius inversion formula., application of the Mobius inversion formula.	1 hour
4.8	Mobius function and its properties.	1 hour
4.9	The Dirichlet Product, Definition and proof.	1 hour
Module 5: Sum of Squares and Continued Fractions		**9 hours**
5.1	Sum of Squares, Sum of two squares.	1 hour
5.2	The Gaussian Integers.	1 hour
5.3	Sum of three squares.	1 hour
5.4	Sum of four squares.	1 hour
5.5	Continued Fractions, Finite continued fractions.	1 hour
5.6	Continued Fractions, Finite continued fractions.	1 hour
5.7	Infinite continued fractions.	1 hour
5.8	Pell's Equation, Definition.	1 hour
5.9	Solution of Pell's equation by continued fractions.	1 hour

ADT294	COMPUTATIONAL FUNDAMENTALS FOR BIOINFORMATICS	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2020

Preamble: Bioinformatics is an interdisciplinary area that combines Computer Science, Molecular Biology, and Mathematics and allied areas of Science. This course covers computational fundamentals of Bioinformatics and Computational Biology such as DNA, genes and proteins, transcription, translation, sequence alignment, representation and basic Python programming required for handling bioinformatics data. The learners will be able to solve basic bioinformatics problems using python programming.

Prerequisite: Basic understanding of programming languages.

Mapping of course outcomes with program outcomes

CO 1	Describe the basic concepts of Bioinformatics with an emphasis on biological macromolecules-DNA, RNA and Protein and synthesis of biomolecules (**Cognitive knowledge level : Understand**)
CO 2	Identify biological data formats and databases, retrieve bio-sequences, and align bio-sequences to identify similarity, dynamic programming (**Cognitive knowledge level : Apply)**
CO 3	Illustrate nucleotide attributes and transcription using programming tools (**Cognitive knowledge level : Apply)**
CO 4	Demonstrate the concepts of Parsing FASTA and Sequences Analysis (**Cognitive knowledge level : Apply)**
CO 5	Compute k-mers, translation of DNA subsequences and Open reading frame. (**Cognitive knowledge level : Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	√	√	√									√
CO2	√	√	√	√	√	√						√
CO3	√	√	√	√	√							√
CO4	√	√	√	√	√							√
CO5	√	√	√	√								√

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	Test1 (%)	Test2 (%)	
Remember	**10**	**10**	**10**
Understand	**30**	**30**	**70**
Apply	**10**	**10**	**20**
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance 10 marks

Continuous Assessment Tests (Average of Internal Tests 1 & 2) 25 marks

Continuous Assessment Assignment 15 marks

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module-1 (Introduction to bioinformatics)
Introduction to bioinformatics, Nature & Scope of Bioinformatics, animal vs plants, Eukaryote vs prokaryote,Nucleus. Chromosome, gene DNA, RNA, amino acids, and Protein, The Central Dogma, Messenger RNA, tRNA, rRNA, Genetic code, Gene Structure, Transcription, translation.

Module-2 (Introduction to bio sequences and analysis)
Introduction to Biological Databases and data storage, NCBI, Genbank, Bio sequence formats-Database Similarity Searching, BLAST, Sequence alignment, Scoring Matrices, Multiple-Sequence Alignment, Dynamic programming

Module 3: (Introduction to Processing Nucleotides)
Tetranucleotide Frequency, Counting the Nucleotides, Writing and Verifying a Solution, Transcribing DNA into mRNA: Mutating Strings, Reading and Writing Files, Reverse Complement of DNA, String Manipulation, Iterating Over a Reversed String.

Module 4: (Processing Nucleotides GC Content and Hamming Distance)
Creating the Fibonacci Sequence, Writing, Testing, and Benchmarking Algorithms, retrieving FASTA Using Biopython, Iterating the Sequences Using a for Loop, Parsing FASTA and Analyzing Sequences, Computing GC Content, Finding the Hamming Distance, Counting Point Mutations

Module 5 (Translation of DNA and subsequence)

K-mers and Codons, Translating Codons, Translating mRNA into Protein, Finding Subsequences of DNA, Find a Motif in DNA, Finding Overlapping Patterns Using Regular Expressions, Sequence Similarity, Finding the Shortest Sequence in a FASTA File, Extracting K-mers from a Sequence, Counting Frequencies of K-mers, Finding Open Reading Frames

Text Books

1. Mount, D. W.. Bioinformatics: Sequence and Genome Analysis. India, CBS Publishers & Distributors, 2005.
2. Youens-Clark, Ken. *Mastering Python for Bioinformatics*. United States: O'Reilly Media, 2021.

References

1. Kelley, S.T. and Didulo, D, *Computational Biology: A Hypertextbook*. John Wiley & Sons, 2020
2. Baxevanis, Andreas D., Gary D. Bader, and David S. Wishart, eds. *Bioinformatics*. John Wiley & Sons, 2020.
3. Shaik, Noor Ahmad, et al. *Essentials of Bioinformatics, Volume I.* Springer, 2019
4. Selzer, Paul M., Richard J. Marhöfer, and Andreas Rohwer, *Applied bioinformatics. An introduction–Springer, Verlag,*, 2008.
5. S C Rastogi, N Mendiratta and P Rastogi, *Bioinformatics: Methods and Applications,* PHI Learning Private Limited, New Delhi, 2015.
6. D E Krane and M L Raymer, *Fundamental Concepts of Bioinformatics*, Pearson Education, 2006.
7. Bassi, Sebastian. *Python for Bioinformatics*. United Kingdom: CRC Press, 2017.
8. Model, Mitchell L. Bioinformatics Programming Using Python. United States: O'Reilly Media, 2010.
9. Antao, Tiago. *Bioinformatics with Python Cookbook*. United Kingdom: Packt Publishing, 2015.Antao, Tiago. Bioinformatics with Python Cookbook: Learn how to Use Modern Python Bioinformatics Libraries and Applications to Do Cutting-edge Research in Computational Biology, 2nd Edition. United Kingdom: Packt Publishing, 2018.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Compare and contrast the DNA and RNA on the basis of structure and functions.
2. Demonstrate with the help of a flow diagram the generation of protein using the transcription and translation process.

Course Outcome 2 (CO2):

1. Identify the following qualifiers for GenBank and give their definitions: [ACCN], [ALL], [AUTH], [ECNO], [FKEY], [GENE], [JOUR], [KYWD]

2. Find the sequence alignment between the following two sequences, locally and Globally
   Sequence1: GATTCTATCTAACTA, Sequence2: GTTCTATTCTAAC
3. Retrieve sequence of Severe acute respiratory syndrome coronavirus 2 and use BLAST to find the similar sequences

Course Outcome 3 (CO3):

1. Write a Python program pseudocode to read the below given sequence as command line argument and print the counts for each of the bases A, C, G, and T.
   Sequence: ACTGCAACGGGCAATATGTCTC
2. Write a python pseudocode to transcribe the following DNA sequence to its mRNA sequence.
   Sequence: TGCAACGGGCAATATGTCTC

Course Outcome 4 (CO4)

1. Solve the problem of generating the Fibonacci sequence using Python.
2. Use a simple python program using a list to find the DNA string having the highest GC content, provided any 5 random DNA strings.

Course Outcome 5 (CO5)

1. Illustrate with the help of an example how an RNA string is getting converted to a protein string.
2. Write a python code to print the position and the number of times a subsequence is present in a given DNA string.

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE (HONOURS) EXAMINATION, MONTH & YEAR

Course Code: ADT294

Course Name: COMPUTATIONAL FUNDAMENTALS FOR BIOINFORMATICS

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Differentiate DNA, Gene, genome and chromosome.
2. What do you mean by Gene expression?
3. Specify the functions of mRNA, tRNA and rRNA?
4. Differentiate between local and global alignment.
5. Find the reverse complement of the following DNA given in 5'-3'order? AAAACCCGGT
6. List any 3 string manipulation construct used in processing nucleotides.
7. Illustrate how recursion is implemented using a Python pseudocode.
8. What is GC content? Give the GC content of the DNA string: "AGCTATAG".
9. Discuss the role of K-mers and codons in protein synthesis.
10. Define motif in DNA. Mention its importance in finding a conserved sequence.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11.	(a)	Discuss the central dogma of molecular biology.	**(7)**
	(b)	How is the primary transcript produced by a prokaryote different from that produced by a eukaryotic cell?	**(7)**
		OR	
12.	(a)	Differentiate between Prokaryote and Eukaryote Cell	**(7)**
	(b)	Describe with the help of a neat diagram, the structure of DNA.	**(7)**
13.	(a)	What is sequence alignment? Explain any five applications of sequence alignment in Bioinformatics?	**(7)**
	(b)	Discuss variants of BLAST with its input and output	**(7)**
		OR	
14.	(a)	Explain the working principles of the Nucleotide BLAST with an example	**(7)**
	(b)	Differentiate primary and secondary databases in Bioinformatics.	**(7)**
15.	(a)	How do you find the reverse complement of a DNA sequence? Write at least 2 different Python pseudocodes using different constructs to print the reverse complement of a given the 5'-3' end of a DNA sequence.	**(10)**
	(b)	Write a Python pseudocode to convert DNA sequence to RNA sequence by using the re.sub() regular expression construct.	**(4)**
		OR	
16.	(a)	What is the need for 'argparse' module in Python? How can we use this module in different ways to do a tetra nucleotide frequency count?	**(7)**
	(b)	Write a Python program pseudocode to read the below given sequence as command line argument and print the counts for each of the bases A, C, G, and T.	**(7)**
17.	(a)	Generate a random DNA sequence using python and find the transcribed	(7)

DNA sequence of its reverse complement

(b) Write a python code using regular expressions to find the DNA sequence having the highest GC content in a DNA sequence. **(7)**

OR

18. (a) Define Hamming distance. Using hamming distance, find the percentage of similarity between the sequence AAACCCGGGTTT and AACCCGGGTTTA with one sequence in line with other. **(7)**

(b) Write a Python code using zip() function to find the hamming distance between 2 sequence. Give comments on each construct used in the code. **(7)**

19. (a) Write a Python program using function and a list comprehension to translate RNA into protein. Illustrate working of the program with an example RNA string. **(10)**

(b) Illustrate with python pseudocode to show how the str.find( ) function can be used to find a substring and its position in an input sequence. **(4)**

OR

20. (a) Illustrate with the help of an example how an RNA string is getting converted to a protein string.. **(6)**

(b) Write notes on ORF. Write a python code to find the ORF using the str.find( ) and str.partition( ) functions. **(8)**

TEACHING PLAN

No	Contents	No of Lecture Hrs
Module-1 (Introduction to bioinformatics)(10 hrs)		
1.1	Introduction to bioinformatics	1
1.2	Nature & Scope of Bioinformatics	1
1.3	Animal vs plants, Eukaryote vs prokaryote	1
1.4	Nucleus. Chromosome, gene	1
1.5	DNA, RNA, and Protein	1
1.6	The Central Dogma introduction	1
1.7	Messenger RNA, tRNA, rRNA,	1
1.8	Genetic code	1
1.9	Gene Structure and Control	1
1.10	Transcription, Translation	1
Module-2 (Introduction to bio sequences and analysis) (10 hrs)		
2.1	Introduction to Biological Databases and data storage	1
2.2	NCBI, Genbank	1
2.3	NCBI, Genbank Sequence retrieval	1
2.4	Bio sequence formats	1
2.5	Database Similarity Searching, BLAST	1
2.6	BLAST Exercises	1
2.7	Sequence alignment	1
2.8	Scoring Matrices	1
2.9	Multiple-Sequence Alignment	1
2.10	Introduction to Dynamic programming in MSA	1
Module-3 (Introduction to Processing Nucleotides) (8 hrs)		
3.1	Counting the Nucleotides, Writing and Verifying a Solution	1

3.2	Transcribing DNA into mRNA	1
3.3	Iterating the Input Files	1
3.4	Mutating Strings	1
3.5	Writing and Reading Output Sequences	1
3.6	Reverse Complement of DNA	1
3.7	String Manipulation	1
3.8	Iterating Over a Reversed String	1

Module-4 (Processing Nucleotides GC Content and Hamming Distance) (8 hrs)		
4.1	Creating the Fibonacci Sequence	1
4.2	Writing, Testing, and Benchmarking Algorithms	1
4.3	Retrieving FASTA Using Biopython	1
4.4	Parsing FASTA and Analysing Sequences	1
4.5	Computing GC Content	1
4.6	Finding the Hamming Distance	1
4.7	Iterating the Characters of Two Strings	1
4.8	Counting Point Mutations	1
Module-5 (Translation of DNA and subsequence) (9 hrs)		
5.1	K-mers and Codons	1
5.2	Translating mRNA into Protein	1
5.3	Finding Subsequence of DNA	1
5.4	Find a Motif in DNA	1
5.5	Finding Overlapping Patterns Using Regular Expressions	1
5.6	Sequence Similarity	1
5.7	Finding the Shortest Sequence in a FASTA File , Extracting K-mers from a Sequence	1
5.8	Counting Frequencies of K-mers	1
5.9	Finding Open Reading Frames	1

ADT296	ADVANCED TOPICS IN COMPUTER GRAPHICS	CATEGORY	L	T	P	CREDITS
		VAC	3	1	0	4

Preamble: This course helps the learners to make awareness about strong theoretical concept in computer graphics. It covers the three-dimensional environment representation in a computer, transformation of 2D/3D objects, basic mathematical techniques and algorithms used to build useful applications. This course enables the learners to develop the ability to create image processing frameworks for different domains and develops algorithms for emerging display technologies.

Prerequisite: A sound knowledge of Mathematics and concepts of any programming language.

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Describe the working principles of graphics devices**(Cognitive Knowledge level: Understand)**
CO2	Illustrate line drawing, circle drawing and polygon filling algorithms**(Cognitive Knowledge level: Apply)**
CO3	Demonstrate geometric representations and transformations on 2D & 3D objects. **(Cognitive Knowledge level: Apply)**
CO4	Demonstrate the working of various clipping algorithms and projection algorithms. **(Cognitive Knowledge level: Apply)**
CO5	Summarize visible surface detection methods**(Cognitive Knowledge level: Understand)**
CO6	Explain the concept of realism in a scene and its performance preservation**(Cognitive Knowledge level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔											✔
CO2	✔	✔	✔	✔	✔							✔
CO3	✔	✔	✔	✔	✔							✔
CO4	✔	✔	✔	✔	✔							✔
CO5	✔											✔
CO6	✔	✔										✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests (Average of SeriesTests1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one full question. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module – 1(Line and Circle drawing algorithms) **S**

Basics of Computer Graphics and its applications. Video Display devices - Refresh Cathode Ray Tubes, Random Scan Displays and systems, Raster scan displays and systems, Color CRT displays, Flat panel display and its categories. Line drawing algorithms - DDA, Bresenham's algorithm. Circle drawing algorithms - Midpoint Circle generation algorithm, Bresenham's algorithm.

Module - 2(Filled Area Primitives and Two dimensional transformations)

Filled Area Primitives- Scan line polygon filling, Boundary filling and flood filling. Two dimensional transformations-Translation, Rotation, Scaling, Reflection and Shearing, Composite transformations, Matrix representations and homogeneous coordinates.

Module - 3 (Clipping and 3D transformations)

Window to viewport transformation. Cohen Sutherland and Midpoint subdivision line clipping algorithms, Sutherland Hodgeman and Weiler Atherton Polygon clipping algorithms. Three dimensional viewing pipeline. Basic 3D transformations.

Module - 4 (Projections and Visible Surface detection)

Projections- Parallel and Perspective projections. Visible surface detection algorithms- Back face detection, Depth buffer algorithm, Scan line algorithm, A buffer algorithm

Module - 5 (Realism and performance)

Realism - Illumination Shading, Shadows, Texture mapping, Bump mapping, Environment mapping, Transparency, Accumulation Buffer, Back face Culling, Visibility Culling.

Text Books

1. Donald Hearn and M. Pauline Baker, Computer Graphics, PHI, 2e, 1996
2. Aditi Majumder and M.Gopi , Introduction to VISUAL COMPUTING Core Concepts in Computer Vision, Graphics, and Image Processing, 2018

References

1) William M. Newman and Robert F. Sproull, Principles of Interactive Computer Graphics. McGraw Hill, 2001
2) Zhigang Xiang and Roy Plastock, Computer Graphics (Schaum's outline Series), McGraw Hill, 2019.
3) David F. Rogers , Procedural Elements for Computer Graphics, Tata McGraw Hill,2001.
4) Donald Hearn, M. Pauline Baker and Warren Carithers, Computer Graphics with OpenGL, PHI, 4e, 2013

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare the working principle of raster scan systems and random scan systems.
2. How much time is spent scanning across each row of pixels during screen refresh on a raster system with resolution of 1280*1024 and a refresh rate of 60 frames per second?

Course Outcome 2 (CO2):

1. Rasterize the line with end points accepted from the user(2,3) and (5,8) using Bresenham's line drawing algorithm and implement it using any appropriate programming language. (Assignment)
2. Illustrate how the 4-connected area filling approach differs from 8- connected area filling in boundary filling algorithm and implement it using any appropriate programming language.(Assignment)

Course Outcome 3 (CO3):

1. Rotate a triangle ABC 45 degree counter clockwise about the pivot point (10,3) , where the position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3).
2. Implement the above transformation using any appropriate programming language with user inputs. (Assignment)

Course Outcome 4 (CO4):

1. Given a clipping window A(20,20), B(60,20), C(60,40) and D(20,40). Using Cohen Sutherland algorithm, find the visible portion of the line segment joining the points P(40,80) and Q(120,30).
2. Implement Cohen Sutherland clipping algorithm using any appropriate programming language with user inputs. (Assignment)

Course Outcome 5 (CO5):

1. Explain scan line algorithm for detecting visible surfaces in an object.

Course Outcome 6 (CO6):

1. You are rendering a black and white checkered tiled floor using a single texture mapped polygon. The view is simulating a person standing on the floor and looking at a point far away from him on the floor. (1)Artifacts at the distant end of the floor can be seen. How would you remove these artifacts? (2) How can you explain why this method works using the sampling theorem?
2. You are seeing an object which is either texture mapped, bump mapped or displacement mapped but you don't know which one. However, you have the liberty to move the light and the viewpoint of an object and see it from different angles and for different positions of the light. How will you figure out which technique was used?

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE (HONOURS) EXAMINATION, MONTH & YEAR

Course Code:ADT296

Course Name: Advanced Topics in Computer Graphics

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Consider a raster system with a resolution of 1024*1024. Compute the size of the raster needed to store 4 bits per pixel? How much storage is needed if 8 bits per pixel are to be stored?
2. How 8-way symmetry of circle can be used for writing circle drawing algorithms? Write the symmetric points if (x, y) is a point on the circle with centre at origin.
3. Show that two successive reflections about either of the coordinate axes is equivalent to a single rotation about the coordinate origin.
4. Determine a sequence of basic transformations that are equivalent to the x-direction shearing matrix.

5. Find the window to viewport normalization transformation with window lower left corner at (1,1) and upper right corner at (2,6).

6. How does Cohen Sutherland algorithm determine whether a line is visible, invisible or a candidate for clipping based on the region codes assigned to the end points of the line?

7. Define the terms (i) Centre of projection (ii) Principal vanishing point

8. Differentiate between the object space and image space method for the hidden surface removal of an image.

9. Describe the steps used to convert the normal map to bump mapping.

10. One artifact of Gouraud shading is that it can miss specular highlights in the interior of the triangles. How can this be explained as an aliasing artifact?

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Derive the initial decision parameter of Bresenham's line drawing algorithm and rasterize a line with endpoints (2,2) and (10,10). **(8)**

(b) Draw the architecture of raster scan display systems and explain its working principle **(6)**

OR

12. (a) Explain the working principle of a Refresh CRT monitor with suitable diagrams. **(7)**

(b) Write Midpoint circle drawing algorithm and plot a circle with radius=20 and center (50,30) using the algorithm. **(7)**

13. (a) Differentiate between boundary fill and flood fill algorithms. **(5)**

(b) Reflect a triangle ABC about the line 3x-4y+8=0, where the position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3). **(9)**

OR

14. (a) A diamond shaped polygon is located at P(-1,0), Q(0,-2), R(1,0) and S(0,2). Find the transformation matrix which would rotate the triangle by 90 degree counter clockwise about the point Q. Using the transformation matrix, find the coordinates of the rotated polygon. **(7)**

(b) Illustrate the working principle of scan line polygon filling algorithm **(7)**

15. (a) Illustrate Weiler – Atherton polygon clipping algorithm. **(6)**

(b) Explain Cohen-Sutherland line clipping algorithm. Use the algorithm to clip line P1 (70, 20) and P2(100,10) against a window lower left hand corner (50,10) and upper right hand corner (80,40). **(8)**

OR

16. (a) Describe the steps required for a general 3D rotation if the rotation axis is not parallel to any one of the principal axis. The rotation axis is defined by the points P1(x1,y1,z1) and P2(x2,y2,z2). Give its composite matrix representation **(6)**

(b) Describe Sutherland Hodgeman polygon clipping algorithm and list out its limitations **(8)**

17. (a) Explain how visible surfaces can be detected using depth buffer algorithm. **(7)**

(b) Define parallel projection. Describe orthographic and oblique parallel projection. **(7)**

OR

18. (a) Illustrate the scan line method used in visible surface detection. **(7)**

(b) Explain the steps involved in performing perspective projections **(7)**

19. (a) Specify any three shading algorithms used in interactive graphics. **(6)**

(b) Explain the procedure of texture to object space mapping. **(8)**

OR

20. (a) Explain the mapping scheme in which the effects of small bumps on the surface of an object can be simulate without changing the number of primitives **(8)**

(b) Describe about object to screen space mapping. **(6)**

TEACHING PLAN

No	Contents	No of Lecture Hrs
Module – 1 (Line and Circle drawing algorithms) (10 hrs)		
1.1	Basics of Computer Graphics and applications	1
1.2	Refresh Cathode Ray Tubes	1
1.3	Random and Raster Scan Displays and systems,	1
1.4	Color CRT displays	1
1.5	Flat panel display and its categories.	1
1.6	DDA Line drawing Algorithm	1
1.7	Bresenham's line drawing algorithm	1
1.8	Midpoint Circle generation algorithm	1
1.9	Bresenham's Circle generation algorithm	1
1.10	Illustration of line and circle drawing algorithms	1
Module - 2 (Filled Area Primitives and Two dimensional transformations) (9 hrs)		
2.1	Scan line polygon filling	1
2.2	Boundary filling and flood filling	1
2.3	Basic 2D transformations-Translation	1
2.4	Basic 2D transformations- Rotation	1
2.5	Basic 2D transformations- Scaling	1
2.6	Reflection and Shearing	1
2.7	Illustration of Basic 2D Transformations	1
2.8	Composite transformations	1
2.9	Matrix representations and homogeneous coordinates	1
Module - 3 (Clipping and 3D transformations) (8 hrs)		
3.1	Window to viewport transformation	1
3.2	Cohen Sutherland Line clipping algorithm	1
3.3	Midpoint subdivision Line clipping algorithm	1
3.4	Sutherland Hodgeman Polygon clipping algorithm	1
3.5	Weiler Atherton Polygon clipping algorithm	1
3.6	Three dimensional viewing pipeline	1

3.7	Basic 3D transformation-Translation and scaling	1
3.8	Basic 3D transformation-Rotation	1
Module - 4 (Projections and Visible Surface detection) (7 hrs)		
4.1	Projections-Parallel projections	1
4.2	Projections- Perspective projections	1
4.3	Illustration of projection methods	1
4.4	Visible surface detection algorithms- Back face detection	1
4.5	Depth buffer algorithm	1
4.6	Scan line visible surface detection algorithm	1
4.7	*A buffer* algorithm	1
Module - 5 (Realism and performance)(10 hrs)		
5.1	Illumination	1
5.2	Shading and Shadows	1
5.3	Texture mapping-Texture to object space mapping	1
5.4	Texture mapping-Object to screen space mapping and Mip Mapping	1
5.5	Bump mapping	1
5.6	Bump mapping-Illustration	1
5.7	Environment mapping and Transparency	1
5.8	Accumulation Buffer and Back face Culling	1
5.9	Visibility Culling	1
5.10	Visibility Culling	1

SEMESTER V

ADT301	FOUNDATIONS OF DATA SCIENCE	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2022

Preamble: This course enables the learners to understand the basic concepts of data science including data preprocessing, missing value management and data visualization. It discusses different models that can be used in classification and prediction. It also includes an introduction to Association mining and Cluster analysis. It also introduces the basics of model evaluation.

Prerequisite: Basic understanding of probability theory, linear algebra and basic programming knowledge.

Course Outcomes: After the completion of the course the student will be able to

CO1	Recall the fundamental concepts and applications of data science, and make inferences on key important points **(Cognitive Knowledge Level: Understand)**
CO2	Identify the concepts in data mining and analyze the different steps in data preprocessing**(Cognitive Knowledge Level: Apply)**
CO3	Illustrate the concepts of classification methods **(Cognitive Knowledge Level: Apply)**
CO4	Perform association mining and analyze clusters using different methods **(Cognitive Knowledge Level: Apply)**
CO5	Evaluate & improve the performance of machine learning classification models **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓							✓
CO2	✓	✓	✓	✓	✓							✓
CO3	✓	✓	✓	✓	✓							✓
CO4	✓	✓	✓	✓	✓							✓
CO5	✓	✓	✓	✓								✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test1 (%)	Test 2(%)	
Remember	40	40	40
Understand	40	40	40
Apply	20	20	20
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests (Average of Internal Tests 1 & 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

SYLLABUS

Module – 1 (Introduction to Data Science)

A brief introduction to data – structured, unstructured, semi-structured, data sets & patterns, Brief history of Data Science, Introduction to Data Science, Importance of Data Science, Differences between AI, ML, DL, Data Science & Data Analytics, Real world applications of data science, Steps in data science process

Simple case study based on real life applications such as - Market research case, tracking disease outbreaks, business predictions, (for example, Rating a product design) etc., Ethical and privacy implications of Data Science.

Tools and Skills Needed – brief introduction of platforms, tools, frameworks, languages, databases and libraries, Current trends & major research challenges in data science.

Module – 2 (Data Mining & Preprocessing)

Data Mining, Kinds of data - mining, Data Preprocessing. An Overview - Data Quality, Need to preprocess the data. Major Tasks in Data Preprocessing.

Data cleaning - Missing Values Noisy Data, Data Cleaning as a Process, Data Integration, Data Reduction, Data transformation and Data Discretization. Introduction to Data Visualization

Module - 3 (Classification Models)

Classification - Basic Concepts, Decision Tree Induction, Bayes Classification Methods- Naıve Bayesian Classification, Rule-Based Classification

Classification Advanced Methods - Bayesian Belief Networks, Classification by Back propagation, A Multilayer Feed-Forward Neural Network, Back propagation, Support Vector Machines, Lazy Learners, K-Nearest-Neighbour Classifiers, Case-Based Reasoning

Module - 4 (Association Mining and Cluster Analysis)

Mining Frequent Patterns, Associations, and Correlations. Basic Concepts Frequent Itemset Mining Methods, Apriori Algorithm, Generating Association Rules from Frequent Itemsets Cluster Analysis, Partitioning Methods, Hierarchical Methods, Agglomerative versus Divisive Hierarchical Clustering, Distance Measures in Algorithmic Methods. Density-Based Methods - DBSCAN

Module - 5 (Evaluation)

Evaluating model performance-Confusion matrices, Precision and recall, Sensitivity and specificity, F-measure, ROC curves, Cross validation, K-fold cross validation, Bootstrap sampling. Improving model performance - Bagging, Boosting, Random forests.

Text Books

1. Sanjeev J. Wagh, Manisha S. Bhende, and Anuradha D. Thakare, *Fundamentals of Data Science,* CRC press
2. Jiawei Han, Michelin Kamber, Jian Pei, *Data mining Concepts and Techniques*, Third Edition, 2012 , Morgan Kaufmann Publishers
3. Brett Lantz, *Machine Learning with R*, Second edition, PackT publishing 2015

Reference Books

1. Arun K. Pujari, *Data Mining Techniques*, Universities Press
2. Foster Provost, Tom Fawcett, *Data Science for Business*, O'Reilly Media
3. Margaret H Dunham, *Data Mining: Introductory And Advanced Topics,* Pearson Education
4. Nina Zumel and John Mount, *Practical Data Science with R*, Manning Publications

Sample Course Level Assessment Questions

Course Outcome1 (CO1):

1. What is data science? Why is data science required?
2. How data science is used in a real life application to enhance business management?
3. Explain the different domains of data science where data science plays an active role
4. Explain the different stages in data science process
5. List and briefly explain various tools and skills required for data science

Course Outcome 2(CO2):

1. Given the following data (in increasing order) for the attribute age: 13, 15, 16, 16, 19, 20, 20, 21, 22, 22, 25, 25, 25, 25, 30, 33, 33, 35, 35, 35, 35, 36, 40, 45, 46, 52, 70.

   (a) Use binning methods to smooth these data, using a bin depth of 3.

   Illustrate your steps. Comment on the effect of this technique for the given data.

2. Use these methods to normalize the following group of data: 200,300,400,600,1000

   (a) min-max normalization by setting min = 0 and max = 1

   (b) z-score normalization

   (c) z-score normalization using the mean absolute deviation instead of standard deviation

   (d) normalization by decimal scaling

Course Outcome 3 (CO3):

1. Given a 5-GB data set with 50 attributes (each containing 100 distinct values) and 512 MB of main memory in your laptop, outline an efficient method that constructs decision trees in such large data sets. Justify your answer by rough calculation of your main memory usage.
2. SVM classifiers suffer from slow processing when training with a large set of data tuples. Discuss how to overcome this difficulty and develop a scalable SVM algorithm for efficient SVM classification in large data sets.
3. Write an algorithm for k-nearest-neighbor classification given k, the nearest number of neighbors, and n, the number of attributes describing each tuple.

Course Outcome 4 (CO4): .

1. Suppose the data containing frequent itemset X is {I1, I2, I5}. What are the association rules that can be generated from X if the nonempty subsets of X are {I1, I2}, {I1, I5}, {I2, I5}, {I1}, {I2}, and {I5} and minimum confidence threshold is 70%? Output the strong association rules.
2. Find the frequent itemsets and generate the association rules using the Apriori algorithm if minimum support is 2 and minimum confidence is 50%.

TID	ITEMSETS
T1	A, B
T2	B, D
T3	B, C
T4	A, B, D
T5	A, C
T6	B, C
T7	A, C
T8	A, B, C, E
T9	A, B, C

3. Mention the general characteristics of different clustering methods.
4. Differentiate between Agglomerative and Divisive Hierarchical Clustering.

5. How can we find dense regions in density-based clustering? How does DBSCAN quantify the neighborhood of an object? How can we assemble a large dense region using small dense regions centered by core objects?

Course Outcome 5 (CO5):

1. Explain the various matrices used to measure the performance of classification algorithms.
2. Explain the concepts of bagging and boosting.
3. Suppose 10000 patients get tested for flu; out of them, 9000 are actually healthy and 1000 are actually sick. For the sick people, a test was positive for 620 and negative for 380. For the healthy people, the same test was positive for 180 and negative for 8820. Construct a confusion matrix for the data and compute the precision and recall for the data.

Model Question Paper

QP CODE: **PAGES : 3**

Reg No: _______________Name: _________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: ADT301

Course Name: Foundations of Data Science

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. List out three ethical issues in data science?

2. Differentiate between Data Analytics and Data Science.

3. Define binning?

4. Demonstrate various data reduction strategies?

5. Discuss the classification processes using Bayesian Belief Networks.

6. Illustrate the strength and weakness of KNN classifiers.

7. Infer the conditions to be satisfied for an association rule to be strong? Illustrate with an example.

8. Cite the orthogonal aspects with which clustering methods can be compared?

9. Compare and contrast precision, recall and F-measure.

10. How can you summarize bootstrap sampling? **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) How data science is used in a real life application to enhance business management? **(9)**

(b) Demonstrate the different stages in the data science process. **(5)**

OR

12. (a) List and briefly explain various tools and skills required for data science. **(7)**

(b) Identify the different domains where data science plays an active role. **(7)**

13. (a) Explain the procedures in data reduction strategy using PCA. **(6)**

(b) Briefly explain the preprocessing techniques available in data mining. **(8)**

OR

14. (a) Discover the value ranges of the following normalization methods? **(6)**

(a) min-max normalization

(b) z-score normalization

(b) Briefly explain the terms data reduction and data transformation with an example. **(8)**

15. (a) Why is naıve Bayesian classification called "naıve"? Briefly outline the major ideas of naıve Bayesian classification. **(6)**

(b) Compare the advantages and disadvantages of eager classification (e.g., decision tree, Bayesian, neural network) versus lazy classification (e.g., k-nearest neighbor, case-based reasoning). **(8)**

OR

16. (a) Illustrate the major steps of decision tree classification. **(6)**

(b) Briefly describe the classification processes using (i) Support Vector machine (ii) Back Propagation. **(8)**

17. (a) What is the Apriori algorithm used for? Give the steps used in the Apriori algorithm to find the most frequent itemsets. **(4)**

(b) Consider the following dataset and find frequent itemsets and generate association rules for them. Let minimum support count be 2 and minimum confidence be 60%. **(10)**

TID	items
T1	I1, I2 , I5
T2	I2,I4
T3	I2,I3
T4	I1,I2,I4
T5	I1,I3
T6	I2,I3
T7	I1,I3
T8	I1,I2,I3,I5
T9	I1,I2,I3

OR

18.	(a)	How does the k-means algorithm work? Clearly state the k-means partitioning algorithm with the help of an example.	**(8)**
	(b)	Explain the requirements for clustering as a data mining tool and aspects that can be used for comparing clustering methods.	**(6)**
19.	(a)	Suppose 10000 patients get tested for flu; out of them, 9000 are actually healthy and 1000 are actually sick. For the sick people, a test was positive for 620 and negative for 380. For the healthy people, the same test was positive for 180 and negative for 8820. Construct a confusion matrix for the data and compute the precision and recall for the data.	**(7)**
	(b)	Explain the various Performance evaluation parameters.	**(7)**

OR

20.	(a)	Assume the following: A database contains 80 records on a particular topic of which 55 are relevant to a certain investigation. A search was conducted on that topic and 50 records were retrieved. Of the 50 records retrieved, 40 were relevant. Construct the confusion matrix for the search and calculate the precision and recall scores for the search.	**(6)**
	(b)	Explain the different methods for improving the model performance.	**(8)**

Teaching Plan

No	**Contents**	**No. of Lecture Hours (45 hrs)**
	Module-1 (Introduction) (8 hours)	
1.1	A brief introduction to data –structured, unstructured,semi-structured, data sets & patterns, Brief history of data science, Introduction to Data Science	1 hour
1.2	Importance of data science, Differences between AI, ML, DL, Data Science & Data Analytics, Real world applications of data science	1 hour
1.3	Steps in data science process- framing the problem, collecting raw data, data preprocessing, model designing	1 hour
1.4	Steps in data science process- model building, in-depth analysis, communicating results.	1 hour
1.5	Simple case study based on real life applications such as - Market research case, tracking disease outbreaks, business predictions, (for example, rating a product design),etc.	1 hour
1.6	Ethical and privacy implications of Data Science.	1 hour
1.7	Tools and Skills Needed – brief introduction of platforms, tools, frameworks,	1 hour

	languages, databases and libraries	
1.8	Current trends & major research challenges in data science.	1 hour
Module-2 (Data Preprocessing) (8 hours)		
2.1	Data mining and Data Preprocessing: An Overview	1 hour
2.2	Data Cleaning- Missing Values, Noisy Data,Data Cleaning as a Process	1 hour
2.3	Integration - Entity Identification Problem, Redundancy and Correlation Analysis	1 hour
2.4	Tuple Duplication, Data Value Conflict Detection and Resolution	1 hour
2.5	Data Reduction- PCA, Regression and Log-Linear Models: Parametric Data Reduction	1 hour
2.6	Data Reduction- Clustering, Data cube aggregation.	1 hour
2.7	Data Transformation and Data Discretization - Data Transformation by Normalization	1 hour
2.8	Data Visualization - An overview	1 hour
Module-3 (Classification Models) (10 hours)		
3.1	Classification: Basic Concepts (TB2 8.1)	1 hour
3.2	Decision Tree Induction (TB2 8.2.1)	1 hour
3.3	Bayes Classification Methods - Naıve Bayesian Classification (TB2 8.3)	1 hour
3.4	Rule-Based Classification (TB2 8.4)	1 hour
3.5	Classification: Advanced Methods - Bayesian Belief Networks (TB2 9.1)	1 hour
3.6	Classification by Backpropagation - A Multilayer Feed-Forward NN (TB2 9.1)	1 hour
3.7	Backpropagation (TB2 9.2.3)	1 hour
3.8	Support Vector Machines (TB2 9.3)	2 hours
3.9	Lazy Learners - k-Nearest-Neighbor Classifiers - Case-Based Reasoning (TB2 9.5)	1 hour
Module-4 (Association Mining and Cluster Analysis) (10 hours)		
4.1	Mining Frequent Patterns, Associations, and Correlations: Basic Concepts (TB2 6.1)	1 hour
4.2	Frequent Itemset Mining Methods : Apriori Algorithm (TB2 6.2.1)	2 hours
4.3	Generating Association Rules from Frequent Itemsets (TB2 6.2.2)	1 hour
4.4	Cluster Analysis (TB2 10.1)	1 hour
4.5	Partitioning Methods (TB2 10.2)	1 hour

4.6	Agglomerative versus Divisive Hierarchical Clustering (TB2 10.3.1)	1 hour
4.7	Distance Measures in Algorithmic Methods (TB2 10.3.2)	1 hour
4.8	Density-Based Methods: DBSCAN (TB2 10.4.1)	2 hours
Module-5 (Evaluation) (9 hours)		
5.1	Evaluating model performance: Confusion matrices	1 hour
5.2	Precision and recall, Sensitivity and specificity	1 hour
5.3	F-measure, ROC curves	1 hour
5.4	Problems on Evaluating Model performance	1 hour
5.5	Cross validation: K-fold cross validation	1 hour
5.6	Bootstrap sampling	1 hour
5.7	Improving model performance: Bagging	1 hour
5.8	Boosting, Random forests	2 hours

CST 303	COMPUTER NETWORKS	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble: Study of this course provides the learners a clear understanding of how computer networks from local area networks to the massive and global Internet are built, how they allow computers to share information and communicate with one another. This course covers the physical aspects of computer networks, layers of OSI Reference model, and inter-networking. The course helps the learners to compare and analyze the existing network technologies and choose a suitable network design for a given system.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO#	Course Outcomes
CO1	Explain the features of computer networks, protocols, and network design models **(Cognitive Knowledge: Understand)**
CO2	Describe the fundamental characteristics of the physical layer and identify the usage in network communication **(Cognitive Knowledge: Apply)**
CO3	Explain the design issues of data link layer, link layer protocols, bridges and switches **(Cognitive Knowledge: Understand)**
CO4	Illustrate wired LAN protocols (IEEE 802.3) and wireless LAN protocols (IEEE 802.11) **(Cognitive Knowledge: Understand)**
CO5	Select appropriate routing algorithms, congestion control techniques, and Quality of Service requirements for a network **(Cognitive Knowledge: Apply)**
CO6	Illustrate the functions and protocols of the network layer, transport layer, and application layer in inter-networking **(Cognitive Knowledge: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1 1	PO12
CO1	✔	✔										✔
CO2	✔	✔	✔									✔
CO3	✔	✔	✔									✔
CO4	✔	✔	✔									✔
CO5	✔	✔	✔	✔								✔
CO6	✔	✔	✔			✔						✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and teamwork
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

Assessment Pattern

Bloom's Category	Test 1 (Marks in percentage)	Test 2 (Marks in percentage)	End Semester Examination (Marks in percentage)
Remember	40	30	30

Understand	**50**	**50**	**50**
Apply	**10**	**20**	**20**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**50**	**100**	**3**

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**
Continuous Assessment Test : **25 marks**
Continuous Assessment Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first series test shall be preferably conducted after completing the first half of the syllabus. The second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer anyone. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module - 1 (Introduction and Physical Layer)

Introduction – Uses of computer networks, Network hardware, Network software. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models.

Physical Layer – Modes of communication, Physical topologies, Signal encoding, Repeaters and hub, Transmission media overview. Performance indicators – Bandwidth, Throughput, Latency, Queuing time, Bandwidth–Delay product.

Module - 2 (Data Link Layer)

Data link layer - Data link layer design issues, Error detection and correction, Sliding window protocols, High-Level Data Link Control(HDLC)protocol. Medium Access Control (MAC) sublayer –Channel allocation problem, Multiple access protocols, Ethernet, Wireless LANs - 802.11, Bridges & switches - Bridges from 802.x to 802.y, Repeaters, Hubs, Bridges, Switches, Routers and Gateways.

Module - 3 (Network Layer)

Network layer design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Distance Vector Routing, Link State Routing, Multicast routing, Routing for mobile hosts. Congestion control algorithms. Quality of Service (QoS) - requirements, Techniques for achieving good QoS.

Module - 4 (Network Layer in the Internet)

IP protocol, IP addresses, Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP), Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First(OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting, IPv6, ICMPv6.

Module – 5 (Transport Layer and Application Layer)

Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP). Transmission Control Protocol (TCP) – Overview of TCP, TCP segment header, Connection establishment &release, Connection management modeling, TCP retransmission policy, TCP congestion control.

Application Layer –File Transfer Protocol (FTP), Domain Name System (DNS), Electronic mail, Multipurpose Internet Mail Extension (MIME), Simple Network Management Protocol

(SNMP), World Wide Web(WWW) – Architectural overview.

Text Books

1. Andrew S. Tanenbaum, Computer Networks, 4/e, PHI (Prentice Hall India).
2. Behrouz A Forouzan, Data Communication and Networking, 4/e, Tata McGraw Hill

Reference Books

1. Larry L Peterson and Bruce S Dave, Computer Networks – A Systems Approach, 5/e, Morgan Kaufmann.
2. Fred Halsall, Computer Networking and the Internet, 5/e.
3. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/e.
4. Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
5. W. Richard Stevens. TCP/IP Illustrated Volume 1, Addison-Wesley, 2005.
6. William Stallings, Computer Networking with Internet Protocols, Prentice-Hall, 2004.
7. Request for Comments (RFC) Pages - IETF -https://www.ietf.org/rfc.html

Course Level Assessment Questions

Course Outcome1 (CO1)

1. Compare TCP/IP and OSI reference model.
2. The purpose of physical layer is to transport a raw bit stream from one machine to another. Justify.

Course Outcome2 (CO2)

1. Write the physical and transmission characteristics of Optical Fibre Cable guided transmission media.
2. The distance between the sender and receiver systems is about 200 KM. The speed of transmission is 2GB/s. Find out the propagation time?

Course Outcome3 (CO3)

1. Ethernet frames must be at least 64 bytes long to ensure that the transmitter is still going in the event of a collision at the far end of the cable. Fast Ethernet has the same 64-byte minimum frame size but can get the bits out ten times faster. How is it possible to maintain the same minimum frame size?
2. What do you mean by bit stuffing?

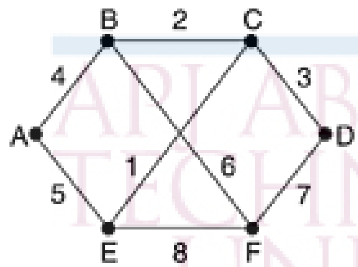
Course Outcome4 (CO4)

1. Draw and explain the frame format for Ethernet.
2. Give the differences between CSMA/CD and CSMA/CA protocol.

Course Outcome5 (CO5)

1. Consider the given subnet in which distance vector routing is used, and the vectors just come in to router C as follows: from B: (5, 0, 8, 12, 6, 2); from D: (16, 12, 6, 0, 9, 10);

and from E: (7, 6, 3, 9, 0, 4). The measured delays from C to B, D, and E, are 6, 3, and 5, respectively. What is C's new routing table? Give both the outgoing line to use and the expected delay.



2. Illustrate the leaky bucket congestion control technique.

Course Outcome 6 (CO6)

1. How do you subnet the Class C IP Address 206.16.2.0 so as to have 30 subnets. What is the subnet mask for the maximum number of hosts? How many hosts can each subnet have?
2. Give the architecture of World Wide Web.

Model Question Paper

QP CODE: **PAGES:** ___

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 303

Course Name : Computer Networks

Max Marks: 100 **Duration: 3 Hours**

PART-A

(Answer All Questions. Each question carries 3 marks)

1. What does "negotiation" mean when discussing network protocols in a layered architecture? Give an example.

2. Define simplex, half-duplex, and full-duplex transmission modes. Give one example for each.

3. Data link protocols almost always put the CRC in a trailer rather than in a header. Why?

4. An 8-bit byte with binary value 10101111 is to be encoded using an even-parity Hamming code. What is the binary value after encoding?

5. Illustrate the Count to Infinity problem in routing.

6. Describe two major differences between the warning bit method and the Random Early Detection (RED) method.

7. The Protocol field used in the IPv4 header is not present in the fixed IPv6 header. Why?

8. How many octets does the smallest possible IPv6 (IP version 6) datagram contain?

9. Can Transmission Control Protocol(TCP) be used directly over a network (e. g. an Ethernet) without using IP? Justify your answer.

10. When Web pages are sent out, they are prefixed by MIME headers. Why?

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) With a neat diagram, explain Open Systems Interconnection (OSI) Reference Model. **(8)**

(b) Compare Twisted Pair, Coaxial Cable and Optical Fibre guided transmission media. **(6)**

OR

12. (a) Consider two networks providing reliable connection-oriented service. One of them offers a reliable byte stream and the other offers a reliable message stream. Are they identical? Justify your answer. **(8)**

(b) Sketch the waveform in Manchester and Differential Manchester Encoding for the bitstream 11000110010. **(6)**

13. (a) A bit stream 10011101 is transmitted using the standard CRC method. The generator polynomial is $\square^{3} + 1$. Show the actual bit string transmitted. Suppose the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end. **(8)**

(b) Explain the working of High-Level Data Link Control (HDLC) protocol. **(6)**

OR

14. (a) Explain the working of IEEE 802.11 MAC sublayer. **(10)**

(b) Distinguish between Bridges and Switches. **(4)**

15. (a) Illustrate Distance Vector Routing algorithm with an example. **(8)**

(b) Explain the characteristics of Routing Information Protocol (RIP). **(6)**

OR

16. (a) A computer on a 6-Mbps network is regulated by a token bucket. The token bucket is filled at a rate of 1 Mbps. It is initially filled to capacity with 8 megabits. How long can the computer transmit at the full 6 Mbps? **(8)**

(b) Explain how routing is performed for mobile hosts. **(6)**

17. (a) Explain the address resolution problem using Address Resolution Protocol (ARP) and Reverse Address Resolution Protocol (RARP)with an example network. **(10)**

(b) A network on the Internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts it can handle? **(4)**

OR

18. (a) How do you subnet the Class C IP address 195.1.1.0 so as to have 10 subnets with a maximum of 12 hosts in each subnet. **(6)**

(b) Draw IPv6 Datagram format and explain its features. **(8)**

19. (a) Distinguish the header formats of Transmission Control protocol (TCP) and User Datagram Protocol (UDP). **(8)**

(b) Explain the principal Domain Name System (DNS) resource record types for **(6)**

IPv4.

OR

20. (a) What is the role of Simple Mail Transfer Protocol (SMTP) in E- mail? **(6)**

(b) With the help of a basic model, explain the working of World Wide Web (WWW). **(8)**

Teaching Plan

No	Contents	No of Lecture Hrs
	Module – 1 (Introduction and Physical Layer) (10 hrs)	
1.1	Introduction, Uses of computer networks.	1 hour
1.2	Network Hardware, Local Area Networks (LAN), Metropolitan Area Networks (MAN), Wide Area Networks (WAN), Wireless networks, Home networks, Internetworks.	1 hour
1.3	Network Software, Protocol hierarchies, Design issues for the layers.	1 hour
1.4	Connection-oriented and Connectionless services, Service primitives, Relationship of services to protocols.	1 hour
1.5	Reference models, The OSI reference model.	1 hour
1.6	The TCP/IP reference model, Comparisonof OSI and TCP/IP reference models.	1 hour
1.7	Physical layer, Modes of communication, Simplex, Half-duplex, and Full-duplex, Physical topologies, Mesh, Star, Bus, Ring, Hybrid.	1 hour
1.8	Signal encoding, Manchester, Differential Manchester.	1 hour
1.9	Transmission media overview, Guided media (twisted pair, coaxial and fiber optic media), Unguided/wireless media (radio, microwave, and infrared).	1 hour
1.10	Performance indicators, Bandwidth (in Hertz and in Bits per Seconds),	1 hour

	Throughput, Latency (Delay), Queuing time, Bandwidth-Delay product.	
	Module 2 – (Data Link Layer) (10 hrs)	
2.1	Data link layer design issues.	1 hour
2.2	Error detection and correction, Error correcting codes	1 hour
2.3	Error detecting codes.	1 hour
2.4	Sliding window protocols.	1 hour
2.5	High-Level Data Link Control(HDLC) protocol.	1 hour
2.6	Medium Access Control (MAC) sublayer, Channel allocation problem, Multiple access protocols.	1 hour
2.7	Ethernet, Ethernet cabling, Manchester encoding, Ethernet MAC sublayer protocol, Binary Exponential Backoff algorithm.	1 hour
2.8	Ethernet performance, Switched Ethernet, Fast Ethernet, Gigabit Ethernet, IEEE 802.2: Logical Link Control.	1 hour
2.9	Wireless LANs, 802.11 protocol stack, Physical layer, MAC Sublayer protocol, Frame structure.	1 hour
2.10	Bridges &switches, Bridges from 802.x to 802.y, Repeaters, Hubs, Bridges, Switches, Routers, and Gateways.	1 hour
	Module 3 - (Network Layer) (8 hrs)	
3.1	Network layer design issues.	1 hour
3.2	Routing algorithms, The Optimality Principle, Shortest path routing, Flooding.	1 hour
3.3	Distance Vector Routing.	1 hour
3.4	Link State Routing.	1 hour
3.5	Multicast routing, Routing for mobile hosts.	1 hour

3.6	General principles of congestion control, Congestion prevention policies, Congestion control in virtual circuit subnets.	1 hour
3.7	Congestion control algorithms, Congestion control in Datagram subnets, Load shedding, Jitter control.	1 hour
3.8	Quality of Service, Requirements, Techniques for achieving good Quality of Service.	1 hour
Module 4 – (Network Layer in the Internet) (9 hrs)		
4.1	Network layer in the Internet, Internet Protocol (IP).	1 hour
4.2	IP Addresses, Subnets, Classless Inter-Domain Routing (CIDR).	1 hour
4.3	IP Addresses, Network Address Translation (NAT).	1 hour
4.4	Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP).	1 hour
4.5	Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP).	1 hour
4.6	Open Shortest Path First (OSPF) protocol.	1 hour
4.7	Border Gateway Protocol (BGP).	1 hour
4.8	Internet multicasting.	1 hour
4.9	IPv6, Header format, Extension headers, Internet Control Message Protocol version 6 (ICMPv6).	1 hour
Module 5 - (Transport Layer and Application Layer) (8 hrs)		
5.1	Transport Service, Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP).	1 hour
5.2	Transmission Control Protocol (TCP), TCP segment header, Connection establishment &release, Connection management modeling.	1 hour
5.3	TCP retransmission policy, TCP congestion control.	1 hour
5.4	Application layer, File Transfer Protocol (FTP).	1 hour

5.5	Domain Name System (DNS).	1 hour
5.6	Electronic Mail, Multipurpose Internet Mail Extension (MIME).	1 hour
5.7	Simple Network Management Protocol (SNMP).	1 hour
5.8	World Wide Web, Architectural overview.	1 hour

AMT 305	INTRODUCTION TO MACHINE LEARNING	Category	L	T	P	Credit	Year Of Introduction
		PCC	3	1	0	4	2020

Preamble: This course enables the learners to understand the advanced concepts and algorithms in machine learning. The course covers the standard and most popular supervised learning algorithms such as linear regression, logistic regression, decision trees, Bayesian learning and the Naive Bayes algorithm, basic clustering algorithms and classifier performance measures. This course helps the students to provide machine learning based solutions to real world problems.

Prerequisite: Basic understanding of probability theory and linear algebra

Course Outcomes: After the completion of the course the student will be able to

CO1	Illustrate Machine Learning concepts and basics of supervised learning concepts. (Cognitive Knowledge Level: **Apply)**
CO2	Describe dimensionality reduction techniques and supervised learning concepts (regression, linear classification). **(**Cognitive Knowledge Level: **Apply**)
CO3	Solve real life problems using appropriate machine learning models and evaluate the performance measures and Illustrate the concepts of Multilayer neural network . **(**Cognitive Knowledge Level: **Apply**)
CO4	Illustrate basics of parameter estimation models and the working of classifier SVM classifier model (Cognitive Knowledge Level: **Apply**)
CO5	Describe unsupervised learning concepts (Cognitive Knowledge Level: **Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔								✔
CO2	✔	✔	✔	✔	✔							✔

CO3	✔	✔	✔	✔								✔
CO4	✔	✔	✔	✔								✔
CO5	✔	✔	✔	✔								✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks (%)**
	Test 1 (%)	**Test 2 (%)**	
Remember	**30**	**30**	**30**
Understand	**30**	**30**	**30**
Apply	**40**	**40**	**40**
Analyze			

Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of Internal Tests 1 & 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module-1 (Overview of machine learning)

Introduction to Machine Learning, Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning.

Supervised learning- Input representation, Hypothesis class, Version space, Vapnik-Chervonenk is (VC) Dimension, Probably Approximately Correct Learning (PAC), Noise, Learning Multiple classes, Model Selection and Generalization

Module-2 (Supervised Learning)

Dimensionality reduction – Subset selection, Principal Component Analysis.

Regression - Linear regression with one variable, Linear regression with multiple variables, solution using gradient descent algorithm and matrix method, basic idea of overfitting in regression. Linear Methods for Classification- Logistic regression, Naive Bayes, Decision tree algorithm ID3.

Case Study: Develop a classifier for face detection.

Module-3 (Classification Assessment and Neural Networks (NN))

Classification Performance measures - Precision, Recall, Accuracy, F-Measure, Receiver Operating Characteristic Curve(ROC), Area Under Curve AUC. Bootstrapping, Cross Validation.

Perceptron, Neural Network - Multilayer feed forward network, Activation functions (Sigmoid, ReLU, Tanh), Back propagation algorithm.

Module-4 (Parameter estimation & SVM Classifier)

Basics of parameter estimation **-** Maximum Likelihood Estimation(MLE) and Maximum a Posteriori estimation(MAP). Bias-Variance decomposition.

Support Vector Machines - Introduction, Maximum Margin hyperplanes, Mathematics behind Maximum Margin Classification, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF), Kernel Trick.

Module-5 (**Unsupervised Learning)**

Ensemble methods, Voting, Bagging, Boosting.

Unsupervised Learning - Clustering Methods -Similarity measures, K-means clustering, Expectation-Maximization for soft clustering, Hierarchical Clustering Methods , Density based clustering.

Text Book

1. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
2. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

Reference Books

1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007.
4. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.
5. Richert and Coelho, Building Machine Learning Systems with Python.
6. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016.
7. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016
8. Davy Cielen, Arno DB Meysman and Mohamed Ali.Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Dreamtech Press 2016.

Course Level Assessment Questions

Course Outcome1 (CO1):

1. Compare different machine learning paradigms with suitable examples.
2. Explain (a) Hypothesis space (b) Version space (c) Most General hypothesis (d) Most specific hypothesis in the context of a classification problem.
3. Define VC dimension. Show that an axis aligned rectangle can shatter 4 points in 2 dimensions.
4. Explain the concept of PAC learning . Derive an expression for PAC learning in such a way that the selected function will have low generalized error.
5. Distinguish between overfitting and underfitting. How it can affect model generalization?

Course Outcome 2(CO2):

1. Suppose that you are asked to perform linear regression to learn the function that outputs $\boldsymbol{y}$, given the $\boldsymbol{D}$-dimensional input $\boldsymbol{x}$. You are given $\boldsymbol{N}$ independent data points, and that all the $\boldsymbol{D}$ attributes are linearly independent. Assuming that $\boldsymbol{D}$ is

around 100, would you prefer the closed form solution or gradient descent to estimate the regressor?

2. Suppose you have a three class problem where class label $y \in 0, 1, 2$ and each training example X has 3 binary attributes $X_1, X_2, X_3 \in 0, 1$. How many parameters (probability distribution) do you need to know to classify an example using the Naive Bayes classifier?
3. Is principal component analysis a supervised learning problem? Justify your answer
4. Explain feature selection and feature extraction method for dimensionality reduction.
5. Use the ID3 algorithm to construct a decision tree for the data in the following table.

Age	Competition	Type	Class (profit)
Old	Yes	Software	Down
Old	No	Software	Down
Old	No	Hardware	Down
Mid	Yes	Software	Down
Mid	Yes	Hardware	Down
Mid	No	Hardware	Up
Mid	No	Software	Up
New	Yes	Software	Up
New	No	Hardware	Up
New	No	Software	Up

Course Outcome 3(CO3):

1. Classifier A attains 100% accuracy on the training set and 70% accuracy on the test set. Classifier B attains 70% accuracy on the training set and 75% accuracy on the test set. Which one is a better classifier? Justify your answer.
2. What are ROC space and ROC curve in machine learning? In ROC space, which points correspond to perfect prediction, always positive prediction and always negative prediction? Why?
3. Suppose there are three classifiers A,B and C. The (FPR, TPR) measures of the three classifiers are as follows – A (0, 1), B (1, 1) , C (1,0.5). Which can be considered as a perfect classifier? Justify your answer.
4. Briefly explain Perceptron Network.
5. Briefly explain BackPropagation Network.
6. Briefly explain one way in which using tanh instead of logistic activations makes optimization easier.
7. ReLU activation functions are most used in neural networks instead of the tanh activation function. Draw both activation functions and give a) an advantage of the

ReLU function compared to the tanh function. b) a disadvantage of the ReLU function compared to the tanh function.

Course Outcome 4(CO4): .

1. What are support vectors and list any three properties of the support vector classifier solution?
2. Why do you use kernels to model a projection from attributes into a feature space, instead of simply projecting the dataset directly?
3. Describe how Support Vector Machines can be extended to make use of kernels. Illustrate with reference to the Gaussian kernel $K(x, y) = e^{-z}$, where $z = (x-y)^2$.
4. A coin is tossed 100 times and lands heads 62 times. What is the maximum likelihood estimate for θ, the probability of heads.
5. Suppose data $x_1, ..., x_n$ are independent and identically distributed drawn from an exponential distribution $exp(\lambda)$. Find the maximum likelihood for λ.
6. Suppose $x_1, ..., x_n$ are independent and identically distributed(iid) samples from a distribution with density

$$f_X(x \mid \theta) = \begin{cases} \dfrac{\theta x^{\theta-1}}{3^\theta}, & 0 \le x \le 3 \\ 0, & \text{otherwise} \end{cases}$$

   Find the maximum likelihood estimate(MLE) for θ.
7. Find the maximum likelihood estimator (MLE) and maximum a posteriori (MAP) estimator for the mean of a univariate normal distribution. Assume that we have N samples, $x_1,..., x_N$ independently drawn from a normal distribution with known variance σ^2 and unknown mean μ and the prior distribution for the mean is itself a normal distribution with mean v and variance β^2. What happens to the MLE and MAP estimators as the number of samples goes to infinity.

Course Outcome 5(CO5): .

1. Illustrate the strength and weakness of the K-means algorithm.
2. Suppose you want to cluster the eight points shown below using **k**-means

	A_1	A_2
x_1	2	10
x_2	2	5
x_3	8	4
x_4	5	8
x_5	7	5
x_6	6	4
x_7	1	2
x_8	4	9

   Assume that **k = 3** and that initially the points are assigned to clusters as follows:

$C_1 = \{x_1, x_2, x_3\}$, $C_2 = \{x_4, x_5, x_6\}$, $C_3 = \{x_7, x_8\}$. Apply the **k**-means algorithm until convergence, using the Manhattan distance.

3. Cluster the following eight points representing locations into three clusters: $A_1(2, 10)$, $A_2(2, 5)$, $A_3(8, 4)$, $A_4(5, 8)$, $A_5(7, 5)$, $A_6(6, 4)$, $A_7(1, 2)$, $A_8(4, 9)$.

   Initial cluster centers are: $A_1(2, 10)$, $A_4(5, 8)$ and $A_7(1, 2)$.

   The distance function between two points $a = (x_1, y_1)$ and $b = (x_2, y_2)$ is defined as $D(a, b) = |x_2 - x_1| + |y_2 - y_1|$

   Use **k**-Means Algorithm to find the three cluster centers after the second iteration.

4. What is ensemble learning? Can ensemble learning using linear classifiers learn classification of linearly non-separable sets?
5. Describe boosting. What is the relation between boosting and ensemble learning?

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AMT305

Course Name: Introduction to Machine Learning

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Distinguish between classification and regression with an example.

2. Determine the hypothesis space H and version space with respect to the following data D.

x	2	11	17	0	1	5	7	13	20
Class	0	1	1	0	0	0	0	1	1

3. Is principal component analysis a supervised learning problem? Justify your answer.

4. Specify the basic principle of gradient descent algorithm.

5. (a)Classifier A attains 100% accuracy on the training set and 70% accuracy on the test set. Classifier B attains 70% accuracy on the training set and 75% accuracy on the test set. Which one is a better classifier? Justify your answer.
(b) How does bias and variance trade-off affect machine learning algorithms?

6. Mention the primary motivation for using the kernel trick in machine learning algorithms?

7. Suppose that you have a linear support vector machine(SVM) binary classifier. Consider a point that is currently classified correctly, and is far away from the decision boundary. If you remove the point from the training set, and re-train the classifier, will the decision boundary change or stay the same? Justify your answer.

8. Differentiate between bagging and boosting.

9. Illustrate the strength and weakness of the k-means algorithm.

10. Expectation maximization (EM) is designed to find a maximum likelihood setting of the parameters of a model when some of the data is missing. Does the algorithm converge? If so, do you obtain a locally or globally optimal set of parameters?

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Define machine learning. Explain different paradigms of machine learning with examples. **(7)**

(b) Calculate the VC dimension of the following

1)An open internal in R is defined as(a,b) = {x€R | a<x<b}. It has two parameters a and b. Calculate the VC dimension of the set of all open intervals.

2) Suppose the instance space X is the set of real numbers and the hypothesis space H is the set of intervals on the real number line. Here, it is evident that H is the set of hypotheses of the form $a < x < b$, where a and b may be any real constants. What is VC(H)?

OR

12. (a) Let $X = R^2$ and C be the set of all possible rectangles in two dimensional plane which are axis aligned (not rotated). Show that this concept class is PAC learnable. **(7)**

(b) What is meant by noise in data? What are the interpretations of noise? **(7)**

13. (a) Consider the hypothesis for the linear regression $h_\theta(x) = \theta_0 + \theta_1 x$, and the cost function $J(\theta_0, \theta_1) = 1/2m \, \Sigma_1^m (h_\theta(x^{(i)}) - y^{(i)})^2$ where m is the number of training examples. Given the following set of training examples. **(7)**

x	y
3	2
1	2
0	1
4	3

Answer the following questions :

1) Find the value of $h_\theta(2)$ if $\theta_0 = 0$ and $\theta_1 = 1.5$

2) Find the value of J(0,1)

3) Suppose the value of $J(\theta_0, \theta_1) = 0$. What can be inferred from this.

(b) Let $X = R^2$ and C be the set of all possible rectangles in two dimensional plane which are axis aligned (not rotated). Show that this concept class is PAC learnable. **(7)**

OR

14. (a) The following dataset can be used to train a classifier that determines whether a given person is likely to own a car or not. There are three features: education level (primary, secondary, or university); residence (city or country); gender (female, male). **(7)**

education	residence	gender	has car?
sec	country	female	yes
univ	country	female	yes
prim	city	male	no
univ	city	male	no
sec	city	female	no
sec	country	male	yes
prim	country	female	yes
univ	country	male	yes
sec	city	male	yes
prim	city	female	no
univ	city	female	no
prim	country	male	yes

Use ID3 Algorithm and find the best attribute at the root level of the tree

(b) Consider a linear regression problem y = w1x + w0, with a training set having m examples (x1, y1), . . .(xm, ym). Suppose that we wish to minimize the mean 5th degree error (loss function) given by 1/m Σ1m(yi −w1xi − w0)5. **(7)**

1. Calculate the gradient with respect to the parameter w1.

2. Write down pseudo-code for on-line gradient descent on w1.

3. Give one reason in favor of on-line gradient descent compared to batch-gradient descent, and one reason in favor of batch over on-line.

15. (a) Suppose the dataset had 9700 cancer-free images from 10000 images from cancer patients. Find precision, recall and accuracy ? Is it a good classifier? Justify. **(7)**

Actual Class\Predicted class	cancer = yes	cancer = no	Total
cancer = yes	**90**	**210**	300
cancer = no	**140**	**9560**	9700
Total	230	9770	10000

(b) Compare ReLU with Sigmoid function. Consider a neuron with four inputs, and weight of edge connecting the inputs are 1, 2, 3 and 4. Let the bias of the node is zero and inputs are 2, 3, 1, 4. If the activation function is linear f(x)=2x, compute the output of the neuron. **(7)**

OR

16. (a) What are ROC space and ROC curve in machine learning? In ROC space, which points correspond to perfect prediction, always positive prediction and always negative prediction? Why? **(7)**

(b) Discuss with a flowchart ,explain how training and testing is performed in back-propagation neural networks? **(7)**

17. (a) Compute the maximum likelihood estimate for the parameter λ in the Poisson distribution whose probability function is $f(x) = \frac{e^{-\lambda}\lambda^{x}}{x!}$ **(8)**

(b) Explain the general MLE method for estimating the parameters of a probability distribution **(6)**

OR

18. (a) State the mathematical formulation to express Soft Margin as a constraint optimization problem **(8)**

(b) Explain Kernel Trick in the context of support vector machine. List any two kernel function used in SVM. **(6)**

19. (a) Suppose that we have the following data (one variable). Use single linkage Agglomerative clustering to identify the clusters. **(8)**

Data: (2, 5, 9, 15, 16, 18, 25, 33, 33, 45).

(b) Given two objects represented by the tuples (22, 1, 42, 10) and (20, 0, 36, 8): **(6)**

(i) Compute the Euclidean distance between the two objects.

(ii) Compute the Manhattan distance between the two objects.

(iii) Compute the Minkowski distance between the two objects, using p = 3

OR

20. (a) Suppose that we have the following data: **(8)**

(2, 0), (1, 2), (2, 2), (3, 2), (2, 3), (3, 3), (2, 4), (3, 4), (4, 4), (3, 5)

Identify the cluster by applying the k-means algorithm, with k = 2. Try using initial cluster centers as far apart as possible

(b) Describe EM algorithm for Gaussian Mixtures **(6)**

TEACHING PLAN

No	Contents	No. of Lecture Hours (44 hrs)
Module -1 (Overview of machine learning) (8 hours)		
1.1	Introduction to Machine Learning, Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning.	1 hour
1.2	Supervised learning- Input representation, Hypothesis class, Version space	2 hours
1.3	Vapnik-Chervonenkis (VC) Dimension	2 hours
1.4	Probably Approximately Correct Learning (PAC)	1 hour
1.5	Noise, Learning Multiple classes	1 hour
1.6	Model Selection and Generalization, Overfitting and Underfitting	1 hour
Module-2 (Supervised Learning) (11 hours)		
2.1	Dimensionality reduction – Subset selection, Principal Component Analysis.	2 hours
2.2	Linear regression with one variable (TB 1: Section 2.6)	1 hour
2.3	Multiple variables, Solution using gradient descent algorithm and matrix method (No derivation required) (TB 1: Section 5.8)	2 hours

2.4	Logistic regression	1 hour
2.5	Naive Bayes (TB 2: Section 18.2)	2 hours
2.6	Decision trees (TB 2: Chapter 19)	1 hour
2.7	Decision trees- ID3 algorithm (TB 2: Chapter 19)	1 hour
2.8	Case Study: Develop a classifier for face detection.	1 hour
Module-3 (Classification Assessment and Neural Networks) (7 hours)		
3.1	Performance measures - Precision, Recall, Accuracy, F-Measure, ROC, AUC. (TB 2: Chapter 22.1)	2 hours
3.2	Bootstrapping, Cross validation	1 hour
3.3	Perceptron, Perceptron Learning	1 hour
3.4	Multilayer Feed forward Network, Activation Functions (Sigmoid, ReLU, Tanh)	1 hour
3.5	Back Propagation Algorithm	1 hour
3.6	Illustrative Example for Back Propagation	1 hour
Module-4 (Parameter estimation & SVM Classifier)) (9 hours)		
4.1	Basics of Parameter estimation	1 hour
4.2	Maximum Likelihood Estimation	1 hour
4.3	Maximum a Posteriori estimation(MAP). Bias-Variance decomposition.	1 hour
4.4	Introduction, Maximum Margin Hyperplane,	1 hour
4.5	Mathematics behind Maximum Margin Classification	1 hour
4.6	Formulation of maximum margin hyperplane and solution	1 hour
4.7	Soft margin SVM, Solution of Soft margin SVM	1 hour
4.8	Non-linear SVM , Kernels for learning non-linear functions, Examples - Linear, RBF, Polynomial, Kernel trick	2 hours
Module-5 (Unsupervised Learning) (9 hours)		
4.1	Ensemble Methods- Voting, Bagging, Boosting	1 hour
4.2	Similarity measures- Minkowski distance measures(Manhattan, Euclidean), Cosine Similarity	1 hour

4.3	K-means clustering (TB 2: Chapter 13)	1 hour
4.4	Clustering - Hierarchical Clustering (TB 2: Chapter 14)	2 hours
4.5	Density based Clustering	2 hours
4.6	Expectation maximization (EM) for soft clustering (TB 2: Chapter 13)	1 hour
4.7	Expectation maximization (EM) for soft clustering (TB 2: Chapter 13)	1 hour

AIT307	INTRODUCTION TO ARTIFICIAL INTELLIGENCE	CATEGORY	L	T	P	CREDITS
		PCC	3	1	0	4

Preamble: The course aims to introduce the fundamental principles of intelligent systems to students. This involves ideas about the characteristics of intelligent systems, knowledge representation schemes, logic and inference mechanisms. The course helps the learner to understand the design of self learning systems along with some of their typical applications in the emerging scenario where the business world is being transformed by the progress made in machine learning.

Prerequisite : NIL

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Explain the fundamental concepts of intelligent systems and their architecture. (**Cognitive Knowledge Level: Understanding)**
CO2	Illustrate uninformed and informed search techniques for problem solving in intelligent systems. **(Cognitive Knowledge Level: Understanding)**
CO3	Solve Constraint Satisfaction Problems using search techniques. (**Cognitive Knowledge Level: Apply**)
CO4	Represent AI domain knowledge using logic systems and use inference techniques for reasoning in intelligent systems. (**Cognitive Knowledge Level: Apply**)
CO5	Illustrate different types of learning techniques used in intelligent systems **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	✓											
CO 2	✓	✓										✓
CO 3	✓	✓	✓	✓								✓
CO 4	✓	✓	✓	✓								✓
CO 5	✓	✓			✓							✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	60	30	40
Apply	20	40	30
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of SeriesTests1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module – 1 (Introduction)

Introduction – What is Artificial Intelligence(AI) ? The Foundations of AI, History of AI, Applications of AI. Intelligent Agents – Agents and Environments, Good behavior: The concept of rationality, Nature of Environments - Specifying the task environment, Properties of task environments. Structure of Agents - Agent programs, Basic kinds of agent programs.

Module – 2 (Problem Solving)

Solving Problems by searching-Problem solving Agents, Example problems, Searching for solutions, Uninformed search strategies, Informed search strategies, Heuristic functions.

Module - 3 (Search in Complex environments)

Adversarial search - Games, Optimal decisions in games, The Minimax algorithm, Alpha-Beta pruning. Constraint Satisfaction Problems – Defining CSP, Example Problems, Constraint Propagation- inference in CSPs, Backtracking search for CSPs, Structure of CSP problems.

Module - 4 (Knowledge Representation and Reasoning)

Logical Agents – Knowledge based agents, Logic, Propositional Logic, Propositional Theorem proving, Agents based on Propositional Logic. First Order Predicate Logic - Syntax and Semantics of First Order Logic, Using First Order Logic, Knowledge representation in First Order Logic. Inference in First Order Logic – Propositional Vs First Order inference, Unification and Lifting, Forward chaining, Backward chaining, Resolution. Classical Planning - Algorithms for planning state space search, Planning Graphs.

Module - 5 (Machine Learning)

Learning from Examples – Forms of Learning, Supervised Learning. Learning Decision Trees- The decision tree representation, Inducing decision trees from examples, Choosing attribute tests, Generaliztion and overfitting. Evaluating and choosing the best hypothesis, Regression and classification with Linear models.

Text Book

1. Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach, 3rd Edition. Prentice Hall.

References

1. Nilsson N.J., Artificial Intelligence - A New Synthesis, Harcourt Asia Pvt. Ltd.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain about the basic types of agent programs in intelligent systems.
2. For the following activities, give a PEAS description of the task environment and characterize it in terms of the task environment properties.
   a) Playing soccer.
   b) Bidding on an item at an auction.

Course Outcome 2 (CO2):

1. Differentiate between uninformed and informed search strategies in intelligent systems.
2. Illustrate the working of Minimax search procedure.

Course Outcome 3 (CO3):

1. Solve the following crypt arithmetic problem by hand, using the strategy of backtracking with forward checking and the MRV & least-constraining-value heuristics.

$$\begin{array}{r} T\ W\ O \\ +\ T\ W\ O \\ \hline F\ O\ U\ R \end{array}$$

Course Outcome 4 (CO4):

1. Prove, or find a counter example to, the following assertion:
If $\alpha \models \gamma$ or $\beta \models \gamma$ (or both) then $(\alpha \wedge \beta \models \gamma$
2. For each pair of atomic sentences, find the most general unifier if it exists:
a) P (A, B, B), P (x, y, z).
b) Q(y, G(A, B)), Q(G(x, x), y).

Course Outcome 5 (CO5):

1. Consider the following data set comprised of three binary input attributes (A1 , A2 , and A3) and one binary output.

Example	A_1	A_2	A_3	Output y
$\mathbf{x}_1$	1	0	0	0
$\mathbf{x}_2$	1	0	1	0
$\mathbf{x}_3$	0	1	0	0
$\mathbf{x}_4$	1	1	1	1
$\mathbf{x}_5$	1	1	0	1

Use the DECISION-TREE-LEARNING algorithm to learn a decision tree for these data. Show the computations made to determine the attribute to split at each node.

2. What is multivariate linear regression? Explain.

Model Question Paper

QP CODE:

Reg No: _______________

Name: __________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT307

Course Name: Introduction To Artificial Intelligence

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1 What is a rational agent? Explain.

2 Describe any two ways to represent states and the transitions between them in agent programs.

3 Differentiate between informed search and uninformed search.

4 Define heuristic function? Give two examples.

5 What are the components of a Constraint Satisfaction Problem? Illustrate with an example.

6 Formulate the following problem as a CSP. Class scheduling: There is a fixed number of professors and classrooms, a list of classes to be offered, and a list of possible time slots for classes. Each professor has a set of classes that he or she can teach.

7 What is a knowledge based agent? How does it work?

8. Represent the following assertion in propositional logic:
"A person who is radical (R) is electable (E) if he/she is conservative (C), but otherwise is not electable."

9 Describe the various forms of learning?

10 State and explain Ockham's razor principle? **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Explain the structure Goal-based agents and Utility-based agents with the help of diagrams. **(8)**

(b) For the following activities, give a PEAS description of the task environment and characterize it in terms of the task environment properties. **(6)**

a) Playing soccer

b) Bidding on an item at an auction.

OR

12. (a) Explain the structure Simple reflex agents and Model-based reflex agents with the help of diagrams. **(8)**

(b) Discuss about any five applications of AI. **(6)**

13. (a) Explain Best First Search algorithm. How does it implement heuristic search? **(6)**

(b) Describe any four uninformed search strategies. **(8)**

OR

14. (a) Write and explain A* search algorithm. **(6)**

(b) Explain the components of a well defined AI problem? Write the standard formulation of 8-puzzle problem. **(8)**

15. (a) (a) Solve the following crypt arithmetic problem by hand, using the strategy of backtracking with forward checking and the MRV and least-constraining-value heuristics. **(8)**

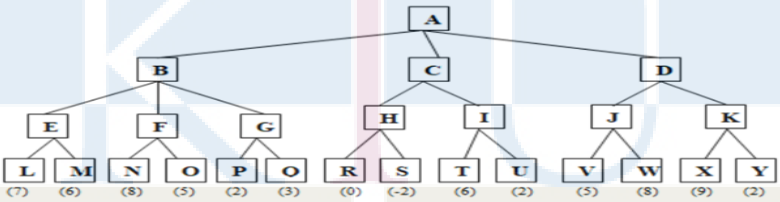
$$\begin{array}{r} T\ W\ O \\ +\ T\ W\ O \\ \hline F\ O\ U\ R \end{array}$$

(b) What is local consistency in CSP constraint propagation? Explain different types local consistencies. **(6)**

OR

16. (a) Illustrate the use of alpha-beta pruning in games. **(6)**

(b) Consider the following game tree in which static evaluation score are all from the players point of view: static evaluation score range is (+10 to -10) **(8)**



Suppose the first player is the maximizing player. What move should be chosen? Justify your answer.

17. (a) Convert the following sentences into first order logic: **(6)**

Everyone who loves all animals is loved by someone.

Anyone who kills an animal is loved by no one.

Jack loves all animals.

Either Jack or Curiosity killed the cat, who is named Tuna.

Did Curiosity kill the cat?

(b) Give a resolution proof to answer the question “Did Curiosity kill the cat? “ **(8)**

OR

18. (a) Draw a planning graph for the “have cake and eat cake too” problem up to level S2. **(6)**

(b) For each pair of atomic sentences, give the most general unifier if it exists: Older (Father (y), y), Older (Father (x), John). **(8)**

19. (a) How is best hypothesis selected from alternatives? **(8)**

(b) Explain Univariate Linear Regression. **(6)**

OR

20. (a) Consider the following data set comprised of two binary input attributes (A1 and A2) and one binary output. **(8)**

Example	A_1	A_2	Output y
x_1	1	1	1
x_2	1	1	1
x_3	1	0	0
x_4	0	0	1
x_5	0	1	0
x_6	0	1	0

Use the DECISION-TREE-LEARNING algorithm to learn a decision tree for these data. Show the computations made to determine the attribute to split at each node.

(b) Explain Linear classification with logistic regression **(6)**

TEACHING PLAN

No	Contents	No of Lecture Hrs (44)
Module – 1 (Introduction) (9 hrs)		
1.1	Introduction, What is Artificial Intelligence(AI)?	1
1.2	The foundations of AI, The history of AI	1
1.3	Applications of AI	1
1.4	Intelligent Agents – Agents and Environments	1
1.5	Good behavior: The concept of rationality	1
1.6	The nature of Environments- - Specifying the task environment	1
1.7	Properties of task environments	1
1.8	The structure of Agents - Agent programs	1
1.9	Basic kinds of agent programs	1
Module - 2 (Problem Solving by searching) (7 hrs)		
2.1	Solving Problems by searching-Problem solving Agents	1
2.2	Illustration of the problem solving process by agents	1
2.3	Searching for solutions	1
2.4	Uninformed search strategies:BFS, Uniform-cost search, DFS, Depth-limited search, Iterative deepening depth-first search	1
2.5	Informed search strategies: Best First search	1
2.6	Informed search strategies: A* Search	1
2.7	Heuristic functions	1
Module - 3 (Problem Solving in complex environments) (8 hrs)		
3.1	Adversarial search - Games	1
3.2	Optimal decisions in games, The Minimax algorithm	1
3.3	Alpha-Beta pruning	1
3.4	Constraint Satisfaction Problems – Defining CSP	1
3.5	Example Problem formulations	1
3.6	Constraint Propagation- inference in CSPs	1
3.7	Backtracking search for CSPs	1
3.8	The structure of problems	1

Module - 4 (Knowledge Representation and Reasoning) (12 hrs)		
4.1	Logical Agents – Knowledge based agents and logic	1
4.2	Propositional Logic	1
4.3	Propositional Theorem proving	1
4.4	Agents based on Propositional Logic	1
4.5	First Order Predicate Logic – Syntax and Semantics of First Order	1

	Logic	
4.6	Using First Order Logic, Knowledge representation in First Order Logic	1
4.7	Inference in First Order Logic – Propositional Vs First Order inference, Unification and Lifting	1
4.8	Forward chaining, Backward chaining	1
4.9	Resolution	1
4.10	Classical Planning	1
4.11	Algorithms for planning state space search	1
4.12	Planning Graphs	1
	Module - 5 (Machine Learning)(8 hrs)	
5.1	Learning from Examples – Forms of Learning	1
5.2	Supervised Learning	1
5.3	Learning Decision Trees- The decision tree representation	1
5.4	Inducing decision trees from examples	1
5.5	Choosing attribute tests	1
5.6	Generaliztion and overfitting	1
5.7	Evaluating and choosing the best hypothesis	1
5.8	Regression and classification with Linear models.	1

CST 309	MANAGEMENT OF SOFTWARE SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		PCC	3	0	0	3	2019

Preamble: This course provides fundamental knowledge in the Software Development Process. It covers Software Development, Quality Assurance, Project Management concepts and technology trends. This course enables the learners to apply state of the art industry practices in Software development.

Prerequisite: Basic understanding of Object Oriented Design and Development.

Course Outcomes: After the completion of the course the student will be able to

CO1	Demonstrate Traditional and Agile Software Development approaches **(Cognitive Knowledge Level: Apply)**
CO2	Prepare Software Requirement Specification and Software Design for a given problem. **(Cognitive Knowledge Level: Apply)**
CO3	Justify the significance of design patterns and licensing terms in software development, prepare testing, maintenance and DevOps strategies for a project. **(Cognitive Knowledge Level: Apply)**
CO4	Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with a traditional/agile framework. **(Cognitive Knowledge Level: Apply)**
CO5	Utilize SQA practices, Process Improvement techniques and Technology advancements in cloud based software models and containers & microservices. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓						✓
CO2	✓	✓	✓	✓		✓				✓	✓	✓
CO3	✓	✓	✓	✓				✓		✓	✓	✓
CO4	✓	✓	✓	✓		✓			✓	✓	✓	✓
CO5	✓	✓	✓	✓		✓						✓

	Abstract POs defined by National Board of Accreditation		
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (Percentage)	Test2 (Percentage)	
Remember	**30**	**30**	**30**
Understand	**40**	**40**	**50**
Apply	**30**	**30**	**20**
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**50**	**100**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Tests : **25 marks**

Continuous Assessment Assignment : **15 marks** (Each student shall identify a software development problem and prepare Requirements Specification, Design Document, Project Plan and Test case documents for the identified problem as the assignment.)

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks.

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing the remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

Syllabus

Module 1 : Introduction to Software Engineering (7 hours)

Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care.

Module 2 : Requirement Analysis and Design (8 hours)

Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering, Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps. Template of a Design Document as per "IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions". Case study: The Ariane 5 launcher failure.

Module 3 : Implementation and Testing (9 hours)

Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management - Code management, DevOps automation, Continuous Integration, Delivery, and Deployment (CI/CD/CD). Software Evolution - Evolution processes, Software maintenance.

Module 4 : Software Project Management (6 hours)

Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.

Module 5 : Software Quality, Process Improvement and Technology trends (6 hours)

Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. Software Process Improvement(SPI), SPI Process CMMI process improvement framework, ISO 9001:2000 for Software. Cloud-based Software - Virtualisation and containers, Everything as a service(IaaS, PaaS), Software as a service. Microservices Architecture - Microservices, Microservices architecture, Microservice deployment.

Text Books

1. Book 1 - Ian Sommerville, Software Engineering, Pearson Education, Tenth edition, 2015.
2. Book 2 - Roger S. Pressman, Software Engineering : A practitioner’s approach, McGraw Hill publication, Eighth edition, 2014
3. Book 3 - Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson Education, First Edition, 2020.

References

1. IEEE Std 830-1998 - IEEE Recommended Practice for Software Requirements SpeciÞcations
2. IEEE Std 1016-2009 IEEE Standard for Information Technology—Systems Design—Software Design Descriptions

3. David J. Anderson, Kanban, Blue Hole Press 2010
4. David J. Anderson, Agile Management for Software Engineering, Pearson, 2003
5. Walker Royce, Software Project Management : A unified framework, Pearson Education, 1998
6. Steve. Denning, The age of agile, how smart companies are transforming the way work gets done. New York, Amacom, 2018.
7. Satya Nadella, Hit Refresh: The Quest to Rediscover Microsoft's Soul and Imagine a Better Future for Everyone, Harper Business, 2017
8. Henrico Dolfing, Project Failure Case Studies: Lessons learned from other people's mistakes, Kindle edition
9. Mary Poppendieck, Implementing Lean Software Development: From Concept to Cash, Addison-Wesley Signature Series, 2006
10. StarUML documentation - https://docs.staruml.io/
11. OpenProject documentation - https://docs.openproject.org/
12. BugZilla documentation - https://www.bugzilla.org/docs/
13. GitHub documentation - https://guides.github.com/
14. Jira documentation - https://www.atlassian.com/software/jira

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the advantages of an incremental development model over a waterfall model?
2. Illustrate how the process differs in agile software development and traditional software development with a socially relevant case study. (Assignment question)

Course Outcome 2 (CO2):

1. How to prepare a software requirement specification?
2. Differentiate between Architectural design and Component level design.
3. How does agile approaches help software developers to capture and define the user requirements effectively?
4. What is the relevance of the SRS specification in software development?
5. Prepare a use case diagram for a library management system.

Course Outcome 3 (CO3):

1. Differentiate between the different types of software testing strategies.
2. Justify the need for DevOps practices?
3. How do design patterns help software architects communicate the design of a complex system effectively?

4. What are the proactive approaches one can take to optimise efforts in the testing phase?

Course Outcome 4 (CO4):

1. Illustrate the activities involved in software project management for a socially relevant problem?
2. How do SCRUM, Kanban and Lean methodologies help software project management?
3. Is rolling level planning in software project management beneficial? Justify your answer.
4. How would you assess the risks in your software development project? Explain how you can manage identified risks?

Course Outcome 5 (CO5):

1. Justify the importance of Software Process improvement?
2. Explain the benefits of cloud based software development, containers and microservices.
3. Give the role of retrospectives in improving the software development process.
4. Illustrate the use of project history data as a prediction tool to plan future socially relevant projects.

Model Question Paper

QP CODE:

Reg No:______________

Name :______________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 309

Course Name: Management of Software Systems

Duration: 3 Hrs **Max. Marks :100**

PART A

Answer all Questions. Each question carries 3 marks

1. Why professional software that is developed for a customer is not simply the programs that have been developed and delivered.
2. Incremental software development could be very effectively used for customers who do not have a clear idea about the systems needed for their operations. Justify.
3. Identify any four types of requirements that may be defined for a software system
4. Describe software architecture
5. Differentiate between GPL and LGPL?
6. Compare white box testing and black box testing.
7. Specify the importance of risk management in software project management?
8. Describe COCOMO cost estimation model.
9. Discuss the software quality dilemma
10. List the levels of the CMMI model? **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Compare waterfall model and spiral model

(8)

(b) Explain Agile ceremonies and Agile manifesto **(6)**

12. (a) Illustrate software process activities with an example. **(8)**

(b) Explain Agile Development techniques and Agile Project Management **(6)**

13. (a) What are functional and nonfunctional requirements? Imagine that you are developing a library management software for your college, list eight functional requirements and four nonfunctional requirements. **(10)**

(b) List the components of a software requirement specification? **(4)**

OR

14. (a) Explain Personas, Scenarios, User stories and Feature identification? **(8)**

(b) Compare Software Architecture design and Component level design **(6)**

15. (a) Explain software testing strategies. **(8)**

(b) Describe the formal and informal review techniques. **(6)**

OR

16. (a) Explain Continuous Integration, Delivery, and Deployment CI/CD/CD) **(8)**

(b) Explain test driven development **(6)**

17. (a) What is a critical path and demonstrate its significance in a project schedule with the help of a sample project schedule. **(8)**

(b) Explain plan driven development and project scheduling. **(6)**

OR

18. (a) Explain elements of Software Quality Assurance and SQA Tasks. **(6)**

(b) What is algorithmic cost modeling? What problems does it suffer from when **(8)** compared with other approaches to cost estimation?

19. (a) Explain elements of Software Quality Assurance and SQA Tasks. **(8)**

(b) Illustrate SPI process with an example. **(6)**

OR

20. (a) Compare CMMI and ISO 9001:2000. **(8)**

(b) How can Software projects benefit from Container deployment and Micro service deployment? **(6)**

Teaching Plan

No	Contents	No of Lecture Hrs
Module 1 : Introduction to Software Engineering (7 hours)		
1.1	Introduction to Software Engineering.[Book 1, Chapter 1]	1 hour
1.2	Software process models [Book 1 - Chapter 2]	1 hour
1.3	Process activities [Book 1 - Chapter 2]	1 hour
1.4	Coping with change [Book 1 - Chapter 2, Book 2 - Chapter 4]	1 hour
1.5	Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care. [Book 1 - Chapter 1]	1 hour
1.6	Agile software development [Book 1 - Chapter 3]	1 hour
1.7	Agile development techniques, Agile Project Management.[Book 1 - Chapter 3]	1 hour
Module 2 : Requirement Analysis and Design (8 hours)		
2.1	Functional and non-functional requirements, Requirements engineering processes [Book 1 - Chapter 4]	1 hour
2.2	Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix [Book 1 - Chapter 4]	1 hour
2.3	Developing use cases, Software Requirements Specification Template [Book 2 - Chapter 8]	1 hour

2.4	Personas, Scenarios, User stories, Feature identification [Book 3 - Chapter 3]	1 hour
2.5	Design concepts [Book 2 - Chapter 12]	1 hour
2.6	Architectural Design [Book 2 - Chapter 13]	1 hour
2.7	Component level design [Book 2 - Chapter 14]	1 hour
2.8	Design Document Template. Case study: The Ariane 5 launcher failure. [Ref - 2, Book 2 - Chapter 16]	1 hour
	Module 3 : Implementation and Testing (9 hours)	
3.1	Object-oriented design using the UML, Design patterns [Book 1 - Chapter 7]	1 hour
3.2	Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD [Book 1 - Chapter 7]	1 hour
3.3	Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. [Book 2 - Chapter 20]	1 hour
34	Informal Review, Formal Technical Reviews, Post-mortem evaluations. [Book 2 - Chapter 20]	1 hour
3.5	Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing and Debugging (basic concepts only). [Book 2 - Chapter 22]	1 hour
3.6	White box testing, Path testing, Control Structure testing, Black box testing. Test documentation [Book 2 - Chapter 23]	1 hour
3.7	Test automation, Test-driven development, Security testing. [Book 3 - Chapter 9]	1 hour
3.8	DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. [Book 3 - Chapter 10]	1 hour
3.9	Software Evolution - Evolution processes, Software maintenance. [Book 1 - Chapter 9]	1 hour
	Module 4 : Software Project Management (6 hours)	
4.1	Software Project Management - Risk management, Managing people, Teamwork [Book 1 - Chapter 22]	1 hour
4.2	Project Planning - Software pricing, Plan-driven development, Project scheduling, Agile planning [Book 1 - Chapter 23]	1 hour
4.3	Estimation techniques [Book 1 - Chapter 23]	1 hour
4.4	Configuration management [Book 1 - Chapter 25]	1 hour

4.5	Agile software management - SCRUM framework [Book 2 - Chapter 5]	1 hour
4.6	Kanban methodology and lean approaches.[Ref 9 - Chapter 2]	1 hour
Module 5 : Software Quality, Process Improvement and Technology trends (6 hours)		
5.1	Software Quality, Software Quality Dilemma, Achieving Software Quality. [Book 2 - Chapter 19]	1 hour
5.2	Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. [Book 3 - Chapter 21]	1 hour
5.3	Software Process Improvement (SPI), SPI Process [Book 2 - Chapter 37]	1 hour
5.4	CMMI process improvement framework, ISO 9001:2000 for Software. [Book 2 - Chapter 37]	1 hour
5.5	Cloud-based Software - Virtualisation and containers, IaaS, PaaS, SaaS.[Book 3 - Chapter 5]	1 hour
5.6	Microservices Architecture - Microservices, Microservices architecture, Microservice deployment [Book 3 - Chapter 6]	1 hour

ADL331	AI & DATA SCIENCE LAB	CATEGORY	L	T	P	Credit	Year of Introduction
		PCC	0	0	3	2	2020

Preamble: The course enables the learners to get hands-on experience in AI and data science using Python programming. It covers implementation of various predictive and descriptive analysis measures, supervised learning algorithms (such as linear regression, logistic regression, decision trees, Bayesian learning and Naive Bayes algorithm) and unsupervised learning algorithms (such as basic clustering algorithms). This helps the learners to develop, implement algorithms and evaluate its performance for real world data.

Prerequisite: Fundamentals of programming, python programming fundamentals, Machine learning.

Course Outcomes: After the completion of the course, the student will be able to:

CO#	Course Outcomes
CO1	Implement various predictive and descriptive analysis measures using Python. Use various packages and libraries in Python for data handling. **(Cognitive Knowledge Level: Apply)**
CO2	Implement different Regression methods such as Linear and Logistic regression to interpret the given dataset. **(Cognitive Knowledge Level: Apply)**
CO3	Implement various supervised learning models like k-Nearest Neighbour, Support Vector Machine, Naïve Bayesian Classifier and Decision Tree algorithms. **(Cognitive Knowledge Level: Apply)**
CO4	Implement mathematical optimization method like the Hill Climbing algorithm and Deep Learning method like Convolutional Neural Network algorithm. **(Cognitive Knowledge Level: Apply)**
CO5	Implement different methods (like Correlation and Covariance) to determine the dependence between features in the dataset and apply dimensionality reduction techniques. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔				✔				✔
CO2	✔	✔	✔	✔				✔				✔
CO3	✔	✔	✔	✔		✔		✔				✔
CO4	✔	✔	✔	✔		✔		✔				✔
CO5	✔	✔	✔	✔		✔		✔				✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and teamwork
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Test (Internal Exam) Marks in percentage	End Semester Examination Marks in percentage
Remember	20	20
Understand	20	20
Apply	60	60
Analyze		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance : **15 marks**
Continuous Evaluation in Lab : **30 marks**
Continuous Assessment Test : **15 marks**
Viva voce : **15 marks**

Internal Examination Pattern:

The internal examination shall be conducted for 100 marks, which will be converted to out of 15, while calculating internal evaluation marks. The marks will be distributed as, Algorithm - 30 marks, Program - 20 marks, Output - 20 marks and Viva - 30 marks.

End Semester Examination Pattern:

The end semester examination will be conducted for a total of 75 marks and shall be distributed as, Algorithm - 30 marks, Program - 20 marks, Output - 20 marks and Viva- 30 marks.

Operating System to Use in Lab : Linux / Windows

Programming Language to Use in Lab : Python

Fair Lab Record:

All the students attending the AI & Data Science Lab should have a fair record. Every experiment conducted in the lab should be noted in the fair record. For every experiment, in the fair record, the right hand page should contain experiment heading, experiment number, date of experiment, aim of the experiment, procedure/algorithm followed, other such details of the experiment and final result. The left hand page should contain a print out of the respective code with sample input and corresponding output obtained. All the experiments noted in the fair record should be verified by the faculty regularly. The fair record, properly certified by the faculty, should be produced during the time of end semester examination for the verification by the examiners.

Syllabus

***Mandatory**

1. Implement a program to perform operations like mean, median, mode, standard deviation, percentile and various data distributions.
2. Review of python programming, Matrix operations, Programs using matplotlib / plotly / bokeh / seaborn for data visualisation and programs to handle data using pandas*
3. Try to open a csv file and sort the content with respect to one column using python.
4. Implement a program to perform linear regression for a dataset that prevails in csv format*
5. Implement a program to perform logistic regression to classify a dataset. Print feature importance after building model*
6. Implement k-Nearest Neighbour algorithm to classify any dataset. Print both correct and wrong predictions. ML library classes can be used for this problem. Assume K=3.*
7. Write a program to construct a Support Vector Machine considering medical data. Use this model to demonstrate the diagnosis of heart patients using the standard Heart Disease Data Set*
8. Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Calculate the accuracy, precision, and recall for your data set*
9. Assuming a set of data that need to be classified, use a decision tree model to perform this task. Preferably use any dataset like medical or others to evaluate the accuracy.*
10. Implement a program to perform Hill climbing algorithm.*
11. Implement convolutional neural network to classify images from any standard dataset in the public domain using Keras framework. Reading and writing different types of dataset.
12. Write a program to find Correlation and Covariance between different features of a dataset in csv format.*
13. Write a program to implement feature reduction using PCA. Calculate the covariance between features to find the optimal number of PCA components.*

Practice Questions

1. Write a Python script to generate a list of random numbers and find their mean and standard deviation.
2. Consider the river temperature data available at https://catalogue.ceh.ac.uk/documents/b8a985f5-30b5-4234-9a62-03de60bf31f7. Create a Python script to select only the data from "Swale at Catterick Bridge" location, and find the mean temperature and median dissolved oxygen. Also plot a histogram showing the distribution of temperature over the time period of study.

3. Consider the river temperature data available at https://catalogue.ceh.ac.uk/documents/b8a985f5-30b5-4234-9a62-03de60bf31f7. Create a Python script to perform linear regression to establish how temperature affects dissolved oxygen levels. Test the model on the whole dataset and find the RMSE.
4. Perform logistic regression to classify Cleveland heart disease dataset. Print the feature importance and accuracy. Drop least important attributes one by one and assess how the accuracy and feature importance changes.
5. Find the correlation and covariance between different attributes of Cleveland heart disease dataset. Which are the top 5 attributes closely related to the predicted attribute?
6. Perform Naive Bayes classification on the "glass" dataset from Kaggle. Interpret the performance of the classifier, and evaluate why the accuracy value is what you obtained.
7. Use the "Car Evaluation Dataset" from UCI Machine Learning repository to generate a decision tree and measure the performance.
8. Implement KNN algorithm to classify iris dataset. Print all necessary performance measures.
9. Implement appropriate CNNs to classify (i) MNIST dataset, and (ii) Fashion MNIST dataset. Redesign the CNN with different hyperparameters and evaluate the performance.
10. Implement dimensionality reduction on Car Evaluation dataset from UCI Machine Learning repository using PCA. Try setting number of PCA components from 2 to 5, and identify the composition that gives the best performance among all of them. Find covariance among all features in the original dataset and try to justify the performance.

Reference Books:

1. Aurelien Geron, "Hands–On Machine Learning with Scikit–Learn and TensorFlow", O'Relily.
2. David dietrich, "EMC education service's, data science and big data analytics, discovering, analyzing, visualizing, and presenting data", John Wiley and sons
3. Stuart J. Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson Education.

CSL 333	DATABASE MANAGEMENT SYSTEMS LAB	Category	L	T	P	Credits	Year of introduction
		PCC	0	0	4	2	2019

Preamble:

The Database Management Systems course is intended to impart the elementary concepts of a database management system to students and equip them to design and implement a database application based on those concepts. This course helps the learners to get practical exposure on database creation, SQL queries creation, transaction processing and NoSQL & MongoDB based operations. The course enables the students to create, manage and administer the databases, develop necessary tools for the design and development of the databases, and to understand emerging technologies to handle Big Data.

Prerequisite: A sound knowledge of the basics of relational DBMS.

Course Outcomes: After the completion of the course the student will be able to

CO#	Course Outcomes
CO1	Design database schema for a given real world problem-domain using standard design and modeling approaches. **(Cognitive Knowledge Level: Apply)**
CO2	Construct queries using SQL for database creation, interaction, modification, and updation. **(Cognitive Knowledge Level: Apply)**
C03	Design and implement triggers and cursors. (Cognitive Knowledge Level: **Apply**)
C04	Implement procedures, functions, and control structures using PL/SQL**. (Cognitive Knowledge Level: Apply)**
CO5	Perform CRUD operations in NoSQL Databases. **(Cognitive Knowledge Level: Apply)**
C06	Develop database applications using front-end tools and back-end DBMS. **(Cognitive Knowledge Level: Create)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔		✔			✔		✔		✔
CO2	✔	✔	✔		✔			✔		✔		✔
CO3	✔	✔	✔	✔	✔			✔		✔		✔
CO4	✔	✔	✔	✔	✔			✔		✔		✔
CO5	✔	✔	✔		✔			✔		✔		✔
CO6	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern:

Bloom's Category	**Continuous Assessment Test (Internal Exam)Percentage**	**End Semester Examination Percentage**
Remember	**20**	**20**
Understand	**20**	**20**
Apply	**60**	**60**
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance : **15 marks**
Continuous Evaluation in Lab : **30 marks**
Continuous Assessment Test : **15 marks**
Viva-voce : **15 marks**

Internal Examination Pattern : The marks will be distributed as Schema/Logic: 30 marks, Program/Queries: 20 marks, Output: 20 marks, and Viva: 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern:
The marks will be distributed as Schema/Logic: 30 marks,
Program/Queries: 20 marks, Output: 20 marks, and Viva: 30 marks. Total 100 marks will be converted out of 75 for the End Semester Examination.

DBMS software: Oracle, MySQL, SQL Server, PostgreSQL, MongoDB.
Front end Tool: Java

Fair Lab Record:
All Students attending the DBMS Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record, the right hand page should contain Experiment Heading, Experiment Number, Date of Experiment, Aim of Experiment, Schemas/Menu & Form Design, and Query questions. The left hand page should contain Queries and sample output(relations created, Form, and Menu Output) obtained for a set of input.

Syllabus

1. Design a database schema for an application with ER diagram from a problem description **.
2. Creation, modification, configuration, and deletion of databases using UI and SQL Commands **.
3. Creation of database schema - DDL (create tables, set constraints, enforce relationships, create indices, delete and modify tables). Export ER diagram from the database and verify relationships** (with the ER diagram designed in step 1).

4. Database initialization - Data insert, Data import to a database (bulk import using UI and SQL Commands)**.
5. Practice SQL commands for DML (insertion, updating, altering, deletion of data, and viewing/querying records based on condition in databases)**.
6. Implementation of built-in functions in RDBMS**.
7. Implementation of various aggregate functions in SQL**.
8. Implementation of Order By, Group By & Having clause **.
9. Implementation of set operators nested queries, and join queries **.
10. Implementation of queries using temp tables.
11. Practice of SQL TCL commands like Rollback, Commit, Savepoint **.
12. Practice of SQL DCL commands for granting and revoking user privileges **.
13. Practice of SQL commands for creation of views and assertions ** .
14. Implementation of various control structures like IF-THEN, IF-THEN-ELSE, IF-THEN-ELSIF, CASE, WHILE using PL/SQL **.
15. Creation of Procedures, Triggers and Functions**.
16. Creation of Packages **.
17. Creation of Cursors **.
18. Creation of PL/SQL blocks for exception handling **.
19. Database backup and restore using commands.
20. Query analysis using Query Plan/Show Plan.
21. Familiarization of NoSQL Databases and CRUD operations**.
22. Design a database application using any front end tool for any problem selected. The application constructed should have five or more tables**.

** mandatory

Text Books

1. Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education, 2013.
2. Sliberschatz A., H. F. Korth and S. Sudarshan, Database System Concepts, 6/e, McGraw Hill, 2011.

References

1. Adam Fowler, NoSQL for Dummies, John Wiley & Sons, 2015
2. NoSQL Data Models: Trends and Challenges (Computer Engineering: Databases and Big Data), Wiley, 2018

Practice Questions

Design a normalized database schema for the following requirement.

The requirement: A library wants to maintain the record of books, members, book issue, book return, and fines collected for late returns, in a database. The database can be loaded with book information. Students can register with the library to be a member. Books can be issued to students with a valid library membership. A student can keep an issued book with him/her for a maximum period of two weeks from the date of issue, beyond which a fine will be charged. Fine is calculated based on the delay in days of return. For 0-7 days: Rs 10, For 7 – 30 days: Rs 100, and for days above 30 days: Rs 10 will be charged per day.

Sample Database Design

BOOK (**Book_Id**, Title, Language_Id, MRP, Publisher_Id, Published_Date, Volume, Status) // Language_Id, Publisher_Id are FK (Foreign Key)

AUTHOR(Author_Id, Name, Email, Phone_Number, Status)

BOOK_AUTHOR(Book_Id, Author_Id) // many-to-many relationship, both columns are PKFK (Primary Key and Foreign Key)

PUBLISHER(Publisher_id, Name, Address)

MEMBER(Member_Id, Name, Branch_Code, Roll_Number, Phone_Number, Email_Id, Date_of_Join, Status)

BOOK_ISSUE(Issue_Id, Date_Of_Issue, Book_Id, Member_Id, Expected_Date_Of_Return, Status) // Book+Id and Member_Id are FKs

BOOK_RETURN(Issue_Id, Actual_Date_Of_Return, LateDays, LateFee) // Issue_Id is PK and FK

LANGUAGE(Language_id, Name) //Static Table for storing permanent data

LATE_FEE_RULE(FromDays, ToDays, Amount) // Composite Key

EXERCISES

1. Create a normalized database design with proper tables, columns, column types, and constraints
2. Create an ER diagram for the above database design.
3. Write SQL commands to
   a. Create a database by name *Library.* Drop the database and re-create it.
   b. Create DDL statements and create the tables and constraints (from the design) in the database created in step-a (*Library*)

Notes: [Create a script file and execute it. Create the script file in such a way that,,if the table exists, drop the tables and recreate)]

c. Create and execute DROP TABLE command in tables with and without FOREIGN KEY constraints.
d. Create and execute ALTER TABLE command in tables with data and without data.
e. Create and execute SQL commands to build indices on Member_Id and Book_Id on table Book_Issue.
f. Create and execute GRANT/REVOKE commands on tables.
g. Create and execute SQL commands to insert data into each of the tables designed
h. Learn and execute bulk import of data to tables from CSV files (insert 1000 records of books into the BOOK table from a CSV file).
i. Create and execute UPDATE/DELETE commands on tables. Try to update/delete rows with Primary and Foreign Keys. Try bulk updates or deletes using SQL UPDATE statement

4. Write SQLQuery to retrieve the following information
    a. Get the number of books written by a given author
    b. Get the list of publishers and the number of books published by each publisher
    c. Get the names of authors who jointly wrote more than one book.
    d. Get the list of books that are issued but not returned
    e. Get the list of students who reads only ‘Malayalam’ books
    f. Get the total fine collected for the current month and current quarter
    g. Get the list of students who have overdue (not returned the books even on due date)
    h. Calculate the fine (as of today) to be collected from each overdue book.
    i. Members who joined after Jan 1 2021 but has not taken any books
5. Book return should insert an entry into the Book_Return table and also update the status in Book_Issue table as ‘Returned’. Create a database *TRANSACTION* to do this operation (stored procedure).
6. Create a database view ‘Available_Books’, which will list out books that are currently available in the library
7. Create a database procedure to add, update and delete a book to the Library database (use parameters).
8. Use cursors and create a procedure to print Books Issue Register (page wise – 20 rows in a page)
9. Create a history table (you may use the same structure without any keys) for the MEMBER table and copy the original values of the row being updated to the history table using a TRIGGER.
10. NoSQL Exercise
    a. Practice Mongo DB CRUD operations. Refer: https://docs.mongodb.com/manual/crud/

b. You may use a MongoDB local installation or cloud MongoDB services like MongoDB Atlas for this exercise
c. For documentation: Refer: https://docs.mongodb.com/manual/introduction/

11.Application Development Problem examples:

1) Inventory Control System.
2) Material Requirement Processing.
3) Hospital Management System.
4) Railway Reservation System.
5) Personal Information System.
6) Web Based User Identification System.
7) Timetable Management System.
8) Hotel Management System.

SEMESTER V

MINOR

CST 381	CONCEPTS IN SOFTWARE ENGINEERING	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2019

Preamble: This course provides fundamental knowledge in the Software Development Process. It covers Software Development, Quality Assurance and Project Management concepts. This course enables the learners to apply state of the art industry practices in Software development.
Prerequisite: Basic understanding of Object Oriented Design and Development.

Course Outcomes: After the completion of the course the student will be able to

CO1	Differentiate Traditional and Agile Software Development approaches **(Cognitive Knowledge Level: Understand)**
CO2	Prepare Software Requirement **Specification** and Software Design for a given problem. **(Cognitive Knowledge Level: Apply**)
CO3	Justify the significance of design patterns and licensing terms in software development, prepare testing, maintenance and DevOps strategies for a project. **(Cognitive Knowledge Level: Apply**)
CO4	Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with proper application of SCRUM, Kanban and Lean frameworks. (**Cognitive Knowledge Level: Apply**)
CO5	Utilize SQA practices, Process Improvement techniques and Technology improvements **namely** cloud based software model and containers & microservices in a Software Development Process. (Cognitive Knowledge Level: **Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔		✔						✔
CO2	✔	✔	✔	✔		✔				✔	✔	✔

CO3	✔	✔	✔	✔				✔		✔	✔	✔
CO4	✔	✔	✔	✔		✔			✔	✔	✔	✔
CO5	✔	✔	✔	✔		✔						✔

	Abstract POs defined by National Board of Accreditation		
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test1 (Percentage)	**Test2 (Percentage)**	
Remember	**30**	**30**	**30**
Understand	**30**	**30**	**30**

Apply	**40**	**40**	**40**
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**50**	**100**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Tests : **25 marks**

Continuous Assessment Assignment : **15 marks** (Each student shall identify a software development problem and prepare Requirements Specification, Design Document, Project Plan and Test case documents for the identified problem as the assignment.)

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks.

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing the remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

Syllabus

Module 1 : Introduction to Software Engineering (8 hours)

Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care.

Module 2 : Requirement Analysis and Design (10 hours)

Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering, Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps. Template of a Design Document as per "IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions". Case study: The Ariane 5 launcher failure.

Module 3 : Implementation and Testing (12 hours)

Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. Software Evolution - Evolution processes, Software maintenance.

Module 4 : Software Project Management (8 hours)

Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.

Module 5 : Software Quality and Process Improvement (6 hours)

Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. Software Process Improvement(SPI), SPI Process CMMI process improvement framework, ISO 9001:2000 for Software.

Text Books

1. Book 1 - Ian Sommerville, Software Engineering, Pearson Education, Tenth edition, 2015.
2. Book 2 - Roger S. Pressman, Software Engineering : A practitioner's approach, McGraw Hill publication, Eighth edition, 2014
3. Book 3 - Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson Education, First Edition, 2020.

References

1. IEEE Std 830-1998 - IEEE Recommended Practice for Software Requirements Specifications
2. IEEE Std 1016-2009 IEEE Standard for Information Technology—Systems Design—Software Design Descriptions
3. David J. Anderson, Kanban, Blue Hole Press 2010
4. David J. Anderson, Agile Management for Software Engineering, Pearson, 2003
5. Walker Royce, Software Project Management : A unified framework, Pearson Education, 1998
6. Steve. Denning, The age of agile, how smart companies are transforming the way work gets done. New York, Amacom, 2018.
7. Satya Nadella, Hit Refresh: The Quest to Rediscover Microsoft's Soul and Imagine a Better Future for Everyone, Harper Business, 2017
8. Henrico Dolfing, Project Failure Case Studies: Lessons learned from other people's mistakes, Kindle edition
9. Mary Poppendieck, Implementing Lean Software Development: From Concept to Cash, Addison-Wesley Signature Series, 2006
10. StarUML documentation - https://docs.staruml.io/
11. OpenProject documentation - https://docs.openproject.org/

12. BugZilla documentation - https://www.bugzilla.org/docs/
13. GitHub documentation - https://guides.github.com/
14. Jira documentation - https://www.atlassian.com/software/jira

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the advantages of an incremental development model over a waterfall model?
2. Compare agile software development with traditional software development?

Course Outcome 2 (CO2):

1. How to prepare a software requirement specification?
2. Differentiate between Architectural design and Component level design.
3. How do agile approaches help software developers to capture and define the user requirements effectively?
4. What is the relevance of the SRS specification in software development?
5. Prepare a use case diagram for a library management system.

Course Outcome 3 (CO3):

1. Differentiate between the different types of software testing strategies.
2. What are the benefits of DevOps?
3. How do design patterns help software architects communicate the design of a complex system effectively?
4. What are the proactive approaches one can take to optimise efforts in the testing phase?

Course Outcome 4 (CO4):

1. What are the activities involved in software project management?
2. What is the need for SCRUM, Kanban and Lean methodologies?
3. What are the benefits of rolling level planning in software project management and how would you implement it?
4. How would you assess the risks in your software development project? How would you plan for risk mitigation and contingency?

Course Outcome 5 (CO5):

1. What is the importance of Software Process improvement?
2. How will retrospectives help in improving the software development process?
3. What are the important skills required for the SQA role?
4. How would you use project history data as a prediction tool to plan future projects?

Model Question Paper

QP CODE:

Reg No:______________

Name :______________

PAGES : 3

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR

Course Code: CST 381

Course Name: Concepts in Software Engineering

Duration: 3 Hrs **Max. Marks : 100**

PART A

Answer all Questions. Each question carries 3 Marks

1. Explain why professional software that is developed for a customer is not simply the programs that have been developed and delivered

2. Incremental software development could be very effectively used for customers who do not have a clear idea about the systems needed for their operations. Discuss.

3. Identify and briefly describe four types of requirements that may be defined for a computer based system.

4. Describe software architecture in your own words.

5. What are the major differences between GPL and LGPL?

6. Compare between white box testing and black box testing.

7. What is the importance of risk management in software project management?

8. Explain COCOMO cost estimation model

9. Describe the software quality dilemma in your own words

10. Which are the levels of the CMMI model?

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 marks)

11. (a) Compare between waterfall model and spiral model **(8)**

    (b) Explain Agile methods and Agile manifesto **(6)**

OR

12. (a) Explain software process activities **(7)**

    (b) Explain Agile Development techniques and Agile Project Management. **(7)**

13. (a) What are functional and nonfunctional requirements? Imagine that you are developing a library management software for your college, identify at least 8 functional requirements and 4 nonfunctional requirements. **(10)**

    (b) What are the contents of a software requirement specification? **(4)**

OR

14. (a) Explain Personas, Scenarios, User stories and Feature identification? **(8)**

    (b) Compare between Software Architecture design and Component level design **(6)**

15. (a) Describe the formal and informal review techniques in detail. **(6)**

    (b) Explain various software testing strategies. **(8)**

OR

16. (a) Explain DevOps CI/CD/CD in detail. **(8)**

    (b) Explain test driven development. **(6)**

17. (a) What is a critical path and demonstrate its significance in a project schedule with the help of a sample project schedule. **(6)**

    (b) Explain plan driven development and project scheduling **(6)**

OR

18. (a) Explain the SCRUM framework. **(8)**

(b) What is algorithmic cost modeling? What problems does it suffer from when compared with other approaches to cost estimation? **(6)**

19. (a) Explain elements of Software Quality Assurance and SQA Tasks. **(8)**

(b) Explain the SPI process. **(6)**

OR

20. (a) Compare between CMMI and ISO 9001:2000 **(8)**

(b) Compare Quality Control and Quality Assurance. **(6)**

Teaching Plan [44 hours]		
	Module 1 : Introduction to Software Engineering (8 hours)	**Hours**
1.1	Introduction to Software Engineering. [Book 1, Chapter 1]	1 hour
1.2	Software process models [Book 1 - Chapter 2]	1 hour
1.3	Process activities [Book 1 - Chapter 2]	1 hour
1.4	Coping with change [Book 1 - Chapter 2, Book 2 - Chapter 4]	1 hour
1.5	Agile software development [Book 1 - Chapter 3]	1 hour
1.6	Agile development techniques [Book 1 - Chapter 3]	1 hour
1.7	Agile Project Management.[Book 1 - Chapter 3]	1 hour
1.8	Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care. [Book 1 - Chapter 1]	1 hour
	Module 2 : Requirement Analysis and Design (10 hours)	
2.1	Functional and non-functional requirements, Requirements engineering processes [Book 1 - Chapter 4]	1 hour

2.2	Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix [Book 1 - Chapter 4]	1 hour
2.3	Developing use cases, Software Requirements Specification Template [Book 2 - Chapter 8]	1 hour
2.4	Personas, Scenarios [Book 3 - Chapter 3]	1 hour
2.5	User stories, Feature identification [Book 3 - Chapter 3]	1 hour
2.6	Design concepts [Book 2 - Chapter 12]	1 hour
2.7	Architectural Design [Book 2 - Chapter 13]	1 hour
2.8	Component level design [Book 2 - Chapter 14]	1 hour
2.9	Component level design, Design Document Template. [Book 2 - Chapter 14, Ref - 2]	1 hour
2.10	Case study: The Ariane 5 launcher failure. [Book 2 - Chapter 16]	1 hour
Module 3 : Implementation and Testing (12 hours)		
3.1	Object-oriented design using the UML, Design patterns [Book 1 - Chapter 7]	1 hour
3.2	Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD [Book 1 - Chapter 7]	1 hour
3.3	Review Techniques - Cost impact of Software Defects, Code review. [Book 2 - Chapter 20]	1 hour
34	Informal Review, Formal Technical Reviews, Post-mortem evaluations. [Book 2 - Chapter 20]	1 hour
3.5	Software testing strategies [Book 2 - Chapter 22]	1 hour
3.6	Software testing strategies [Book 2 - Chapter 22]	1 hour
3.7	White box testing, Path testing, Control Structure testing [Book 2 - Chapter 23]	1 hour
3.8	Black box testing. Test documentation [Book 2 - Chapter 23]	1 hour
3.9	Test automation, Test-driven development [Book 3 - Chapter 9]	1 hour
3.10	Security testing. DevOps and Code Management [Book 3 - Chapter 9, Chapter 10]	1 hour
3.11	DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. [Book 3 - Chapter 10]	1 hour

3.12	Software Evolution - Evolution processes, Software maintenance. [Book 1 - Chapter 9]	1 hour
Module 4 : Software Project Management (8 hours)		
4.1	Software Project Management - Risk management, Managing people, Teamwork [Book 1 - Chapter 22]	1 hour
4.2	Project Planning - Software pricing, Plan-driven development, Project scheduling, Agile planning [Book 1 - Chapter 23]	1 hour
4.3	Estimation techniques [Book 1 - Chapter 23]	1 hour
4.4	Configuration management [Book 1 - Chapter 25]	1 hour
4.5	Agile software management - SCRUM framework [Book 2 - Chapter 5]	1 hour
4.6	Agile software management - SCRUM framework [Book 2 - Chapter 5]	1 hour
4.7	Kanban methodology and lean approaches. [Ref 9 - Chapter 2]	1 hour
4.8	Kanban methodology and lean approaches.[Ref 9 - Chapter 2]	1 hour
Module 5 : Software Quality, Process Improvement and Technology trends (6 hours)		
5.1	Software Quality, Software Quality Dilemma, Achieving Software Quality. [Book 2 - Chapter 19]	1 hour
5.2	Elements of Software Quality Assurance, SQA Tasks [Book 3 - Chapter 21]	1 hour
5.3	Software measurement and metrics. [Book 3 - Chapter 21]	1 hour
5.4	Software Process Improvement(SPI), SPI Process[Book 2 - Chapter 37]	1 hour
5.5	Software Process Improvement(SPI), SPI Process[Book 2 - Chapter 37]	1 hour
5.6	CMMI process improvement framework, ISO 9001:2000 for Software. [Book 2 - Chapter 37]	1 hour

CST 383	CONCEPTS IN MACHINE LEARNING	Category	L	T	P	Credit	Year of introduction
		VAC	3	1	0	4	2019

Preamble: This course enables the learners to understand the fundamental concepts and algorithms in machine learning. The course covers the standard and most popular supervised learning algorithms such as linear regression, logistic regression, decision trees, Bayesian learning & the naive Bayes algorithm, support vector machines& kernels, basic clustering algorithms and dimensionality reduction methods. This course helps the students to provide machine learning based solutions to real world problems.

Prerequisite: Familiarity with basics in linear algebra, probability and Python programming.

	Course Outcomes
CO1	Illustrate Machine Learning concepts and basic parameter estimation methods.**(Cognitive Knowledge Level: Apply)**
CO2	Demonstrate supervised learning concepts (regression, linear classification). **(Cognitive Knowledge Level**: **Apply**)
CO3	Illustrate the concepts of Multilayer neural network and Support Vector Machine **(Cognitive Knowledge Level: Apply**)
CO4	Describe unsupervised learning concepts and dimensionality reduction techniques. (**Cognitive Knowledge Level**: **Apply**)
CO5	Solve real life problems using appropriate machine learning models and evaluate the performance measures (**Cognitive Knowledge Level: Apply**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO1 2
CO1	✓	✓	✓	✓	✓							✓
CO2	✓	✓	✓	✓	✓							✓
CO3	✓	✓	✓	✓	✓							✓

CO4	✓	✓	✓	✓	✓							✓
CO5	✓	✓	✓	✓	✓	✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test1 (Percentage)	**Test2 (Percentage)**	
Remember	**30**	**30**	**30**
Understand	**30**	**30**	**30**
Apply	**40**	**40**	**40**
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration**
150	**50**	**100**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Tests : **25 marks**

Continuous Assessment Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Syllabus

Module-1 (Overview of machine learning)

Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. Basics of parameter estimation - maximum likelihood estimation(MLE) and maximum a posteriori estimation(MAP). Introduction to Bayesian formulation.

Module-2 (Supervised Learning)

Regression - Linear regression with one variable, Linear regression with multiple variables, solution using gradient descent algorithm and matrix method, basic idea of overfitting in regression. Linear Methods for Classification- Logistic regression, Perceptron, Naive Bayes, Decision tree algorithm ID3.

Module-3 (Neural Networks (NN) and Support Vector Machines (SVM))

NN - Multilayer feed forward network, Activation functions (Sigmoid, ReLU, Tanh), Backpropagation algorithm.

SVM - Introduction, Maximum Margin Classification, Mathematics behind Maximum Margin Classification, Maximum Margin linear separators, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF).

Module-4 (Unsupervised Learning)

Clustering - Similarity measures, Hierarchical Agglomerative Clustering, K-means partitional clustering, Expectation maximization (EM) for soft clustering. Dimensionality reduction – Principal Component Analysis, factor Analysis, Multidimensional scaling, Linear Discriminant Analysis.

Module-5 (Classification Assessment)

Classification Performance measures - Precision, Recall, Accuracy, F-Measure, Receiver Operating Characteristic Curve(ROC), Area Under Curve(AUC. Bootstrapping, Cross Validation, Ensemble methods, Bias-Variance decomposition. Case Study: Develop a classifier for face detection.

Text Book

1. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
2. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016.
3. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016
4. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

Reference Books

1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007.
4. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.
5. Richert and Coelho, Building Machine Learning Systems with Python.
6. Davy Cielen, Arno DB Meysman and Mohamed Ali. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Dreamtech Press 2016.

Sample Course Level Assessment Questions

Course Outcome1(CO1):

1. A coin is tossed 100 times and lands heads 62 times. What is the maximum likelihood estimate for $\boldsymbol{\theta}$, the probability of heads.
2. Suppose data $x_1, \ldots, x_n$ are independent and identically distributed drawn from an exponential distribution ***exp(λ)***. Find the maximum likelihood for λ.
3. Suppose $x_1, \ldots, x_n$ are independent and identically distributed(iid) samples from a distribution with density

$$f_X(x \mid \theta) = \begin{cases} \dfrac{\theta x^{\theta-1}}{3^{\theta}}, & 0 \leq x \leq 3 \\ 0, & \text{otherwise} \end{cases}$$

   Find the maximum likelihood estimate(MLE) for $\boldsymbol{\theta}$.
4. Find the maximum likelihood estimator (MLE) and maximum a posteriori (MAP) estimator for the mean of a univariate normal distribution. Assume that we have N samples, $x_1, \ldots, x_N$ independently drawn from a normal distribution with known variance σ^2 and unknown mean μ and the prior distribution for the mean is itself a normal distribution with mean v and variance β^2. What happens to the MLE and MAP estimators as the number of samples goes to infinity.

Course Outcome 2 (CO2):

1. Explain the difference between (batch) gradient descent and stochastic gradient descent. Give an example of when you might prefer one over the other.
2. Suppose that you are asked to perform linear regression to learn the function that outputs y, given the D-dimensional input x. You are given N independent data points, and that all the D attributes are linearly independent. Assuming that D is around 100, would you prefer the closed form solution or gradient descent to estimate the regressor?
3. Suppose you have a three class problem where class label $y \in 0, 1, 2$ and each training example X has 3 binary attributes $X_1, X_2, X_3 \in 0, 1$. How many parameters (probability distribution) do you need to know to classify an example using the Naive Bayes classifier?

Course Outcome 3 (CO3):

1. What are support vectors and list any three properties of the support vector classifier solution?
2. Why do you use kernels to model a projection from attributes into a feature space, instead of simply projecting the dataset directly?
3. Describe how Support Vector Machines can be extended to make use of kernels. Illustrate with reference to the Gaussian kernel $K(x, y) = e^{-z}$, where $z = (x-y)^2$.

4. Briefly explain one way in which using tanh instead of logistic activations makes optimization easier.
5. ReLU activation functions are most used in neural networks instead of the tanh activation function. Draw both activation functions and give a) an advantage of the ReLU function compared to the tanh function. b) a disadvantage of the ReLU function compared to the tanh function.

Course Outcome 4(CO4):

1. Describe cluster analysis? Identify two applications where cluster analysis can be applied to multimedia data?
2. Given two objects represented by the tuples (22, 1, 42, 10) and (20, 0, 36, 8):

(i) Compute the Euclidean distance between the two objects.

(ii) Compute the Manhattan distance between the two objects.

3. Use PCA to reduce the dimension from 2 to 1 for the design matrix ***X***.

$$X = \begin{bmatrix} 6 & -4 \\ -3 & 5 \\ -2 & 6 \\ 7 & -3 \end{bmatrix}$$

4. What is Principal Component Analysis (PCA)? Which eigen value indicates the direction of largest variance?
5. Suppose that one runs a principal component analysis on a data set and tells that the percentage of variance explained by the first 3 components is 80%. How is this percentage of variance explained?

Course Outcome 5 (CO5):

1. Suppose that you are contacted by a food processing company that wants you to develop a classifier that detects whether a rat is present in an image. You collect a large dataset of images by crawling the web, and have annotators determine which images contain rats. This set of images can then be used as the training set for your classifier.
   a. Suggest a machine learning method to use for this classification task and evaluate its performance.
   b. After you have delivered your solution to the company, they get back to you and complain that when they evaluate on a new test set, they get precision and recall values that are much lower than what you reported to them. Explain what might have gone wrong and propose remedial measures .
2. A real estate firm would like to build a system that predicts the sale prices of a house. They create a spreadsheet containing information about 1,500 house sales in the Kochi

area. In addition to the price, there are 10 features describing the house, such as number of bedrooms, total indoor area, lot area, a swimming pool, location, etc. Explain how you would implement a machine learning model that would solve this prediction task. Give all steps you would carry out when developing it. Explain why the model you built is probably useless in the long run.

3. For a classifier, the confusion matrix is given by:

	+	-
+	9	9
-	1	5

What is the precision, recall and accuracy of that classifier?

Model Question Paper

QP CODE: PAGES:3

Reg No:________________

Name:__________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR

Course Code: CST 383

Course Name: CONCEPTS IN MACHINE LEARNING

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Define supervised learning? Name special cases of supervised learning depending on whether the inputs/outputs are categorical, or continuous.
2. Differentiate between Maximum Likelihood estimation (MLE) and Maximum a Posteriori (MAP) estimation?
3. What is overfitting and why is it a problem? Give an example of a method to reduce the risk of overfitting.
4. Specify the basic principle of gradient descent algorithm.
5. Suppose that you have a linear support vector machine(SVM) binary classifier. Consider a point that is currently classified correctly, and is far away from the decision boundary. If you

remove the point from the training set, and re-train the classifier, will the decision boundary change or stay the same? Justify your answer.

6. Mention the primary motivation for using the kernel trick in machine learning algorithms?
7. Expectation maximization (EM) is designed to find a maximum likelihood setting of the parameters of a model when some of the data is missing. Does the algorithm converge? If so, do you obtain a locally or globally optimal set of parameters?
8. Illustrate the strength and weakness of k-means algorithm.
9. Classifier A attains 100% accuracy on the training set and 70% accuracy on the test set. Classifier B attains 70% accuracy on the training set and 75% accuracy on the test set. Which one is a better classifier. Justify your answer.
10. How does bias and variance trade-off affect machine learning algorithms?

(10x3=30)

Part B

Answer any one Question from each module. Each question carries 14 Marks

11. a) Suppose that $\boldsymbol{X}$ is a discrete random variable with the following probability mass function: where $\boldsymbol{0 \leq \theta \leq 1}$ is a parameter. The following 10 independent observations

X	0	1	2	3
$P(X)$	$2\theta/3$	$\theta/3$	$2(1-\theta)/3$	$(1-\theta)/3$

were taken from such a distribution: ***(3, 0, 2, 1, 3, 2, 1, 0, 2, 1)***. What is the maximum likelihood estimate of $\boldsymbol{\theta}$. **(6)**

b) A gamma distribution with parameters $\boldsymbol{\alpha, \beta}$ has the following density function, where $\boldsymbol{\Gamma(t)}$ is the gamma function.

$$p(x) = \frac{\beta^\alpha}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}$$

If the posterior distribution is in the same family as the prior distribution, then we say that the prior distribution is the conjugate prior for the likelihood function. Using the Gamma distribution as a prior, show that the Exponential distribution is a conjugate prior of the Gamma distribution. Also, find the maximum a posteriori estimator for the parameter of the Exponential distribution as a function of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$. **(8)**

OR

12. a) Traffic between 8AM and 9AM at a certain place was measured by counting the number of vehicles that passed at that time. Suppose the counts follow a Poisson process. A random sample of 9 observations was collected, having observed the following number of vehicles: (95, 100, 80, 70, 110, 98, 97, 90, 70). Derive the maximum likelihood estimator for the

average number of vehicles that pass by that place between 8 AM and 9 AM, and compute the corresponding estimate using the given sample. **(7)**

b) Find the maximum a posteriori (MAP) estimator for the mean of a univariate normal distribution. Assume that we have N samples, $x_1,..., x_N$ independently drawn from a normal distribution with known variance σ^2 and unknown mean μ and the prior distribution for the mean is itself a normal distribution with mean ν and variance β^2. **(7)**

13.a) Derive the gradient descent training rule assuming for the target function $o_d = w_0 + w_1x_1 + ... + w_nx_n$. Define explicitly the squared cost/error function E, assuming that a set of training examples D is provided, where each training example $d \in D$ is associated with the target output t_d. **(10)**

b) How can we interpret the output of a two-class logistic regression classifier as a probability? **(4)**

OR

14. a) In a two-class logistic regression model, the weight vector $w = [4, 3, 2, 1, 0]$. We apply it to some object that we would like to classify; the vectorized feature representation of this object is $x = [-2, 0, -3, 0.5, 3]$. What is the probability, according to the model, that this instance belongs to the positive class? **(6)**

b) The following dataset can be used to train a classifier that determines whether a given person is likely to own a car or not. There are three features: education level (primary, secondary, or university); residence (city or country); gender (female, male).

education	residence	gender	has car?
sec	country	female	yes
univ	country	female	yes
prim	city	male	no
univ	city	male	no
sec	city	female	no
sec	country	male	yes
prim	country	female	yes
univ	country	male	yes
sec	city	male	yes
prim	city	female	no
univ	city	female	no
prim	country	male	yes

Find the root attribute and justify your answer **(8)**

15. a) Consider a support vector machine whose input space is 2-D, and the inner products are computed by means of the kernel ***K(x, y) = (x.y + 1)²-1***, where ***x.y*** denotes the ordinary inner product. Show that the mapping to feature space that is implicitly defined by this kernel is the mapping to 5-D given by **(10)**

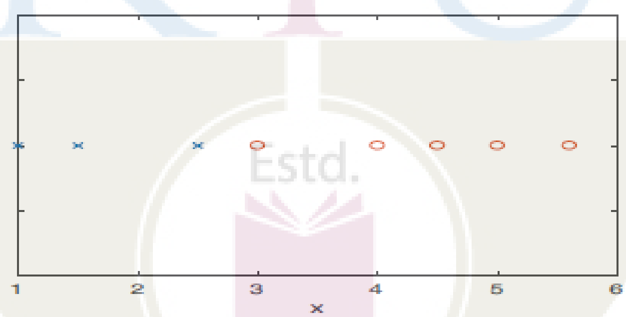
$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \rightarrow \phi(\mathbf{x}) = \begin{bmatrix} x_1^2 \\ x_2^2 \\ \sqrt{2}\, x_1 x_2 \\ \sqrt{2}\, x_1 \\ \sqrt{2}\, x_2 \end{bmatrix}.$$

b) What is the basic idea of a Support Vector Machine? **(4)**

OR

16. a) Explain how back propagation can be used to solve XOR problem which is not linearly separable. **(8)**

b) Consider the following one dimensional training data set, 'x' denotes negative examples and 'o' positive examples. The exact data points and their labels are given in the table. Suppose a SVM is used to classify this data. Indicate which are the support vectors and mark the decision boundary. Find the equation of the hyperplane. (6)



x	1	1.5	2.5	3	4	4.5	5	5.6
y	-1	-1	-1	1	1	1	1	1

17. a)Suppose that we have the following data (one variable). Use single linkage Agglomerative clustering to identify the clusters.
Daa: (2, 5, 9, 15, 16, 18, 25, 33, 33, 45). **(8)**

b) Given two objects represented by the tuples (22, 1, 42, 10) and (20, 0, 36, 8):
(i) Compute the Euclidean distance between the two objects.
(ii) Compute the Manhattan distance between the two objects.

(iii) Compute the Minkowski distance between the two objects, using p = 3 **(6)**

OR

18. a) Suppose that we have the following data:

a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*
(2,0)	(1,2)	(2,2)	(3,2)	(2,3)	(3,3)	(2,4)	(3,4)	(4,4)	(3,5)

Identify the cluster by applying the k-means algorithm, with k = 2. Try using initial cluster centers as far apart as possible. **(10)**

b) List the steps involved in Principal Component Analysis. **(4)**

19. a) Suppose the dataset had 9700 cancer-free images from 10000 images from cancer patients. Find precision, recall and accuracy ? Is it a good classifier? Justify. **(8)**

Actual Class\ Predicted class	**cancer = yes**	**cancer = no**	**Total**
cancer = yes	90	210	300
cancer = no	140	9560	9700
Total	230	9770	10000

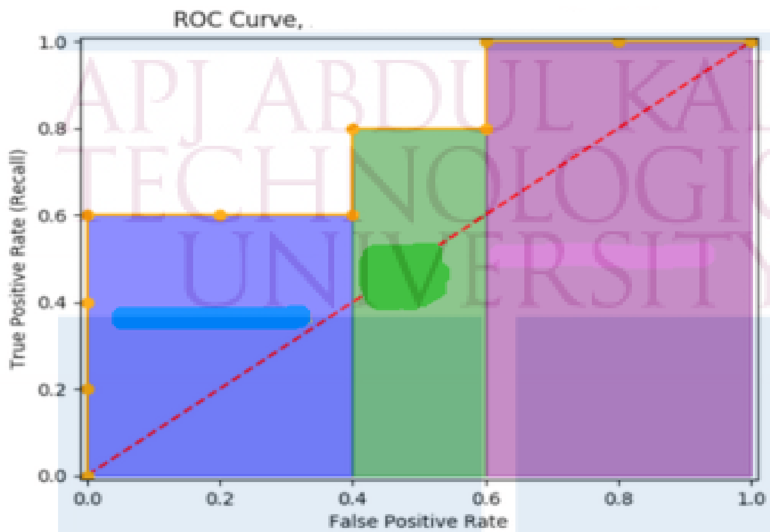
b) Suppose that you have a classification problem where our feature representation contains about 10,000,000 features. We would like to develop a classifier that can be deployed in a mobile phone, so preferably it should have a small memory footprint. Discuss one solution for how this can be done. **(6)**

OR

20. a) What are ROC space and ROC curve in machine learning? In ROC space, which points correspond to perfect prediction, always positive prediction and always negative prediction? Why? **(6)**

b)Suppose there are three classifiers A,B and C. The (FPR, TPR) measures of the three classifiers are as follows – A (0, 1), B (1, 1) , C (1,0.5). Which can be considered as a perfect classifier? Justify your answer. **(4)**

c) Given the following ROC Curve? Find the AUC? **(4)**



Teaching Plan

No	**Contents**	**No of Lecture Hrs**
	Module 1 :Overview of machine learning (7 hours)	
1.1	Supervised, semi-supervised, unsupervised learning, reinforcement learning (Text Book (TB) 1: Chapter 1)	1hour
1.2	Maximum likelihood estimation(MLE) (TB 1: Section 4.2)	1hour
1.3	Maximum likelihood estimation (MLE)- example (TB 1: Section 4.2)	1hour
1.4	Maximum a posteriori estimation(MAP) (TB 4: Section 6.2)	1hour
1.5	Maximum a posteriori estimation(MAP)-example (TB 4: Section 6.2)	1hour
1.6	Bayesian formulation (TB 1: Section 14.1, 14.2)	1hour
1.7	Bayesian formulation -example (TB 1: Section 14.1, 14.2)	1hour
	Module 2 : Supervised Learning (8 hours)	

2.1	Linear regression with one variable (TB 1: Section 2.6)	1hour
2.2	Multiple variables, Solution using gradient descent algorithm and matrix method (No derivation required) (TB 1: Section 5.8)	1hour
2.3	Overfitting in regression, Lasso and Ridge regularization	1hour
2.4	Logistic regression	1hour
2.5	Perceptron	1hour
2.6	Naive Bayes (TB 2: Section 18.2)	1hour
2.7	Decision trees (TB 2: Chapter 19)	1hour
2.8	Decision trees- ID3 algorithm (TB 2: Chapter 19)	1hour
Module 3 : Neural Networks and Support Vector Machines (TB 2: Chapter 21) (11 hours)		
3.1	Multilayer Feed forward Network, Activation Functions (Sigmoid, ReLU, Tanh)	1hour
3.2	Back Propagation Algorithm	1hour
3.3	Illustrative Example for Back Propagation	1hour
3.4	Introduction, Maximum Margin Hyperplane,	1hour
3.5	Mathematics behind Maximum Margin Classification	1hour
3.6	Formulation of maximum margin hyperplane and solution	1hour
3.7	Soft margin SVM	1hour
3.8	Solution of Soft margin SVM	1hour
3.9	Non-linear SVM	1hour
3.10	Kernels for learning non-linear functions and properties of kernel functions.	1hour
3.11	Example Kernels functions- Linear, RBF, Polynomial.	1hour
Module 4 : Unsupervised Learning (10 hours)		
4.1	Similarity measures- Minkowski distance measures(Manhattan, Euclidean), Cosine Similarity	1hour
4.2	Clustering - Hierarchical Clustering (TB 2: Chapter 14)	1hour
4.3	K-means partitional clustering (TB 2: Chapter 13)	1hour
4.4	Expectation maximization (EM) for soft clustering (TB 2: Chapter 13)	1hour
4.5	Expectation maximization (EM) for soft clustering (TB 2: Chapter 13)	1hour

4.6	Dimensionality reduction – Principal Component Analysis (TB 1: Section 6.3)	1hour
4.7	Dimensionality reduction – Principal Component Analysis (TB 1: Section 6.3)	1hour
4.8	Factor Analysis (TB 1: Section 6.4)	1hour
4.9	Multidimensional scaling (TB 1: Section 6.5)	1hour
4.10	Linear Discriminant Analysis (TB 1: Section 6.6)	1hour
Module 5 : Classification Assessment (8 hours)		
5.1	Performance measures - Precision, Recall, Accuracy, F-Measure, ROC, AUC. (TB 2: Chapter 22.1)	1hour
5.2	Boot strapping, Cross validation	1hour
5.3	Ensemble methods- bagging	1hour
5.4	Ensemble methods- boosting	1hour
5.5	Bias-Variance decomposition (TB 2: Chapter 22.3)	1hour
5.6	Bias-Variance decomposition (TB 2: Chapter 22.3)	1hour
5.7	Face detection (TB 3: Chapter 5 Section Application: A Face Detection Pipeline)	1hour
5.8	Face detection (TB 3: Chapter 5 Section Application: A Face Detection Pipeline)	1hour

CST 385	CLIENT SERVER SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

The syllabus is prepared with the view of preparing the Engineering Graduates to build effective Client/Server applications. This course aims at providing a foundation in decentralized computer systems, using the client/server model. The course content is decided to cover the essential fundamentals which can be taught within the given slots in the curriculum.

Prerequisite: **Basic knowledge in Computer**

Course Outcomes: After the completion of the course the student will be able to

	Course Outcomes
CO 1	Identify the basics of client/server systems and the driving force behind the development of client/server systems**(Cognitive Knowledge Level: Understand)**
CO 2	Outline the architecture and classifications of client/server systems**(Cognitive Knowledge Level: Understand)**
CO 3	Summarize the client/server network services for an application**(Cognitive Knowledge Level: Understand)**
CO 4	Identify management services and issues in network **(Cognitive Knowledge Level: Understand)**
CO 5	Outline the Client/Server technology in respect of databases and Client/Server database architecture **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										✓
CO2	✓	✓										✓
CO3	✓	✓										✓
CO4	✓											✓
CO5	✓	✓										✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test 1 (Percentage)	Test 2 (Percentage)	
Remember	40	40	40
Understand	40	40	40
Apply	20	20	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Test 1 (for theory, for 2 hrs) : **20 marks**

Continuous Assessment Test 2 (for lab, internal examination, for 2hrs) : **20 marks**

Internal Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), having 3 marks for each question. Students should answer all questions. Part B also contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), of which a student should answer any one. The questions should not have sub-divisions and each one carries 7 marks.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Computing in client server architecture over Mainframe architecture has certain advantages and disadvantages. Describe at least three advantages and disadvantages for each architecture.

Course Outcome 2 (CO2):

1. Explain the role of mainframe-centric model in Client/Server computing?

Course Outcome 3(CO3):

1. Describe the client server system development methodology? Explain different phases of System Integration Life-Cycle.

Course Outcome 4 (CO4):

1. Explain about network management and remote system management. How can security be provided to the network?

Course Outcome 5 (CO5):

1. Explain various types of Client/Server Database Architecture

Syllabus

Module – 1 (Introduction)

Introduction to Client/Server computing - Basic Client/Server Computing Model, Server for Every Client- File Server, Print Server, Application Server, Mail Server, Directory Services Server, Web Server, Database Server, Transaction Servers. Client/Server-Fat or Thin, Stateless or Stateful, Servers and Mainframes, Client/Server Functions. Driving Forces behind Client/Server Computing- Business Perspective, Technology Perspective.

Module -2 (Client/Server Classification)

Client/Server Types-Single Client/Single Server, Multiple Clients/Single Server, Multiple Clients/Multiple Servers, Integration With Distributed Computing, Alternatives To Client/Server Systems. Classification of Client/Server Systems- Two-Tier Computing, Middleware, Three-Tier Computing- Model View Controller (MVC), Principles behind Client/Server Systems.Client/Server Topologies. Existing Client/Server Architecture. Architecture for Business Information System.

Module -3 (Client/Server Application Components)

Client- Services, Request for services, RPC, Windows services, Print services, Remote boot services, other remote services, Utility Services. Server- Detailed server functionality, Network operating system, Available platforms, Server operating system. Organizational Expectations, Improving performance of client/server applications, Single system image, Downsizing and Rightsizing, Advantages and disadvantages of Client/Server computing, Applications of Client/Server.

Module -4 (Client/ Server Systems Services and Support)

Services and Support- System administration, Availability, Reliability, Scalability, Observability, Agility, Serviceability. Software Distribution, Performance, Network management. Remote Systems Management- RDP, Telnet, SSH, Security. LAN and Network Management issues.

Module -5(Client/Server Technology and Databases)

Client/Server Technology and Databases **-** Storing Data, Database System Architectures. Client/Server In Respect Of Databases- Client/Server Databases, Client/Server Database Computing, Database Computing Vs. Mainframe, PC/File Server Computing. Client/Server Database Architecture - Process-Per-Client Architecture, Multi-Threaded Architecture, Hybrid Architecture. Database Middleware Component - Application Programming Interface, Database Translator, Network Translator.

Text Book

1. Patrick Smith &Steve Guengerich, Client / Server Computing, PHI

2. Subhash Chandra Yadav, Sanjay Kumar Singh, An Introduction to Client/Server Computing, New Age International Publishers

Reference Books

1. Jeffrey D.Schank, “Novell’s Guide to Client-Server Application & Architecture” Novell Press

2. Robert Orfali, Dan Harkey, Jeri Edwards, Client/Server Survival Guide, Wiley-India Edition, Third Edition

3. Dawna Travis Dewire, Client Server Computing — McGraw Hill

4. W.H.Inman, Developing Client Server Applications, BPB

Model Question Paper

QP CODE: **PAGES: ___**

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR

Course Code: CST 385

Course Name : Client Server Systems

Max Marks: 100 **Duration: 3 Hours**

PART-A

(Answer All Questions. Each question carries 3 marks)

1. Differentiate between Stateful and Stateless servers

2. List the different phases and activities of client/server system development methodology.

3. How does transmission protocol work in client/server applications?

4. List any six services in single system image environment.

5. Specify the role of the client in Client/Server computing and also list any six services provided by the client.

6. Why do most RPC system support call by value semantics for parameter passing?

7. What do you mean by a thin client network? List three advantages of the Thin

Client Network system.

8. How are connectivity and interoperability between .client/server achieved?

9. One disadvantage of the Client/Server system is lack of control in a Database Management environment. Justify.

10. Explain the DBMS concept in client/server architecture.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Differentiate between Transaction server and Data server system with examples. **(7)**

(b) Computing in client server architecture over Mainframe architecture has certain advantages and disadvantages. Describe at least three advantages and disadvantages for each architecture. **(7)**

OR

12. (a) Explain various Clients/Server system development tools. **(6)**

(b) Classify and describe the driving forces that drive the move to Client/Server computing. **(8)**

13. (a) Explain the role of mainframe-centric model in Client/Server computing? **(5)**

(b) Describe the three types of Client/Server systems in existence **(9)**

OR

14. (a) List and explain the general forces behind the architecture for business information systems **(7)**

(b) Explain the different distribution styles. **(7)**

15. (a) Illustrate the concept of rightsizing and downsizing in Client/Server Computing **(7)**

(b) What is client server system development methodology? Explain the **(7)** different phases of System Integration Life-Cycle.

OR

16. (a) In Client/Server computing, explain the following with examples **(10)**
    i. Dynamic Data Exchange
    ii. RPC, Remote Procedure Call
    iii. Remote Boot Service
    iv. Diskless Computer
    v. Object-linking and embedding

(b) Explain the functions and features of Network Operating System **(4)**

17. (a) Explain about network management and remote system management. How can security be provided to the network ? **(10)**

(b) In client server architecture, what do you mean by Availability, Reliability, Serviceability and Security? Explain with examples. **(4)**

OR

18. (a) Client server is modular infrastructure, this is intended to improve Usability, Flexibility, Interoperability and Scalability. Explain each term with an example, in each case how it helps to improve the functionality of client server architecture. **(7)**

(b) Explain about network management and remote system management. How can security be provided to network? **(7)**

19. (a) Explain the different types of Client/Server Database Architecture **(9)**

(b) List and explain the main components of Database middleware **(5)**

OR

20. (a) Discuss types of database utilities, tools and their functions **(7)**

(b) Discuss about the role of traditional and web databases in handling client/server based applications. **(7)**

Teaching Plan

Module- 1(Introduction)		**(10 hours)**
1.1	Basic Client/Server Computing Model	1 hour
1.2	Server for Every Client- File Server, Print Server	1 hour
1.3	Application Server, Mail Server, Directory Services Server	1 hour
1.4	Web Server, Database Server	1 hour
1.5	Transaction Servers	1 hour
1.6	Client/Server-Fat or Thin	1 hour
1.7	Stateless or Stateful	1 hour
1.8	Servers and Mainframes	1 hour
1.9	Client/Server Functions	1 hour
1.10	Driving Forces behind Client/Server Computing- Business Perspective, Technology Perspective	1 hour
Module- 2 (Client/Server Classification)		**(10 hours)**
2.1	Client/Server Types-Single Client/Single Server	1 hour
2.2	Multiple Clients/Single Server, Multiple Clients/Multiple Servers	1 hour
2.3	Integration With Distributed Computing	1 hour
2.4	Alternatives To Client/Server Systems	1 hour
2.5	Classification of Client/Server Systems- Two-Tier Computing, Middleware	1 hour
2.6	Three-Tier Computing- Model View Controller (MVC)	1 hour
2.7	Principles behind Client/Server Systems.	1 hour
2.8	Client/Server Topologies	1 hour
2.9	Existing Client/Server Architecture	1 hour
2.10	Architecture for Business Information System	1 hour
Module -3 (Client/Server Application Components)		**(9 hours)**
3.1	The client: Services, Request for services, RPC	1 hour
3.2	Windows services, Print services, Remote boot services	1 hour

3.3	Utility Services & Other Services	1 hour
3.4	Server- Detailed server functionality, Network operating system	1 hour
3.5	Available platforms, Server operating system	1 hour
3.6	Organizational Expectations, Improving performance of client/server applications	1 hour
3.7	Single system image, Downsizing and Rightsizing	1 hour
3.8	Advantages and disadvantages of Client/Server computing	1 hour
3.9	Applications of Client/Server	1 hour
Module -4 (Client/ Server Systems Services and Support)		**(8 hours)**
4.1	Services and Support, System administration	1 hour
4.2	Availability, Reliability	1 hour
4.3	Scalability, Observability, Agility	1 hour
4.4	Serviceability, Software Distribution	1 hour
4.5	Performance	1 hour
4.6	Network management	1 hour
4.7	Remote Systems Management- RDP, Telnet, SSH	1 hour
4.8	Security, LAN and Network Management issues	1 hour
Module -5(Client/Server Technology and Databases)		**(8 hours)**
5.1	Client/Server Technology and Databases - Storing Data	1 hour
5.2	Database System Architectures	1 hour
5.3	Client/Server In Respect Of Databases- Client/Server Databases	1 hour
5.4	Client/Server Database Computing	1 hour
5.5	Database Computing Vs. Mainframe, PC/File Server Computing	1 hour
5.	Client/Server Database Architecture - Process-Per-Client Architecture	1 hour
5.7	Multi-Threaded Architecture, Hybrid Architecture	1 hour
5.8	Database Middleware Component - Application Programming Interface, Database Translator, Network Translator	1 hour

SEMESTER V

HONOURS

CST 393	CRYPTOGRAPHIC ALGORITHMS	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

The course on Cryptographic Algorithms aims at exploring various algorithms deployed in offering confidentiality, integrity, authentication and non-repudiation services. This course covers classical encryption techniques, symmetric and public key crypto-system, key exchange and management, and authentication functions. The concepts covered in this course enable the learners in effective use of cryptographic algorithms for real life applications.

Prerequisite: A sound background in Number Theory**.**

Course Outcomes: After the completion of the course the student will be able to

CO1	Identify the security services provided for different types of security attacks. (**Cognitive Knowledge Level : Understand**)
CO2	Summarize the classical encryption techniques for information hiding. (**Cognitive Knowledge Level: Apply**)
CO3	Illustrate symmetric / asymmetric key cryptographic algorithms for secure communication.(**Cognitive Knowledge Level: Apply**)
CO4	Interpret key management techniques for secure communication.(**Cognitive Knowledge Level: Understand)**
CO5	Summarize message authentication functions in a secure communication scenario.(**Cognitive Knowledge Level: Understand**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO1 0	PO11	PO1 2
CO1	✓	✓	✓									✓

CO2	✓	✓	✓		✓	✓						✓
CO3	✓	✓	✓	✓	✓	✓						✓
CO4	✓	✓	✓	✓	✓	✓						✓
CO5	✓	✓	✓	✓	✓	✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test1 (Percentage)	**Test2 (Percent**	

		age)	
Remember	**30**	**30**	**30**
Understand	**30**	**30**	**30**
Apply	**40**	**40**	**40**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Tests : **25 marks**

Continuous Assessment Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks.

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module-1 (Introduction to the Concepts of Security)

Need for security, Security approaches, Principles of security, Types of attacks, OSI Security Architecture, Classical encryption techniques - Substitution techniques, Transposition techniques. Stream cipher, Block cipher, Public key cryptosystems vs. Symmetric key cryptosystems, Encrypting communication channels.

Module-2 (Symmetric Key Cryptosystems)

Overview of symmetric key cryptography, Block cipher principles, Data Encryption Standard (DES), Differential and Linear cryptanalysis, Double DES, Triple DES, International Data Encryption Algorithm (IDEA), Advanced Encryption Algorithm (AES),Block cipher modes of operation, Stream cipher, RC4.

Module-3 (Public Key Cryptosystems)

Principles of public key cryptosystems, RSA algorithm, RSA illustration, Attacks, ElGamal cryptographic system, Knapsack algorithm, Diffie-Hellman key exchange algorithm, Elliptical curve cryptosystems.

Module-4 (Key Management)

Symmetric key distribution using symmetric encryption, Symmetric key distribution using asymmetric encryption, Distribution of public keys, Generating keys, transferring keys, Verifying keys, Updating keys, Storing keys, Backup keys, Compromised keys, Public key infrastructure.

Module – 5 (Authentication)

Authentication requirements, Authentication functions, Message authentication codes (MAC), Hash functions, Security of Hash functions and MAC, Message Digest 5 (MD5), Secure Hash Algorithm (SHA)-512, Hash-based Message Authentication Code (HMAC), Cipher-based Message Authentication Code (CMAC), X.509 Authentication services.

Text Books

1. William Stallings, Cryptography and Network Security Principles and Practice, Pearson Edu, 6e.
2. Bruice Schneier, Applied Cryptography Protocols, Algorithms and source code in C, Wiley,2e.

References

1. Behrouz A. Forouzan, Cryptography and Network Security, McGraw Hill, 2e.

2. Johannes A. Buchmann, Introduction to Cryptography, Springer, 2e.

3. DouglasR. Stinson, Cryptography Theory and Practice, 3e,Chapman & Hall/CRC, 2006.

4. Bernard Menezes, Network Security and Cryptography, Cengage Learning, 2011.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Consider an automated teller machine (ATM) in which users provide a personal identification number (PIN) and a card for account access. Give examples of confidentiality, integrity, and availability requirements associated with the system and, in each case, indicate the degree of importance of the requirement.

2. Discuss the different security services provided for preventing security attacks.

Course Outcome 2 (CO2):

1. The encryption key in a transposition cipher is (3,2,6,1,5,4). Find the decryption key

2.Discuss the process of encryption in Vernam cipher

Course Outcome 3 (CO3):

1. Devise a meet-in-the-middle attack for a triple DES.

2. Write an algorithm for the InvSubBytes transformation and implement using python (**Assignment**)

3. Consider the following elliptic curve signature scheme. We have a global elliptic curve, prime *p*, and "generator" G. Alice picks a private signing key X_A and forms the public verifying $Y_A = X_A G$. To sign a message *M*:
   - Alice picks a value k
   - Alice sends Bob *M*, k and the signature $S = M - kX_A G$.
   - Bob verifies that $M = S + kY_A$.

   Show that the verification process produces an equality if the signature is valid.

4. Write an algorithm to add two points on an elliptic curve over GF(*p*) and implement using Python. **(Assignment)**

5. Write an algorithm for encryption using knapsack cryptosystem and implement using Java. **(Assignment)**

Course Outcome4 (CO4):

1. List four general categories of schemes for the distribution of public keys.
2. What are the essential ingredients of a public-key directory?

Course Outcome 5 (CO5):

1. State the value of the length field in SHA-512 if the length of the message is 1919 bits and 1920 bits.
2. Write an algorithm in pseudo code for HMAC and implement using Python (**Assignment**)

Model Question Paper

QP CODE:

Reg No:_______________

Name :_______________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION(HONORS), MONTH & YEAR

Course Code: CST 393

Course Name: Cryptographic Algorithms

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. State the two approaches in attacking a cipher.
2. Define Substitution Cipher. Encrypt using one time pad M = HONORS and K = CIPHER.
3. Specify the purpose of S-Boxes in Data Encryption Standard (DES).
4. Differentiate between diffusion and confusion.
5. Perform encryption using RSA Algorithm for the following p=7; q=11; e=13; M=5.
6. Is Diffie-Hellman key exchange protocol vulnerable? Justify.
7. List the techniques for distribution of public keys.
8. Define a certificate authority and its relation to public key cryptography.
9. Distinguish between integrity and message authentication.
10. What types of attacks are addressed by message authentication?

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11.	(a)	With a neat sketch, Explain OSI Security architecture model.	**(8)**
	(b)	How does link encryption differ from end-to-end encryption? Explain.	**(6)**

OR

12.	(a)	Encrypt the text "cryptography" using the Hill Cipher with the key $\begin{pmatrix} 9 & 4 \\ 5 & 7 \end{pmatrix}$. Show the calculations.	**(8)**
	(b)	Illustrate the steps involved in encrypting a plain text using playfair cipher with an example.	**(6)**
13.	(a)	With a neat sketch, explain a single round in DES.	**10**
	(b)	Explain encryption and decryption using 2 keys and 3 keys of triple DES.	**(4)**

OR

14.	(a)	Explain the block cipher modes i) Cipher feedback mode ii) Output feedback mode.	**(8)**
	(b)	Describe the four types of transformations in AES.	**(6)**
15.	(a)	Write an algorithm for generating public and private key using Elliptical curve cryptography.	**(10)**

(b) The equation $y^2=x^3+x+1$, the calculation is done modulo 13. Add two points R= P+Q, where P= (4,2) and Q= (10,6). **(4)**

OR

16. User A and B use the Diffie-Hellman key exchange technique with a common prime q=71 and primitive root alpha=7.

(a) If user A has private key X_A =3, What is A's public key Y_A? **(7)**

(b) If user B has private key X_B =6, What is A's public key Y_B? **(7)**

17. (a) Define a session key and show how a KDC can create can create a session key between Alice and Bob. **(7)**

(b) What are the requirements for the use of a public-key certificate scheme? **(7)**

OR

18. (a) What are the core components of a PKI? Briefly describe each component. **(8)**

(b) Describe the following (i) Updating keys (ii) Compromised Keys. **(6)**

19. (a) Describe how SHA-512 logic produce message digest **(10)**

(b) Distinguish between HMAC and CMAC **(4)**

OR

20. (a) Specify the format for X.509 certificate. Explain the steps required to obtain user's certificate. **(7)**

(b) With suitable block diagrams, explain the types of functions that may be used to produce an authenticator. **(8)**

Teaching Plan

No	Contents	No of Lecture Hrs
Module - 1 (Introduction to the Concepts of Security) (9 hrs)		
1.1	Need for security, Security approaches	1 hour
1.2	Principles of security, Types of attacks	1 hour
1.3	OSI Security Architecture	1 hour
1.4	Classical encryption techniques: Substitution techniques(Caesar cipher, Monoalphabetic cipher, Playfair cipher)	1 hour
1.5	Classical encryption techniques: Substitution techniques (Hill cipher, Polyalphabetic cipher, One-time pad)	1 hour
1.6	Classical encryption techniques: Transposition techniques	1 hour
1.7	Stream cipher, Block cipher	1 hour
1.8	Public- key cryptosystems vs. Symmetric key cryptosystems	1 hour
1.9	Encrypting communication channels	1 hour
Module - 2 (Symmetric key cryptosystems) (11 hrs)		
2.1	Overview of symmetric key cryptography	1 hour
2.2	Block cipher principles	1 hour
2.3	Data Encryption Standard (DES)	1 hour
2.4	DES design criteria	1 hour
2.5	Differential and Linear cryptanalysis	1 hour
2.6	Double DES, Triple DES	1 hour

2.7	IDEA	1 hour
2.8	Advanced Encryption Algorithm (AES structure)	1 hour
2.9	Advanced Encryption Algorithm (Transformations)	1 hour
2.10	Block cipher modes of operation	1 hour
2.11	Stream cipher, RC4	1 hour
	Module - 3 (Public key cryptosystems) (8 hrs)	
3.1	Principles of public key cryptosystems	1 hour
3.2	RSA algorithm	1 hour
3.3	RSA illustration, Attacks	1 hour
3.4	ElGamal cryptographic system	1 hour
3.5	Knapsack algorithm	1 hour
3.6	Diffie-Hellman key exchange algorithm	1 hour
3.7	Elliptical curve cryptosystems(Elliptical curve arithmetic)	1 hour
3.8	Elliptical curve cryptosystems (Elliptical curve algorithm)	1 hour
	Module - 4 (Key Management) (8 hrs) [Text book-2]	
4.1	Symmetric key distribution using symmetric encryption	1 hour
4.2	Symmetric key distribution using asymmetric encryption	1 hour
4.3	Distribution of public keys	1 hour
4.4	Generating keys, Transferring keys	1 hour

4.5	Verifying keys, Updating keys	1 hour
4.6	Storing keys, Backup keys	1 hour
4.7	Compromised keys	1 hour
4.8	Public key infrastructure	1 hour
	Module - 5 (Authentication) (9 hrs)	
5.1	Authentication requirements	1 hour
5.2	Authentication functions	1 hour
5.3	Message Authentication Codes (MAC)	1 hour
5.4	Hash functions	1 hour
5.5	Security of Hash functions and MAC	1 hour
5.6	MD5	1 hour
5.7	SHA-512	1 hour
5.8	HMAC, CMAC	1 hour
5.9	X.509 Authentication services	1 hour

AIT395	COMPUTATIONAL BIOLOGY	CATEGORY	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2020

Preamble: This course helps the learners to understand concepts in Genomics, Proteomics Computational Biology, Next Generation Sequencing, NGS Data Analysis and Systems biology. It enables the learners to understand various Next Generation Sequencing Techniques, analysis and interpretation of the NGS Data. Also, course introduces computational and mathematical analysis and modeling of complex biological systems and Systems Biology

Prerequisite: Basic background in Bioinformatics

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Describe the basic concepts of genomics, microarray, protein structure determination and prediction(**Cognitive knowledge level: Understand**)
CO 2	Explain the fundamental aspects drug discovery and molecular modelling (**Cognitive knowledge level: Apply)**
CO 3	Demonstrate Networks in Biology, types of networks and its representation (**Cognitive knowledge level : Apply)**
CO 4	Explain Next Generation sequencing Technologies and DNA Protein interaction analysis(**Cognitive knowledge level: Understand)**
CO 5	Illustrate Next Generation sequence analysis, Mapping approaches and algorithms (**Cognitive knowledge level: Understand**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	√	√										√
CO2	√	√	√	√	√							√
CO3	√	√	√	√	√							√
CO4	√	√	√	√	√							√
CO5	√	√			√							√

PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	Test1 (%)	Test2 (%)	
Remember	**30**	**30**	**30**
Understand	**50**	**50**	**50**
Apply	**20**	**20**	**20**
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests (Average of Series Tests 1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS`

Module -01 (Genomics and Proteomics)

Genes, Genes in genomes, Genomes of prokaryotes and Eukaryotes, Protein-coding genes, RNA, Single-nucleotide polymorphisms, Microarray, Analysis of microarray data, Proteins and peptides, Experimental Protein structure identification, computational methods for protein structure prediction, Homology modelling, Protein folding and fold recognition.

Module-02 (Computer Aided Drug Discovery)

Drug discovery pipeline, Drug target identification & validation, Active site identification, pharmacophore, Lead/Ligand identification, lead compound optimization, Binding energy calculation, Energy Minimization. Molecular modelling in drug discovery, concept of Molecular Dynamics, concept of Absorption, Distribution, Metabolism and Excretion (ADME), Quantitative Structure-Activity Relationships.

Module-03 (Network Biology)

Transcriptional Regulatory Networks, Genes and DNA Regulatory Regions, Genetic Interaction Map, Protein Interaction Networks, Experimental methodologies to obtain Protein Interaction Data, Computational methods to Predict Protein-Protein Interactions, Visualization of Protein Interaction Networks,Metabolic Networks, Interacting Partners, Mathematical Representation

Module-04 (Next Generation Sequencing and analysis)

A Typical NGS Experimental Workflow, Next-Generation Sequencing (NGS) Technologies, Illumina Reversible Dye-Terminator Sequencing, Ion Torrent Semiconductor Sequencing, Pacific Biosciences Single Molecule Real-Time (SMRT) Sequencing, RNA-sequencing (RNA Seq), Protein-DNA Interaction Analysis (ChIP-Seq)

Module-05 (NGS Data Analysis)

Base Calling, FASTQ File Format, and Base Quality Score, NGS Data Quality Control and Preprocessing, Reads Mapping, Mapping Approaches and Algorithms, Selection of Mapping Algorithms and Reference Genome Sequences, SAM/BAM as the Standard Mapping File Format, Mapping File Examination and Operation, Tertiary Analysis

Books

1. Lesk, Arthur M. Introduction to Bioinformatics. United Kingdom, Oxford University Press, 2019.
2. Biological Networks. Singapore, World Scientific Publishing Company, 2007.
3. Wang, Xinkun. Next-Generation Sequencing Data Analysis. United States, CRC Press, 2016.

References

1. Tiwary, Basant K.. Bioinformatics and Computational Biology: A Primer for Biologists. Singapore, Springer Singapore, 2021.
2. Benfey, Philip N.. Quickstart Molecular Biology: An Introductory Course for Mathematicians, Physicists, and Computational Scientists. United States, Cold Spring Harbor Laboratory Press, 2014.
3. Baxevanis, Andreas D., Gary D. Bader, and David S. Wishart, eds. *Bioinformatics*. John Wiley & Sons, 2020.
4. Shaik, Noor Ahmad, et al. *Essentials of Bioinformatics, Volume I.* Springer, 2019
5. Selzer, Paul M., Richard J. Marhöfer, and Andreas Rohwer, *Applied bioinformatics. An introduction–Springer, Verlag,*, 2008.
6. S C Rastogi, N Mendiratta and P Rastogi, *Bioinformatics: Methods and Applications* , PHI Learning Private Limited, New Delhi, 2015.
7. D E Krane and M L Raymer, *Fundamental Concepts of Bioinformatics*, Pearson Education, 2006.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare and contrast the genomes of Prokaryotes and Eukaryotes
2. Summarize the method of DNA microarray and its analysis.
3. Using the online tool SWISS-MODEL, develop model of Homo sapiens (Human) Leptin protein and interpret your result

Course Outcome 2 (CO2):

1. Explain the process of computer aided drug discovery and various step involved in it
2. Explain the process of molecular modelling in drug discovery

Course Outcome 3 (CO3):

1. Differentiate between Transcriptional and protein interaction networks
2. From the STRING database identify the interactions of Homo sapiens TP53 protein and interpret your result

Course Outcome 4 (CO4):

1. Summarize Next Generation Sequencing methods.
2. Explain The Protein- DNA interaction analysis with the help of ChIP-Seq
3. What can RNA-seq reveal?

Course Outcome 5 (CO5):

1. Illustrate the process involved in Data Quality control and preprocessing in Next Generation Sequencing
2. Explain the mapping algorithms and reference genome sequences

TEACHING PLAN

No	Contents	No of Lecture (45Hrs)
	Module -01 (Genomics and Phylogenetics) (9hrs)	
1.1	Genes, Genes in genomes.	1
1.2	Genomes of prokaryotes and Eukaryotes	1
1.3	Protein-coding genes, RNA, Single-nucleotide polymorphisms	1
1.4	Microarrays	1
1.5	Analysis of microarray data	1
1.6	Proteins and peptides	1
1.7	Experimental Protein structure identification	1
1.8	Computational methods for protein structure prediction	1
1.9	Homology modelling, Protein folding and fold recognition	1
	Module-02 (Computer Aided Drug Discovery)(9hrs)	
2.1	Drug discovery pipeline	1
2.2	Drug target identification & validation	1
2.3	Active site identification, pharmacophore	1
2.4	Lead/Ligand identification	1
2.5	lead compound optimization, Binding energy calculation, Energy Minimization	1
2.6	Molecular modelling in drug discovery	1

2.7	Concept of Molecular Dynamics	1
2.8	Concept of Absorption, Distribution, Metabolism and Excretion (ADME)	1
2.9	Quantitative Structure-Activity Relationship	1
Module-03 (Network Biology)(9hrs)		
3.1	Transcriptional Regulatory Networks	1
3.2	Genes and DNA Regulatory Regions,	1
3.3	Genetic Interaction Map,	1
3.4	Protein Interaction Networks	1
3.5	Experimental methodologies to obtain Protein Interaction Data	1
3.6	Computational methods to Predict Protein-Protein Interactions	1
3.7	Visualization of Protein Interaction Networks	1
3.8	Metabolic Networks- Interacting Partners	
3.9	Metabolic Networks- Mathematical Representation	

Module-04 (Next Generation Sequencing and analysis) (8hrs)		
4.1	A Typical NGS Experimental Workflow	1
4.2	Next-Generation Sequencing (NGS) Technologies	1
4.3	Next-Generation Sequencing (NGS) Technologies	1
4.4	Illumina Reversible Dye-Terminator Sequencing	1
4.5	Ion Torrent Semiconductor Sequencing	1
4.6	Pacific Biosciences Single Molecule Real-Time (SMRT) Sequencing	1
4.7	RNA-sequencing (RNA Seq)	1
4.8	Protein-DNA Interaction Analysis (ChIP-Seq)	1
Module-05 (NGS Data Analysis)(10hrs)		
5.1	NGS data,FASTQ File Format	1
5.2	Base Calling, Base Quality Score	1
5.3	NGS Data Quality Control	1
5.4	NGS data Preprocessing	1
5.5	Reads Mapping, Mapping Approaches and Algorithms,	1

5.6	Selection of Mapping Algorithms and Reference Genome Sequences	1
5.7	SAM/BAM as the Standard Mapping	1
5.8	Mapping File Examination and Operation	1
5.9	Tertiary Analysis	1
5.10	Demonstration of NGS Data Analysis	1

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES: 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT395

Course Name: COMPUTATIONAL BIOLOGY

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Distinguish between Genes, Genes in genomes.
2. What are the structural features of Eukaryotic cells?
3. What are SNPs and why are they important?
4. How do you identify the active site of a protein?
5. What is protein energy minimization?
6. List any three types of biochemical networks with one line description
7. What are reversible Dye-Terminators in NGS sequencing?
8. What is the difference between the DNA sent for Whole Exome sequencing vs ChIP sequencing?
9. List any three features of FastQ file format.
10. What is SAM format? How is BAM different from SAM? **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) With the help of a neat diagram, explain a prokaryotic gene structure. Is a promoter at the upstream or downstream of a transcription unit? **(7)**

(b) What is homology modeling? Discuss the steps involved in the same **(7)**

OR

12. (a) Explain the design of a microarray experiment, detailing the various phases. **(7)**

(b) What experimental method is used to determine the tertiary protein structure? What are the computational methods? **(7)**

13. (a) Illustrate the computational drug discovery pipeline with a suitable flowchart **(7)**

(b) What is Molecular modeling in drug discovery? Explain the process of molecular modelling. **(7)**

OR

14. (a) Explain the scoring functions in molecular docking. **(7)**

(b) Explain lead compound optimization, Binding energy calculation, Energy Minimization in the process of Computer aided drug discovery **(7)**

15. (a) What is transcriptional control and why is it important? Explain how transcriptional regulatory networks plays an important role in gene expression and control? **(7)**

(b) Explain how the computational methods helps in identifying the Protein–Protein Interactions **(7)**

OR

16. (a) How the Protein–Protein Interactions are identified by using experimental methods. **(7)**

(b) What is metabolic network? What are type of data are needed for metabolic network reconstruction? **(7)**

17. (a) Explain any two next-generation sequencing techniques with their steps. **(7)**

(b) How do you interpret a FastQC report? **(7)**

OR

18. (a) What are the steps in RNA sequencing?Why is RNA-seq better than microarrays? **(7)**

(b) illustrate the steps involved in mapping protein-DNA interactions using ChIP-sequencing **(7)**

19. (a) How do you interpret per base sequence quality?What is the purpose of mapping reads to a reference genome? **(7)**

(b) Explain any three mapping algorithms for the NGS. **(7)**

OR

20. (a) Illustrate steps involved in the NGS data Preprocessing and Quality Control **(7)**

(b) Discuss the significance of NGS in clinical diagnosis. **(7)**

AIT397	ADVANCED CONCEPTS IN COMPUTER VISION	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2020

Preamble: This course enables the learners to understand the advanced concepts in computer vision. The course covers the basics of image processing, imaging geometry, image segmentation, feature extraction, object recognition and classification and common applications of computer vision. This course helps the students to design solutions for complex real-life problems.

Prerequisite: A sound knowledge of Mathematics and concepts of any programming language.

Course Outcomes: After the completion of the course the student will be able to

CO1	Illustrate the concepts of image formation and image model. **(Cognitive Knowledge Level: Understand)**
CO2	Demonstrate various feature extraction and edge detection techniques. **(Cognitive Knowledge Level: Apply**
CO3	Apply edge-based and region-based image segmentation techniques. **(Cognitive Knowledge Level: Apply)**
CO4	Understand and implement image recognition and classification methods. **(Cognitive Knowledge Level: Apply)**
CO5	Explain the various applications of computer vision. **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO11	PO1 2
CO1	✓		✓		✓							✓
CO2	✓	✓	✓	✓	✓	✓						✓
CO3	✓	✓	✓	✓	✓	✓						✓
CO4	✓	✓	✓	✓	✓	✓						✓
CO5	✓	✓	✓	✓	✓	✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks (%)**
	Test 1 (%)	**Test 2 (%)**	
Remember	**30**	**30**	**30**
Understand	**30**	**30**	**30**
Apply	**40**	**40**	**40**

Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of Internal Tests 1 & 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

Syllabus

Module – 1 (Image Formation and Processing)

Image formation and Image model- Components of a vision system- Cameras- camera model and camera calibration-Radiometry- Light in space- Light in surface - Sources, shadows and shading.

Fundamentals of Image processing: Basic steps of Image processing system sampling and quantization of an Image – Basic relationship between pixels.

Module - 2(Feature Extraction)

Points and Patches – Feature detectors, feature descriptors, feature matching, feature tracking. **Edges –** edge detection, edge linking. **Lines** - Successive approximation, Hough transforms, Vanishing points.

Module - 3 **(Image Segmentation)**

Classification of segmentation techniques, Edge detection, Edge linking, Thresholding, Region growing, Region splitting and merging, Watershed based segmentation. Shadow detection and removal. Image processing using OpenCV - blending, smoothing, and reshaping.

Module - 4 (**Image Recognition and Classification**)

Shape based object classification, Motion based object classification, Viola Jones Object Detection Framework, Object classification using CNNs, use of RCNN for object classification.

Module - 5 (**Applications**)

Speech and Handwriting Recognition, Automatic Face Recognition, Video Segmentation and Keyframe Extraction, Real-Time Hand Pose Recognition.

Text Books

1. David A. Forsyth & Jean Ponce, Computer vision – A Modern Approach, Prentice Hall, 2002.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer.
3. Maheshkumar H Kolekar, "Intelligent Video Surveillance Systems: An Algorithmic Approach", CRC Press.

4. Francesco Camastra, Alessandro Vinciarelli, "Machine Learning for Audio, Image and Video Analysis: Theory and Applications", Springer 2015.

Reference Books

1. Reinhard Klette, "Concise Computer Vision: An Introduction into Theory and Algorithms", Springer London, 2014.

2. Olivier Faugeras, "Three-Dimensional Computer Vision", The MIT Press, 1993.

Course Level Assessment Questions

Course Outcome1 (CO1):

1.Explain the components of a visual system.

2.Elaborate on the image formation model.

Course Outcome 2(CO2):

1. Explain edge linking through Hough Transform.
2. Discuss how feature extraction is done in image processing.

Course Outcome 3(CO3):

1. Compare the following methods for image segmentation: a) multiple thresholding, b) global thresholding c) local thresholding.
2. Justify the role of region growing, region splitting and region merging operations in any of the computer vision applications.

Course Outcome 4(CO4): .

1. Explain convolution stage and pooling stage of a typical CNN layer.
2. Illustrate Viola Jones object detection framework.

Course Outcome 5(CO5):

1. Elaborate on how computer vision helps in automatic face recognition applications.
2. Discuss how computer vision helps in tackling complex real world problems.

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT397

Course Name: Advanced Concepts in Computer Vision

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Explain the working of a pinhole camera, Derive the expression for pinhole perspective projection.

2. Illustrate "foreshortening" with a neat diagram.

3. Explain edge linking through Hough Transform.

4. Illustrate any two techniques for vanishing point detection in an image.

5. Compare following methods for image segmentation
a, multiple thresholding, b, global thresholding c, local thresholding.

6. Draw the flowchart of foreground-pixel extraction by edge-based shadow removal

7. Why is a convolutional neural network preferred over a dense neural network for an image classification task?

8. Assess the relevance of selective search algorithm in RCNN for object classification

9. Draw the diagram which shows the general scheme of a recognition system.

10. Illustrate steps in feature extraction from handwritten images.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) State different limitations of pinhole cameras and how to overcome these limitations. **(9)**

(b) What are shadows? Differentiate umbra from penumbra. How is a self shadow different from a cast shadow? **(5)**

OR

12. (a) Explain the local shading model.How are area sources different from line sources? **(7)**

(b) Define Camera Calibration. Explain intrinsic and extrinsic parameters of a camera. **(7)**

13. (a) Assess the role of adaptive non-maximal suppression (ANMS) in feature detection. **(4)**

(b) Illustrate following techniques: **(10)**

i) Bias and gain normalization (MOPS).

ii) Gradient location-orientation histogram (GLOH)

OR

14. (a) Illustrate any 2 techniques in Successive approximation. **(4)**

(b) Compare Scale invariant feature transform (SIFT) and PCA-SIFT. **(5)**

15. (a) Illustrate Gradient operator and Laplacian operator with one example for each. **(10)**

(b) Illustrate Watershed Algorithms. **(4)**

OR

16. (a) With the help of a diagram illustrate region splitting and merging. **(7)**

(b) Compare blending, smoothing, and reshaping functions using OpenCV. **(7)**

17. (a) Differentiate between convolution stage and pooling stage of a typical CNN layer. **(8)**

(b) Assess the role of dispersedness in shape based object classification. **(6)**

OR

18. (a) Illustrate Viola Jones object detection framework. **(8)**

(b) Explain the steps in motion based object classification. **(6)**

19. (a) Illustrate shot boundary detection through pixel-based approaches and block-based approaches . **(7)**

(b) Explain different approaches in keyframe extraction problems. **(7)**

OR

20. (a) Illustrate shot boundary detection through histogram-based approaches and clustering-based approaches. **(6)**

(b) Illustrate HMM training in speech and handwriting recognition. **(8)**

TEACHING PLAN

No	Contents	No. of Lecture Hours (42 hrs)
Module – 1 (Image Formation and Processing) (8 hours)		
1.1	Image formation and Image model-Introduction	1 hour
1.2	Components of a vision system- Cameras-Camera model	1 hour
1.3	Camera calibration	1 hour
1.4	Radiometry- Light in space-Light in surface	1 hour
1.5	Sources-Shadows and shading	1 hour
1.6	Fundamentals of Image processing: Basic steps of Image processing system	1 hour
1.7	Sampling and quantization of an Image	1 hour
1.8	Basic relationship between pixels.	1 hour
Module-2(Feature Extraction) (8 hours)		
2.1	**Points and Patches** – Feature detectors	1 hour
2.2	Feature descriptors	1 hour
2.3	Feature matching	1 hour
2.4	Feature tracking.	1 hour
2.5	**Edges** – edge detection, edge linking.	1 hour
2.6	**Lines** - Successive approximation	1 hour
2.7	Hough transforms	1 hour
2.8	Vanishing points	1 hour

Module-3(Image Segmentation)(9 hours)		
3.1	Classification of segmentation techniques, Edge detection	1 hour
3.2	Edge linking	1 hour
3.3	Thresholding, Region growing	2 hours
3.4	Region splitting and merging	1 hour
3.5	Watershed based segmentation.	1 hour
3.6	Shadow detection and removal	1 hour
3.7	Image processing using OpenCV - blending	1 hour
3.8	Smoothing, and reshaping	1 hour
Module-4(Image Recognition and Classification) (9 hours)		
4.1	Shape based object classification	1 hour
4.2	Motion based object classification	2 hours
4.3	Viola Jones Object Detection Framework	2 hours
4.4	Object classification using CNNs	2 hours
4.6	Use of RCNN for object classification.	2 hours
Module-5(Applications)(8 hours)		
5.1	Speech and Handwriting Recognition	1 hour
5.2	Handwriting Recognition	1 hour
5.3	Automatic Face Recognition	2 hours
5.4	Video Segmentation	2 hours
5.5	Keyframe Extraction	1 hour
5.6	Real-Time Hand Pose Recognition.	1 hour

SEMESTER VI

ADT302	CONCEPTS IN BIG DATA ANALYTICS	Category	L	T	P	Credits	Year of Introduction
		PCC	3	1	0	4	2020

Preamble: This course helps the learner to understand the basic concepts of big data analytics. This course covers on big data technologies used for storage, analysis and manipulation of data. The student will learn about fundamentals of Hadoop, MapReduce, Pig, Hive, R and have hand on training on the same It also help to develop projects and apply existing data analytics tools to gain comprehensive knowledge on Data analytics. It enables the learners to perform data analysis on a real-world scenario using appropriate tools.

Prerequisite : Basic knowledge in programming

Course Outcomes : After the completion of the course the student will be able to

CO#	Course Outcomes
CO1	Outline the basic big data concept. **(Cognitive KnowledgeLevel: Understand)**
CO2	Categorize and summarize the processing in Big Data and its importance. **(Cognitive Knowledge Level:Understand)**
CO3	Simulate various Big data technologies like Hadoop MapReduce, Pig, Hive, Hbase.**(CognitiveKnowledge Level: Apply)**
CO4	Determine tools and techniques to analyze Big Data **(CognitiveKnowledge Level: Apply)**
CO5	Resolve problems associated with big data with the features of R programming **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										✓
CO2	✓	✓	✓									✓
CO3	✓	✓	✓	✓								✓
CO4	✓	✓	✓	✓								✓
CO5	✓	✓	✓	✓	✓							✓

Abstract POs Defined by National Board of Accreditation

PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1(%)	Test 2(%)	
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30

Mark Distribution

Total marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	4

Continuous Internal Evaluation Pattern:

Attendance 10 marks
Continuous Assessment Tests (Average of Series Tests 1& 2) 25 marks
Continuous Assessment Assignment 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which students should answer any one. Each question can have a maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module – 1 (Introduction to Big Data)

Introduction to Big data, Conventional Data vs Big data, Big data architecture, Big data platforms, Nature of data, Analytic processes and tools, 5 V's of Big data, Big data analytical method, Intelligent data analysis, Big data analytics life cycle.

Module - 2 (Introduction to Stream Computing)

Introduction to stream concepts – Streaming data architecture, Stream data model, Sampling techniques for efficient stream processing, Filtering streams – Bloom filter, Count distinct problem – Flajolet martin algorithm, Estimating moments, Counting oneness in a window – DGIM Algorithm

Module - 3 (Hadoop Distributed File System)

History of Hadoop, Hadoop Ecosystem, Core Components, HDFS- Architecture, Using HDFS Files, HDFS Design, Blocks, Namenodes and Data nodes, Basic File system Operations, Hadoop Specific File Types, Anatomy of a file read, Anatomy of a file write. Data Processing with MapReduce: Execution Pipeline, Runtime Coordination and Task Management in MapReduce, Designing MapReduce implementations: Using MapReduce as a framework for parallel processing, Example-Road Enrichment.

Module - 4 (Pig, Hive, HBase)

Pig : Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS.

Module - 5 (Introduction to R programming)

Introduction to R – Overview of modern data analytic tools, Introduction to R, R Graphical User Interfaces - Features of R Language, Vectors, Filtering, Creating Matrices , Applying Functions to Matrix Rows and Columns, Lists , Creating List , General List Operations, Data Frames , Creating Data Frames , Matrix like Operations in Frames , Applying Functions to Data Frames ,Reading and Writing Files.

Text Book

1. Tom White " Hadoop: The Definitive Guide" Third Edit on, O'reily Media, 2012.
2. Michael Minelli, Michelle Chambers and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
3. Boris Lublinsky, Kevin T. Smith, Alexey Yakubovich ,Professional Hadoop Solutions.

4. Norman Matloff , “The Art of R Programming: A Tour of Statistical Software Design”, NoStarch Press.

References Books

1. Bill Franks, “Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics”, 1st Edition, Wiley and SAS Business Series,2012.
2. Jure Leskovec, Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2014.
3. Seema Acharya, Subhasni Chellappan, “Big Data And Analytics”, Wiley Publications.
4. BIG DATA, Black Book TM, DreamTech Press, 2016 Edition.
5. Nathan Marz and James Warren, “BIG DATA- Principles and Best Practices of Scalable Real-time Systems”.
6. Jason Rutherglen, Dean Wampler, Edward Capriolo, Programming Hive, O'Reilly.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the features of the integrated IT solution for Big data management.
2. Define the term “Big data”. How do 5 V’s help to decide whether a given data source contributes to big data.
3. Identify the differences between data analysis and data reporting.

Course Outcome 2 (CO2):

1. Some websites check availability of username by searching millions of usernames registered with it. Identify one effective method to filter data as in this type of scenario.
2. Discuss the issues in stream processing.
3. An array consists of some elements A=8,10,… and the size of array is set to 10. Check whether 96, 21 lies in the array or not. [Hash functions: 3x+3 mod6, 3x+7mod8, 2x+9 mod2, 2x+3mod5]

Course Outcome 3 (CO3):

1. Explain the components of Hadoop.
2. Illustrate map reduce job execution flow.
3. Explain HBase client ecosystem.

Course Outcome 4 (CO4):

1. Explain two execution types or modes in PIG.
2. Summarize any three relational operations in Pig Latin with examples
3. Illustrate managed tables and external tables in HIVE.

Course Outcome 5 (CO5):

1. Illustrate any three R functions used in data analytics.
2. Explain the different categories of attributes and data types in R.
3. Write a short note about how the different types of files can be read and write in R.

Model Question Paper

QP CODE: **PAGES : 3**

Reg No: _______________Name: _________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: ADT302

Course Name: Concepts In Big Data Analytics

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. How are big data and hadoop related to each other?
2. What are the 5 Vs of Big Data
3. Explain the features and column families of HBase.
4. Compare the specific file types of HDFS.
5. How does Map Reduce Framework provide support for application development?
6. Describe the Map Reduce job implementation in the case of Road Enrichment example.
7. Describe Filtering Streams.
8. Explain about the partitioned and managed tables in Hive.
9. Identify the ways in which a pig program can be executed.
10. Discuss the general list operations in R with example. **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Illustrate Big Data Architecture. **(10)**

(b) Compare conventional Data and Big Data **(4)**

OR

12. (a) Explain the life cycle of big data analytics in detail. **(10)**

(b) Compare the types of Big Data with examples. **(4)**

13. (a) Suppose we have a window of length N (say N=24) on a binary system, we want at all times to be able to answer a query of the form “ How many 1’s are there in the last K bits?” for K<=N. Suggest an algorithm to solve this issue with detailed explanation. Find the total number of ones, when 0111 enters into the given stream ….101011000101110110010110…. (Assume, the new **(8)**

bit enters from the right side and time stamp of first new bit is 100)

(b) Write the advantages and disadvantages of Data Stream. **(8)**

OR

14. (a) Illustrate the working of Bloom filter with examples for **(10)**
i) Inserting an element
ii) Searching an element.

(b) Why is conventional data processing insufficient for stream processing? **(4)**

15. (a) Explain the data model and architecture of HBase. **(10)**

(b) Discuss on the general guidelines for HBase Schema Design. **(4)**

OR

16. (a) Explain the anatomy of MapReduce Job run using classic MapReduce **(6)**

(b) Explain the types of Schedulers available in YARN. **(8)**

17. (a) Explain the main components of Hadoop Pig framework. **(4)**

(b) Write the syntax to create a table and partition in Hive. **(10)**

OR

18. (a) Describe about Data Types and File Formats in Hive. **(8)**

(b) Write about Pig Latin Structure and functions **(6)**

19. (a) Explain in detail about the Matrix handling in R. **(8)**

(b) List and explain four R functions used in descriptive statistics. **(6)**

OR

20. (a) Discuss the data visualization for multiple variables in R **(8)**

(b) Describe the R functions used for cleaning dirty data **(6)**

Teaching Plan

No	Contents	No of Lecture Hrs (45)
	Module – 1(Introduction to Big Data) (9 hrs)	
1.1	Introduction to Big data, Conventional Data vs Big data	1
1.2	Big data architecture	1
1.3	Big data platforms	1
1.4	Nature of data,	1
1.5	Analytic processes and tools.	1
1.6	5 V's of Big data	1
1.7	Big data analytical method	1
1.8	Intelligent data analysis	1
1.9	Big data analytics life cycle	1
	Module – 2 (Introduction to Stream Computing) (8 hrs)	
2.1	Introduction to stream concepts	1
2.2	Streaming data architecture.	1
2.3	Stream data model	1
2.4	Sampling techniques for efficient stream processing	1
2.5	Filtering streams – Bloom filter	1
2.6	Count distinct problem - Flajolet martin algorithm	1
2.7	Estimating moments	1
2.8	Counting oneness in a window – DGIM algorithm	1
	Module - 3 (Hadoop Distributed File System) (13 hrs)	
3.1	History of Hadoop	1

3.2	Hadoop Ecosystem and Core Components	1
3.3	HDFS Architecture	1
3.4	Using HDFS Files ,HDFS Design	1
3.5	Blocks, Namenodes and Data nodes	1
3.6	Basic File system Operations	1
3.7	Hadoop Specific File Types	1
3.8	Anatomy of a file read	1
3.9	Anatomy of a file write	1
3.10	Execution pipeline	1
3.11	Runtime Coordination and Task Management in MapReduce	1
3.12	Using MapReduce as a framework for parallel processing	1
3.13	Road Enrichment Example	1
	Module - 4 (Pig, Hive, Hbase) (7 hrs)	
4.1	Pig : Introduction to PIG, Execution Modes of Pig	1
4.2	Comparison of Pig with Databases, Grunt.	1
4.3	Pig Latin, User Defined Functions, Data Processing operators	1
4.4	Hive : Hive Shell, Hive Services	1
4.5	Hive Metastore, Comparison with Traditional Databases.	1
4.6	HiveQL, Tables, Querying Data and User Defined Functions.	1
4.7	Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS.	1
	Module - 5 (Introduction to R programming) (8 hrs)	
5.1	Introduction to R – Overview of modern data analytic tools, Introduction to R, R Graphical User Interfaces	1
5.2	Features of R Language, Vectors	1
5.3	Filtering and Creating Matrices	1

5.4	Applying Functions to Matrix Rows and Columns	1
5.5	Creating List and General List Operations	1
5.6	Examining Multiple Variable	1
5.7	Creating Data Frames and Matrix like Operations in Frames	1
5.8	Applying Functions to Data Frames and Reading and Writing Files	1

AIT304	ROBOTICS AND INTELLIGENT SYSTEM	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2022

Preamble: This course enables the learners to understand the fundamental concepts and algorithms in Robotics and Intelligent systems. The course covers the standard hardware and kinematic concepts for robot design. Standard algorithms for localization, mapping, path planning, navigation and obstacle avoidance, to incorporate intelligence in robots are included in the course. This course helps the students to design robots with intelligence in a real world environment.

Prerequisite: Basic understanding of probability theory, linear algebra, machine learning, artificial intelligence

Course Outcomes: After the completion of the course the student will be able to

CO1	Understand the concepts of manipulator and mobile robotics. **(Cognitive Knowledge Level: Understand)**
CO2	Choose the suitable sensors, actuators and control for robot design. **(Cognitive Knowledge Level: Apply)**
CO3	Developing kinematic model of mobile robot and understand robotic vision intelligence. **(Cognitive Knowledge Level: Apply)**
CO4	Discover the localization and mapping methods in robotics. **(Cognitive Knowledge Level: Apply)**
CO5	Plan the path and navigation of robot by applying artificial intelligence algorithm. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓				✓	✓						✓
CO2	✓	✓			✓							✓
CO3	✓	✓		✓	✓	✓						✓
CO4	✓			✓	✓	✓						✓
CO5	✓			✓	✓	✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of Internal Tests 1 & 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carries 14 marks.

SYLLABUS

Module – 1 (Introduction to robotics)

Introduction to robotics – Degrees of freedom, Robot types- Manipulators- Anatomy of a robotic manipulator-links, joints, actuators, sensors, controllers. Robot configurations-PPP, RPP, RRP, RRR. Mobile robots- wheeled, legged, aerial robots, underwater robots, surface water robots . Dynamic characteristics- speed of motion, load carrying capacity & speed of response. Introduction to End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and Passive grippers. Ethics in robotics - 3 laws - applications of robots.

Module - 2(Sensors, Actuators and Control)

Sensor classification- touch, force, proximity, vision sensors. Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, non contact type; Digital Camera - CCD camera - CMOS camera - Omnidirectional cameras
Sensor characteristics. Actuators - DC Motors - H-Bridge - Pulse Width Modulation - Stepper Motors – Servos, Hydraulic & pneumatic actuators. Control - On-Off Control - PID Control - Velocity Control and Position Control

Module – 3 (Robotic vision & Kinematics)

Robotic Vision: Sensing, Pre-processing, Segmentation, Description, Recognition, Interpretation, Feature extraction -Camera sensor hardware interfacing. Representation of Transformations - Representation of a Pure Translation - - Pure Rotation about an Axis - Combined Transformations - Transformations Relative to the Rotating Frame.

Basic understanding of Differential-Drive Wheeled Mobile Robot, Car-Like Wheeled Mobile Robot. Kinematic model of a differential drive and a steered mobile robot, Degree of freedom and manoeuvrability, Degree of steerability, Degree of mobility - different wheel configurations, holonomic and nonholonomic robots. Omnidirectional Wheeled Mobile Robots.

Module - 4 (Localization and Mapping)

Position and Orientation - Representing robot position. Basics of reactive navigation; Robot Localization, Challenges in localization - An error model for odometric position estimation

Map Representation - Continuous representations - Decomposition strategies - Current challenges in map representation. Probabilistic map-based localization (only Kalman method), Autonomous map building, Simultaneous localization and mapping (SLAM) - Mathematical definition of SLAM - Visual SLAM with a single camera - Graph-based SLAM - Particle filter SLAM - Open challenges in SLAM

Module - 5 (Path Planning and Navigation)

Path Planning- Graph search, deterministic graph search - , breadth first search - depth first search- Dijkstra' s algorithm, A*, D* algorithms, Potential field based path planning. Obstacle avoidance - Bug algorithm - Vector Field Histogram - Dynamic window approaches. Navigation Architectures - Modularity for code reuse and sharing - Control localization - Techniques for decomposition. Alternatives for navigation - Neural networks - Processing the image - Training the neural network for navigation - Convolutional neural network robot control implementation

Text Books

1. R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots ,, MIT Press, USA, 2011
2. Thomas Bräunl - Embedded Robotics,Mobile Robot Design and Applications with Embedded Systems-Springer (2006)
3. S.G. Tzafestas - Introduction to Mobile Robot Control-Elsevier (2014)
4. Francis X. Govers - Artificial Intelligence for Robotics-Packt Publishing (2018)
5. Saeed B. Niku - Introduction to Robotics_ Analysis, Control, Applications

Reference Books

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005
2. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
3. Peter Corke - Robotics, Vision and Control_ Fundamental Algorithms in MATLAB® - Springer-Verlag Berlin Heidelberg (2021)

Course Level Assessment Questions

Course Outcome1 (CO1):

1. Categorise the various types of Grippers used in robot manipulators.
2. Differentiate between active and passive grippers.
3. Explain speed of motion and load carrying capacity of a mobile robot.
4. You wish to build a dynamically stable robot with a single wheel only. For each of the four basic wheel types, explain whether or not it may be used for such a robot.

Course Outcome 2(CO2):

1. Categorise the sensors used in robotics
2. Explain any four characteristics of a sensor
3. Illustrate the sensor performance measuring parameters
4. Suggest any two mechanism to realise 360^o Camera

Course Outcome 3(CO3):

1. Determine the degrees of mobility, steerability, and maneuverability for each of the following: (a) bicycle; (b) dynamically balanced robot with a single spherical wheel (c) automobile.
2. A frame F was rotated about the y-axis 90^o, followed by a rotation about the o-axis of 30^o, followed by a translation of 5 units along the n-axis, and finally, a translation of 4 units along the x-axis. Find the total transformation matrix.
3. Explain the camera sensor hardware interfacing.
4. What is an omni directional robot? Explain two configurations to set up an omni directional robot.

Course Outcome 4(CO4): .

1. Explain the challenges of localization
2. How Kalman method can be used in localization of mobile robots
3. What are the Decomposition strategies in map representation
4. How Visual SLAM can be performed with a single camera

Course Outcome 5(CO5):

1. Explain Dijkstra's algorithm with a suitable example.
2. Identify the steps of Generic temporal decomposition of a navigation architecture.
3. What is meant by control decomposition? Explain two types of control decomposition.
4. Why does SLAM work better with wheel odometer data available?

5. In the Floor Finder algorithm, what does the Gaussian blur function does to improve the results?

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT304

Course Name: ROBOTICS AND INTELLIGENT SYSTEM

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. What do you mean by degrees of freedom? How many degrees of freedom are required for a drone to achieve any position in 3D space? And how many more DOF required for achieving any orientation as well.

2. Explain how leg configuration affects the stability of mobile robot.

3. Explain Dynamic range, Linearity and Resolution of a Sensor.

4. Explain the working of a Mechanical accelerometer with a block diagram

5. Differentiate between holonomic and nonholonomic robots.

6. What is the significance of differential drive in mobile robot?

7. How will you represent the position and orientation of a wheeled mobile robot?

8. Identify the 2 mobile robot localization problems.

9. Explain the Bug algorithm for obstacle avoidance. .

10. What is Voronoi diagram method and its advantages? **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Explain the general features of wheeled, legged and aerial robots. **(9)**

(b) Explain the anatomy of a robotic manipulator with a neat diagram. **(5)**

OR

12. (a) Briefly explain the dynamic characteristics of robots. **(9)**

(b) Assume an object of mass 140 kg is to be lifted up with an acceleration of 10 m/s2. Calculate the gripper force required for the operation, if coefficient of friction between contact surfaces is 0.2, number of fingers in gripper is 2 and acceleration due to gravity is 9.8 m/s2 **(5)**

13. (a) Explain the working of an Optical Encoder. **(5)**

(b) A mobile robot is designed for unidirectional motion with constant velocity. Illustrate the mechanism to make the robot move in forward and reverse direction with variable speed. Support with necessary diagrams **(9)**

OR

14. (a) Compare and contrast the working of CCD and CMOS camera **(9)**

(b) Illustrate the significance of the PID controller with a neat block diagram **(5)**

15. (a) Outline the seven stages of robot vision. **(14)**

OR

16. (a) Derive the kinematic model of a differential drive mobile robot. **(7)**

(b) A frame B was rotated about the x-axis 90^o, then it was translated about the current a-axis 3 inches before it was rotated about the z-axis 90^o. Finally, it was translated about the current o–axis 5 inches. **(7)**

(a) Write an equation that describes the motions.

(b) Find the final location of a point p(1,5,4)T attached to the frame relative to the reference frame.

17. (a) Derive error model for odometric position estimation **(8)**

(b) Illustrate the SLAM problem with suitable diagrams **(6)**

OR

18. (a) Compare and Contrast graph based and particle SLAM **(8)**

(b) Describe the concept of mobile robot localization with suitable Block diagrams **(6)**

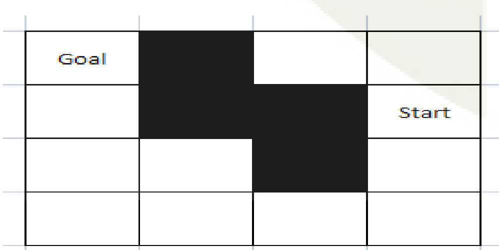
19. (a) Compare and contrast local and global Dynamic window approaches in obstacle avoidance. **(7)**

(b) Explain the concepts of floor finding Algorithm **(7)**

OR

20. (a) Illustrate the Incorporation of Neural network approach in Robot navigation? List its advantages **(6)**

(b) Make the robot to run from start position to goal position in the Following diagram using A* Algorithm **(8)**



TEACHING PLAN

No	Contents	No. of Lecture Hours (45 hrs)
Module-1 (Introduction to robotics) (8 hours)		
1.1	Introduction to robotics – Degrees of freedom - Robot types	1 hour
1.2	Manipulators- Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller	1 hour
1.3	Robot configurations-PPP, RPP, RRP, RRR- Mobile robots- wheeled	1 hour
1.4	Legged robots, Aerial robots, underwater robots, surface water robots -	1 hour
1.5	Dynamic characteristics of robot- speed of motion, load carrying capacity & speed of response	1 hour
1.6	Introduction to End effectors - mechanical grippers, special tools, Magnetic grippers	1 hour
1.7	Vacuum grippers, adhesive grippers, Active and Passive grippers	1 hour
1.8	Ethics in robotics - 3 laws - applications of robots	1 hour
Module-2 (Sensors, Actuators and Control) (9 hours)		
2.1	Sensor classification- touch, force, proximity, vision sensors.	1 hour
2.2	Internal sensors-Position sensors, velocity sensors	1 hour
2.3	Acceleration sensors, Force sensors;	1 hour
2.4	External sensors-contact type, non-contact type	1 hour

2.5	Digital Camera - CCD camera - CMOS camera	1 hour
2.6	Omnidirectional cameras - Sensor characteristics	1 hour
2.7	Actuators - DC Motors - H-Bridge - Pulse Width Modulation	1 hour
2.8	Stepper Motors – Servos - Control - On-Off Control	1 hour
2.9	PID Control - Velocity Control and Position Control	1 hour
Module-3 (Robotic vision & Kinematics) (9 hours)		
3.1	Robot Vision: Sensing, Pre-processing, Segmentation, Description	1 hour
3.2	Recognition, Interpretation, Feature extraction -Camera sensor hardware interfacing	1 hour
3.3	Representation of Transformations - Representation of a Pure Translation - Pure Rotation about an Axis	1 hour
3.4	Combined Transformations - Transformations Relative to the Rotating Frame	1 hour
3.5	Basic understanding of Differential Drive Wheeled Mobile Robot - Car Like Wheeled Mobile Robot	1 hour
3.6	Kinematic model of a differential drive and a steered mobile robot.	1 hour
3.7	Degree of freedom and manoeuvrability, Degree of steerability	1 hour
3.8	Degree of mobility, Different wheel configurations	1 hour
3.9	Holonomic and Nonholonomic robots, Omnidirectional Wheeled Mobile Robots	1 hour
Module-4 (Localization and Mapping) (9 hours)		

4.1	Position and Orientation - Representing robot position, Basics of reactive navigation	1 hour
4.2	Robot Localization, Challenges in localization	1 hour
4.3	An error model for odometric position estimation	1 hour
4.4	Map Representation - Continuous representations - Decomposition strategies	1 hour
4.5	Current challenges in map representation, Probabilistic map-based localization (only Kalman method)	1 hour
4.6	Probabilistic map-based localization (only Kalman method)	1 hour
4.7	Autonomous map building, Simultaneous localization and mapping (SLAM) - Mathematical definition of SLAM	1 hour
4.8	Visual SLAM with a single camera - Graph-based SLAM	1 hour
4.9	Particle filter SLAM - Open challenges in SLAM	1 hour
Module-5 (Path Planning and Navigation) (10 hours)		
5.1	Path Planning- Graph search	1 hour
5.2	Deterministic graph search - breadth first search - depth first search- Dijkstra's algorithm	1 hour
5.3	A*, D* algorithms, Potential field based path planning	1.5 hour
5.4	Obstacle avoidance - Bug algorithm - Vector Field Histogram - Dynamic window approaches	1.5 hour

5.5	Navigation Architectures - Modularity for code reuse and sharing - Control localization - Techniques for decomposition	1 hour
5.6	Alternatives for navigation - Neural networks	1 hour
5.7	Processing the image - Training the neural network for navigation	1.5 hour
5.8	Training the neural network for navigation - Convolutional neural network robot control implementation	1.5 hour

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CST 306	ALGORITHM ANALYSIS AND DESIGN	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2019

Preamble:

The course introduces students to the design of computer algorithms, as well as analysis of algorithms. Algorithm design and analysis provide the theoretical backbone of computer science and are a must in the daily work of the successful programmer. The goal of this course is to provide a solid background in the design and analysis of the major classes of algorithms. At the end of the course students will be able to develop their own versions for a given computational task and to compare and contrast their performance.

Prerequisite:

Strong Foundation in Mathematics, Programming in C, Data Structures and Graph Theory.

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Analyze any given algorithm and express its time and space complexities in asymptotic notations. **(Cognitive Level: Apply)**
CO2	Derive recurrence equations and solve it using Iteration, Recurrence Tree, Substitution and Master's Method to compute time complexity of algorithms. **(Cognitive Level: Apply)**
CO3	Illustrate Graph traversal algorithms & applications and Advanced Data structures like AVL trees and Disjoint set operations. **(Cognitive Level: Apply)**
CO4	Demonstrate Divide-and-conquer, Greedy Strategy, Dynamic programming, Branch-and Bound and Backtracking algorithm design techniques (**Cognitive Level: Apply)**
CO5	Classify a problem as computationally tractable or intractable, and discuss strategies to address intractability **(Cognitive Level: Understand)**
CO6	Identify the suitable design strategy to solve a given problem. **(Cognitive Level: Analyze)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓								✓
CO4	✓	✓	✓	✓								✓
CO5	✓	✓										√
CO6	✓	✓	✓	✓								✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40

Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests (Average of SeriesTests1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module-1 (Introduction to Algorithm Analysis)

Characteristics of Algorithms, Criteria for Analysing Algorithms, Time and Space Complexity - Best, Worst and Average Case Complexities, Asymptotic Notations - Big-Oh (O), Big- Omega (Ω), Big-Theta (Θ), Little-oh (o) and Little- Omega (ω) and their properties. Classifying functions by their asymptotic growth rate, Time and Space Complexity Calculation of simple algorithms.

Analysis of Recursive Algorithms: Recurrence Equations, Solving Recurrence Equations – Iteration Method, Recursion Tree Method, Substitution method and Master's Theorem (Proof not required).

Module–2 (Advanced Data Structures and Graph Algorithms)

Self Balancing Tree - AVL Trees (Insertion and deletion operations with all rotations in detail, algorithms not expected); Disjoint Sets- Disjoint set operations, Union and find algorithms.

DFS and BFS traversals - Analysis, Strongly Connected Components of a Directed graph, Topological Sorting.

Module–3 (Divide & Conquer and Greedy Strategy)

The Control Abstraction of Divide and Conquer- 2-way Merge sort, Strassen's Algorithm for Matrix Multiplication-Analysis. The Control Abstraction of Greedy Strategy- Fractional Knapsack Problem, Minimum Cost Spanning Tree Computation- Kruskal's Algorithms - Analysis, Single Source Shortest Path Algorithm - Dijkstra's Algorithm-Analysis.

Module-4 (Dynamic Programming, Back Tracking and Branch & Bound))

The Control Abstraction- The Optimality Principle- Matrix Chain Multiplication-Analysis, All Pairs Shortest Path Algorithm - Floyd-Warshall Algorithm-Analysis. The Control Abstraction of Back Tracking – The N Queen's Problem. Branch and Bound Algorithm for Travelling Salesman Problem.

Module-5 (Introduction to Complexity Theory)

Tractable and Intractable Problems, Complexity Classes – P, NP, NP- Hard and NP-Complete Classes- NP Completeness proof of Clique Problem and Vertex Cover Problem- Approximation algorithms- Bin Packing, Graph Coloring. Randomized Algorithms (Definitions of Monte Carlo and Las Vegas algorithms), Randomized version of Quick Sort algorithm with analysis.

Text Books

1. T.H.Cormen, C.E.Leiserson, R.L.Rivest, C. Stein, Introduction to Algorithms, 2nd Edition, Prentice-Hall India (2001)
2. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", 2nd Edition, Orient Longman Universities Press (2008)

3. Sara Baase and Allen Van Gelder ―Computer Algorithms, Introduction to Design and Analysis, 3rd Edition, Pearson Education (2009)

Reference Books

1. Jon Kleinberg, Eva Tardos, "Algorithm Design", First Edition, Pearson (2005)
2. Robert Sedgewick, Kevin Wayne, "Algorithms",4th Edition Pearson (2011)
3. GIlles Brassard, Paul Brately, "Fundamentals of Algorithmics", Pearson (1996)
4. Steven S. Skiena, "The Algorithm Design Manual", 2nd Edition, Springer(2008)

Course Level Assessment Questions

Course Outcome 1 (CO1):

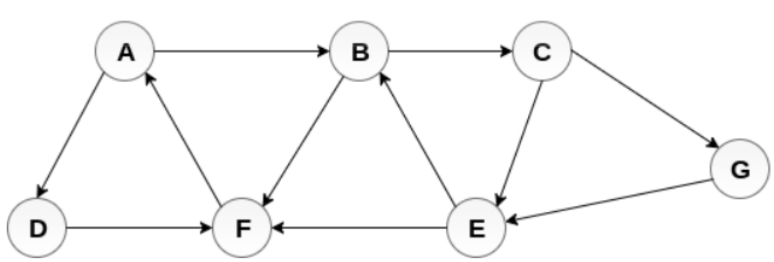
1. Is $2^{n+1} = O(2^n)$? Is $2^{2n} = O(2^n)$? Justify your answer.
2. What is the need of asymptotic analysis in calculating time complexity? What are the notations used for asymptotic analysis?
3. Calculate the time complexity for addition of two matrices.
4. Define time complexity and space complexity. Write an algorithm for adding n natural numbers and analyse the time and space requirements of the algorithm.

Course Outcome 2 (CO2):

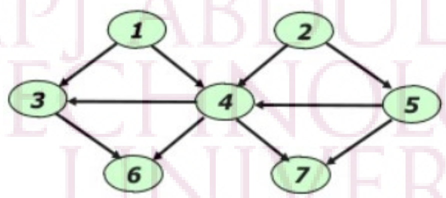
1. State Master's theorem for solving recurrences.
2. Solve the recurrence T(n) = 3T(n-2), using iteration method
3. State the conditions in recurrences where Master Theorem is not applicable.
4. Solve the following recurrence equations using Master's theorem.
   a) $T(n) = 8T(n/2) + 100 n^2$
   b) $T(n) = 2T(n/2) + 10 n$
5. Using Recursion Tree method, Solve $T(n)= 2T(n/10)+ T(9n/10)+n$. Assume constant time for small values of n.

Course Outcome 3 (CO3):

1. Explain the rotations performed for insertion in AVL tree with example.
2. Write down BFS algorithm and analyse the time complexity. Perform BFS traversal on the given graph starting from node A. If multiple node choices are available for next travel, choose the next node in alphabetical order.

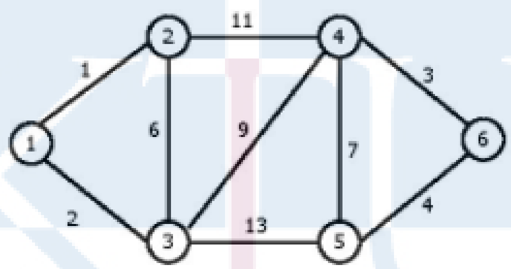


3. Find the minimum and maximum height of any AVL-tree with 7 nodes? Assume that the height of a tree with a single node is 0. (3)
4. Find any three topological orderings of the given graph.

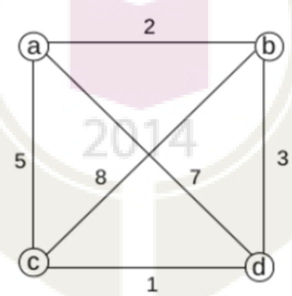


Course Outcome 4 (CO4):

1. Give the control abstraction for Divide and Conquer method.
2. Construct the minimum spanning tree for the given graph using Kruskal's algorithm. Analyse the complexity of the algorithm.



3. Compare Divide and Conquer and Dynamic programming methodologies
4. What is Principle of Optimality?
5. Define Travelling Salesman Problem (TSP). Apply branch and bound algorithm to solve TSP for the following graph, assuming the start city as 'a'. Draw the state space tree.



Course Outcome 5 (CO5):

1. Compare Tractable and Intractable Problems
2. With the help of suitable code sequence convince Vertex Cover Problem is an example of NP-Complete Problem

3. Explain Vertex Cover problem using an example. Suggest an algorithm for finding Vertex Cover of a graph.
4. Write short notes on approximation algorithms.
5. Compare Conventional quick sort algorithm and Randomized quicksort with the help of a suitable example?

Course Outcome 6 (CO6): (CO attainment through assignment only, not meant for examinations)

Choosing the best algorithm design strategy for a given problem after applying applicable design strategies – Sample Problems Given.

1. Finding the Smallest and Largest elements in an array of ‘n’ numbers
2. Fibonacci Sequence Generation.
3. Merge Sort
4. Travelling Sales Man Problem
5. 0/1 Knapsack Problem

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 306

Course Name: Algorithm Analysis and Design

Max. Marks : 100 **Duration: 3 Hours**

PART A

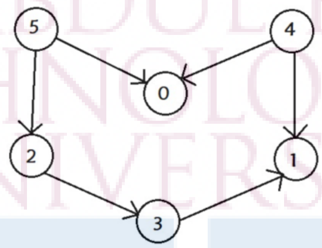
Answer All Questions. Each Question Carries 3 Marks

1. Define asymptotic notation? Arrange the following functions in increasing order of asymptotic growth rate.

   $n^3, 2^n, \log n^3, 2^{100}, n^2 \log n, n^n, \log n, n^{0.3}, 2^{\log n}$

2. State Master's Theorem. Find the solution to the following recurrence equations using Master's theorem.
   a) $T(n) = 8T(n/2) + 100\, n^2$
   b) $T(n) = 2T(n/2) + 10\, n$

3. Find any two topological ordering of the DAG given below.



4. Show the UNION operation using linked list representation of disjoint sets.

5. Write the control abstraction of greedy strategy to solve a problem.

6. Write an algorithm based on divide-and-conquer strategy to search an element in a given list. Assume that the elements of list are in sorted order.

7. List the sequence of steps to be followed in Dynamic Programming approach.

8. Illustrate how optimal substructure property could be maintained in Floyd-Warshall algorithm.

9. Differentiate between P and NP problems.

10. Specify the relevance of approximation algorithms.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Define Big O, Big Ω and Big Θ Notation and illustrate them graphically. **(7)**

    (b) Solve the following recurrence equation using recursion tree method **(7)**

$$T(n) = T(n/3) + T(2n/3) + n \text{ , where } n>1$$
$$T(n) = 1\text{, Otherwise}$$

OR

12. (a) Explain the iteration method for solving recurrences and solve the following recurrence equation using iteration method. **(7)**

$$T(n) = 3T(n/3) + n; \; T(1) = 1$$

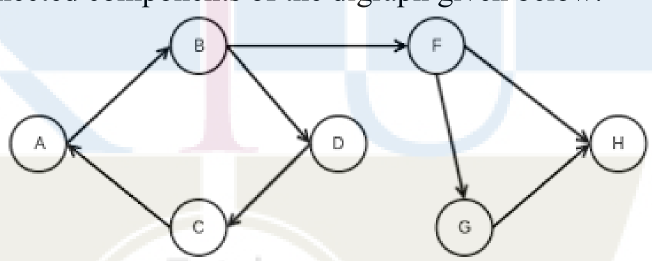
(b) Determine the time complexities of the following two functions fun1( ) and fun2( ). **(7)**

i)
```
int fun1(int n)
{
    if (n <= 1) return n;
    return 2*fun1(n-1);
}
```

ii)
```
int fun2 (int n)
{
    if (n <= 1) return n;
    return fun2 (n-1) + fun2 (n-1)
}
```

13. (a) Write DFS algorithm and analyse its time complexity. Illustrate the classification of edges in DFS traversal. **(7)**

(b) Find the strongly connected components of the digraph given below: **(7)**



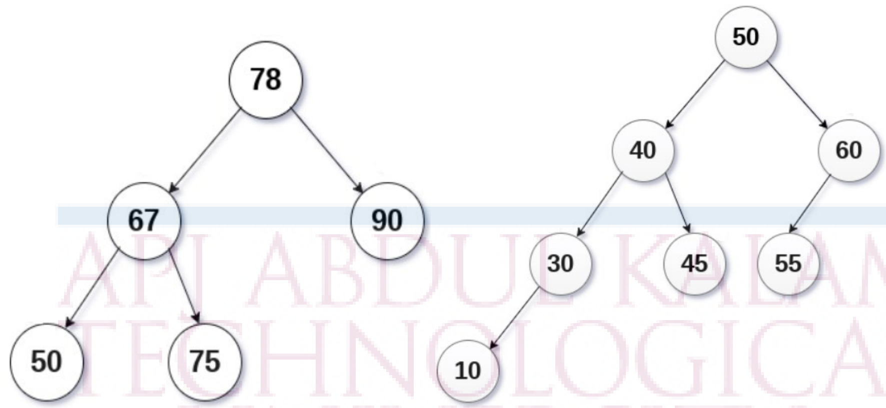
OR

14. (a) Illustrate the advantage of height balanced binary search trees over binary search trees? Explain various rotations in AVL trees with example. **(7)**

(b) Perform the following operations in the given AVL trees. **(7)**

i) Insert 70

ii) Delete 55



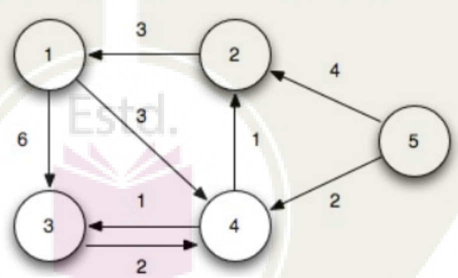
15. (a) State Fractional Knapsack Problem and write Greedy Algorithm for Fractional Knapsack Problem. **(7)**

(b) Find the optimal solution for the following Fractional Knapsack problem. Given the number of items(n) = 7, capacity of sack(m) = 15, W={2,3,5,7,1,4,1} and P = {10,5,15,7,6,18,3} **(7)**

OR

16. (a) Write and explain merge sort algorithm using divide and conquer strategy using the data {30, 19, 35, 3, 9, 46, 10}. Also analyse the time complexity. **(7)**

(b) Write the pseudo code for Dijkstra's algorithm. Compute the shortest distance from vertex 1 to all other vertices using Dijkstra's algorithm. **(7)**



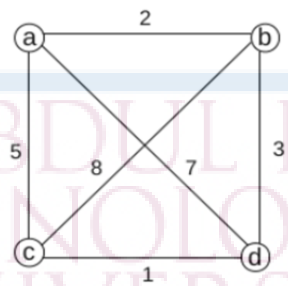
17. (a) Write Floyd-Warshall algorithm and analyse its complexity. **(5)**

(b) Write and explain the algorithm to find the optimal parenthesization of matrix chain product whose sequence of dimension is 4x10,10x3, 3x12,12x20. **(9)**

OR

18. (a) Explain the concept of Backtracking method using 4 Queens problem. **(7)**

(b) Define Travelling Salesman Problem (TSP). Apply branch and bound algorithm to solve TSP for the following graph, assuming the start city as ‘a’. Draw the state space tree. **(7)**



19. (a) State bin packing problem? Explain the first fit decreasing strategy **(7)**

(b) Prove that the Clique problem is NP-Complete. **(7)**

OR

20. (a) Explain the need for randomized algorithms. Differentiate Las Vegas and Monte Carlo algorithms. **(6)**

(b) Explain randomized quicksort and analyse the expected running time of randomized quicksort with the help of a suitable example? **(9)**

Teaching Plan

No	Topic	No. of Hours (45 hrs)
	Module -1 (Introduction to Algorithm Analysis) 9 hrs.	
1.1	Introduction to Algorithm Analysis: Characteristics of Algorithms.	1 hour
1.2	Criteria for Analysing Algorithms, Time and Space Complexity - Best, Worst and Average Case Complexities.	1 hour
1.3	Asymptotic Notations - Properties of Big-Oh (O), Big- Omega (Ω), Big-Theta (Θ), Little-Oh (o) and Little- Omega (ω).	1 hour
1.4	Illustration of Asymptotic Notations	1 hour

1.5	Classifying functions by their asymptotic growth rate	1 hour
1.6	Time and Space Complexity Calculation of algorithms/code segments.	1 hour
1.7	Analysis of Recursive Algorithms: Recurrence Equations, Solving Recurrence Equations – Iteration Method.	1 hour
1.8	Recursion Tree Method	1 hour
1.9	Substitution method and Master's Theorem and its Illustration.	1 hour
Module-2 (Advanced Data Structures and Graph Algorithms) 10 Hrs.		
2.1	Self Balancing Trees - Properties of AVL Trees, Rotations of AVL Trees	1 hour
2.2	AVL Trees Insertion and Illustration	1 hour
2.3	AVL Trees Deletion and Illustration	1 hour
2.4	Disjoint set operations.	1 hour
2.5	Union and find algorithms.	1 hour
2.6	Illustration of Union and find algorithms	1 hour
2.7	Graph Algorithms: BFS traversal, Analysis.	1 hour
2.8	DFS traversal, Analysis.	1 hour
2.9	Strongly connected components of a Directed graph.	1 hour
2.10	Topological Sorting.	1 hour
Module-3 (Divide & Conquer and Greedy Method) 8 Hrs		
3.1	Divide and Conquer: The Control Abstraction.	1 hour
3.2	2-way Merge Sort, Analysis.	1 hour
3.3	Strassen's Algorithm for Matrix Multiplication, Analysis	1 hour

3.4	Greedy Strategy: The Control Abstraction.	1 hour
3.5	Fractional Knapsack Problem.	1 hour
3.6	Minimum Cost Spanning Tree Computation- Kruskal's Algorithm, Analysis.	1 hour
3.7	Single Source Shortest Path Algorithm - Dijkstra's Algorithm	1 hour
3.8	Illustration of Dijkstra's Algorithm-Analysis.	1 hour
Module-4 (Dynamic Programming, Back Tracking and Branch and Bound) 8 Hrs.		
4.1	Dynamic Programming: The Control Abstraction, The Optimality Principle.	1 hour
4.2	Matrix Chain Multiplication-Analysis.	1 hour
4.3	Illustration of Matrix Chain Multiplication-Analysis.	1 hour
4.4	All Pairs Shortest Path Algorithm- Analysis and Illustration of Floyd-Warshall Algorithm.	1 hour
4.5	Back Tracking: The Control Abstraction .	1 hour
4.6	Back Tracking: The Control Abstraction – The N Queen's Problem.	1 hour
4.7	Branch and Bound:- Travelling salesman problem.	1 hour
4.8	Branch and Bound:- Travelling salesman problem.	1 hour
Module-5 (Introduction to Complexity Theory) 10 Hrs		
5.1	Introduction to Complexity Theory: Tractable and Intractable Problems.	1 hour
5.2	Complexity Classes – P, NP.	1 hour
5.3	NP- Hard and NP-Complete Problems.	1 hour
5.4	NP Completeness Proof of Clique Problem.	1 hour

5.5	NP Completeness Proof of Vertex Cover Problem.	1 hour
5.6	Approximation algorithms- Bin Packing Algorithm and Illustration.	1 hour
5.7	Graph Colouring Algorithm and Illustration.	1 hour
5.8	Randomized Algorithms (definitions of Monte Carlo and Las Vegas algorithms).	1 hour
5.9	Randomized Version of Quick Sort Algorithm with Analysis.	1 hour
5.10	Illustration of Randomized Version of Quick Sort Algorithm with Analysis.	1 hour

ADT308	COMPREHENSIVE COURSE WORK	Category	L	T	P	Credit	Year of Introduction
		PCC	1	0	0	1	2019

Preamble: The objective of this Course work is to ensure the comprehensive knowledge of each studentinthemostfundamentalcorecoursesinthecurriculum.Five core courses credited from semesters 3, 4 and 5 are chosen for the detailed study in this course work. This course helps the learner to become competent in cracking GATE, placement tests and other competitive examinations.

Prerequisite:

1. **Introduction to Machine Learning**
2. **Data Structures**
3. **Operating Systems**
4. **Database Management Systems**
5. **Foundation of Data Science**

Course Outcomes: After the completion of the course the student will be able to

CO1:	Comprehend the concepts in machine learning (Cognitive Knowledge Level: **Understand)**
CO2:	Comprehend the concepts and applications of data structures (Cognitive Knowledge Level: **Understand)**
CO3 :	Comprehend the concepts, functions and algorithms in Operating System (Cognitive Knowledge Level: **Understand)**)
CO4:	Comprehend the fundamental principles of database design and manipulation (Cognitive Knowledge Level: **Understand**)
CO5:	Comprehend the basic concepts of data science (Cognitive Knowledge Level: **Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔										✔
CO2	✔	✔										✔
CO3	✔	✔										✔
CO4	✔	✔										✔
CO5	✔	✔										✔

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	**10**
Understand	**20**
Apply	**20**
Analyse	
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
50	**0**	**50**	**1 hour**

End Semester Examination Pattern: Objective Questions with multiple choice, a maximum of four options. Question paper include fifty questions of one mark each, distributed equally from all the five identified courses.

SYLLABUS

Full Syllabus of all five selected Courses.

1. **Introduction to Machine Learning**
2. **Data Structures**
3. **Operating Systems**
4. **Database Management Systems**
5. **Foundation of Data Science**

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**INTRODUCTION TO MACHINE LEARNING**	
1.1	Mock Test on Module 1, Module 2 and Module 3	1 hour
1.2	Mock Test on Module 4 and Module 5	1 hour
1.3	Feedback and Remedial class	1 hour
2	**DATA STRUCTURES**	
2.1	Mock Test on Module 1, Module 2 and Module 3	1 hour
2.2	Mock Test on Module 4 and Module 5	1 hour
2.3	Feedback and Remedial class	1 hour
3	**OPERATING SYSTEMS**	
3.1	Mock Test on Module 1 and Module 2	1 hour
3.2	Mock Test on Module 3, Module 4 and Module 5	1 hour
3.3	Feedback and Remedial class	1 hour
4	**DATABASE MANAGEMENT SYSTEMS**	
4.1	Mock Test on Module 1, Module 2 and Module 3	1 hour
4.2	Mock Test on Module 4 and Module 5	1 hour

4.3	Feedback and Remedial class	1 hour
5	**FOUNDATIONS OF DATA SCIENCE**	
5.1	Mock Test on Module 1, Module 2 and Module 3	1 hour
5.2	Mock Test on Module 4 and Module 5	1 hour
5.3	Feedback and Remedial class	1 hour

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES :7**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: ADT308

Course Name: Comprehensive Course Work

Max. Marks: 50 **Duration: 1 Hour**

Objective type questions with multiple choices. Mark one correct answer for each question. Each Question Carries 1 Mark

1. Application of machine learning methods to large databases is called

   (A) Data Mining (B) Artificial Intelligence

   (C) Big Data Computing (D) Internet of Things

2. If machine learning model output involves target variable, then that model is called as

   (A) Descriptive Model (B) Predictive Model

   (C) Reinforcement Learning (D) All of the above

3. In what type of learning labelled training data is used

   (A) Unsupervised Learning (B) Supervised Learning

   (C) Reinforcement Learning (D) Active Learning

4. In following type of feature selection method we start with empty feature set

(A) Forward Feature Selection (B) Backward Feature Selection

(C) Both A and B (D) None of the above

5. Which of the following is the best machine learning method?

(A) Scalable (B) Accuracy

(C) Fast (D) All of the above

6. Data used to build a data mining model.

(A) Training data (B) Validation data

(C) Test data (D) Hidden data

7. You are given reviews of few netflix series marked as positive, negative and neutral. Classifying reviews of a new netflix series is an example of

(A) Supervised learning (B) Unsupervised learning

(C) Semisupervised learning (D) Reinforcement learning

8. Following are the types of supervised learning

(A) Classification (B) Regression

(C) subgroup discovery (D) all of the above

9. The output of training process in machine learning is

(A) machine learning model (B) machine learning algorithm

(C) null (D) accuracy

10. PCA is

(A) forward feature selection (B) backward feature selection

(C) feature extraction (D) all of the above

11. Consider the following sequence of operations on an empty stack.
push(22); push(43); pop(); push(55); push(12); s=pop();
Consider the following sequence of operations on an empty queue.
enqueue(32);enqueue(27); dequeue(); enqueue(38); enqueue(12); q=dequeue();
The value of s+q is ___________
(A) 44 (B) 54 (C) 39 (D) 70

12. A B-tree of order (degree)5 and of height 3 will have a minimum of ___ keys.
A. 624
B. 249
C. 124
D. 250

13. Construct a binary search tree by inserting 8, 6, 12, 3, 10, 9 one after another. To make the resulting tree as AVL tree which of the following is required?
(A) One right rotation only
(B) One left rotation followed by two right rotations
(C) One left rotation and one right rotation
(D) The resulting tree itself is AVL

14. In a complete 4-ary tree, every internal node has exactly 4 children or no child. The number of leaves in such a tree with 6 internal nodes is:
(A) 20 (B) 18 (C) 19 (D) 17

15. Select the postfix expression for the infix expression *a+b-c+d*(e/f)*.
(A) ab+c-d+e*f/ (B) ab+c-def/*+
(C) abc-+def/*+ (D) ab+c-def/*+

16. Consider a hash table of size seven, with starting index zero, and a hash function (2x + 5)mod7. Assuming the hash table is initially empty, which of the following is the contents of the table when the sequence 1, 4, 9, 6 is inserted into the table using closed hashing? Note that '_' denotes an empty location in the table.
(A) 9, _, 1, 6, _, _, 4 (B) 1, _, 6, 9, _, _, 4
(C) 4, _, 9, 6, _, _, 1 (D) 1, _, 9, 6, _, _, 4

17. **Compute the time complexity of the following function:**
```
void function(int n)
{
        int count = 0;
        for (int i=n/2; i<=n; i++)
                for (int j=1; j<=n; j = j + 2)
                        for (int k=1; k<=n; k = k * 2)
                                count++;}
```
A. $O(n^2 logn)$
B. $O(n\ log^2 n)$
C. $O(n^3)$
D. $O(n\ logn^2)$

18. How many distinct binary search trees can be created out of 6 distinct keys?
(A) 7 (B) 36 (C) 140 (D) 132

19. Which tree traversal performed on a binary search tree, results in ascending order listing of the keys?
A. Pre-order
B. In-order
C. Post-order
D. Level-order

20. You are given pointers to first and last nodes of a singly linked list, which of the following operations are dependent on the length of the linked list?
    (A) Delete the first element
    (B) Insert a new element as a first element
    (C) Add a new element at the end of the list
    (D) Delete the last element of the list

21. Suppose a disk has 400 cylinders, numbered from 0 to 399. At some time the disk arm is at cylinder 58, and there is a queue of disk access requests for cylinder 66, 349, 201, 110, 38, 84, 226, 70, 86. If Shortest-Seek Time First (SSTF) is being used for scheduling the disk access, the request for cylinder 86 is serviced after servicing ____________ number of requests.
    (A) 1 (B) 2 (C)3 (D)4

22. If frame size is 4KB then a paging system with page table entry of 2 bytes can address _______ bytes of physical memory.
    (A) 2^12 (B) 2^16 (C) 2^18 (D) 2^28

23. Calculate the internal fragmentation if page size is 4KB and process size is 103KB.
    (A) 3KB (B) 4KB (C) 1KB (D) 2KB

24. Which of the following scheduling policy is likely to improve interactiveness?
    (A) FCFS (B) Round Robin
    (C) Shortest Process Next (D) Priority Based Scgeduling

25. Consider the following program

```
        Semaphore X=1, Y=0
Void A ( )                      Void B ( )
{                               {
        While (1)                       While (1)
        {                               {
        P(X);                           P(Y);
        Print'1';                       P(X);
        V(Y);                           Print'0';
        }                               V(X);
}                                       }
                                }
```

    The possible output of the program:
    (A) Any number of 0's followed by any number of 1's.
    (B) Any number of 1's followed by any number of 0's.
    (C) 0 followed by deadlock
    (D) 1 followed by deadlock

26. In a system using single processor, a new process arrives at the rate of 12 processes per minute and each such process requires 5 seconds of service time. What is the percentage of CPU utilization?

(A) 41.66 (B) 100.00 (C) 240.00 (D) 60.00

27. A system has two processes and three identical resources. Each process needs two resources to proceed. Then
(A) Deadlock is possible (B) Deadlock is not possible
(C) Starvation may be present (D) Thrashing

28. Which of the following is true with regard to Round Robin scheduling technique?
(A) Responds poorly to short process with small time quantum.
(B) Works like SJF for larger time quantum
(C) Does not use a prior knowledge of burst times of processes.
(D) Ensure that the ready queue is always of the same size.

29. Thrashing can be avoided if
(A) the pages, belonging to working set of programs, are in main memory
(B) the speed of CPU is increased
(C) the speed of I/O processor is increased
(D) none of the above

30. The circular wait condition can be prevented by
(A) using thread
(B) defining a linear ordering of resource types
(C) using pipes
(D) all of the above

31. Let E1, E2 and E3 be three entities in an E/R diagram with simple single-valued attributes. R1 and R2 are two relationships between E1 and E2, where R1 is one-to-many, R2 is many-to-many. R3 is another relationship between E2 and E3 which is many-to-many. R1, R2 and R3 do not have any attributes of their own. What is the minimum number of tables required to represent this situation in the relational model?
(A) 3 (B) 4 (C) 5 (D) 6

32. Identify the minimal key for relational scheme R(U, V, W, X, Y, Z) with functional dependencies $F = \{U \rightarrow V, V \rightarrow W, W \rightarrow X, VX \rightarrow Z\}$
(A) UV (B) UW (C) UX (D) UY

33. It is given that: "Every student need to register one course and each course registered by many students", what is the cardinality of the relation say "Register" from the "Student" entity to the "Course" entity in the ER diagram to implement the given requirement.
(A) M:1 relationship (B) M:N relationship
(C) 1:1 relationship (D) option (B) or(C)

34. Consider the relation branch(branch_name, assets, branch_city)
SELECT DISTINCT T.branch_name FROM branch T, branch S WHERE T.assets>L.assets AND S.branch_city = "TVM" .
Finds the names of
(A) All branches that have greater assets than all branches located in TVM.

(B) All branches that have greater assets than some branch located in TVM.
(C) The branch that has the greatest asset in TVM.
(D) Any branch that has greater asset than any branch located in TVM.

35. Consider the following relation instance, where "A" is primary Key.

A1	A2	A3	A4
1	1	1	Null
5	2	5	1
9	5	13	5
13	13	9	15

Which one of the following can be a foreign key that refers to the same relation?
(A) A2 (B) A3 (C) A4 (D) ALL

36. A relation R(ABC) is having the tuples(1,2,1),(1,2,2),(1,3,1) and (2,3,2). Which of the following functional dependencies holds well?
(A) A → BC (B) AC → B (C) AB → C (D) BC → A

37. Consider a relation R with attributes A, B, C, D and E and functional dependencies A→BC, BC→E, E→DA. What is the highest normal form that the relation satisfies?
(A) BCNF (B) 3 NF (C) 2 NF (D) 1 NF

38. For the given schedule S, find out the conflict equivalent schedule.
S : r1(x); r2(Z) ; r3(X); r1(Z); r2(Y); r3(Y);W1(X); W2(Z); W3(Y); W2(Y)
(A) T1→T2→T3 (B) T2->T1->T3
(C) T3→T1→T2 (D) Not conflict serializable

39. Specialization is __________ process.
(A) top-down (B) bottom up
(C) Both (A) and (B) (D) none of these

40. If D1, D2, .., Dn are domains in a relational model, then the relation is a table, which is a subset of
(A) D1+D2+ … +Dn (B) D1×D2× … ×Dn
(C) D1 ∪ D2 ∪ ⋯ ∪Dn (D) D1–D2– … –Dn

41.For each value of the ___, the distribution of the dependent variable must be normal.

(A) Independent variable (B)Depended variable

(C)Intermediate variable (D)None of the mentioned above

42. Data Analytics uses ___ to get insights from data.

(A)Statistical figures (B)Numerical aspects

(C)Statistical methods (D)None of the mentioned above

43. Linear Regression is the supervised machine learning model in which the model finds the best fit ___ between the independent and dependent variable.

(A)Linear line (B)Nonlinear line

(C) Curved line (D) All of the mentioned above

44. Amongst which of the following is / are the types of Linear Regression,

(A) Simple Linear Regression (B)Multiple Linear Regression

(C)Both A and B (D)None of the mentioned above

45. Amongst which of the following is / are the true about regression analysis?

(A)Describes associations within the data

(B)Modeling relationships within the data

(C)Answering yes/no questions about the data

(D)All of the mentioned above

46. The process of quantifying data is referred to as ___.

(A)Decoding (B)Structure

(C)Enumeration (D)Coding

47. Data Analysis is a process of,

(A)Inspecting data (B)Data Cleaning

(C) Transforming of data (D)All of the mentioned above

48. Least Square Method uses ___.

(A)Linear polynomial (B)Linear regression

(C) Linear sequence (D)None of the mentioned above

49. What is a hypothesis?

(A)A statement that the researcher wants to test through the data collected in a study

(B)A research question the results will answer

(C)A theory that underpins the study

(D)A statistical method for calculating the extent to which the results could have happened by chance

50. ___ are used when we want to visually examine the relationship between two quantitative variables.

(A)Bar graph (B)Scatterplot

(C)Line graph (D)Pie chart

QNo	Ans. Key	QNo	Ans. Key	QNo	Ans. Key	QNo	Ans. Key	QNo	Ans. Key
1	(A)	11	(C)	21	(C)	31	(C)	41	(A)
2	(B)	12	(B)	22	(D)	32	(A)	42	(C)
3	(B)	13	(A)	23	(C)	33	(D)	43	(A)
4	(A)	14	(C)	24	(B)	34	(C)	44	(C)
5	(D)	15	(D)	25	(D)	35	(B)	45	(B)
6	(A)	16	(D)	26	(B)	36	(D)	46	(C)
7	(A)	17	(A)	27	(B)	37	(D)	47	(D)
8	(D)	18	(D)	28	(C)	38	(B)	48	(B)
9	(A)	19	(B)	29	(A)	39	(C)	49	(A)
10	(C)	20	(D)	30	(B)	40	(D)	50	(A)

ADL332	BIG DATA ANALYTICS LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	3	2019

Preamble: The purpose of the course is to offer the students a hands-on experience on Big Data concepts using open source technologies such as Hadoop, Map Reduce, Hive, Pig and Apache Spark. The hands-on experience with R Programming language helps in statistical analysis and equip the students with data driven solutions for the next-generation data management. As data continues to grow it is known that via big data solutions, organizations generate insights and make well-informed decisions, discover trends, and improve productivity and the learner will be able to work on and solve data processing problems.

Prerequisite: Fundamental knowledge in Java programming, Statistics and Python and Big Data Analytics

Course Outcomes: At the end of the course, the student should be able to :

CO1	Illustrate the setting up of and Installing Hadoop in one of the three operating modes.**(Cognitive knowledge: Understand)**
CO2	Implement the file management tasks in Hadoop and explore the shell commands **(Cognitive knowledge: Apply)**
CO3	Implement different tasks using Hadoop Map Reduce programming model.**(Cognitive knowledge: Apply)**
CO4	Implement Pig Scripting operations and Spark Application functionalities.**(Cognitive knowledge: Apply)**
CO5	Implement data extraction from files and other sources and perform various data manipulation tasks on them using R Program.**(Cognitive knowledge: Apply)**
CO6	Illustrate the knowledge of R gained to data analytics for real life applications. **(Cognitive knowledge: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓			✓			✓		✓		✓
CO2	✓	✓	✓		✓			✓		✓		✓
CO3	✓	✓	✓		✓			✓		✓		✓
CO4	✓	✓	✓		✓			✓		✓		✓
CO5	✓	✓	✓		✓			✓		✓		✓
CO6	✓	✓	✓		✓			✓		✓		✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and teamwork
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

Assessment Pattern:

Bloom's Category	Continuous Assessment Test(Internal Exam) Marks in percentage	End Semester Examination Marks in percentage
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**75**	**75**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Evaluation in Lab : 30 marks
Continuous Assessment Test : 15 marks
Viva Voce : 15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern: The percentage of marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva30 marks. Total 75 marks.

Operating System to Use in Lab : Linux
Compiler/Software to Use in Lab :
Programming Language to Use in Lab : Java, R, Python

Fair Lab Record:
All Students attending the Big Data Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record, the right-hand page should contain Experiment Heading, Experiment Number, Date of experiment, Aim of the Experiment and the operations performed on them, Details of experiment including algorithm and result of Experiment. The left-hand page should contain a print out of the code used for experiment and sample output obtained for a set of input.

SYLLABUS

BIG DATA ANALYTICS LAB

* Mandatory

1. Perform setting up and Installing Hadoop in any of the three operating modes: Standalone, Pseudo distributed, Fully distributed.*
2. Explore the various shell commands in Hadoop.
3. Implement the following file management tasks in Hadoop:
    - Adding Files and Directories
    - Retrieving Files
    - Deleting Files
4. Implement a word count program using Map Reduce.
5. Write a R program to find the factorial and check for palindromes.*
6. Write a R program to solve linear regression and make predictions.*
7. Write a R program to solve logistic regression.*
8. Implement statistical operations using R.*
9. Implement a program to find variance, covariance and correlation between different types of attributes.*
10. Implement SVM/Decision tree Classifier.*
11. Implement clustering algorithm.*

12. To explore Hive with its basic commands
13. Write Pig Latin scripts to sort, group, join, project, and filter your data.
14. Install, Deploy and configure Apache Spark.

BIG DATA PROCESSING LAB - PRACTICE QUESTIONS

1. Write a MapReduce Program to retrieve data from documents.
2. Write word count program that only count the words starting with 'a'
3. Write a word count program that only counts the words whose length is longer than 10.
4. Using the structure of the Word Count program, write a Hadoop program that calculates the average word length of all words that start with each character.
5. Implement matrix multiplication with Hadoop Map Reduce
6. Write a Map Reduce program for removing stop words from the given text files.
7. Write a MapReduce Program to count the number of lines in a document.
8. Write Pig Latin script to count the number of occurrences of each word in an input text file.
9. Write a program to simulate Singular Value Decomposition
10. Write a program to simulate PCA.
11. Write a single Spark application that:
    a. Transposes the original Amazon food dataset, obtaining a Pair RDD of the type: user-id – list of the product-ids reviewed by user-id
    b. Counts the frequencies of all the pairs of products reviewed together;
    c. Writes on the output folder all the pairs of products that appear more than once and their frequencies.
    d. The pairs of products must be sorted by frequency..
12. Write a program to implement a stop word elimination problem. Input: A large textual file containing one sentence per line. A small file containing a set of Stop Words (One Stop Word per line) Output: A textual file containing the same sentences of the large input file without the words appearing in the small file
13. Implement matrix multiplication with Map Reduce.
14. Implement basic Pig Latin Scripts based on different scenarios.
15. Implement Frequent Item set algorithm

16. Implement Clustering algorithm
17. Implement Page Rank algorithm
18. Implement Bloom Filter
19. Write a R program to create a sequence of numbers from 20 to 50 and find the mean of numbers from 20 to 60 and sum of numbers from 51 to 91.
20. Write a R program to create a vector which contains 10 random integer values between -50 and +50.
21. Write a R program to find the maximum and the minimum value of a given vector.
22. Write a R program to get the unique elements of a given string and unique numbers of vectors.
23. Write a R program to create a list of random numbers in normal distribution and count occurrences of each value.
24. Write a R program to read the .csv file and display the content.
25. Write a R program to create an array, passing in a vector of values and a vector of dimensions. Also provide names for each dimension.
26. Write a R program to create a simple bar plot of five subjects' marks.
27. Write a R program to compute the sum, mean and product of a given vector element.
28. Write a R program to create a Data Frames which contain details of 5 employees and display the details.

ADD334	MINI PROJECT	CATEGORY	L	T	P	CREDITS
		PWS	0	0	3	2

Preamble: The objective of this course is to apply the fundamental concepts of Artificial Intelligence / Data Science principles for the effective development of an application/research project. Mini project enables the students to boost their skills, widen the horizon of thinking and their ability to resolve real life problems. The students are expected to design and develop a software/hardware project to innovatively solve a real-world problem.

Prerequisite :A sound knowledge in any programming language and Subjects studied up to sixth semester.

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Identify technically and economically feasible problems of social relevance **(Cognitive Knowledge Level: Apply)**
CO2	Identify and survey the relevant literature for getting exposed to related solutions **(Cognitive Knowledge Level: Apply)**
CO3	Perform requirement analysis and identify design methodologies and develop adaptable and reusable solutions of minimal complexity by using modern tools and advanced programming techniques **(Cognitive Knowledge Level: Apply)**
CO4	Prepare technical report and deliver presentation**(Cognitive Knowledge Level: Apply)**
CO5	Apply engineering and management principles to achieve the goal of the project **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3

Split-up of Continuous Internal Evaluation :

Attendance **10 marks**
Project Guide **15 marks**
Project Report **10 marks**

Evaluation by the Committee (will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement) **40 marks**

Split-up of End Semester Examination: The marks will be distributed as

Presentation	: 30 marks
Demonstration	: 20 marks
Viva	: 25 marks.
Total	: 75 marks.

Course Plan

Student Groups with 3 or 4 members should identify a topic of interest in consultation with Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Innovative design concepts, performance, scalability, reliability considerations, aesthetics/ergonomic, user experience and security aspects taken care of in the project shall be given due weight.

The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted with the Head of the Department or a senior faculty, Mini Project coordinator and project guide as the members. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight. The internal evaluation shall be made based on the progress/outcome of the project, reports and a viva-voce examination, conducted internally by a 3-member committee. A project report is required at the end of the semester. The product/application has to be demonstrated for its full design specifications.

Guidelines for the Report preparation

A bonafide report on mini project shall be submitted within one week after the final presentation. Minimum number of pages should be 40.

- Use Times New Roman font for the entire Report – Chapter / Section Title –Times New Roman 18, Bold; Heading 2 – Times New Roman 16, Bold; Heading 3 – Times New Roman 14,Bold; Body- Times New Roman12, Normal.
- Line Spacing – Between Heading 2 – 3 lines, between lines in paragraph 1.5 lines.
- Alignments – Chapter / Section Title – Center, Heading 2 & 3 should be LeftAligned. Ensure that all body text is paragraph justified.
- Figures & Tables – Ensure that all Figures and Tables are suitably numbered and given proper names/headings. Write figure title under the figure and table title above the table
- Suggestive order of documentation:
    - i. Top Cover
    - ii. Title page
    - iii. Certification page
    - iv. Acknowledgement

v. Abstract
vi. Table of Contents
vii. List of Figures and Tables
viii. Chapters
ix. Appendices, if any
x. References/Bibliography

SEMESTER VI

PROGRAM ELECTIVE I

AIT312	RECOMMENDATION SYSTEM	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PEC	2	1	0	3	2020

Preamble: The course is prepared with the view of facilitating the learner to get an overview of recommender system. This course covers the concepts like Introduction to basic concepts and Recent developments, Collaborative Filtering, Content-based recommendation, Knowledge based recommendation, Hybrid approaches and Evaluating Recommender System. The course enables the learners to develop state-of-the-art recommender systems that automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Describe the basic concepts of recommender systems **(Cognitive Knowledge Level : Understand)**
CO 2	Summarize the features of constraint based and case-based knowledge-based recommender systems **(Cognitive Knowledge Level : Understand)**
CO 3	Explain different hybridizing algorithms and illustrate them with suitable examples. **(Cognitive Knowledge Level : Understand)**
CO 4	Analyze the design issues in offline recommender evaluation **(Cognitive Knowledge Level : Apply)**
CO 5	Explain the features of attack-resistant recommender systems **(Cognitive Knowledge Level : Understand)**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	✔	✔										✔
CO2	✔	✔	✔									✔
CO3	✔	✔										✔
CO4	✔	✔	✔									✔
CO5	✔	✔										✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (percentage)	Test2 (percentage)	
Remember	40	40	40
Understand	40	40	40
Apply	20	20	20
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of Internal Tests 1 & 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks.First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

SYLLABUS

Module 1(Introduction to basic concepts and Recent developments)

Introduction to basic concepts and Recent developments , Collaborative recommendation -User-based nearest neighbor recommendations, Item-based nearest neighbour recommendation, Collaborative recommendation ratings , Model-based and preprocessing-based approaches , Recent practical approaches and systems Content-based recommendation - Content representation and content similarity Similarity-based retrieval and Other text classification methods

Module 2 (Knowledge-based recommendation)

Knowledge-based recommendation - Knowledge representation and reasoning , Constraints, Cases and similarities, Interacting with constraint-based recommenders - Defaults Dealing with unsatisfiable requirements and empty result set, Proposing repairs for unsatisfiable requirements, Ranking the items/utility-based recommendation, Interacting with case-based recommenders, Critiquing -Compound critiquing, Dynamic critiquing

Module 3 (Hybrid recommendation approaches)

Hybrid recommendation approaches - Opportunities for hybridization Recommendation paradigms, Hybridization designs, Monolithic hybridization design - Feature combination hybrids, Feature augmentation hybrids, Parallelized hybridization design - Mixed hybrids, Switching hybrids, Weighted hybrids, Pipelined hybridization design Cascade hybrids, Meta-level hybrids Limitations of hybridization strategies

Module 4 (Evaluating Recommender Systems)

Introduction - Evaluation Paradigms , User Studies , Online Evaluation Offline Evaluation with Historical Data Sets, General Goals of Evaluation Design - Accuracy, Coverage , Confidence and Trust , Novelty , General Goals of Evaluation Design - Serendipity ,Diversity , Robustness and Stability Scalability, Design Issues in Offline Recommender Evaluation - Case Study of the Netflix Prize Data Set , Segmenting the Ratings for Training and Testing - Hold-Out , Cross-Validation , Comparison with Classification, Accuracy Metrics in Offline Evaluation - Measuring the Accuracy of Ratings Prediction , RMSE versus MAE, Impact of the Long Tail, Evaluating Ranking via Correlation , Evaluating Ranking via Utility Evaluating Ranking via Receiver Operating Characteristic, Limitations of Evaluation Measures - Avoiding Evaluation Gaming

Module 5 (Attack-Resistant Recommender Systems)

Introduction Understanding the Trade-Offs in Attack Models - Quantifying Attack Impact Types of Attacks - Random Attack . Average Attack Bandwagon, Reverse Bandwagon Attack, Probe Attack Segment Attack, Effect of Base Recommendation Algorithm, Detecting Attacks on Recommender Systems - Individual Attack Profile Detection , Group Attack Profile Detection - Preprocessing Methods Online Methods Strategies for Robust Recommender Design - Preventing Automated Attacks with CAPTCHAs Using Social Trust. Designing Robust Recommendation Algorithms - Incorporating Clustering in Neighborhood Methods Fake Profile Detection during Recommendation Time Association - Based Algorithms

Text Books

1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press(2011)
2. C.C. Aggarwal, Recommender Systems: The Textbook, Springer, 2016.

Reference Books

1. F. Ricci, L Rokach, B. Shapira and P.B. Kantor, Recommender systems handbook, Springer 2010
2. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer (2013), 1st ed.

Course Level Assessment Questions

Course Outcome 1 (CO1): Discuss the cases in which content-based recommendations will not perform as well as collaborative filtering.

Course Outcome 2 (CO2): Analyze, in detail, different techniques available to support users in the interaction with constraint-based recommender applications.

Course Outcome 3(CO3): Explain about the feature combination and feature augmentation hybrid mechanisms.

Course Outcome 4 (CO4): With appropriate case study, explain the design issues in offline recommender evaluation .

Course Outcome 5 (CO5): Illustrate different methods used to detect attacks on existing recommender system.

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT312

Course Name: Recommendation System

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. List any two purposes of recommender systems.
2. Indicate the main idea of collaborative recommendation approaches.
3. Describe the two types of outputs generated with pure collaborative approaches that takes matrix of given user–item ratings as the only input .
4. Define case amplification. How it can be computed?
5. Explain the need of item-based nearest neighbor recommendation system.
6. Define classical constraint satisfaction problem (CSP).
7. Differentiate between parallelized hybridization design and pipelined hybridization design with suitable diagram.
8. What is meant by monolithic hybridization design?
9. Differentiate between internal validity and external validity.
10. Specify the effect of base recommendation algorithm. **(10x3=30)**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11.	(a)	Describe about user-based nearest neighbor recommendation system which deals with new items for which no ratings exist.	**(7)**
	(b)	Explain about Rocchio's relevance feedback method	**(7)**

OR

12.	(a)	Summarize the implicit and explicit rating mechanism in collaborative recommendation approaches.	**(7)**
	(b)	Explain any two techniques that deal with data sparsity and the cold-start problem.	**(7)**
13.	(a)	Explain ***QuickXPlain*** algorithm that calculates one conflict set at a time for a given set of constraints.	**(7)**
	(b)	Which are the ways available to specify defaults? Explain how derived defaults can be determined.	**(7)**

OR

14.	(a)	Explain about the ranking of items/utility-based recommendation.	**(7)**
	(b)	Describe ***DynamicCritiquing*** algorithm.	**(7)**
15.	(a)	Explain about feature combination hybrids.	**(7)**
	(b)	Describe feature augmentation hybrid.	**(7)**

OR

16.	(a)	Explain about different parallelized hybridization strategies.	**(7)**
	(b)	Describe pipelined hybridization design methods.	**(7)**
17.	(a)	Explain about offline and online evaluations in recommender systems.	**(7)**
	(b)	Describe the general goals of evaluation design.	**(7)**

OR

18.	(a)	Discuss about the design issues in offline recommender evaluation. Illustrate with a case study.	**(7)**
	(b)	Explain about accuracy metrics in offline evaluation.	**(7)**
19.	(a)	How do you quantify attack impact on recommender system?	**(7)**

(b) Discuss about different attacks on recommender system. **(7)**

OR

20. (a) Discuss about different methods available to detect attacks on recommender system. **(7)**

(b) Explain how to design robust recommendation algorithms. **(7)**

Teaching Plan		
No	**Contents**	**No. of Lecture Hours (36 hrs)**
Module - 1 (Introduction to basic concepts)		**(7 hours)**
1.1	Introduction to basic concepts and Recent developments	1 hour
1.2	Collaborative recommendation :User-based nearest neighbor recommendation	1 hour
1.3	Collaborative recommendation : Item-based nearest neighbor recommendation	1 hour
1.4	Collaborative recommendation ratings	1 hour
1.5	Model-based and preprocessing-based approaches, Recent practical approaches and systems	1 hour
1.6	Content-based recommendation - Content representation and content similarity	1 hour
1.7	Similarity-based retrieval and Other text classification methods	1 hour
Module - 2 (Knowledge-based recommendation)		**(8 hours)**
2.1	Knowledge representation and reasoning , Constraints, Cases and similarities	1 hour
2.2	Interacting with constraint-based recommenders - Defaults	1 hour
2.3	Dealing with unsatisfiable requirements and empty result sets	1 hour
2.4	Proposing repairs for unsatisfiable requirements	1 hour
2.5	Ranking the items/utility-based recommendation	1 hour
2.6	Interacting with case-based recommenders Introduction	1 hour
2.7	Critiquing -Compound critiquing	1 hour
2.8	Dynamic critiquing	1 hour
Module- 3 (Hybrid recommendation)		**(7 hours)**
3.1	Hybrid recommendation approaches - Opportunities for hybridization Recommendation paradigms, Hybridization designs	1 hour
3.2	Monolithic hybridization design - Feature combination hybrids	1 hour
3.3	Feature augmentation hybrids	1 hour
3.4	Parallelized hybridization design -Mixed hybrids, Switching hybrids	1 hour
3.5	Weighted hybrids	1 hour

3.6	Pipelined hybridization design Cascade hybrids, Meta-level hybrids	1 hour
3.7	Limitations of hybridization strategies	1 hour
Module - 4 (Evaluating Recommender Systems)		**(8 hours)**
4.1	Introduction - Evaluation Paradigms , User Studies , Online Evaluation Offline Evaluation with Historical Data Sets	1 hour
4.2	Goals of Evaluation Design - Accuracy, Coverage , Confidence and Trust , Novelty	1 hour
4.3	General Goals of Evaluation Design - Serendipity ,Diversity , Robustness and Stability Scalability	1 hour
4.4	Design Issues in Offline Recommender Evaluation - Case Study of the Netflix Prize Data Set	1 hour
4.5	Design Issues in Offline Recommender Evaluation -Segmenting the Ratings for Training and Testing - Hold-Out , Cross-Validation , Comparison with Classification	1 hour
4.6	Accuracy Metrics in Offline Evaluation - Measuring the Accuracy of Ratings Prediction , RMSE versus MAE, Impact of the Long Tail	1 hour
4.7	Evaluating Ranking via Correlation , Evaluating Ranking via Utility Evaluating Ranking via Receiver Operating Characteristic	
4.8	Limitations of Evaluation Measures - Avoiding Evaluation Gaming	1 hour
Module- 5 (Attack-Resistant Recommender Systems)		**(6 hours)**
5.1	Introduction Understanding the Trade-Offs in Attack Models - Quantifying Attack Impact	1 hour
5.2	Types of Attacks - Random Attack . Average Attack Bandwagon	1 hour
5.3	Reverse Bandwagon Attack , Probe Attack Segment Attack , Effect of Base Recommendation Algorithm	1 hour
5.4	Detecting Attacks on Recommender Systems - Individual Attack Profile Detection ,Group Attack Profile Detection - Preprocessing Methods Online Methods	1 hour
5.5	Strategies for Robust Recommender Design - Preventing Automated Attacks with CAPTCHAs Using Social Trust . Designing Robust Recommendation Algorithms - Incorporating Clustering in Neighborhood Methods Fake Profile Detection during Recommendation Time	1 hour
5.6	Association-Based Algorithms	1 hour

AIT322	CONCEPTS IN COMPUTER GRAPHICS AND IMAGE PROCESSING	Category	L	T	P	Credit	Year of Introduction
		PEC	2	1	0	4	2019

Preamble: The purpose of this course is to make awareness about strong theoretical relationships between computer graphics and image processing. This course helps the learner to understand three-dimensional environment representation in a computer, transformation of 2D/3D objects, basic mathematical techniques and algorithms used to build useful applications, imaging, and image processing techniques. The study of computer graphics and image processing develops the ability to create image processing frameworks for different domains and develops algorithms for emerging display technologies.

Prerequisite: A sound knowledge of Mathematics and a programming language.

Course Outcomes: After the completion of the course the student will be able to

CO#	CO
CO1	Describe the working principles of graphics devices**(Cognitive Knowledge level: Understand)**
CO2	Illustrate line drawing, circle drawing and polygon filling algorithms(Cognitive Knowledge level: Apply)
CO3	Demonstrate geometric representations, transformations on 2D & 3D objects, clipping algorithms and projection algorithms(Cognitive Knowledge level: Apply)
CO4	Summarize visible surface detection methods(Cognitive Knowledge level: Understand)
CO5	Summarize the concepts of digital image representation, processing and demonstrate pixel relationships(Cognitive Knowledge level: Apply)
CO6	Solve image enhancement and segmentation problems using spatial domain techniques(Cognitive Knowledge level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓								✓
CO4	✓		✓									✓
CO5	✓	✓	✓	✓								
CO6	✓	✓	✓	✓		✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40

Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of SeriesTests1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one full question. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module – 1 (Basics of Computer graphics and Algorithms)

Basics of Computer Graphics and its applications. Video Display devices- Refresh Cathode Ray Tubes, Random Scan Displays and systems, Raster scan displays and systems. Line drawing algorithms- DDA, Bresenham's algorithm. Circle drawing algorithms- Midpoint Circle generation algorithm, Bresenham's algorithm.

Module – 2 (Filled Area Primitives and transformations)

Filled Area Primitives- Scan line polygon filling, Boundary filling and flood filling. Two dimensional transformations-Translation, Rotation, Scaling, Reflection and Shearing, Composite transformations, Matrix representations and homogeneous coordinates. Basic 3D transformations.

Module - 3 (Clipping and Projections)

Window to viewport transformation. Cohen Sutherland Line clipping algorithm.Sutherland Hodgeman Polygon clipping algorithm. Three-dimensional viewing pipeline. Projections-Parallel and Perspective projections. Visible surface detection algorithms- Depth buffer algorithm, Scan line algorithm.

Module - 4 (Fundamentals of Digital Image Processing)

Introduction to Image processing and applications. Image as 2D data. Image representation ingrayscale, Binary and Colour images. Fundamental steps in image processing. Components of image processing system.Coordinate conventions. Sampling and quantization. Spatial and Gray Level Resolution. Basic relationship between pixels– neighbourhood, adjacency, connectivity.

Module - 5 (Image Enhancement in Spatial Domain and Image Segmentation)

Basic gray level transformation functions- Log transformations, Power-Law transformations, Contrast stretching. Histogram equalization. Basics of spatial filtering - Smoothing spatial filter- Linear and nonlinear filters, and Sharpening spatial filters-Gradient and Laplacian.

Fundamentals of Image Segmentation.Thresholding-Basics of Intensity thresholding and Global Thresholding. Region based Approach- Region Growing, Region Splitting and Merging. Edge Detection - Edge Operators- Sobel and Prewitt.

Text Book

1. Donald Hearn and M. Pauline Baker, Computer Graphics, PHI, 2e, 1996
2. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. Pearson, 4e, 2017

References

1) William M. Newman and Robert F. Sproull, Principles of Interactive Computer Graphics. McGraw Hill, 2001
2) Zhigang Xiang and Roy Plastock, Computer Graphics (Schaum's outline Series), McGraw Hill, 2019.

3) David F. Rogers , Procedural Elements for Computer Graphics, Tata McGraw Hill,2001.
4) M. Sonka, V. Hlavac, and R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson India Edition, 4e, 2017.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare the working principle of raster scan systems and random scan systems.
2. How much time is spent scanning across each row of pixels during screen refresh on a raster system with resolution of 1280*1024 and a refresh rate of 60 frames per second?

Course Outcome 2 (CO2):

1. Rasterize the line with end points(2,3) and (5,8) using Bresenham's line drawing algorithm.
2. Explain how the 4-connected area filling approach differs from 8- connected area filling in boundary filling algorithm

Course Outcome 3 (CO3):

1. Rotate a triangle ABC 45 degree counter clockwise about the pivot point (10,3), where the position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3).
2. Given a clipping window A(20,20), B(60,20), C(60,40) and D(20,40). Using Cohen Sutherland algorithm, find the visible portion of the line segment joining the points P(40,80) and Q(120,30)

Course Outcome 4 (CO4):

1. Explain scan line algorithm for detecting visible surfaces in an object.

Course Outcome 5 (CO5):

1. Give an image representation model and describe how the representation changes in grayscale, binary and colour images.
2. Consider an image segment shown below.

   3 1 2 1 (q)

   2 2 0 2

   1 2 1 1

   (p) 1 0 1 2

   (a) Let V={0,1} and compute the length of the shortest 4-,8- and m- path between p and q. If a particular path does not exist between these two points , explain why?

   (b) Repeat for V={1,2}.

3. The spatial resolution of an image is given by 128 X 128.What is its storage requirements if it is represented by 64 gray levels?

Course Outcome 6 (CO6):

1. A skilled medical technician is charged with the job of inspecting a certain class of monochrome images generated by electronic microscope. To facilitate the inspection, the technician uses image processing aids. However when he examines the images he finds the following problems.
   (a) Presence of bright isolated dots that are not of interest.
   (b) Lack of sharpness
   (c) Poor contrast

   Identify the sequence of preprocessing steps that the technician may use to overcome the above mentioned problems and explain it.

2. A 4x4, 4 bits/pixel original image is given by

$$\begin{pmatrix} 10 & 12 & 8 & 9 \\ 10 & 12 & 12 & 14 \\ 12 & 13 & 10 & 9 \\ 14 & 12 & 10 & 12 \end{pmatrix}$$

   (a) Apply histogram equalisation to the image by rounding the resulting image pixels to integers
   (b) Sketch the histogram of the original image and the histogram-equalised image.

3. You have Sobel operator and Laplacian operator for edge detection. Which operator will you select for edge detection in the case of noisy image? Explain.**(Assignment)**

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT322

Course Name: Concepts in Computer Graphics and Image Processing

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Justify the approach of using integer arithmetic in Bresenham's line drawing algorithm.

2. Consider a raster system with a resolution of 1024*1024. What is the size of the raster needed to store 4 bits per pixel? How much storage is needed if 8 bits per pixel are to be stored?

3. Show that two successive reflections about either of the coordinate axes is equivalent to a single rotation about the coordinate origin.

4. Determine a sequence of basic transformations that are equivalent to the x-direction shearing matrix.

5. Find the window to viewport normalization transformation with window lower left corner at (1,1) and upper right corner at (2,6).

6. Find the orthographic projection of a unit cube onto the x=0, y=0 and z=0 plane.

7. Define Sampling and Quantization of an image.

8. Give any three applications of digital image processing.

9. A captured image appears very dark because of wrong lens aperture setting. Describe an enhancement technique which is appropriate to enhance such an image.

10. Suggest an approach of thresholding that should be used in case of uniform illumination.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Write Midpoint circle drawing algorithm and use it to plot a circle with radius=20 and center is (50,30). **(10)**

(b) Draw the architecture of raster scan display systems and explain its working principle. **(4)**

OR

12. (a) Derive the initial decision parameter of Bresenham's line drawing algorithm and use the algorithm to rasterize a line with endpoints (2,2) and (10,10). **(10)**

(b) Explain the working principle of color CRT monitors with suitable illustrations. **(4)**

13. (a) Compare boundary fill algorithm and flood fill algorithm. **(5)**

(b) Reflect a triangle ABC about the line 3x-4y+8=0. The position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3). **(9)**

OR

14. (a) Explain the need of using vanishing points in projections. **(4)**

(b) Explain Cohen-Sutherland line clipping algorithm. Use the algorithm to clip line P1(70, 20) and P2(100,10) against a window lower left hand corner (50,10) and upper right hand corner (80,40). **(10)**

15. (a) Describe Sutherland Hodegman polygon clipping algorithm and what are its limitations. **(7)**

(b) Explain how visible surfaces can be detected using depth buffer algorithm. **(7)**

OR

16. (a) Describe Sutherland Hodegman polygon clipping algorithm and what are its limitations. **(7)**

(b) Explain how visible surfaces can be detected using depth buffer algorithm. **(7)**

17. (a) Explain the components of an image processing system with suitable diagram **(9)**

(b) Define Resolution of an image. Explain the spatial and gray level resolution of an image with an example. **(5)**

OR

18. (a) Define 4-adjacency, 8 adjacency and m-adjacency. Consider the image segment shown. **(7)**

4 2 3 2 (q)
3 3 1 3
2 3 2 2
(p) 2 1 2 3

Let V={1,2} and compute the length of the shortest 4- ,8- and m- path between p and q. If a particular path does not exist between these two points, explain why?

(b) Using any one application, explain the steps involved in image processing. **(7)**

19. (a) A 5x5 image patch is shown below. Compute the value of the marked pixel if it is smoothened by a 3x3 average filterand median filter. **(4)**

$$f(m,n)=\begin{pmatrix} 0 & 1 & 2 & 3 & 2 \\ 5 & 6 & 7 & 8 & 4 \\ 4 & 3 & 2 & 1 & 2 \\ 8 & 7 & 6 & 5 & 3 \\ 1 & 5 & 3 & 7 & 6 \end{pmatrix}$$

(b) Define Image segmentation and describe in detail method of edge and region **(10)** based segmentation technique.

OR

20. (a) Distinguish between smoothing and sharpening filters in terms of **(10)**
    - **(i)** Functionality
    - **(ii)** Types
    - **(iii)** Applications
    - **(iv)** Mask Coefficients

    (b) Describe how an image is segmented using split and merge technique in association with the region adjacency graph. **(8)**

TEACHING PLAN

No	Contents	No of Lecture Hrs (36 hrs)
Module – 1 (Basics of Computer Graphics and Algorithms) (8 hrs)		
1.1	Basics of Computer Graphics and applications	1 hour
1.2	Refresh Cathode Ray Tubes	1 hour
1.3	Random Scan Displays and systems,Raster scan displays and systems	1 hour
1.4	DDA Line drawing Algorithm	1 hour
1.5	Bresenham’s line drawing algorithm	1 hour
1.6	Midpoint Circle generation algorithm	1 hour
1.7	Bresenham’s Circle generation algorithm	1 hour
1.8	Illustration of line drawing and circle drawing algorithms	1 hour
Module - 2 (Filled Area Primitives and transformations) (8 hrs)		
2.1	Scan line polygon filling	1 hour
2.2	Boundary filling and flood filling	1 hour
2.3	Basic 2D transformations-Translation, Rotation and Scaling	1 hour

2.4	Reflection and Shearing	1 hour
2.5	Composite transformations	1 hour
2.6	Matrix representations and homogeneous coordinates	1 hour
2.7	Basic 3D transformation-Translation and scaling	1 hour
2.8	Basic 3D transformation-Rotation	1 hour
Module - 3 (Clipping and Projections) (7 hrs)		
3.1	Window to viewport transformation	1 hour
3.2	Cohen Sutherland Line clipping algorithm	1 hour
3.3	Sutherland Hodgeman Polygon clipping algorithm	1 hour
3.4	Practice problems on Clipping algorithms	1 hour
3.5	Three-dimensional viewing pipeline, Projections-Parallel projections,Perspective projections	1 hour
3.6	Visible surface detection algorithms- Depth buffer algorithm	1 hour
3.7	Scan line visible surface detection algorithm	1 hour
Module - 4 (Fundamentals of Digital Image Processing) (6 hrs)		
4.1	Introduction to Image processing-Image as a 2D data, Image representation-Gray scale, Binary and Colour images.	1 hour
4.2	Fundamental steps in image processing and applications	1 hour
4.3	Components of image processing system	1 hour
4.4	Coordinate conventions, Sampling and quantization, Spatial and Gray Level Resolution	1 hour
4.5	Basic relationship between pixels – neighbourhood, adjacency, connectivity	1 hour
4.6	Illustration of basic relationship between pixels– neighbourhood, adjacency, connectivity	1 hour

Module - 5 (Image Enhancement in spatial domain and Image Segmentation) (7 hrs)		
5.1	Basic gray level transformation functions- Log transformations, Power law transformation, Contrast stretching	1 hour
5.2	Histogram equalization with illustration	1 hour
5.3	Basics of spatial filtering, Smoothing spatial filter- Linear and nonlinear filters	1 hour
5.4	Sharpening spatial filtering-Gradient filter mask, Laplacian Filter Mask	1 hour
5.5	Fundamentals of Image Segmentation, Basics of Intensity thresholding, Basic Global Thresholding	1 hour
5.6	Region Based Approach- Region Growing, Region Splitting and Merging	1 hour
5.7	Basics of Edge Detection- Sobel and Prewitt edge detection masks	1 hour

CST 332	FOUNDATIONS OF SECURITY IN COMPUTING	Category	L	T	P	Credit	Year Of Introduction
		PEC	2	1	0	3	2019

Preamble: The purpose of this course is to create awareness among learners about the fundamentals of security and number theory. This course covers Integer & Modular Arithmetic, Primes & Congruences, Discrete Logarithms & Elliptic Curve Arithmetic and an overview of computer security. The concepts covered in this course enable the learners in effective use of cryptographic algorithms and to identify the security threats in computing.

Prerequisite: A sound knowledge in Mathematics, Discrete Computational Structures, Operating Systems and Database Systems.

Course Outcomes: After the completion of the course, the student will be able to

CO1	Illustrate the operations and properties of algebraic structures, integer arithmetic and modular arithmetic. **(Cognitive Knowledge Level: Understand)**
CO2	Use the concepts of prime numbers and factorization for ensuring security in computing systems **(Cognitive Knowledge Level: Apply)**
CO3	Illustrate the concepts of Linear Congruence, Primitive Roots, Discrete Logarithms and Elliptic Curve Arithmetic **(Cognitive Knowledge Level: Apply)**
CO4	Summarize the threats and attacks related to computer and program security **(Cognitive Knowledge Level: Understand)**
CO5	Outline the key aspects of operating system and database security **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔									✔
CO2	✔	✔	✔	✔								✔
CO3	✔	✔	✔	✔								✔
CO4	✔	✔	✔			✔		✔				✔
CO5	✔	✔	✔			✔		✔				✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Test 1 (%)	Test 2 (%)	End Semester Examination (%)
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			

Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**50**	**100**	**3**

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Test : **25 marks**

Continuous Assessment Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module-1 (Modular Arithmetic)

Integer arithmetic - Integer division, Divisibility, Greatest Common Divisor (GCD), Euclid's algorithm for GCD, Extended Euclid's algorithm, Linear Diophantine Equations. Modular arithmetic - Operations, Properties. Algebraic structures - Groups, Rings, Fields, Finite fields, GF(p), GF (2^n).

Module-2 (Prime Numbers and Factorization)

Prime numbers - Prime numbers and prime-power factorization, Fermat and Mersenne primes, Fermat's theorem, Applications, Euler's theorem, Euler's totient function, Applications. Primality testing – Deterministic algorithms and Probabilistic algorithms. Factorization - Fermat's factorization, Pollard p-1 method.

Module-3 (Linear Congruence, Primitive Roots and Elliptic Curve Arithmetic)

Linear congruence - Simultaneous linear congruence, Chinese Remainder Theorem (CRT). Congruence with a prime - Power modulus, Arithmetic modulo p, Pseudoprimes and Carmichael numbers, Solving congruence modulo prime powers. Primitive roots - Existence of primitive roots for primes, Discrete logarithms. Elliptic curve arithmetic – Prime curves, Binary curves, Addition of two points, Multiplication of a point by a constant.

Module-4 (Computer and Program Security)

Introduction to computer security – Threats, Vulnerabilities, Controls. Browser attack types, Web attacks targeting users, Email attack types. Introduction to program security - Non-malicious programming oversights, Malware.

Module-5 (Operating System and Database Security)

Operating system security – Security in operating system, Security in design of operating system. Database security – Security requirements of databases, Reliability and integrity, Database disclosure.

Text Books

1. Behrouz A Forouzan, Cryptography and Network Security, 3/e, Tata McGraw-Hill.
2. Charles P Pfleeger, Shari Lawrence Pfleeger, Jonathan Margulies, Security in Computing, 5/e, Prentice Hall.
3. G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007

References

1. William Stallings, Cryptography and Network Security Principles and Practices, 4/e, Pearson Ed.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Find the n- bit word that is represented by the polynomial $x^2 +1$ in $GF(2^5)$.
2. Solve the linear Diophantine equation $21x + 14y=35$.

Course Outcome 2 (CO2):

1. Prove that a Carmichael number cannot be the product of two distinct primes.
2. Use the Pollard p-1 method to find a factor of 57247159 with the bound B=8.

Course Outcome 3 (CO3):

1. Find an integer that has a remainder of 3 when divided by 7 and 13, but is divisible by 12.
2. In the elliptic curve E(1,2) over the field GF(11), find the equation of the curve and all the points on the curve.

Course Outcome 4 (CO4):

1. List three controls that could be applied to detect or prevent off-by-one errors.
2. How does fake email messages act as spam?

Course Outcome 5 (CO5):

1. Discuss the importance of auditability and access control in database security.
2. Explain the various factors which can make data sensitive.

Model Question Paper

QP CODE: **PAGES: ___**

Reg No:_______________
Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 332
Course Name : FOUNDATIONS OF SECURITY IN COMPUTING

Max Marks: 100 **Duration: 3 Hours**

PART A
(Answer All Questions. Each question carries 3 marks)

1. List the four properties of divisibility with examples.
2. Find gcd (401,700) using Euclid's algorithm.
3. Use Fermat's Little theorem to show that 91 is not a prime.
4. If m is relatively prime to n , show that $\Phi(mn) = \Phi(m)\ \Phi(n)$.
5. Solve the congruence relation 103x ≡ 57 (mod 211).
6. Find a solution for the congruence $3x \equiv 5 \bmod 7^3$
7. What are the problems created by an off-by-one error?
8. How does a clickjacking attack succeed?
9. Explain the significance of correctness and completeness in the design of operating systems.
10. How does the two-phase update technique help the database manager in handling failures?

(10x3=30)

Part B
(Answer any one question from each module. Each question carries 14 Marks)

11. (a) For the group G = < Z_6*, x>, prove that it is an Abelian group. Also show the result of 5 x 1 and 1 ÷ 5. **(6)**

(b) Find a particular and the general solution to the following linear Diophantine equations. **(8)**
i) 19 x+13y = 20 ii) 40 x + 16 y =88

OR

12. (a) Describe the properties of modular arithmetic and modulo operator. **(6)**

(b) Using Extended Euclidean algorithm, find the multiplicative inverse of (i) 131 in Z_{180} and (ii) 23 in Z_{100}. **(8)**

13. (a) State and prove Fermat's theorem. **(6)**

(b) Explain Fermat's factorization method and use it to factor 809009. **(8)**

OR

14. (a) Define Euler's totient function. Prove that, Ø(pq)=(p-1)(q-1) where p and q are prime numbers. **(7)**

(b) Define Fermat primes. Show that any two distinct Fermat numbers are relatively prime. **(7)**

15. (a) Using Chinese Remainder Theorem, solve the system of congruence, x ≡2(mod 3), x ≡3(mod 5), x ≡2(mod 7). **(7)**

(b) Define Carmichael number and show that a Carmichael number must be the product of at least three distinct primes. **(7)**

OR

16. (a) For the group G = <Z_{19*}, x>, find the primitive roots in the group. **(6)**

(b) Consider the elliptic curve $y^2 = x^3 + x + 1$ defined over Z_{23}. If P = (3, 10) and Q = (9,7) are two points on the elliptic curve, find 2P and P + Q. **(8)**

17. (a) Distinguish the terms vulnerability, threat and control. **(4)**

(b) With the help of suitable examples, explain the security problems created by incomplete mediation and time-of-check to time-of use. **(10)**

OR

18. (a) Differentiate between man-in-the-browser attack and page-in-the-middle attack. **(4)**

(b) Explain the four aspects of malicious code infection. **(10)**

19. (a) List any six computer security related functions addressed by operating systems. **(6)**

(b) How does a kernelized design support in enforcing security mechanisms? **(8)**

OR

20. (a) Explain any four security requirements of databases. **(4)**

(b) How can database disclosure be prevented? With the help of suitable examples, explain any six types of disclosure. **(10)**

Teaching Plan

No	Contents	No.of Lecture Hrs
	Module-1 (Modular Arithmetic) (6 hrs)	
1.1	Integer arithmetic, Integer division, Divisibility, Greatest Common Divisor (GCD)	1
1.2	Euclid's algorithm for GCD, Extended Euclid's algorithm	1
1.3	Linear Diophantine Equations	1
1.4	Modular arithmetic operations, Properties of modular arithmetic	1
1.5	Groups, Rings and Fields	1
1.6	Finite fields – GF(p), GF(2^n)	1
	Module-2 (Prime Numbers and Factorization) (7 hrs)	
2.1	Prime numbers and prime-power factorization	1
2.2	Fermat and Mersenne primes	1
2.3	Fermat's theorem, Applications – Exponentiation, Multiplicative inverse	1
2.4	Euler's theorem, Euler's totient function, Applications	1
2.5	Primality testing – Deterministic algorithms – Divisibility algorithm	1

2.6	Primality testing – Probabilistic algorithms-Fermat test, Square root test, Miller - Rabin test	1
2.7	Factorization - Fermat's factorization, Pollard p-1 method	1
Module-3 (Linear Congruence, Primitive Roots and Elliptic Curve Arithmetic) (7 hrs)		
3.1	Linear congruence, Simultaneous linear congruence	1
3.2	Chinese Remainder Theorem (CRT)	1
3.3	Congruence with a Prime-Power Modulus, Arithmetic modulo p	1
3.4	Pseudo-primes and Carmichael numbers	1
3.5	Solving congruence modulo prime powers	1
3.6	Primitive roots, Existence of primitive roots for primes, Discrete logarithms	1
3.7	Elliptic curve arithmetic – Prime curves, Binary curves, Addition of two points, Multiplication of a point by a constant	1
Module-4 (Computer and Program Security) (7 hrs) (Text book2: Chapters 1, 3, 4)		
4.1	Threats, Vulnerabilities, Controls	1
4.2	Browser attack types	1
4.3	Web attacks targeting users	1
4.4	Email attack types	1
4.5	Non-malicious programming oversights (Lecture 1)	1
4.6	Non-malicious programming oversights (Lecture 2)	1
4.7	Malware – Four aspects of infection	1
Module-5 (Operating System and Database Security) (8 hrs)(Text book2: Chapters 5, 7)		
5.1	Security in operating system (Lecture 1)	1
5.2	Security in operating system (Lecture 2)	1
5.3	Security in design of operating system (Lecture 1)	1

5.4	Security in design of operating system (Lecture 2)	1
5.5	Security requirements of databases	1
5.6	Reliability & integrity	1
5.7	Database disclosure (Lecture 1)	1
5.8	Database disclosure (Lecture 2)	1

ADT342	DATA VISUALIZATION	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTIO
		PEC	2	1	0	3	2019

Preamble: The syllabus is prepared with the view of facilitating the learner to get an overview of data visualization. This course aims at providing fundamental knowledge in various data visualization techniques using R programming language and D3. It also deals with security aspects involved in data visualization. The learner will be able to understand the process and security aspects involved in data visualization and apply the tools in solving complex problems.

Prerequisite: Programming experience in any language and basic knowledge in R.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Summarize the key techniques and theory used in visualization **(Cognitive Knowledge Level : Understand)**
CO 2	Design and use various methodologies present in data visualization. **(Cognitive Knowledge Level : Understand)**
CO 3	Employ appropriate processes and tools for data visualization. **(Cognitive Knowledge Level : Apply)**
CO 4	Use interactive data visualization to make inferences. **(Cognitive Knowledge Level : Apply)**
CO 5	Recognize the process involved and security issues present in data visualization. **(Cognitive Knowledge Level : Understand)**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	✔											✔
CO2	✔	✔	✔									✔
CO3	✔	✔	✔	✔	✔							✔
CO4	✔	✔	✔	✔	✔							✔
CO5	✔	✔										✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (percentage)	Test2 (percentage)	
Remember	40	40	40
Understand	40	40	40
Apply	20	20	20
Analyze			
Evaluate			
Create			

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance: 10 marks
Continuous Assessment Tests : 25 marks
Continuous Assessment Assignment: 15 marks

Internal Examination Pattern:
Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing the remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

SYLLABUS

Module 1 (Introduction to Data Visualization)
Introduction to Visualization – Need and purpose, External representation – Interactivity – Difficulty in Validation, Data Abstraction: Dataset types – Attribute types – Semantics, Task Abstraction – Analyze, Produce, Search, Query, Four levels of validation – Validation approaches – Validation examples. Marks and Channels. Data Visualization tools.

Module 2 (Arranging Spatial Data and Networks)
Arrange tables: Categorical regions – Spatial axis orientation – Spatial layout density, Arrange spatial data: Geometry – Scalar fields – Vector fields – Tensor fields. Arrange networks and trees: Connections, Matrix views – Containment, Map color: Color theory, Color maps and other channels.

Module 3 (Data Visualization using R)
Basic and Interactive Plots: scatter plot, interactive scatter plot, bar plot, line plot, interactive Gantt/timeline chart, Merging histograms, interactive bubble plot, waterfall plot, Heat Maps and Dendrograms: simple dendrogram, dendrograms with colors and labels, heat map, heat map with customized colors, three-dimensional heat map and a

stereo map, tree map. Maps: regional maps, choropleth maps, contour maps, maps with bubbles, Integrating text with maps, shapefiles, cartograms, Pie Chart and Its Alternatives, Adding the Third Dimension: 3D scatter plot, 3D pie chart, 3D histogram, 3D contour plot.

Module 4 (Interactive Data Visualization using D3)

Drawing with data: Drawing divs, SVG's, Making a bar chart, scatterplot – Scales - Axes – Updates, Transition and Motion – Modernizing the bar chart, Updating data, transitions, Interactivity – Layouts – Geomapping – Framework – D3.js, tableau.

Module 5 (Security Data Visualization)

Port scan visualization - Vulnerability assessment and exploitation - Firewall log visualization - Intrusion detection log visualization - Attacking and defending visualization systems – Creating security visualization system.

Text Books

1. Tamara Munzner, Visualization Analysis and Design, AK Peters Visualization Series, CRC Press, Nov. 2014
2. Atmajitsinh Gohil, "R Data Visualization Cookbook", PACKT, 2015.
3. Scott Murray, "Interactive data visualization for the web", O"Reilly Media, Inc., 2013.
4. Greg Conti, "Security Data Visualization: Graphical Techniques for Network Analysis", NoStarch Press Inc, 2007.

Reference Books

1. A Julie Steele and Noah Iliinsky, Designing Data Visualizations: Representing Informational Relationships, O'Relly.
2. Andy Kirk, Data Visualization: A Successful Design Process, PAKT.
3. Nathan Yau, "Data Points: Visualization that means something", Wiley, 2013.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the four levels of validation in Data Visualization.

Course Outcome 2 (CO2): Discuss the different methods to arrange spatial data.

Course Outcome 3(CO3): Write sample code in R to generate a simple pie chart showing data on brain injury across different branches of the military:

Military Branch	Army	Navy	Air Force	Marines
No:	179718	41370	41914	44280

Also draw the resultant pie chart.

Course Outcome 4 (CO4): Given a dataset: [5, 10, 13, 19, 21, 25, 22, 18, 15, 13, 11, 12, 15, 20, 18, 17, 16, 18, 23, 25] to plot a bar graph. This dataset was later modified as [11, 12, 15, 20, 18, 17, 16, 18, 23, 25, 5, 10, 13, 19, 21, 25, 22, 18, 15, 13]. Write the sample code in d3 to update the contents of a bar chart with new data values.

Course Outcome 5 (CO5): Explain Intrusion detection log visualization.

Model Question Paper

QPCODE: PAGES: 3

RegNo:__________

Name :___________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

***Course Code:* ADT 342**

Course Name: Data Visualization

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. What is data visualization? Why do we use it? Illustrate the need of data visualization.
2. Why do data semantics and data types matter in data visualization?
3. Describe the HSL system.
4. Describe scatterplot with an example.
5. How is the waterfall plot constructed in R?
6. Compare chloropleth maps and cartograms.
7. Illustrate the use of ease() and delay() functions in transitions with an example.
8. Specify any three types of D3 layouts?
9. Describe port scan visualization.
10. What is meant by vulnerability assessment in visualization? (10x3=30)

Part B

Answer any one Question from each module. Each question carries 14 Marks

11.a "Splitting the complex problem of visualization design into four cascading levels provides an analysis framework that lets you address different concerns separately". Explain the four cascading levels with a diagram? (10 marks)

11.b What are the threats to validity at each of the levels? (4 marks)

OR

12.a	Define marks and channels. Explain how visual channels control the appearance of marks. How are these visual channels and marks used for encoding various chart types?	(8 marks)
12.b	Illustrate Various data visualization tools.	(6 marks)
13.a	Differentiate between node-link diagrams and matrix views. Also specify the costs and benefits of each.	(8 marks)
13.b	Explain Treemaps and GrouseFlocks.	(6 marks)
	OR	
14.a	What is colour mapping? Explain the different types of colour maps.	(8 marks)
14.b	Explain scalar fields, vector fields and tensor fields.	(6 marks)
15.a	What is a dendrogram? Write the R code to construct a dendrogram.	(7 marks)
15.b	What is a pie chart? What are its limitations? Write the steps involved in its construction in R.	(7 marks)
	OR	
16.a	Why do we need a 3D scatter plot? Write the sample code to generate a 3D scatter plot in R.	(7 marks)
16.b	What are shape files? Why do we use them? Write the step-by-step procedure to construct a shape file.	(7 marks)
17.a	Given a data set = [5, 10, 13, 19, 21, 25, 22, 18, 15, 13,11, 12, 15, 20, 18, 17, 16, 18, 23, 25]; Write the D3 code to plot the given data set as bar chart with dual encoding of the data values in terms of both height and color. The data bars should have centered labels. Also plot the resultant bar graph for the given data set.	(7 marks)
17.b	Given another data set dataset = [[5, 20], [480, 90], [250, 50], [100, 33], [330,95], [410, 12], [475, 44], [25, 67], [85, 21], [220, 88]]; where [[]] indicate an array within another array. Plot this data set and specify the name of the plot obtained	(7 marks)
	OR	
18.a	What are named transitions? Explain with an example.	(7 marks)
18.b	What are tooltips? Explain with an example. What are the different types of tooltips?	(7 marks)
19.a	Write about firewall log visualization.	(7 marks)
19.b	Discuss in detail about intrusion detection log visualization.	(7 marks)
	OR	
20.a	Describe the concept of attacking and defending visualization systems.	(7 marks)
20.b	Describe about security visualization system.	(7 marks)

(14X5=70)

Teaching Plan

No	Contents	No. of Lecture Hours (35)
	Module - 1 (Introduction to Data Visualization)	**(6 hours)**
1.1	Introduction to Visualization – Need and purpose	1 hour
1.2	Data Abstraction: Dataset types	1 hour
1.3	Attribute types – Semantics	1 hour
1.4	Task Abstraction, Four levels of validation	1 hour
1.5	Validation approaches	1 hour
1.6	Data Visualization tools	1 hour
	Module - 2 (Arranging Spatial Data and Networks)	**(7 hours)**
2.1	Arrange tables: Categorical regions – Spatial axis orientation	1 hour
2.2	Spatial layout density	1 hour
2.3	Arrange spatial data: Geometry – Scalar fields	1 hour
2.4	Vector fields – Tensor fields	1 hour
2.5	Arrange networks and trees: Connections, Matrix views – Containment	1 hour
2.6	Map color: Color theory, Color maps and other channels	1 hour
2.7	Map color	1 hour
	Module - 3 (Data Visualization using R)	**(8 hours)**
3.1	Basic and Interactive Plots: scatter plot, interactive scatter plot	1 hour
3.2	Interactive Gantt/timeline chart, Merging histograms, interactive bubble plot, waterfall plot	1 hour
3.3	Heat Maps and Dendrograms : simple dendrogram, dendrograms with colors and labels, heat map	1 hour
3.4	heat map with customized colors, three-dimensional heat map and a stereo map, tree map	1 hour
3.5	Maps: regional maps, choropleth maps, contour maps	1 hour
3.6	maps with bubbles, Integrating text with maps, shape files, cartograms	1 hour
3.7	Pie Chart and Its Alternatives	1 hour
3.8	Adding the Third Dimension: 3D scatter plot, 3D pie chart, 3D histogram, 3D contour plot.	1 hour

	Module- 4 (Interactive Data Visualization using D3)	**(8 hours)**
4.1	Drawing with data	1 hour
4.2	Scales	1 hour
4.3	Axes	1 hour
4.4	Updates, Transition and Motion – Modernizing the bar chart	1 hour
4.5	Updating data, transitions	1 hour
4.6	Interactivity	1 hour
4.7	Layouts	1 hour
4.8	Geomapping	1 hour
	Module- 5 (Security Data Visualization)	**(6 hours)**
5.1	Port scan visualization	1 hour
5.2	Vulnerability assessment and exploitation	1 hour
5.3	Firewall log visualization	1 hour
5.4	Intrusion detection log visualization	1 hour
5.5	Attacking and defending visualization systems	1 hour
5.6	Creating security visualization system	1 hour

AIT352	ARTIFICIAL NEURAL NETWORKS TECHNIQUES	Category	L	T	P	Credit	Year of Introduction
		PEC	2	1	0	3	2019

Preamble: This course enables the learners to understand the fundamental concepts regarding Artificial Neural networks. The course covers basic analogy between ANN and human brain, the basic learning laws, fundamental ANN algorithms, Back Propagation Feed Forward Network, Self Organising Maps, RBF net, BAM and ART networks. This course enables the students to apply techniques and methods to solve real-world problems involving the application of ANN.

Prerequisite: Nil.

Course Outcomes: After the completion of the course the student will be able to

CO1	Summarize the basic concepts and the learning rules of ANN. **(Cognitive Knowledge Level: Understand)**
CO2	Utilize the fundamental learning algorithms namely, Mc-Culloch Pitts, Hebb Perceptron and Adaline to solve real world problems.**(Cognitive Knowledge Level: Apply)**
CO3	Implement Back propagation learning algorithm, Generic Radial Basis Function network. **(Cognitive Knowledge Level: Apply)**
CO4	Demonstrate Self Organizing Maps and Adaptive Resonance Theory.**(Cognitive Knowledge Level: Understand)**
CO5	Implement training algorithms for pattern association. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔									✔
CO2	✔	✔	✔	✔	✔							✔
CO3	✔	✔	✔	✔	✔							✔
CO4	✔	✔			✔							✔
CO5	✔	✔	✔	✔	✔							✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	**30**	**30**	**30**
Understand	**40**	**40**	**40**
Apply	**30**	**30**	**30**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**50**	**100**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 marks**
Continuous Assessment Tests(Average of Internal Tests 1 & 2)	**25 marks**
Continuous Assessment Assignment	**15 marks**

Internal Examination Pattern

Two internal examinations of two hours duration has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module – 1 (Basics of Artificial Neural Network and Learning Methods)

Characteristics of the human brain, Neurons, Introduction to Artificial Neural Networks, Terminology, Models of ANN, Topology, Network Architectures, Knowledge Representation, Learning Process, Learning Tasks. Categories of learning - Hebbian learning, Perceptron Learning Rule, Delta Learning Rule, Generalized Delta Learning Rule, Competitive learning, Error-correction learning, Reinforcement learning, Stability and Convergence.

Module – 2(Basic ANN Models)

McCulloch-Pitts Neuron, Architecture, Algorithm and Applications. Biases and Thresholds, Linear Separability. Hebb Net - Algorithm, Applications. Perceptron - Architecture, Algorithm, Applications. Perceptron Learning Rule Convergence Theorem. Adaline - Architecture, Algorithm, Applications.

Module - 3 (Multilayer Perceptrons)

Multi-Layered network architecture, Back propagation Algorithm, Applications, XOR problem, Replacing and Modifying Back propagation Algorithms Using Heuristics.

Cover's Theorem on the Separability of patterns, The Interpolation Problem, Radial Basis Function Networks, Comparison of MLP and RBF Networks(Theory only).

Module – 4 (SOMs and ART Networks)

Self-organizing maps - Building, Training, Evaluating, Interpreting and Visualizing a Self-organizing Map. Applications of Self Organizing Maps.

Adaptive Resonance Theory -Stability Plasticity Dilemma, ART-1-Architeture, Algorithm, Applications. ART-2 – Architeture, Algorithm, Applications.

Module – 5 (Training Algorithms for Pattern Association)

Introduction, Hetero associative neural network- Architecture, Applications. Auto Associative Net -Architecture, Applications. Iterative Auto Associative Net – Architecture, Applications. Discrete Hopfield Network. Bidirectional Auto-associative Memory – Architecture, Applications.

Text Books

1. Simon Haykin, "Neural Networks, A comprehensive Foundation"(2nd edition), Pearson Education (Module - 4)
2. Laurene Faucett, "Fundamentals of Artificial Neural Networks, architecture algorithm and applications"(Modules – 2,3,5)
3. Yegnanarayana, "Artificial Neural Networks", Phi Learning (Module -1)

Reference Books

1. Christopher M Bishop," Neural networks for Pattern Recognition
2. Mohammad H Hassoun, "Fundamentals of Artificial Neural Networks"

Course Level Assessment Questions

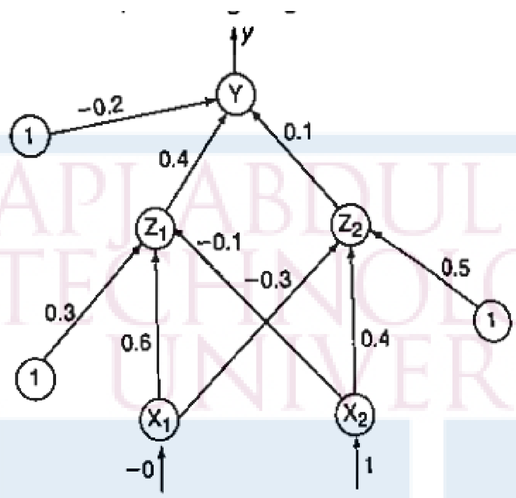
Course Outcome1 (CO1):

1. What are the different types of competitive learning?
2. Demonstrate the significance of different Activation functions.
3. Explain the terms cell body, axon, synapse, dendrite and neuron with reference to abiological neural network.
4. Illustrate examples of pattern recognition tasks to demonstrate the superiority of the biological neural network over a conventional computer system. (Assignment Question)

Course Outcome 2 (CO2):

1. How is training adopted in Adaline network and state the characteristics of weighted interconnections in Adaline .
2. How is the linear separability concept implemented using Perceptron Network training?
3. Implement NAND logical function using Perceptron Network in Python language(Assignment Question)

Course Outcome 3(CO3):



1. Find the new weights of Back propagation net shown in the figure for the input pattern (0,-1) and the target output 1, Use 0.25 as learning rate.
2. Why is gradient descent method adopted to minimize error? Explain in relation to Back propagation of error phase of BPNN?
3. Implement RBF network using Python language. (Assignment Question)

Course Outcome 4(CO4): .

1. Design an ART1 used to cluster four vectors with low vigilance. The values and description of the parameters are given in the table. Cluster the vectors, (1,1,0,0), (0,0,0,1), (1,0,0,0), (0,0,1,1) in at most three clusters.

n=4	Number of components in the input vector
m=3	It was an excellent game.
P=0.4	Vigilence parameter
L=2	Parameter used in update of bottom-up weights
$b_{ij}(0)=1/n+1$	Initial bottom-up weights
$t_{ij}(0)=1$	Initial top-down weights

2.Use NeuPy library of Python to implement Adaptive Resonance Theory (ART1) Network for binary data clustering.
3.Implement Self Organizing Map in Python to demonstrate how does the grid automatically arrange, using colour patterns and evaluate the effect of Learning Rate and Radius. (Assignment Question)

Course Outcome 5(CO5):

1. Compare and contrast auto associative and hetero associative networks with examples.

2. Implement Bidirectional Associative Memory using Python without using specific libraries. (Assignment Question)

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT352

Course Name: Artificial Neural Networks Techniques

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1.	What are the main differences among the three models of artificial neurons, namely, McCulloch-Pitts, Perceptron and Adaline?	**3**
2.	Compare the stability and convergence of ANN	**3**
3.	Design a Mc-Culloch Pitts neural network to implement AND function.	**3**
4.	Define Perceptron Learning Rule Convergence theorem.	**3**
5.	What is the significance of momentum factor in backpropagation learning?	**3**
6.	Compare RBF network and Multilayer Perceptron network.	**3**
7.	Illustrate the feature mapping models.	**3**
8.	What is the significance of 'resonance' in ART network?	**3**

9. Explain the hebb rule for pattern association **3**

10. Interpret cross talk and perfect recall using suitable examples **3**

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Describe any four attractive features of the biological neural network that make it superior to the most sophisticated Artificial Intelligence computer system for pattern recognition tasks. **(8)**

(b) Compare LMS, Perceptron and Delta learning laws. **(6)**

OR

12. (a) Compare the performance of a computer and that of a biological neural network in terms of speed of processing, size and complexity, storage, fault tolerance and control mechanism. **(8)**

(b) What is reinforcement learning? In what way it is different from supervised learning? **(6)**

13. (a) Explain Hebb net algorithm and implement logical AND function using bipolar inputs. **(4)**

(b) Use Adaline nerwork to train AND NOT function with bipolar inputs and targets. Perform one epoch of training. **(10)**

OR

14. (a) Using the Perceptron Learning rule find the weights required to perform the following classifications. Vectors (1,1,1,1) and (-1,1,-1,-1) are members of the class and hence target value 1; vectors (1,1,1,-1) and (1, -1, -1, 1) are not the members of the class and hence target value -1. Use learning rate of 1 and starting value of weights as 0, test the response of the net. **(10)**

(b) XOR function is non·linearly separable by a single decision boundary line. Justify. **(4)**

15. (a) Analyse Cover's theorem based on XOR problem. **(10)**

(b) Explain the learning factors of of Back propagation network algorithm **(4)**

OR

16. (a) Relate Hidden layer and Output layer error terms with back propagation of error term phase in Back Propagation Network algorithm. **(10)**

(b) Explain the architecture and algorithm of RBF network . **(8)**

17. (a) Explain the statistical properties exhibited by SOM after convergence. **(10)**

(b) Interpret stability-plasticity dilemma in relation with ART network. **(4)**

OR

18. (a) Show the architecture of Kohonen's Self Organising Map and demonstrate the competitive process in Kohonen's self organising Map. **(8)**

(b) Explain the basic architecture of ART-2 and its algorithm. **(6)**

19. (a) Describe the architecture and algorithm of Discrete Bidirectional Associative Memory **(5)**

(b) Use the Hebb rule to store the vetors (1,1,1,1)and (1,1,-1,-1) in an auto associative neural net. **i.(9)**

a. Fnd the weight matrix(Do not set the diagonal terms to zero)

b. Test the net, using the following vectors as input

i. (1,1,1,1)

ii. (1,1,-1,-1)

iii. (1,1,1,0)

Repeat parts a and b with diagonal weight matrix set to zero. Identify the differences in the response.

OR

20. (a) Design a BAM net to associate the letters"A" and "C" given in bipolar 5X3 vectors to the bipolar codes (-1,1) and (1,1) respectively. **(10)**

(b) Compare Iterative Autoassocative with Discrete Hopfield Net. **(4)**

TEACHING PLAN

No	Contents	No of Lecture Hrs: 35
Module -1 : Basics of Artificial Neural Network and Learning methods (7 hours)		
1.1	Introduction to Neural Network, The human brain - Characteristics of Neural Network.	1
1.2	Artificial Neural Network - Terminology, Models of a neuron, Topology	1
1.3	Network architectures, Knowledge representation.	1
1.4	Learning Process, Learning tasks.Categories of learning- Hebbian learning, Competitive learning.	1
1.5	Error-correction learning.	1
1.6	Reinforcement learning.	1
1.7	Stability and Convergence.	1
Module - 2 : Basic ANN Models(7 hours)		
2.1	McCulloch-Pitts Neuron - Architecture, Algorithm and Applications.	1
2.2	Biases and thresholds, Linear separability.	1
2.3	Hebb net - Algorithm , Applications	1
2.4	Perceptron -Architecture, Algorithm	1
2.5	Perceptron -Applications, Perceptron learning rule convergence theorem.	1
2.6	Perceptron learning rule convergence theorem. Adaline - Architecture, Algorithm	1
2.7	Adaline - Applications	1
Module 3 : Multilayer Perceptrons (7 hours)		
3.1	Multilayered Feed Forward Network Architecture,	1

3.2	Back propagation algorithm, Activation functions, Rate of learning, Stopping criteria	1
3.3	Applications, XOR problem, Heuristics for making the Back propagation algorthm perform better.	1
3.4	Cover's Theorem on the separability of patterns.	1
3.5	Cover's Theorem on the separability of patterns, XOR problem.	1
3.6	The interpolation problem, Radial Basis Function networks.	1
3.7	The interpolation problem, Radial Basis function networks, Comparison of RBF network and Multi-Layer perceptrons.	1
Module 4 : SOMs and ART networks (7 hours)		
4.1	Two basic feature mapping methods.	1
4.2	Self Organizing Map, Competitive process, Cooperative process, Adaptive process.	1
4.3	Properties of the feature map.	1
4.4	Stability Plasticity Dilemma, ART-1-Architeture**.**	1
4.5	ART-1 - Algorithm, Applications.	1
4.6	ART-2 - Architeture-Algorithm	1
4.7	ART-2 - Applications.	1
Module 5 : Training Algorithms for pattern Association (7 hours)		
5.1	Introduction, Hebb rule for pattern association, Delta rule for pattern association	1
5.2	Hetero Associative Neural Network-Architecture , Applications,	1
5.3	Auto-associative Net - Architecture, Algorithm, Applications, Storage capacity.	1
5.4	Iterative Auto Associative Net - Architecture, Applications	1
5.5	Discrete Hopfield network - Architecture, Algorithm, Applications**.**	1
5.6	Bidirectional Auto-associative Memory-Architecture, Algorithm.	1
5.7	Bidirectional Auto-associative Memory – Applications.	1

AIT362	PROGRAMMING IN R	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PEC	2	1	0	3	2019

Preamble: The objective of this course is to enable the learner to make use of R Programming language to perform analysis and extraction of information from data irrespective of the quantity. It encompasses the R programming environment, syntax, data representations, data processing, statistical analysis and visualization. This course facilitates the learner to develop modular software solutions to perform statistical analysis and data extraction.

Prerequisite: Fundamental concepts in programming in C and Probability and Statistical Modeling

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Illustrate uses of conditional and iterative statements in R programs. (Cognitive Knowledge level: Apply)
CO 2	Write, test and debug R programs (Cognitive Knowledge level: Apply)
CO 3	Illustrate the use of Probability distributions and basic statistical functions. (Cognitive Knowledge level: Apply)
CO 4	Visualize different types of data (Cognitive Knowledge level: Apply)
CO 5	Comprehend regression modeling using R (Cognitive Knowledge level: Understand)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	✔	✔	✔		✔							✔
CO2	✔	✔	✔		✔							✔
CO3	✔	✔	✔	✔	✔							✔
CO4	✔	✔	✔	✔	✔							✔
CO5	✔	✔			✔							✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (percentage)	Test2 (percentage)	
Remember	20	20	20
Understand	40	40	40
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance: 10 marks
Continuous Assessment Tests : 25 marks
Continuous Assessment Assignment: 15 marks

Internal Examination Pattern:
Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing the remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

SYLLABUS

Module -1 (Introduction to R)
The R Environment - Command Line Interface and Batch processing, R Packages, Variables, Data Types, Vectors- vector operations and factor vectors, List- operations, Data Frames, Matrices and arrays, Control Statements- Branching and looping - For loops, While loops, Controlling loops. Functions- Function as arguments, Named arguments

Module -2(Reading and writing data)
Importing data from Text files and other software, Exporting data, importing data from databases- Database Connection packages, Missing Data - NA, NULL
Combining data sets, Transformations, Binning Data, Subsets, summarizing functions. Data Cleaning, Finding and removing Duplicates, Sorting.

Module -3 (Statistics with R)
Analyzing Data, Summary statistics, Statistical Tests- Continuous Data, Discrete Data, Power tests, Common distributions- type arguments. Probability distributions, Normal distributions

Module -4(Data Visualization)
R Graphics- Overview, Customizing Charts, Graphical parameters, Basic Graphics functions, Lattice Graphics - Lattice functions, Customizing Lattice Graphics, Ggplot.

Module - 5 (Regression Models)
Building linear models - model fitting, Predict values using models, Analyzing the fit, Refining the model, Regression- types, Unusual observation and corrective measures,

Comparison of models, Generalized linear models - Logistic Regression, Poisson Regression, Nonlinear least squares

Text Book

1. Joseph Adler, " R in a Nutshell", Second edition,O'reilly,2012

Reference Books

1. Jared P Lander, R for Everyone- Advanced analytics and graphics, Addison Wesley data analytics series, Pearson
2. Norman matloff, The art of R programming, A Tour of Statistical, Software Design, O'reilly
3. Robert Kabacoff, R in action, Data analysis and graphics with R, Manning
4. Garret Grolemund, Hands-on programming with R, Write your own functions and simulations, O'reilly

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is Coercion? How is it done in R?
2. Write a program to find the factorial of a number.
3. Write a program to compute roots of a quadratic equation.

Course Outcome 2 (CO2):

1. Write a program to read data from a table 'table123' in a database named 'db123' and display the values .
2. Explain Data cleaning in R
3. How missing data is handled in R?

Course Outcome 3(CO3):

1. Explain summary function in R
2. Illustrate how statistical testing is performed in R
3. Describe about probability distributions.

Course Outcome 4 (CO4):

1. Illustrate the use of ggplot() and various data visualization tools using appropriate datasets

Course Outcome 5 (CO5):

1. Illustrate the steps to predict the weight of a person when his height is unknown using linear regression for the data given below.

Height	151	174	138	186	128	136	179	163	152	130
Weight	63	81	56	91	47	57	76	72	62	48

Model Question Paper

QP CODE: PAGES:3

Reg No:__________

Name :__________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

***Course Code:* AIT 362**

Course Name: Programming in R

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Write a R program to add element "23" to the vector (24,56,67) in the second position.
2. Discuss the general list operations in R with example.
3. Calculate the cumulative sum and cumulative product for the given data 23, 1, 7,2,8,10, 17 using R Program.
4. Explain aggregate function in R.
5. List the applications of R programming.
6. Illustrate summary function.
7. List any three graphics functions.
8. Explain Lattice function.
9. Suppose that you have a dataset D1 and you design a linear regression model of degree 3 polynomial and you found that the training and testing error is "0" or in other terms it perfectly fits the data. What will happen when you fit a degree 2 polynomial in linear regression?
10. Explain logistic regression function in R.

(10x3=30)

Part B

Answer any one Question from each module. Each question carries 14 Marks

11.a	Write a R program to extract every nth element from a vector.	(7 marks)
11.b	Find the Nth highest value of a vector in R.	(7 marks)
	OR	
12.a	Write a R program to create a data frame using two given vectors and display the duplicate elements and unique rows of the said data frame.	(7 marks)

12.b Write a R program to compare two data frames to find the row(s) in the first data frame that are not present in the second data frame. (7 marks)

13.a Write a R program to call the (built-in) dataset air quality. Remove the variables 'Solar.R' and 'Wind' and display the data frame. (7 marks)

13.b Illustrate transformation functions in R. (7 marks)

OR

14.a Write a R program to write the following data to a CSV file. (7 marks)

	Country	Population_1_july_2018	Population_1_july_2019	change_in_percents
1	China	1,427,647,786	1,433,783,686	+0.43%
2	India	1,352,642,280	1,366,417,754	+1.02%
3	United States	327,096,265	329,064,917	+0.60%
4	Indonesia	267,670,543	270,625,568	+1.10%
5	Pakistan	212,228,286	216,565,318	+2.04%

14.b Given a file "auto.csv" of automobile data with the fields index, company, body-style, wheel-base, length, engine-type, num-of-cylinders, horsepower, average-mileage, and price, write R program to print total cars of all companies, Find the average mileage of all companies. (7 marks)

15.a Write a note on data analysis using R. (7 marks)

15.b Explain how statistical test are performed using R functions. (7 marks)

OR

16.a Write R code to generate the probability distribution table for number of successes from a binomial distribution where n=5 and probability of success in each trial is 0.25. (7 marks)

16.b Fit a Poisson distribution with the following data using the following data (7 marks)

X	0	1	2	3	4	5
F	142	156	69	27	5	1

OR

17 Given the sales information of a company as CSV file with the following, fields month_number, face cream, facewash, toothpaste, bathingsoap, shampoo, moisturizer, total_units, total_profit. Write R codes to visualize the data as follows:

a) Toothpaste sales data of each month and show it using a scatter plot. (7 marks)

b) Calculate total sale data for last year for each product and show it using a Pie chart. (7 marks)

OR

18.a Explain ggplot() with and example. (7 marks)

18.b Describe how categorical data is visualized using R. (7 marks)

19.a Illustrate model fitting in simple linear model. (7 marks)

19.b Explain different types of regression. (7 marks)

OR

20.a Describe the unusual observations in the regression model. (7 marks)

20.b Explain corrective measures of unusual observations in regression modelling. (7 marks)

TEACHING PLAN

No	Contents	No of Lecture Hours (35 Hours)
	Module -1 (Introduction to R)	**(8 hours)**
1.1	The R Environment- Command Line Interface and Batch processing, R Packages	1 hour
1.2	Variables, Data Types	1 hour
1.3	Vectors- vector operations and factor vectors	1 hour
1.4	List- List operations, Data Frames	1 hour
1.5	Matrices and arrays	1 hour
1.6	Control Statements- If and else, switch, if else	1 hour
1.7	Loops- For loops, While loops, Controlling loops	1 hour
1.8	Functions- Function as arguments, Named arguments	1 hour
	Module -2(Reading and writing data)	**(8 hours)**
2.1	Importing data from Text files and other software, Exporting data	1 hour
2.2	Importing data from databases- Database Connection packages	1 hour
2.3	Missing Data-NA, NULL	1 hour
2.4	Combining data sets, Transformations	1 hour
2.5	Binning Data, Subsets, summarizing functions	1 hour
2.6	Data Cleaning	1 hour
2.7	Finding and removing Duplicate	1 hour
2.8	Sorting	1 hour
	Module -3 (Statistics with R)	**(6 hours)**
3.1	Analyzing Data	1 hour
3.2	Summary statistics	1 hour
3.3	Statistical Tests- Continuous Data, Discrete Data, Power tests	1 hour
3.4	Common distributions- type arguments	1 hour
3.5	Probability distributions	1 hour
3.6	Normal distributions	1 hour
	Module -4(Data Visualization)	**(6 hours)**
4.1	R Graphics- Overview	1 hour
4.2	Customizing Charts	1 hour
4.3	Graphical parameters, Basic Graphics functions	1 hour
4.4	Lattice Graphics - Lattice functions	1 hour
4.5	Customizing Lattice Graphics	1 hour
4.6	ggplot	1 hour
	Module - 5 (Regression Models)	**(7 hours)**

5.1	Building linear models - model fitting	1 hour
5.2	Predict values using models, Analyzing the fit, Refining the model	1 hour
5.3	Regression- types of regression	1 hour
5.4	Unusual observations and corrective measures	1 hour
5.5	Comparison of models	1 hour
5.6	Generalized linear models -Logistic Regression, Poisson Regression	1 hour
5.7	Nonlinear least squares	1 hour

AMT372	MACHINE LEARNING MODELS AND STORAGE MANAGEMENT	Category	L	T	P	Credit	Year of Introduction
		PEC	2	1	0	3	2020

Preamble: This course enables the learners to understand the basic machine learning models and different storage concepts. The course covers the standard and most popular supervised learning algorithms, storage technology, storage architecture, network storage system and securing and managing storage infrastructures. This course helps the students to choose the appropriate storage infrastructure for typical real world applications.

Prerequisite: Nil

Course Outcomes: After the completion of the course the students will be able to

CO1	Illustrate the concepts of machine learning techniques and models**(Cognitive Knowledge Level: Apply)**
CO2	Demonstrate various storage management technologies **(Cognitive Knowledge Level: Apply)**
CO3	Explain Storage Systems Architecture and interaction of file systems **(Cognitive Knowledge Level: Understand)**
CO4	Explain the different Network storage protocols **(Cognitive Knowledge Level: Understand)**
CO5	Illustrate the concepts of management metric and standards**(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔	✔	✔							✔
CO2	✔	✔	✔									✔
CO3	✔	✔	✔									✔
CO4	✔	✔	✔									✔
CO5	✔	✔	✔									✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests(Average of Internal Tests 1 & 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

Module – 1 (MACHINE LEARNING MODELS)

Introduction to Machine Learning, Examples of Machine Learning applications, Linear Regression: single & multiple variables, Classification: Logistic Regression - Decision Trees, Overfitting & Underfitting, Bias -Variance trade-off, Support Vector Machines, Canonical Cases for Conditional Independence-Naive Bayes' Classifier.

Module - 2(STORAGE TECHNOLOGY)

Information Storage-Data, Bigdata, Information, evolution of storage Architecture. Data Centre Infrastructure-Core elements, characteristics, Virtualization and Cloud Computing, Disk drive components, Physical disk structure, Zone Bit recording, Logical block addressing, Disk drive Performance, Direct Attached Storage, Storage design based on application requirements disk performance

Module- 3(STORAGE SYSTEM ARCHITECTURE)

RAID, Implementation methods, RAID -Techniques-Striping, Mirroring, Parity. RAID Levels, RAID impact on disk performance. Components of an Intelligent Storage System-Front end, Cache, Back end, Storage provisioning-traditional vs virtual. Types of Intelligent storage systems

Backup and Archive- Backup Purpose, Backup Granularity, Backup methods , Backup architectures, Backup topologies

Module - 4 (NETWORK STORAGE SYSTEM)

Fibre Channel Storage Area Networks- SAN and Its Evolution, Components of FC SAN, Fibre Channel Architecture, Fibre Channel Protocol Stack, FC SAN Topologies, Virtualization in SAN, IP SAN and FCoE- iSCSI- Components, FCIP Protocol Stack, Topology, FCoE.

Network-Attached Storage- Benefits of NAS, File Systems and Network File Sharing, Components of NAS, NAS Implementations-Unified NAS, Unified NAS Connectivity, Gateway NAS, Connectivity, NAS File-Sharing Protocols.

Module - 5 (SECURING AND MANAGING STORAGE INFRACTURES)

Information Security Framework, Risk Triad, Storage Security Domains- Securing the Application Access Domain, Securing the Management Access Domain, Securing Backup, Replication, and Archive. Security Implementations in Storage Networking-FC SAN, NAS, IP SAN, Monitoring the Storage Infrastructure, Storage Infrastructure Management Activities, Storage Infrastructure Management Challenges, Information Lifecycle Management, Storage Tiering.

Text Books

1. Introduction to machine learning, Second Edition, EthemAlpayd The MIT Press Cambridge, Massachusetts London, England
2. Information Storage and Management: Storing, Managing, and Protecting Digital Information in Classic, Virtualized, and Cloud Environments, Somasundaram, Gnanasundaram, Alok Shrivastava Editor: EMC Education Services, Wiley, 2012 .

Reference Books

1. Information Storage and Management: Storing, Managing, and Protecting Digital Information, Antonio Cantiago, Wiley, 2009
2. Storage Area Network Essentials: A Complete Guide To Understanding And Implementing Sans, Richard Barker, Paul Massiglia, 2008
3. Storage Networks Explained: Basics and Application of Fibre Channel SAN, NAS, ISCSI, InfiniBand and FCoE, Ulf Troppens and Rainer Erkens, Wiley, 2009

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare different machine learning paradigms with suitable examples.
2. Distinguish between overfitting and underfitting. How it can affect model generalization?

Course Outcome 2 (CO2):

1. What is structured and unstructured data? Research the challenges of storing and managing unstructured data.
2. Discuss the benefits of information-centric storage architecture over server-centric storage architecture.

Course Outcome 3 (CO3):

1. What is zoning? Discuss a scenario: a. Where WWN zoning is preferred over port zoning. b. Where port zoning is preferred over WWN zoning.
2. Describe the process of assigning an FC address to a node when logging on to the network for the first time.
3. Seventeen switches, with 16 ports each, are connected in a full mesh topology. How many ports are available for host and storage connectivity?

Course Outcome 1 (CO4):

1. SAN is configured for a backup–to-disk environment, and the storage configuration has additional capacity available. Can you have a NAS gateway configuration use this SAN-attached storage? Discuss the implications ofsharing the backup-to-disk SAN environment with NAS.
2. Compared to a standard IP packet, what percentage of reduction can be realized in protocol overhead in an iSCSI, configured to use jumbo frames with an MTU value of 9,000 bytes?

Course Outcome 5 (CO5):

1. Describe Storage Management strategies for any two real world application scenarios (Storage Allocation to a New Server/Host, File System Space Management)

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AMT372

Course Name: Machine Learning Models and Storage Management

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1.	Explain the significance of Naive assumption in Bayesian classifier	**3**
2.	Compare Classification with regression with an example	**3**
3.	What are the advantages of a virtualized data center over a classic data center?	**3**
4.	Which components constitute the disk service time? Which component contributes the largest percentage of the disk service time in a random I/O operation?	**3**
5.	What is meant by intelligent storage system.	**3**
6.	Why is RAID 1 not a substitute for a backup?	**3**
7.	Compare the topologies of FC-SAN, NAS, IP-SAN.	**3**
8.	What are the Factors affecting NAS performance.	**3**
9.	List the different security goals.	**3**
10.	How does the use of jumbo frames affect the NAS performance?	**3**

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) For the following set of training samples, find which attribute can be chosen as the root for decision tree classification **(8)**

Instance	Classification	a1	a2
1	+	T	T
2	+	T	T
3	-	T	F
4	+	F	F
5	-	F	T
6	-	F	T

(b) Explain the working principles of SVM classifiers. **(6)**

OR

12. (a) What is overfitting? Explain Bias -Variance trade off. **(7)**

(b) Use the following data to construct a linear regression model for the auto insurance premium as a function of number of years the vehicle used. **(7)**

Years used	1	3	5	8	10	12
Insurance Premium	9000	7000	6000	5000	4000	3000

13. (a) The average I/O size of an application is 64 KB. The following specifications are available from the disk manufacturer: average seek time = 5 ms, 7,200 RPM, and transfer rate = 40 MB/s. Determine the maximum IOPS that could be performed with this disk for the application. Using this case as an example, explain the relationship between disk utilization and IOPS **(7)**

(b) Illustrate any three Disk Drive Components. **(7)**

OR

14. (a) Define the following terms **(8)**

(i)Disk Service Time
(ii)Seek Time
(iii)Rotational Latency
(iv)Data Transfer Rate

(b) List the benefits and limitations of Direct Attached Storage **(6)**

15. (a) Explain the terms :Striping, Mirroring, Parity **(6)**

(b) Describe the Components of an Intelligent Storage System **(8)**

OR

16. (a) Explain the process of data recovery in case of a drive failure in RAID 5. What are the benefits of using RAID 3 in a backup application? **(7)**

(b) Explain the Array caching properties and algorithms. **(7)**

17. (a) Illustrate the NAS File-Sharing Protocols. **(10)**

(b) Explain Fibre Channel Architecture and Protocol Stack. **(4)**

OR

18. (a) Describe the Benefits of CAS? **(8)**

(b) Explain the Components of IP-SAN? **(6)**

19. (a) Explain how security is provided in application access domain and management access domain. **(10)**

(b) List out the challenges in storage Infrastructure management **(4)**

OR

20. (a) Describe the secure user access in NAS environment **(6)**

(b) Discuss different aspects of monitoring the storage infrastructure **(8)**

Teaching Plan

No	Contents	No. of Lecture Hours (37hrs)
Module – 1 (FUNDAMENTALS) (7 hours)		
1.1	Introduction to Machine Learning, Examples of Machine Learning applications	1 hour
1.2	Linear Regression: single & multiple variables,	1 hour
1.3	Classification: Logistic Regression	1 hour
1.4	Decision Trees	1 hour
1.5	Overfitting & Underfitting, Bias Variance Trade-off	1 hour
1.6	Support Vector Machines	1 hour
1.7	Canonical Cases for Conditional Independence-Naive Bayes' Classifier.	1 hour
Module - 2(STORAGE TECHNOLOGY) (5 hours)		
2.1	Information Storage-Data, Bigdata, Information, evolution of storage Architecture	1 hour
2.2	Data Centre Infrastructure-Core elements, characteristics, Virtualization and Cloud Computing	1 hour
2.3	Disk drive components, Physical disk structure, Zone Bit recording, Logical block addressing	1 hour
2.4	Disk drive Performance, Direct Attached Storage	1 hour
2.5	Storage design based on application requirements disk performance	1 hour
Module - 3 (STORAGE SYSTEM ARCHITECTURE) (8 hours)		

3.1	RAID, Implementation methods, RAID -Techniques-Striping, Mirroring, Parity.	
3.2	RAID Levels, RAID impact on disk performance	
3.3	Components of an Intelligent Storage System-Front end, Cache, Back end,	
3.4	Storage provisioning-traditional vs virtual.	
3.5	Types of Intelligent storage systems	
3.6	Backup and Archive- Backup Purpose	
3.7	Backup Granularity, Backup methods , Backup architectures	
3.8	Backup topologies	
Module - 4 (NETWORK STORAGE SYSTEM) (10 hours)		
4.1	Fibre Channel Storage Area Networks- SAN and Its Evolution, Components of FC SAN	1 hour
4.2	Fibre Channel Architecture, Fibre Channel Protocol Stack	1 hour
4.3	Zoning	1 hour
4.4	FC SAN Topologies, Virtualization in SAN	1 hour
4.5	IP SAN- FCoE and iSCSI, Components, topologies	1 hour
4.6	iSCSI Protocol stack	1 hour
4.7	FCoE, Components of FCoE	1 hour
4.8	Network-Attached Storage- Benefits of NAS, File Systems and Network File Sharing,	
4.9	Components of NAS, NAS Implementations-Unified NAS, Unified NAS Connectivity, Gateway NAS, Connectivity,	
4.10	NAS File-Sharing Protocols	
Module - 5 (MANAGING AND MONITORING) (7 hours)		
5.1	Managing & Monitoring: Management philosophies	1 hour
5.2	Industry management standards (SNMP, SMI-S, CIM)	1 hour
5.3	Standard framework applications, Key management metrics (thresholds,	1 hour

	availability, capacity, security, performance)	
5.4	Standard framework applications, Key management metrics (thresholds, availability, capacity, security, performance)	1 hour
5.5	Provisioning & configuration change planning	1 hour
5.6	Problem reporting	1 hour
5.7	prioritization and handling techniques, Management tools overview	1 hour

SEMESTER VI

MINOR

CST 382	INTRODUCTION TO SOFTWARE TESTING	Category	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

This is a course in theoretical computer science that includes test cases for white-box, black-box, and grey-box approaches. This course describes the various techniques for test case design used to test software artifacts, including requirements, design, and code. The course includes different techniques for test case design based on graphs, programming language syntaxes and inputs. The course also covers symbolic execution using PEX tool.

Course Outcomes: After the completion of the course the student will be able to:-

CO1	List a range of different software testing techniques and be able to apply specific unit testing method to the projects using Junit**. (Cognitive Knowledge Level: Understand)**
CO2	Explain mutation testing method for a given piece of code to identify hidden defects that can't be detected using other testing methods. **(Cognitive Knowledge Level: Understand)**
CO3	Explain graph coverage criteria in terms of control flow graph and data flow graph for a given program. **(Cognitive Knowledge Level: Understand**)
CO4	Demonstrate the importance of black-box approaches in terms of domain and functional testing. **(Cognitive Knowledge Level: Understand)**
CO5	Illustrate the use of PEX tool with symbolic execution. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10	PO11	PO12
CO1	✔	✔	✔									✔
CO2	✔	✔	✔	✔						✔		✔

CO3	✔	✔	✔	✔						✔		✔
CO4	✔	✔	✔	✔								✔
CO5	✔	✔	✔	✔						✔		✔

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test 1 (Marks)	**Test 2 (Marks)**	
Remember	**30**	**30**	**30**
Understand	**40**	**40**	**40**
Apply	**30**	**30**	**30**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment - Test : **25 marks**

Continuous Assessment - Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module - 1 (Introduction to Software Testing)

Some Popular Errors – Ariane 5, Therac 25, Intel Pentium Bug. What is Software testing? Why should it be tested? Software Quality, Role of Testing. Testing Process - Level 0 thinking, Level 1 thinking, Level 2 thinking, Level 3 thinking, Level 4 thinking. Software Testing Terminologies - Verification, Validation and Testing, Faults, Error and Bug, Test cases, Coverage Criteria. Types of Testing- Unit testing, integration testing, System testing, Acceptance testing, Beta testing, Functional testing, Stress testing, Performance testing, Usability testing and Regression testing. Testing Methods - Black Box testing, White Box testing, Grey Box testing.

Module - 2 (Unit Testing)

Concept of Unit testing. Static Unit testing. Dynamic Unit testing - Control Flow testing, Data Flow testing, Domain testing, Functional Program testing. Mutation testing - Mutation and Mutants, Mutation operators, Mutation score. Junit - Framework for Unit testing. Case Study - Mutation testing using Junit and Muclipse.

Module - 3 (Unit Testing - White Box Approaches)

Overview of Graph Coverage Criteria. Structural Graph Coverage Criteria - Node/vertex coverage, Edge coverage, Edge pair coverage, Path coverage, Complete path coverage, Prime path coverage, Complete round trip coverage, Simple round trip coverage. Data Flow Criteria - du paths, du pairs. Subsumption Relationships among Graph Coverage Criteria. Graph Coverage for Source Code - Control flow graphs for code, CFG: If statement, CFG: If statement with return, CFG: Switch-case, CFG: Loops, CFG: Exceptions (try-catch). Example program – Statistics. Graph Coverage for Design Elements - Call graphs and classes, Class inheritance testing: Coverage criteria, Coverage criteria on inheritance graph, Data flow at the design level, Inter-procedural DU pairs, Coupling du-pairs example. Example - Quadratic Root. Case Study - Graph Based testing using JUnit Framework.

Module - 4 (Unit Testing - Black Box Approaches)

Domain Testing / Input Space Partitioning - Partitions of a set. Input domain modelling - Interface-based approach, Functionality-based approach. Identifying values. Multiple partitions of the inputdomain - All Combinations Coverage (ACoC), Each Choice Coverage (ECC), Pair-wise Coverage, T-wise Coverage, Base Choice Coverage, Multiple Base Choices Coverage. TriTyp example. Functional Testing - Functional Testing Concepts of Howden. Functional testing - Important Steps. Types of Functional testing - Equivalence Class Partitioning, Boundary Value Analysis, Decision Tables, Random Testing. Case Study - Black Box testing approaches using JUnit.

Module - 5 (Grey Box Testing Approaches)

Introduction to Grey Box testing - Why Grey Box testing, Gray Box Methodology, Advantages and Disadvantages. Techniques of Grey Box Testing - Matrix Testing, Regression Testing, Orthogonal Array Testing or OAT, Pattern Testing. An Introduction to PEX - Parameterized Unit Testing, The Testing Problem. Symbolic Execution – Example, Symbolic execution tree. PEX application Case Study – PEX.

Text Books

1. Paul Ammann and JeffOffutt ,Introduction to Software Testing.
2. KshirasagarNaik and PriyadarshiTripathy, Software Testing And Quality Assurance: Theory And Practice.

Reference Materials

1. https://www.csc.ncsu.edu/academics/undergrad/honors/thesis/muclipsebinder.pdf - Muclipse tutorial.
2. King, James C, “Symbolic Execution and Program Testing”, Association for Computing Machinery, July 1976.

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Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the following types of testing methods with examples.

(i) Balck-box testing.

(ii) White-box testing.

(iii) Grey-box testing.

Course Outcome 2 (CO2): Define 12 mutants for the following method *power*() using effective mutation operators. Try to use each mutation operator at least once. Approximately, how many mutants do you think there would be, if all mutants for *power*() were created?

```
public static int power (int left, int right)
{
//***********************************
// Raises Left to the power of Right
// precondition : Right >= 0
// postcondition: Returns Left**Right
//***********************************
      intrslt;
      rslt = Left;
```

```
if (Right == 0)
{
        rslt = 1;
}
else
{
        for (int i = 2; i <= Right; i++)
        rslt = rslt * Left;
}
return (rslt);
}
```

Course Outcome 3 (CO3): Draw the control flow graph and data flow graph of given piece of code.

```
public static double ReturnAverage(int value[],int AS, int MIN, int MAX){
/*
Function: ReturnAverageComputes the averageof all those numbers in the input array in
the positive range [MIN, MAX]. The maximumsize of the array is AS. But, the array size
could be smaller than AS in which case the endof input is represented by -999.
*/
int i, ti, tv, sum;
doubleav;
i = 0; ti = 0; tv = 0; sum = 0;
while (ti< AS && value[i] != -999) {
ti++;
if (value[i] >= MIN && value[i] <= MAX) {
tv++;
sum = sum + value[i];
}
i++;
}
if (tv> 0)
av = (double)sum/tv;
```

```
else
av = (double) -999;
return (av);
}
```

Course Outcome 4 (CO4): Explain the following with examples.

1. Input domain modelling.
2. All Combinations Coverage (ACoC)
3. Each Choice Coverage (ECC)
4. Pair-wise Coverage
5. T-wise Coverage
6. Base Choice Coverage
7. Multiple Base Choices Coverage.

Course Outcome 5 (CO5): Draw the symbolic execution tree for the following program code and explain the symbolic execution of testme (α1, α2).

```
int twice (int v) {
 return 2 ∗ v;
 }
 void testme (int x, int y ) {
 z = twice ( y);
 if ( z == x ){
 if ( x > y + 10)
ERROR;
 }
 }
int main() {
 x = sym input();
 y = sym input();
testme ( x , y);
 return(0);
}
```

Model Question Paper

QP CODE: **PAGES: 4**

Reg No:______________ **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR

Course Code: CST 382

Course Name: Introduction to Software Testing

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Explain the differences between Validation and Verification.
2. Explain the differences between Fault, Error, and Bug?
3. Define Ground string, Mutation score, and Mutants.
4. What are the functions of Test driver and Test stubs in dynamic unit testing?
5. Define Node coverage, Edge coverage and Prime path coverage in a control flow graph.
6. What are du paths and du pairs in a data flow graph?
7. Explain the two approaches in input domain modelling.
8. Explain the difference between Equivalence Class Partitioning and Boundary Value Analysis.
9. Briefly explain three techniques of Grey box testing.
10. Explain the concept of symbolic execution with the help of a toy example.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Explain the following types of testing
(i) Black Box testing (ii) White Box testing (iii) Grey Box testing **(14)**

(iv) Unit testing (v) Integration testing (vi) System testing (vii) Acceptance testing

OR

12. (a) Explain the following coverage criterias based on the code fragment given below. (i) Functional coverage (ii) Statement coverage (iii)Conditional coverage (iv)Branch coverage **(8)**

```
int foo (int x, int y){
    int z = 0;
    if ((x > 0) && (y > 0)){
    z = x;}
    return z;
    }
```

(b) Write positive and negative test cases for an ATM Machine? **(6)**

13. (a) Explain Dynamic unit test environment with a neat figure. **(8)**

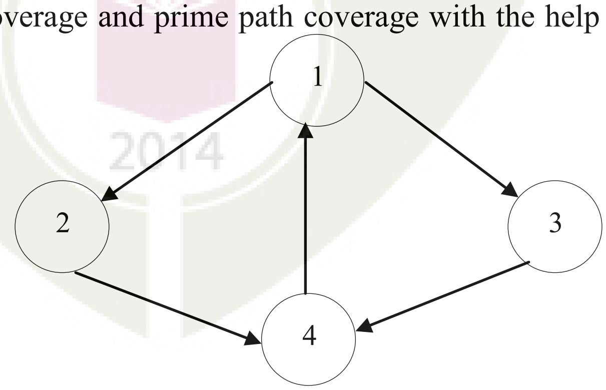
(b) Explain the major difference between control flow testing and data flow testing. **(6)**

OR

14. Explain seven types of mutation operators with neat examples. **(14)**

15. (a) Explain touring, side trips and detours with a neat example. **(7)**

(b) Explain simple path coverage and prime path coverage with the help of CFG given below. **(7)**



OR

16. (a) Draw CFG fragment for

(i) Simple *if* (ii) Simple *while* loop (iii) Simple *for* loop **(7)**

(b) Explain the following concepts with examples. **(7)**

(i)Call graph (ii) Inheritance graph (iii) Coupling du-pairs

17. (a) What are the four important steps in functional testing? **(7)**

(b) Briefly explain input domain modelling approaches. **(7)**

OR

18. (a) Consider the triangle classification program with a specification: **(6)**

The program reads floating values from the standard input. The three values *A*, *B*, and *C* are interpreted as representing the lengths of the sides of triangle. The program then prints a message to the standard output that states whether the triangle, if it can be formed, is scalene, isosceles, equilateral, or right angled. Determine the following for the above program:

(i) For the boundary condition $A + B > C$ case (scalene triangle), identify test cases to verify the boundary.

(ii) For the boundary condition $A = C$ case (isosceles triangle), identify test cases to verify the boundary.

(iii) For the boundary condition $A = B = C$ case (equilateral triangle), identify test cases to verify the boundary.

(b) Develop a decision table to generate test cases for this specification. **(8)**

19. (a) Explain the importance of grey box testing, its advantages and disadvantages. **(9)**

(b) Explain the concept of symbolic execution tree. **(5)**

OR

20. (a) Consider the code fragment given below: - **(7)**

1. POWER: PROCEDURE(X, Y);
2. Z ← 1;
3. J ← 1;
4. LAB: IF Y ≥ J THEN

5. DO; Z← Z * X;
6. J ← J + 1;
7. GO TO LAB; END;
8. RETURN (Z) ;
9. END;

a) Explain Symbolic execution of POWER (αl, α2).

(b) Explain Execution tree for POWER (αl, α2) in the above code fragment. **(7)**

TEACHING PLAN

Index	Topics	No. of Hours (45)
	Module 1 (Introduction to Software Testing) 9 Hours	
1.1	Some Popular Errors– Ariane 5, Therac 25, Intel Pentium Bug.	1 Hour
1.2	What is Software testing? Why should it be tested? Software Quality, Role of Testing.	1 Hour
1.3	Testing Process - Level 0 thinking, Level 1 thinking, Level 2 thinking, Level 3 thinking, Level 4 thinking.	1 Hour
1.4	Software Testing Terminologies- Verification, Validation and Testing, Faults, Error and Bug, Test cases, Coverage Criteria.	1 Hour
1.5	Types of Testing- Unit testing, integration testing, System testing, Acceptance testing, Beta testing	1 Hour
1.6	Functional testing, Stress testing	1 Hour
1.7	Performance testing, Usability testing and Regression testing.	1 Hour
1.8	Testing Methods - Black Box testing	1 Hour
1.9	Grey Box testing.	1 Hour
	Module 2 (Unit testing) 8 Hours	

2.1	Concept of Unit testing.	1 Hour
2.2	Static Unit testing.	1 Hour
2.3	Dynamic Unit testing - Control Flow testing, Data Flow testing	1 Hour
2.4	Domain testing, Functional Program testing.	
2.5	Mutation testing - Mutation and Mutants, Mutation operators, Mutation score.	1 Hour
2.6	Junit - Framework for Unit testing.	1 Hour
2.7	Case Study - Mutation testing using Junit	1 Hour
2.8	Case Study - Mutation testing using Muclipse	1 Hour
Module 3 (Unit Testing:- White Box Approaches) 10 Hours		
3.1	Overview of Graph Coverage Criteria	1 Hour
3.2	Structural Graph Coverage Criteria - Node/vertex coverage, Edge coverage, Edge pair coverage, Path coverage	1 Hour
3.3	Complete path coverage, Prime path coverage, Complete round trip coverage, Simple round trip coverage.	1 Hour
3.4	Data Flow Criteria - du paths, du pairs	1 Hour
3.5	Subsumption Relationships among Graph Coverage Criteria.	1 Hour
3.6	Graph Coverage for Source Code - Control Flow Graphs (CFG) for code, CFG: If statement, CFG: If statement with return, CFG: Switch-case, CFG: Loops, CFG: Exceptions (try-catch). Example program - Statistics	1 Hour
3.7	Graph Coverage for Design Elements - Call graphs and classes, Class inheritance testing: Coverage criteria, Coverage criteria on inheritance graph,	1 Hour

3.8	Data flow at the design level, Inter-procedural DU pairs, Coupling du-pairs example. Example - Quadratic Root	1 Hour
3.9	Case Study - Graph Based testing using JUnit Framework. (Lecture 1)	1 Hour
3.10	Case Study - Graph Based testing using JUnit Framework. (Lecture 2)	1 Hour
Module 4 (Unit Testing:- Black Box Approaches) 9 Hours		
4.1	Domain Testing / Input Space Partitioning - Partitions of a set.	1 Hour
4.2	Input domain modelling - Interface-based approach, Functionality-based approach.	1 Hour
4.3	Identifying values.	1 Hour
4.4	Multiple partitions of the input domain - All Combinations Coverage (ACoC), Each Choice Coverage (ECC), Pair-wise Coverage, T-wise Coverage, Base Choice Coverage, Multiple Base Choices Coverage.	1 Hour
4.5	TriTyp example.	1 Hour
4.6	Functional Testing - Functional Testing Concepts of Howden. Important Steps.	1 Hour
4.7	Types of Functional testing - Equivalence Class Partitioning, Boundary Value Analysis	1 Hour
4.8	Decision Tables, Random Testing.	1 Hour
4.9	Case Study - Black Box testing approaches using JUnit.	1 Hour
Module 5 (Grey Box Testing Approaches) 9 Hours		
5.1	Introduction to Grey Box testing - Why Grey Box testing, Gray Box Methodology, Advantages and Disadvantages.	1 Hour
5.2	Techniques of Grey Box Testing - Matrix Testing, Regression Testing,	1 Hour

5.3	Orthogonal Array Testing or OAT, Pattern Testing.	1 Hour
5.4	An Introduction to Pex - Parameterized Unit Testing, The Testing Problem.	1 Hour
5.5	Symbolic Execution – Example, Symbolic execution tree.	1 Hour
5.6	PEX application.	1 hour
5.7	Case Study – PEX (Lecture 1)	1 Hour
5.8	Case Study – PEX (Lecture 2)	1 Hour
5.9	Case Study – PEX (Lecture 3)	1 Hour

CST 384	CONCEPTS IN DEEP LEARNING	Category	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

This course aims to introduce the learner to an overview of the concepts and algorithms involved in deep learning. Deep learning is a subfield of machine learning, a subfield of artificial intelligence. Basic concepts and application areas of machine learning, deep networks, convolutional neural network and recurrent neural network are covered here. This is a foundational program that will help students understand the capabilities, challenges, and consequences of deep learning and prepare them to participate in the development of leading-edge AI technology. They will be able to gain the knowledge needed to take a definitive step in the world of AI.

Prerequisite: Sound knowledge in Basics of linear algebra and probability theory.

CO1	Demonstrate basic concepts in machine learning.**(Cognitive Knowledge Level: Understand)**
CO2	Illustrate the validation process of machine learning models using hyper-parameters and validation sets. **(Cognitive Knowledge Level: Understand)**
CO3	Demonstrate the concept of the feed forward neural network and its training process. **(Cognitive Knowledge Level: Apply)**
CO4	Build CNN and Recurrent Neural Network (RNN) models for different use cases. **(Cognitive Knowledge Level: Apply)**
CO5	Use different neural network/deep learning models for practical applications. **(Cognitive Knowledge Level: Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓	✓							✓
CO4	✓	✓	✓	✓	✓	✓						✓
CO5	✓	✓	✓	✓	✓	✓						✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test1 (Percentage)	Test2 (Percentage)	
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Tests : **25 marks**

Continuous Assessment Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Syllabus

INTRODUCTION TO DEEP LEARNING

(General Instructions: Instructors are to introduce students to any one software platform and demonstrate the working of the algorithms in the syllabus using suitable use cases and public datasets to give a better understanding of the concepts discussed. Tutorial hour may be used for this purpose)

Module-1 (Introduction)

Key components - Data, models, objective functions, optimization algorithms, Learning algorithm. Supervised learning- regression, classification, tagging, web search, page ranking, recommender systems, sequence learning, Unsupervised learning, Reinforcement learning, Historical Trends in Deep Learning. Other Concepts - overfitting, underfitting, hyperparameters and validation sets, estimators, bias and variance.

Module- 2 (Optimization and Neural Networks)

Neural Networks –Perceptron, Gradient Descent solution for Perceptron, Multilayer perceptron, activation functions, architecture design, chain rule, back propagation, gradient based learning. Introduction to optimization– Gradient based optimization, linear least squares. Stochastic gradient descent, Building ML algorithms and challenges.

Module -3 (Convolutional Neural Network)

Convolutional Neural Networks – convolution operation, motivation, pooling, Structure of CNN, Convolution and Pooling as an infinitely strong prior, variants of convolution functions, structured outputs, data types, efficient convolution algorithms. Practical challenges of common deep learning architectures- early stopping, parameter sharing, dropout. Case study: AlexNet, VGG, ResNet.

Module- 4 (Recurrent Neural Network)

Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, Practical use cases for RNNs.

Module-5 (Application Areas)

Applications – computer vision, speech recognition, natural language processing, common word embedding: continuous Bag-of-Words, Word2Vec, global vectors for word representation (GloVe). Research Areas – autoencoders, representation learning, boltzmann machines, deep belief networks.

Text Book

1. Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press 2015 ed.
2. Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, Dive into Deep Learning, August 2019.
3. Neural Networks and Deep Learning, Aggarwal, Charu C., c Springer International Publishing AG, part of Springer Nature 2018

Reference Books

1. Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks by Russell Reed, Robert J MarksII, A Bradford Book,2014
2. Practical Convolutional Neural Networks by MohitSewak, Md. Rezaul Karim, PradeepPujari,Packt Publishing 2018
3. Hands-On Deep Learning Algorithms with Python by SudharsanRavichandran,Packt Publishing 2019
4. Deep Learning with Python by Francois Chollet,Manning Publications Co.,2018

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

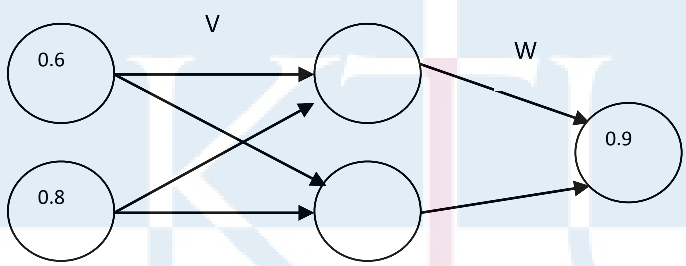
1. Compare regression and classification.
2. Define supervised learning? Distinguish between regression and classification.
3. Discuss the different learning approaches used in machine learning.

Course Outcome 2 (CO2):

1. What are hyperparameters? Why are they needed?
2. What issues are to be considered while selecting a model for applying machine learning in a given problem?

Course Outcome 3 (CO3):

1. Update the parameters V_{11} in the given MLP using back propagation with learning rate as 0.5 and activation function as sigmoid. Initial weights are given as V_{11}= 0.2, V_{12}=0.1, V_{21}=0.1, V_{22}=0.3, V_{11}=0.2, W_{11}=0.5, W_{21}=0.2



2. Draw the architecture of a multi-layer perceptron.
3. Derive update rules for parameters in the multi-layer neural network through the gradient descent.

Course Outcome 4 (CO4):

1. Give two benefits of using convolutional layers instead of fully connected ones for visual tasks.
2. Suppose that a CNN was trained to classify images into different categories. It performed well on a validation set that was taken from the same source as the training set but not on a testing set. What could be the problem with the training of such a CNN? How will you ascertain the problem? How can those problems be solved?
3. Explain how the cell state is updated in the LSTM model from Ct-1 to Ct
4. Show the steps involved in an LSTM to predict stock prices.

Course Outcome 5 (CO5):

1. Explain how the cell state is updated in the LSTM model from Ct-1 to Ct
2. Show the steps involved in an LSTM to predict stock prices.
3. Illustrate the workings of the RNN with an example of a single sequence defined on a vocabulary of four words.

Course Outcome 6 (CO6):

1. Development a deep learning solution for problems in the domain i) natural language processing or ii Computer vision (Assignment
2. Illustrate the workings of the RNN with an example of a single sequence defined on a vocabulary of four words.

Model Question Paper

QP CODE: PAGES:4

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR

Course Code: CST 384

Course Name: CONCEPTS IN DEEP LEARNING

Max. Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Distinguish between supervised learning and Reinforcement learning. Illustrate with an example.

2. Differentiate classification and regression.

3. Compare overfitting and underfitting. How it can affect model generalization.

4. Why does a single perceptron cannot simulate simple XOR function? Explain how this limitation is overcome?

5. Illustrate the strengths and weaknesses of convolutional neural networks.

6. Illustrate convolution and pooling operation with an example

7. How many parameters are there in AlexNet? Why the dataset size (1.2 million) is important for the success of AlexNet?

8. Explain your understanding of unfolding a recursive or recurrent computation into a computational graph.

9. Illustrate the use of deep learning concepts in Speech Recognition.

10. What is an autoencoder? Give one application of an autoencoder

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E." What is your understanding of the terms task, performance and experience. Explain with two example **(10)**

(b) "How does bias and variance trade-off affect machine learning algorithms? **(4)**

OR

12. (a) Illustrate the concepts of Web search, Page Ranking, Recommender systems with suitable examples. **(10)**

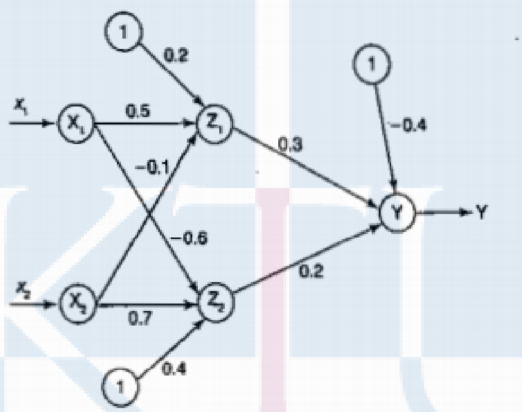
(b) List and discuss the different hyper parameters used in fine tuning the **(4)** traditional machine learning models

13. (a) How multilayer neural networks learn and encode higher level features from input features. **(7)**

(b) Explain gradient decent and delta rule? Why stochastic approximation to gradient descent is needed? **(7)**

OR

14. (a) Find the new weights for the network using backpropogation algorithm, the network is given with a input pattern[-1,1] and target output as +1, Use learning rate of alpha=0.3 and bipolar sigmoid function. **(7)**



(b) Write an algorithm for backpropgation which uses stochastic gradient descent method. Comment on the effect of adding momentum to the network. **(7)**

15. (a) Input to CNN architecture is a color image of size 112x112x3. The first convolution layer comprises of 64 kernels of size 5x5 applied with a stride of 2 and padding 0. What will be the number of parameters? **(5)**

(b) Let X=[-1, 0, 3, 5] W=[.3 ,.5 .2,.1] be the the input of i^{th} layer of a neural network and to apply softmax function. What should be the output of it? **(4)**

(c) Draw and explain the architecture of convolutional network **(5)**

OR

16. (a) Explain the concept behind i) Early stopping ii) dropout iii) weight decay **(9)**

(b) How backpropagation is used to learn higher-order features in a convolutional Network? **(5)**

17\. (a) Explain the working of RNN and discuss how backpropagation through time is used in recurrent networks. **(8)**

(b) Describe the working of a long short term memory in RNNs. **(6)**

OR

18\. (a) What is the vanishing gradient problem and exploding gradient problem? **(8)**

(b) Why do RNNs have a tendency to suffer from exploding/vanishing gradient? How to overcome this challenge? **(6)**

19\. (a) Explain any two word embedding techniques **(8)**

(b) Explain the merits and demerits of using Auto encoders in Computer Vision. **(6)**

OR

20\. (a) Illustrate the use of representation learning in object classification. **(7)**

(b) Compare Boltzmann Machine with Deep Belief Network. **(7)**

Teaching Plan

CONCEPTS IN DEEP LEARNING (45 Hours)		
Module 1 : Introduction (9 hours)		
1.1	Key components - Data, models, objective functions, optimization algorithms. (TB2: Section 1.1-1.2)	1 hour

1.2	Learning algorithm (TB1: Section 5.1), Supervised learning- regression, classification (TB2: Section 1.3.1)	1 hour
1.3	tagging, web search, page ranking (TB2: Section 1.3.1)	1 hour
1.4	Recommender systems, Sequence learning, Unsupervised learning, Reinforcement learning(TB2: Section 1.3.2-1.3.4)	1 hour
1.5	Historical Trends in Deep Learning (TB1: Section 1.2).	1 hour
1.6	Concepts: over-fitting, under-fitting, hyperparameters and validation sets. (TB1: Section 5.2-5.3)	1 hour
1.7	Concepts: Estimators, bias and variance. (TB1: Section 5.4)	1 hour
1.8	Demonstrate the concepts of supervised learning algorithms using a suitable platform.	1 hour
1.9	Demonstrate the concepts of unsupervised using a suitable platform.	1 hour
	Module 2 : Optimization and Neural Networks (9 hours)	
2.1	Perceptron, Stochastic Gradient descent, Gradient descent solution for perceptron (TB3: Section 1.1 - 1.2.1)	1 hour
2.2	Multilayer perceptron (TB3: Section 1.2.2), (TB1: Section 6.1,6.3)	1 hour
2.3	Activation functions- Sigmoid, tanh, Softmax, ReLU, leaky ReLU (TB3: Section 1.2.1.3 - 1.2.1.5)	1 hour
2.4	Architecture design (TB1: Section 6.4, TB3: Section 1.6)	1 hour
2.5	Chain rule, back propagation (TB3: Section 1.3)	1 hour

2.6	Gradient based learning (TB1: Section 6.2)	1 hour
2.7	Gradient based optimization (TB1: Section 4.3)	1 hour
2.8	Linear least squares using a suitable platform. (TB1: Section 4.5)	1 hour
2.9	Building ML Algorithms and Challenges (TB3: 1.4, TB1: 5.10-5.11)	1 hour
	Module 3 :Convolution Neural Network (10 hours)	
3.1	Convolution operation, Motivation, pooling (TB1:Section 9.1-9.3)	1 hour
3.2	Structure of CNN (TB3: Section 8.2)	1 hour
3.3	Convolution and Pooling as an infinitely strong prior (TB1: Section 9.4)	1 hour
3.4	Variants of convolution functions – multilayer convolutional network, tensors, kernel flipping, downsampling, strides and zero padding. (TB1: Section 9.5)	1 hour
3.5	Variants of convolution functions - unshared convolutions, tiled convolution, training different networks. (TB1: Section 9.5)	1 hour
3.6	Structured outputs, data types (TB1: Section 9.6-9.7)	1 hour
3.7	Efficient convolution algorithms. (TB1: Section 9.8,9.10)	1 hour
3.8	Practical challenges of common deep learning architectures- early Stopping (TB3: 4.6)	1 hour
3.9	Practical challenges of common deep learning architectures- parameter sharing, drop-out (TB3: Section 4.9, 4.5.4)	1 hour
3.10	Case Study: AlexNet,VGG, ResNet. (TB3: Section 8.4.1-8.4.3,8.4.5)	1 hour

Module 4 :Recurrent Neural Network (8 hours)		
4.1	Computational graphs (TB1: Section 10.1)	1 hour
4.2	RNN (TB1: Section 10.2-10.3)	1 hour
4.3	Encoder – decoder sequence to sequence architectures. (TB1: Section 10.4)	1 hour
4.4	Deep recurrent networks (TB1: Section 10.5)	1 hour
4.5	Recursive neural networks , Modern RNNs, (TB1: Section 10.6, 10.10)	1 hour
4.6	LSTM and GRU (TB1: Section 10.10, TB3: Section 7.5-7.6)	1 hour
4.7	Practical use cases for RNNs. (TB1: Section 11.1-11.4)	1 hour
4.8	Demonstrate the concepts of RNN using a suitable platform.	1 hour
Module 5 : Applications and Research (9 hours)		
5.1	Computer vision. (TB1: Section 12.2)	1 hour
5.2	Speech recognition. (TB1: Section 12.3)	1 hour
5.3	Natural language processing. (TB1: Section 12.4)	1 hour
5.4	Common Word Embedding -: Continuous Bag-of-Words, Word2Vec (TB3: Section 2.6)	1 hour
5.5	Common Word Embedding -: Global Vectors for Word Representation(GloVe) (TB3: Section 2.9.1- Pennigton 2014)	1 hour
5.6	Brief introduction on current research areas- Autoencoders, Representation learning. (TB3: Section 4.10)	1 hour

5.7	Brief introduction on current research areas- representation learning. (TB3: Section 9.3)	1 hour
5.8	Brief introduction on current research areas- Boltzmann Machines, Deep belief networks. (TB1: Section 20.1, TB3 Section 6.3)	1 hour
5.9	Brief introduction on current research areas- Deep belief networks. (TB1: Section 20.3)	1 hour

CST 386	WIRELESS NETWORKS AND IoT APPLICATIONS	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

This course equips the learners with fundamental wireless technologies for the Internet of Things(IoT) and the IoT ecosystem. It covers the underlying concepts in wireless networks, communication mechanisms, protocols, hardware, software, and the cloud platforms for IoT. The students will be able to design smart IoT applications for real world problems..

Prerequisite: Sound knowledge in Data Communication, Computer Networks and Programming in C

Course Outcomes: After the completion of the course the students will be able to

CO1	Recognize wireless technologies required for IoT ecosystem **(Cognitive Knowledge Level : Understand)**
CO2	Perceive the concept of IoT and M2M architecture, IoT examples, and Data Management in IoT **(Cognitive Knowledge Level :Apply)**
CO3	Outline the hardware components used in IoT including Sensors, Actuators and development boards **(Cognitive Knowledge Level : understand)**
CO4	Explain the software components of IoT **(Cognitive Knowledge Level :Understand)**
CO5	Demonstrate the protocols used in IoT and build IoT Programs **(Cognitive Knowledge Level : Apply)**
CO6	Build IoT-based smart real-time applications such as Smart Healthcare, Smart Agriculture, Smart Environment and Smart Home **(Cognitive Knowledge Level : Apply)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔	✔									✔
CO2	✔	✔	✔									✔

CO3	✓	✓	✓	✓	✓							✓
CO4	✓	✓	✓	✓	✓							✓
CO5	✓	✓	✓	✓	✓							✓
CO6	✓	✓	✓	✓	✓	✓						

Abstract POs Defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and teamwork
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Blooms Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test 1 (Percentage)	**Test 2 (Percentage)**	
Remember	**30**	**30**	**30**
Understand	**50**	**40**	**40**
Apply	**20**	**30**	**30**

Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance **10 marks**
Continuous Assessment Tests **25 marks**
Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First Internal Examination shall be preferably conducted after completing the first half of the syllabus, and the Second Internal Examination shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer anyone. Each question can have a maximum 2 subdivisions and carries 14 marks.

Syllabus

Module- 1 (Introduction to IoT and wireless technologies required for IoT)

Internet of Things, Role of Things and the Internet, Wireless IoT. Wireless Networks - Network Topologies, Types of Networks. Role of Wireless Standards in IoT. Protocol Stack - OSI Model, TCP/IP Model, IEEE 802 Reference Model, Protocols for Wireless IoT. Bluetooth - Transceiver, Frequency Channels, Typical Range, Access and Spread Spectrum, Modulation and Data Rate, Error Correction and Detection, Network Topology. ITU G.9959, Zwave, IEEE 802.15.4, Zigbee Specification, Thread, WiFi, 6LowPAN, IPv6, LoRaWAN.

Module- 2 (IoT architecture, Data and Device management)

Internet of Things - IoT Architectural View, Technology Behind IoT - Server End Technology, Sources of Internet of Things, M2M Communication. IoT Application Areas. IoT Examples. IoT Data Management - Device Management Gateways. Design Principles for Web Connectivity - Web Communication Protocols for Connected Devices, Web Connectivity for Connected Devices using Gateways. Internet Connectivity Principles – Internet Connectivity, Internet based communication, IP addressing in the IoT.

Module- 3 (Data Acquiring and Enabling Technologies)

Data Acquiring and Storage for IoT Sevices- Organization of Data, Big data, Acquiring Methods, Management Techniques, Analytics, Storage Technologies. Cloud Computing for Data storage - IoT Cloud based Services using Xively, Nimbits, and Other Platforms. Sensor Technologies for IoT Devices - Sensor Technology, Participatory Sensing, Industrial IoT and Automotive IoT, Actuators for Various Devices, Sensor Data Communication Protocols, Wireless Sensor network Technology

Module-4 (Prototyping the Embedded Devices for IoT)

Embedded Computing Basics, Embedded Hardware Unit. Embedded Platforms for Prototyping - Arduino, Intel Galileo, Intel Edison, Raspberry Pi, BeagleBone, mBed. Prototyping and Designing the Software for IoT Applications- Introduction, Prototyping Embedded DeviceSoftware- Programming using Arduino, Programming for an Arduino Controlled Traffic Control Lights at a Road Junction, Basic Arduino Programs to Blink LED, Find the Distance using Ultrasonic Sensor, Estimate Room Temperature, Measuring Soil Moisture Level

Module 5 (Business Models and Case Studies)

Business Models and Processes using IoT. Value Creation in the Internet of Things. Cloud PaaS- Xively, Nimbits, IBM Bluemix, CISCO IoT, AWS IoT, TCS Connected AWS Platform, Case studies- Smart Home, Smart Environment, Smart healthcare, Smart agriculture

Text Books

1. Daniel Chew, "Wireless Internet of Things -A Guide to the lower layers", IEEE Standards and Association, IEEE Press, Wiley
2. Rajkamal, "Internet of Things : Architecture and Design Principles", McGraw Hill (India) Private Limited.

References

1. ArshadeepBahga, Vijay Madisetti, "Internet of Things: A hands-on approach", University Press, 2015 (First edition)
2. Dieter Uckelmann, Mark Harrison, Michahelles Florian (Ed.), Architecting the internet of things, Springer, 2011
3. Dr. Ovidiu Vermesan, Dr. Peter Friess, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, River Publishers, 2013
4. Simon Monk, "Programming Arduino: Getting Started with Sketches", McGraw Hill Publications

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare Bluetooth and Bluetooth LE power classes
2. Demonstrate Zigbee Specification Protocol Stack

Course Outcome 2 (CO2):

1. What are the major components of IOT system? Briefly explain each
2. Correlate M2M architectural Levels with IOT architectural Levels

Course Outcome 3 (CO3):

1. Describe the use of GPIO pins ?
2. What are actuators ? Mention the roles of actuators in IoT systems

Course Outcome 4(CO4):

1. Identify the role of HBase in Hadoop File System
2. Differentiate Edge computing and Distributed computing
3. Illustrate open protocols, tools and frameworks generally used in M2M

Course Outcome 5(CO5):

1. What do you mean by Arduino sketches?
2. Write an Arduino program to blink LED

Course Outcome 6(CO6):

1. How IoT technology helps TELEMEDICINE in India?
2. How soil moisture can be detected in Smart Agriculture?

Model Question Paper

QP CODE: PAGES :2

Reg No: _______________

Name: _________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR

Course Code: CST 386

Course Name: WIRELESS NETWORKS AND IoT APPLICATIONS

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Illustrate Role of *things* and *internet* in IoT

2. What is Bluetooth? Explain the range and frequency channels of Bluetooth?

3. List any three the features of Constrained Application Protocol (COAP).

4. Compare Raspberry Pi and BeagleBoard boards.

5. Identify the role of HBase in Hadoop File System.

6. Differentiate Edge computing and Distributed computing.

7. Give an example of Raspberry Pi applications for Industrial IoT.

8. What are the on-board functional units in Intel Galileo?

9. Interpret the concept of value creation in IoT.

10. Explain the use of PaaS in IoT Smart applications with any three examples.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Compare various Network topologies used in Wireless Networks. **(8)**

(b) Describe the following wireless technologies on i) *Zigbee* ii) *WiFi* iii) *Thread.* **(6)**

OR

12. (a) Explain protocol stacks used in wireless networks for IoT applications. **(8)**

(b) Illustrate the Architectural design of LoRaWAN. **(6)**

13. (a) Define M2M. Explain M2M architecture. Correlate M2M architectural levels with IoT architectural levels. **(8)**

(b) Compare SOAP and REST protocols. **(6)**

OR

14. (a) Summarize different Online Transactions and Processing techniques. **(8)**

(b) Identify the functions of Device-Management Gateway . **(6)**

15. (a) Define actuators ? Describe the roles of actuators in IoT systems. **(8)**

(b) Explain the usage contexts of analog sensors and digital sensors. **(6)**

OR

16. (a) How data collection, storage & computing services done using Nimbits? **(10)**

(b) List any four features of Xively. **(4)**

17. (a) What do you mean by Arduino sketches? **(4)**

(b) Write an Arduino program to blink LED **(10)**

OR

18. (a) Demonstrate an example of Raspberry Pi applications for Industrial IoT. **(10)**

(b) Compare the features of Arduino-R3 and Arduino Yun boards. **(4)**

19. (a) Explain various tasks of a smart irrigation monitoring service. **(8)**

(b) Demonstrate the tasks of Soil-Moisture monitoring service. **(6)**

OR

20. (a) a) Mr. Kiran Mathew has been a chronic diabetic patient for the past few years. He was under regular check up at the hospital every two weeks. All of a sudden the pandemic like COVID-19 arises in the country and the government issues a lockdown for a period of two months. Illustrate how Mr. Kiran can be monitored by the health care worker using intelligent healthcare techniques. **(10)**

(b) Mention any four sensors used in smart healthcare **(4)**

TEACHING PLAN

No	**Contents**	**No of Lecture Hrs(45)**
Module – 1 (Introduction to IoT and wireless technologies required for IoT) (8 hrs) (TB-1, Chapter 1...)		
1.1	Internet Of Things, Role of things and internet ,Wireless IoT	1
1.2	Wireless Networks- Network Topologies-Types of Networks,Role of	1

	Wireless standards in IoT	
1.3	Protocol Stack-OSI Model- TCP/IP Model-IEEE 802 reference model	1
1.4	Protocols for Wireless IoT-Bluetooth-Transceiver, Frequency Channels-Typical Range, Access and Spread Spectrum, Modulation and Data Rate	1
1.5	Error Correction and Detection-Network Topology.	1
1.6	ITU G.9959, Zwave, IEEE 802.15.4, Zigbee Specification	1
1.7	Thread, Wifi, 6LowPAN, IPv6	1
1.8	LoRaWAN	1
Module- 2 (IOT architecture, Data and Device management) (9hrs)		
2.1	Internet of Things -IoT Architectural view	1
2.2	Technology Behind IOT-Server End Technology,Sources of Internet of Things	1
2.3	M2M Communication.	1
2.4	IoT Application Areas. IOT Examples.	1
2.5	IoT Data Management, Device Management Gateways.	1
2.6	Design Principles for Web Connectivity	1
2.7	Web communication protocols for connected devices,	1
2.8	Web connectivity for connected devices using Gateways.	1
2.9	Internet connectivity Principles – Internet Connectivity, Internet based communication, IP addressing in the IoT.	1
Module- 3 (Data Acquiring and Enabling Technologies (8 hrs)		
3.1	Data acquiring and storage for IoT devices- Organization of Data, Big data	1
3.2	Acquiring methods, management techniques, Analytics, Storage technologies.	1
3.3	Cloud computing for Data storage-IoT Cloud based services using Xively,	1

	Nimbits, and other platforms.	
3.4	Cloud computing-Nimbits	1
3.5	Sensor Technologies for IoT Devices-Sensor Technology, Participatory sensing	1
3.6	Industrial IoT and Automotive IoT	1
3.7	Actuators for various devices, Sensor data communication protocols	1
3.8	Wireless Sensor network Technology	1
Module 4(Prototyping the Embedded Devices for IoT)(9hrs)		
4.1	Introduction, Embedded Computing Basics, Embedded Hardware Unit.	1
4.2	Embedded Platforms for Prototyping-Arduino, Intel Galileo	1
4.3	Intel Edison, Raspberry Pi, BeagleBone, mBed	1
4.4	Prototyping and designing the software for IoT applications-Introduction, Prototyping embedded device software	1
4.5	Prototyping and designing the software for IoT applications-Introduction, Prototyping embedded device software	1
4.6	Programming concepts in Arduino	1
4.7	Programming for an arduino controlled traffic control lights at a road junction	1
4.8	Basic Arduino programs to blink LED, Find the distance using ultrasonic sensor	1
4.9	Estimate room temperature, Measuring soil moisture level	1
Module 5 (higher level protocols and case studies)(9 hrs)		
5.1	Business Models and Processes using IOT, Value creation in the Internet of Things.	1

5.2	Xively, Nimbits, IBM Bluemix	1
5.3	CISCO IoT, AWS IoT, TCS Connected AWS Platform	1
5.4	Case Study- Smart Environment	1
5.5	Case Study- Smart Environment	1
5.6	Case study Smart Home	1
5.7	Case study Smart Home	1
5.8	Case study Smart healthcare (Lecture I)	1
5.9	Case study Smart healthcare (Lecture II)	1
5.10	Case study -Smart agriculture (Lecture I)	1
5.11	Case study -Smart agriculture (Lecture II)	1

SEMESTER VI

HONOURS

CST 394	NETWORK SECURITY	Category	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

The purpose of this course is to create a better understanding of the network security concepts. This course covers network security standards, email security services, web security mechanisms, firewalls and wireless security mechanisms. This course helps the learner to gain insight into the key aspects of secure network communication and enables to apply in real-life scenarios.

Prerequisite: A sound background in Number Theory and Cryptographic Algorithms.

Course Outcomes: After the completion of the course the student will be able to

CO#	Course Outcomes
CO1	Identify the key aspects of security, intrusion detection systems and digital signature schemes **(Cognitive Knowledge Level: Apply)**
CO2	Explain the security standards used in network communication **(Cognitive Knowledge Level:Understand)**
CO3	Identify the mechanisms in email security services **(Cognitive Knowledge Level: Apply)**
CO4	Summarize the protocols used to provide web security **(Cognitive Knowledge Level: Understand)**
CO5	Explain the fundamental concepts of wireless network security and firewalls **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓								✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓	✓	✓						✓
CO5	✓	✓	✓	✓								✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Lifelong learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance : **10 marks**

Continuous Assessment Tests : **25 marks**

Continuous Assessment Assignment : **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. The first series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module – 1 (Network Security Basics)

Introduction to network security - Security requirements, Challenges of security, Network security model. Malicious programs – Worms, Viruses, Trojans, Spyware, Adware. Intrusion Detection Systems (IDS) - Uses, Techniques. Digital signatures - ElGamal, Schnorr, Digital Signature Standard (DSS).

Module – 2 (Network Security Standards)

Kerberos v4 – Configuration, Authentication, Encryption, Message formats. Kerberos v5 – Cryptographic algorithms, Message formats. Public Key Infrastructure (PKI) – Trust models, Revocation. Real-time communication security – Perfect Forward Secrecy (PFS), Denial-of-Service protection, Endpoint identifier hiding, Live partner reassurance. Internet Protocol Security (IPSec) - Authentication Header (AH), Encapsulating Security Payload (ESP), Internet Key Exchange (IKE) phases.

Module – 3 (Email Security)

Introduction to email security - Security services for email, Establishing keys, Privacy, Authentication, Message integrity, Non-repudiation. Privacy Enhanced Mail (PEM) – Encryption, Source authentication and integrity protection, Message formats. Secure/Multipurpose Internet Mail Extensions (S/MIME) – Messages, Differences from PEM. Pretty Good Privacy (PGP) - Encoding, Certificate and key revocation, Anomalies, Object formats.

Module – 4 (Web Security)

Introduction to web security - Web security considerations, Threats. Secure Sockets Layer (SSL) – Architecture, Protocols, Transport Layer Security (TLS) – Differences from SSL. Hypertext Transfer Protocol Secure (HTTPS) – Connection initiation, Closure. Secure Shell (SSH) – Transport layer protocol, User authentication protocol, Connection protocol.

Module – 5 (Wireless Network Security and Firewalls)

IEEE 802.11 Wireless LAN - Network components, Architectural model, Services. IEEE 802.11i wireless LAN security - Services, Phases of operation. Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA), WPA2, Wireless Application Protocol (WAP) – Services, Protocol architecture. Firewalls – Need for firewalls, Packet filters, Circuit-level firewalls, Application layer firewalls.

Text Books

1. C. Kaufman, R. Perlman and M. Speciner, “Network Security: Private Communication in a Public World”, 2/e, PHI.
2. William Stallings, “Cryptography and Network Security Principles and Practice”, 5/e, Pearson

Education Asia.

References

1. Behrouz A. Forouzan, Debdeep Mukhopadhyay, “Cryptography and Network Security”, 3/e, Tata McGraw Hill.
2. Tyler Wrightson, “Wireless Network Security A Beginner’s Guide”, 2012, Tata McGraw Hill.
3. William Stallings, “Network Security Essentials: Applications and Standards”, 4/e, Prentice Hall.
4. Schiller J., Mobile Communications, 2/e, Pearson Education.
5. Roberta Bragg et. al., “Network Security: The Complete Reference”, Tata McGraw Hill.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Using the Schnorr digital signature scheme, let $q = 83$, $p = 997$ and $d = 23$. Find values for e_1 and e_2.
2. The Digital Signature Algorithm (DSA) specifies that if the signature generation process results in a value of zero, a new value of k should be generated and the signature should be recalculated. Give reason.

Course Outcome 2 (CO2):

1. In Kerberos v4, the authenticator field is not of security benefit when asking the Key Distribution Center (KDC) for a ticket for Bob, but useful when logging in as Bob. Give reasons for your answer.
2. How does the stateless cookie protocol provide clogging protection?

Course Outcome 3 (CO3):

1. If Alice is sending an ENCRYPTED message, she first signs the message digest with her private key and then encrypts the message digest with the pre-message secret key. Why this last encryption was considered necessary for encrypted messages and not for MIC-CLEAR or MIC-ONLY?
2. Which security services are considered desirable in the following cases? (i) Sending a purchase order (ii) Sending a ransom note. (iii) Sending a mission description to security officials.
3. Explain the security mechanism used in Gmail communication.

Course Outcome 4 (CO4):

1. Is it possible in SSL for the receiver to reorder SSL record blocks that arrive out of order? If so, how it can be done? If not, why?
2. Describe any five web security threats, their consequences and countermeasures.

Course Outcome 5 (CO5):

1. Explain the security areas addressed by IEEE 802.11i.
2. Describe the advantages and disadvantages of application layer firewalls.

Model Question Paper

QP CODE:
Reg. No:______________
Name:________________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH. DEGREE (HONORS) EXAMINATION, MONTH &YEAR
Course Code: CST 394

Course Name: Network Security

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Distinguish between signature-based and anomaly-based intrusion detection techniques.
2. A trusted third party is considered as a main component in a network security model. Why?
3. How is endpoint identifier hiding achieved in real-time communication?
4. Show how encryption is used to provide privacy and integrity in Kerberos v5.
5. End-to-end privacy is essential for e-mail security. How is this achieved?
6. List the four steps for preparing an EnvelopedData MIME entity.
7. Show the operation of a Secure Sockets Layer (SSL) Record protocol.
8. For Secure Shell (SSH) packets, what is the advantage of not including the MAC in the scope of packet encryption?
9. List the three security services provided by IEEE 802.11i.
10. Define the terms Access Point, Basic Service Set, Extended Service Set.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Using the ElGamal scheme, let p = 881 and d = 700, find values for e1 and e2. Choose r = 17. Find the value of S1 and S2 if M = 400. **(8)**

(b) Explain the requirements and challenges of network security. **(6)**

OR

12. (a) In ElGamal, Schnorr and DSS, what happens if an attacker can find the value of random secret key used by the signer? Also, what happens if a user uses the same value of random secret key to sign two messages? Explain your answer for each scheme separately. **(8)**

(b) Explain the network security model with the help of a neat diagram. **(6)**

13. (a) Alice wishes to log into Bob's workstation remotely. List the steps involved in this communication if Kerberos v4 is used. **(7)**

(b) How does Diffie-Hellman technique provide perfect forward secrecy using signature keys? **(7)**

OR

14. (a) Explain the algorithm for Message Authentication Code (MAC) calculation and verification in Kerberos v5 rsa-md5-des. **(8)**

(b) Compare the aggressive mode and main mode of Phase 1 Internet Key Exchange (IKE). **(6)**

15. (a) Describe the different methods by which authentication of source is performed in email communication. **(7)**

(b) Explain the Signed data and Clear-signed data functions provided by S/MIME. **(7)**

OR

16. (a) Explain the advantages of Pretty Good Privacy (PGP) over Privacy Enhanced Mail (PEM). **(7)**

	(b)	Define non-repudiation. Describe the different ways by which it is implemented in email communication.	**(7)**
17.	(a)	Describe the significance of pseudo-random function of Transport Layer Security.	**(7)**
	(b)	Explain the four different phases of Secure Sockets Layer (SSL) HandshakeProtocol.	**(7)**

OR

18.	(a)	Describe how connection initiation and connection closure is done in Hyper Text Transfer Protocol Secure (HTTPS).	**(7)**
	(b)	Illustrate the sequence of events in Secure Shell (SSH) transport layer protocol packet exchanges.	**(7)**
19.	(a)	Explain the Discovery phase and Authentication phase of IEEE 802.11i operation.	**(7)**
	(b)	Why are firewalls needed? Compare the features of packet filters and circuit level firewalls.	**(7)**

OR

20.	(a)	Explain the two authentication methods used in Wired Equivalent Privacy (WEP).	**(7)**
	(b)	Describe the three transaction classes provided by Wireless Transaction Protocol.	**(7)**

Teaching Plan

No	Contents	No of Lecture Hrs
Module - 1 (Network Security Basics) (7 hrs)		
1.1	Security requirements, Challenges of security	1
1.2	Network security model	1
1.3	Worms, Viruses, Trojans, Spyware, Adware	1
1.4	Intrusion Detection Systems (IDS) uses, Techniques	1
1.5	ElGamal digital signature	1
1.6	Schnorr digital signature	1
1.7	Digital Signature Standard (DSS)	1
Module - 2 (Network Security Standards) (12 hrs)		
2.1	Kerberos v4 configuration, Authentication	1
2.2	Kerberos v4 encryption	1
2.3	Kerberos v4 message formats	1
2.4	Kerberos v5 cryptographic algorithms – rsa-md5-des, des-mac, des-mac-k	1
2.5	Kerberos v5 cryptographic algorithms - rsa-md4-des, rsa-md4-des-k, Encryption for privacy and integrity	1
2.6	Kerberos v5 message formats	1
2.7	Public Key Infrastructure (PKI) trust models	1
2.8	PKI revocation	1
2.9	Perfect Forward Secrecy (PFS), Denial-of-Service protection	1
2.10	Endpoint identifier hiding, Live partner reassurance	1
2.11	Internet Protocol Security (IPSec) Authentication Header (AH), Encapsulating Security Payload (ESP)	1

2.12	Internet Key Exchange (IKE) phases	1
Module - 3 (Email Security) (9 hrs)		
3.1	Security services for email, Establishing keys, Privacy	1
3.2	Authentication, Message integrity, Non-repudiation	1
3.3	Privacy Enhanced Mail (PEM) encryption, Source authentication	1
3.4	PEM integrity protection, Message formats (Lecture 1)	1
3.5	PEM message formats (Lecture 2)	1
3.6	Secure/Multipurpose Internet Mail Extensions (S/MIME) – Messages, Differences from PEM	1
3.7	Pretty Good Privacy (PGP) encoding, Certificate and key revocation, Anomalies	1
3.8	PGP Object formats (Lecture 1)	1
3.9	PGP Object formats (Lecture 2)	1
Module – 4 (Web Security)(9 hrs)		
4.1	Web security considerations, Threats, Secure Sockets Layer (SSL) architecture	1
4.2	SSL protocols (Lecture 1)	1
4.3	SSL protocols (Lecture 2)	1
4.4	Transport Layer Security (TLS) differences from SSL (Lecture 1)	1
4.5	TLS differences from SSL (Lecture 2)	1
4.6	Hypertext Transfer Protocol Secure (HTTPS) connection initiation, Closure	1
4.7	Secure Shell (SSH) transport layer protocol	1
4.8	SSH user authentication protocol	1
4.9	SSH connection protocol	1

Module - 5 (Wireless Security and Firewalls) (8 hrs)		
5.1	IEEE 802.11 Wireless LAN network components, Architectural model, Services	1
5.2	IEEE 802.11i wireless LAN security services, Phases of operation (Lecture 1)	1
5.3	IEEE 802.11i phases of operation (Lecture 2)	1
5.4	Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA), WPA2	1
5.5	Wireless Application Protocol (WAP) services, Protocol architecture (Lecture 1)	1
5.6	WAP protocol architecture (Lecture 2)	1
5.7	Need for firewalls, Packet filters	1
5.8	Circuit-level firewalls, Application layer firewalls	1

AIT396	MACHINE LEARNING IN COMPUTATIONAL BIOLOGY	CATEGORY	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2020

Preamble: This course is intended to provide the learners a outlook towards application of Machine learning algorithms in the field of computational biology. This course helps the learners to apply the Machine learning methods - clustering algorithms, dimensionality reduction, decision drees, Artificial Neural Network, Support Vector Machine to the computational biology problems. Also the course discuss Challenges of Machine Learning in Computational Biology and Future directions of Machine Learning in Computational Biology.

Prerequisite: Basic background in Bioinformatics and Machine Leaning

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Describe the basic concepts of Machine Leaning, Classification, regression and clustering problems, parameters and measures (**Cognitive knowledge level: Understand**)
CO 2	Demonstrate the clustering algorithm on computational biology problems (**Cognitive knowledge level: Apply)**
CO 3	Explain Dimensionality reduction techniques and Decision Trees in computational biology (**Cognitive knowledge level : Apply)**
CO 4	Illustrate Feature Extraction and Pattern recognition and Classification in the domain of Computational Biology analysis **(Cognitive knowledge level: Apply)**
CO 5	Explain the role and challenges of Machine Learning in Computational (**Cognitive knowledge level: Understand**)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✔	✔										✔
CO2	✔	✔	✔	✔	✔							✔
CO3	✔	✔	✔	✔	✔							✔
CO4	✔	✔	✔	✔								✔
CO5	✔	✔			✔							✔

PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	Test1 (%)	Test2 (%)	
Remember	**30**	**30**	**30**
Understand	**50**	**50**	**50**
Apply	**20**	**20**	**20**
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance **10 marks**

Continuous Assessment Tests (Average of Series Tests 1& 2) **25 marks**

Continuous Assessment Assignment **15 marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Machine Learning in Computational Biology

Module 1 (Overview of Machine Learning)

Overview of Machine Learning, fitting predictive models to data, Supervised and unsupervised learning, Classification, regression and clustering problems, Loss or cost functions. Parameters and hyperparameters, Training. validation and testing, Inductive bias and the bias variance trade-off, Use of clustering models.

Module 2 (Clustering problems Computational Biology)

Hierarchical Clustering, Partition Clustering, Overview Model-Based Clustering, k-Means clustering, k-Means clustering algorithm, Advantages, Disadvantages, illustrative example of k-Means clustering, Clustering for creating phylogenetic trees, Using Clustering Approach to Identify Patients' Subtypes, Application of clustering algorithms on gene expression data.

Module 3 (Supervised techniques for Computational Biology)

Proteomics Dataset, Data Pre-processing Algorithms, Dimension and Feature Subset Selection, Dimensionality reduction - Principal Component Analysis (PCA), Partial Least Square (PLS), Linear Discriminant Analysis (LDA), Protein Classification, Decision Trees in Bioinformatics, Proteomic Mass Spectra Classification Using Decision Tree Technique.

Module 4 (Machine-Learning Algorithms for Computational Biology)

Machine-Learning Algorithms for Feature Selection from Gene Expression Data, Feature Extraction and Pattern recognition from sequence data, measures of a Feature. Artificial Neural Network (ANN) in Bioinformatics, Genetic Algorithms (GA) in Bioinformatics, Designing ANN for Bioinformatics, ANN in Protein Bioinformatics, Support Vector Machine with Feature Elimination.

Module 5 (Scope of Machine Learning in Computational Biology)

Role of Machine Learning in Computational Biology, Creation and analysis of sequence data, Challenges of Machine Learning in Computational Biology, Data Errors, Mean Square Error Generative versus Discriminative, Approximation Versus Explanation, Single Versus Multiple Methods, Future directions of Machine Learning in Computational Biology.

Text Books

1. Statistical Modelling and Machine Learning Principles for Bioinformatics Techniques, Tools, and Applications. Germany, Springer Singapore, 2020.
2. Yang, ZhengRong. Machine Learning Approaches to Bioinformatics. Singapore, World Scientific Publishing Company, 2010.

References

1. Izadkhah, Habib. Deep Learning in Bioinformatics: Techniques and Applications in Practice. Netherlands, Elsevier Science, 2022.
2. Agapito, Giuseppe, et al. Artificial Intelligence in Bioinformatics: From Omics Analysis to Deep Learning and Network Mining. Netherlands, Elsevier Science, 2022.
3. Data Analytics in Bioinformatics: A Machine Learning Perspective. United States, Wiley, 2021.
4. Michailidis, George, et al. Introduction to Machine Learning and Bioinformatics. United Kingdom, CRC Press, 2008.
5. Zhang, Yanqing, and Rajapakse, Jagath C, Machine Learning in Bioinformatics, Germany, Wiley, 2009.
6. Baldi, Professor Pierre, et al. Bioinformatics, Second Edition: The Machine Learning Approach. India, Bradford, 2001.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare and contrast Supervised and unsupervised learning
2. Differentiate Classification with regression with an example
3. Explain the parameters and hyperparameters of a model?
4. Summarize validation and testing in machine learning?

Course Outcome 2 (CO2):

1. Write K-means algorithm and separate {5, 11, 19, 27, 23, 25, 6, 18, 2, 8, 10, 12, 31, 29, 4} into 3 clusters
2. Illustrate application of clustering algorithms on gene expression data
3. Differentiate K-means clustering and hierarchical clustering

Course Outcome 3 (CO3):

1. Illustrate dimensionality reduction methods - Principal Component Analysis (PCA), Partial Least Square (PLS), Linear Discriminant Analysis (LDA)
2. Explain Decision trees in Bioinformatics with a toy example.

Course Outcome 4 (CO4):

1. Explain the process involved in feature extraction and pattern recognition from sequence data
2. Design and implement an ANN model for the prediction of relative solvent accessibility

Course Outcome 5 (CO5):

1. Summarize role of Machine Learning in Computational Biology
2. Explain Challenges of Machine Learning approaches in Computational Biology

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES: 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH (Honors) DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT 396

Course Name: MACHINE LEARNING IN COMPUTATIONAL BIOLOGY

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1.	What does the regression line equation tell you?	**(3)**
2.	How do you create a predictive data model using machine learning?	**(3)**
3.	Write the major differences between K-means clustering and hierarchical clustering	**(3)**
4.	List any three resources of Proteomics Datasets	**(3)**
5.	What is the importance of using PCA before applying Machine learning method?	**(3)**
6.	Draw example of an ANN architecture including 4 independent variables, one hidden layer with 3 hidden neurons and 2 dependent variables	**(3)**
7.	What is the role of the Activation functions in Neural Networks?	**(3)**
8.	What is Hinge Loss in SVM?	**(3)**
9.	What is mean square error? how will you evaluate it?	**(3)**
10.	What are discriminative machine learning models?	**(10x3=30)**

Part B
(Answer any one question from each module. Each question carries 14 Marks)

11.	(a)	With example, differentiate Supervised and unsupervised learning	**(7)**

	(b)	What is loss function and cost function in machine Learning. write the difference and example of loss function and cost function	**(7)**
	OR		
12.	(a)	Define Train, Validation, and Test Datasets. how do you divide the data into Train, Validation, and Test Datasets.	**(7)**
	(b)	Explain Classification, regression and clustering methods with examples of each	**(7)**
13.	(a)	Use K Means clustering to cluster the following data into two groups. Assume cluster centroid are m1=2 and m2=4. The distance function used is Euclidean distance. { 2, 4, 10, 12, 3, 20, 30, 11, 25 }	**(7)**
	(b)	Illustrate with a toy example the application of clustering algorithms on gene expression data	**(7)**
		OR	
14.	(a)	Explain the advantages, disadvantages of k-Means clustering	**(7)**
	(b)	What is the advantage of using hierarchical clustering over K means clustering? When to use the hierarchical clustering?	**(7)**
15.	(a)	Explain Dimension and Feature Subset Selection	**(7)**
	(b)	20 physicochemical properties of 100 set of proteins were given with the help of PCA, explain how will you reduce 20x100 in to Five properties (5x100) for the next level analysis	**(7)**
		OR	
16.	(a)	Explain how Linear Discriminant Analysis can be used for the dimensionality reduction with the help of a scenario in computational biology	**(7)**
	(b)	How do decision tree classifiers work? what types of problems can they solve in Computational Biology	**(7)**
17.	(a)	Explain the process of Feature Extraction and Pattern recognition from sequence data	**(7)**
	(b)	Illustrate the design of Artificial Neural Network for solving Computational Biology question	**(7)**
		OR	
18.	(a)	Explain crossover and mutation in genetic algorithm with an example	**(7)**
	(b)	Explain how to construct a support vector machine (SVM) to classify ovarian	**(7)**

		cancer from 30 individuals from the 15 features obtained from each patient.	
19.	(a)	What role does machine learning and have to play in Computational Biology?	**(7)**
	(b)	Explain different kinds of Data Errors in Machine Learning that would happen in case of applying it in to the Computational Biology domain?	**(7)**
		OR	
20.	(a)	What are the advantages and disadvantages of application of machine learning in Computational Biology?	**(7)**
	(b)	"The transformation of huge volume of data into knowledge is the biggest challenge faced in computational biology" How can machine learning techniques help in this?	**(7)**

TEACHING PLAN

No	Contents	No of Lecture (45 Hrs)
	Module 1 (Overview of Machine Learning) (9 hrs)	
1.1	Overview of Machine Learning	1
1.2	Fitting predictive models to data	1
1.3	Supervised and unsupervised learning	1
1.4	Classification, regression and clustering problems	1
1.5	Loss or cost functions	1
1.6	Proteins and peptides	1
1.7	Parameters and hyperparameters	1
1.8	Training. validation and testing	1
1.9	Inductive bias and the bias variance trade-off, Use of clustering models	1
	Module 2 (Clustering problems Computational Biology) (9 hrs)	
2.1	Hierarchical Clustering	1
2.2	Partition Clustering, Overview Model-Based Clustering	1
2.3	k-Means clustering, k-Means clustering algorithm	1
2.4	k-Means clustering advantages, disadvantages	1
2.5	illustrative example of k-Means clustering	1

2.6	Clustering for creating phylogenetic trees	1
2.7	Using Clustering Approach to Identify Patients' Subtypes	1
2.8	Application of clustering algorithms on gene expression data	1
2.9	Application of clustering algorithms on gene expression data	1
Module 3 (Supervised techniques for Computational Biology) (9 hrs)		
3.1	Proteomics Datasets	1
3.2	Data Pre-processing Algorithms	1
3.3	Dimension and Feature Subset Selection	1
3.4	Dimensionality reduction	1
3.5	Principal Component Analysis (PCA)	1
3.6	Partial Least Square (PLS), Linear Discriminant Analysis (LDA)	1
3.7	Protein Classification case study	1
3.8	Decision Trees in Bioinformatics	1
3.9	Proteomic Mass Spectra Classification Using Decision Tree Technique	1

Module 4 (Machine-Learning Algorithms for Computational Biology) (8 hrs)		
4.1	Machine-Learning Algorithms for Feature Selection from Gene Expression Data	1
4.2	Feature Extraction and Pattern recognition from sequence data	1
4.3	Measures of a Feature	1
4.4	Artificial Neural Network (ANN) in Bioinformatics	1
4.5	Genetic Algorithms (GA) in Bioinformatics	1
4.6	Designing ANN for Bioinformatics	1
4.7	Designing ANN for Bioinformatics	1
4.8	ANN in Protein Bioinformatics	1
4.9	Support Vector Machine with Feature Elimination.	1
Module 5 (Scope of Machine Learning in Computational Biology) (10 hrs)		
5.1	Role of Machine Learning in Computational Biology	1
5.2	Creation and analysis of sequence data	1

5.3	Challenges of Machine Learning in Computational Biology	1
5.4	Data Errors in Machine Learning, Mean Square Error	1
5.5	Generative versus Discriminative	1
5.6	Approximation Versus Explanation	1
5.7	Single Versus Multiple Methods	1
5.8	Future directions of Machine Learning in Computational Biology	1
5.9	Future directions of Machine Learning in Computational Biology	1

AIT398	IMAGE AND VIDEO PROCESSING	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2020

Preamble: This course enables the learners to understand how digital images are stored and processed. The learners are exposed to different spatial and frequency domain methods for image enhancement, image restoration techniques, morphological operations that could be performed on digital images and also various image and video compression techniques. The course also gives an introduction to the basics of video processing and video segmentation.

Prerequisite: Advanced Computer Graphics, Advanced Concepts in Computer Vision

Course Outcomes: After the completion of the course the student will be able to

CO1	Summarize the steps of digital image processing and pixel relationships. **(Cognitive Knowledge Level: Understand)**
CO2	Apply spatial and frequency domain methods for image enhancement. **(Cognitive Knowledge Level: Apply**
CO3	Apply restoration techniques and morphological operations on digital images. **(Cognitive Knowledge Level: Apply)**
CO4	Compare different methods for digital image and video compression. **(Cognitive Knowledge Level: Apply)**
CO5	Understand the basics of video processing and video segmentation. **(Cognitive Knowledge Level: Understand)**

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							✓
CO2	✓	✓	✓	✓	✓	✓						✓
CO3	✓	✓	✓	✓	✓	✓						✓
CO4	✓	✓	✓	✓	✓	✓						✓
CO5	✓											✓

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	**PO7**	Environment and Sustainability
PO2	Problem Analysis	**PO8**	Ethics
PO3	Design/Development of solutions	**PO9**	Individual and team work
PO4	Conduct investigations of complex problems	**PO10**	Communication
PO5	Modern tool usage	**PO11**	Project Management and Finance
PO6	The Engineer and Society	**PO12**	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hrs

Continuous Internal Evaluation Pattern:

Attendance	**10 marks**
Continuous Assessment Tests(Average of Internal Tests 1 & 2)	**25 marks**
Continuous Assessment Assignment	**15 marks**

Internal Examination Pattern

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing the remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A.

Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 full questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carries 14 marks.

SYLLABUS

Module – 1

Fundamentals of Image processing: Basic steps of Image processing system, sampling and quantization of an Image, basic relationship between pixels and connectivity.

Image Enhancement: Spatial Domain methods - Gray level transformations, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial filters, Sharpening Spatial filters.

Module -2

Image Transforms: Unitary transforms, 2D Discrete Fourier Transform, Discrete Cosine Transform (DCT), Discrete Wavelet transforms.

Frequency Domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, homomorphic filtering.

Module - 3

Image Restoration: Image degradation/Restoration model, Noise models, Restoration in presence of noise only - spatial filtering, Periodic Noise reduction by frequency domain filtering.

Morphological Operations: Erosion, Dilation, Opening, Closing, Hit-or-miss transformation, Boundary extraction.

Module - 4

Image compression fundamentals – Coding Redundancy, spatial and temporal redundancy.

Compression models : Lossy and Lossless, Huffman coding, Arithmetic coding, LZW coding, run length coding, Bit Plane coding, JPEG standards.

Module - 5

Video processing: Basics of Video Processing: Analog video, Digital Video.

Video segmentation: Introduction to video segmentation, Change detection.

Video Compression: Introduction to video compression, video compression based on motion compensation, Search for motion vectors, H.261 standard, Transform coding, predictive coding-MPEG.

Text Books

1. Gonzalez and Woods , “Digital Image Processing”, 3rd edition , Pearson, 2009.

2. Li, Ze-Nian, Mark S. Drew, and Jiangchuan Liu. “Fundamentals of multimedia”, Pearson Prentice Hall, 2004.

3. Bovik, Alan C. “Handbook of image and video processing”, Academic press, 2010.

Reference Books

1. David A. Forsyth & Jean Ponce, Computer vision – A Modern Approach, Prentice Hall, 2002.

2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer.

3. Maheshkumar H Kolekar, “Intelligent Video Surveillance Systems: An Algorithmic Approach”, CRC Press.

4. Francesco Camastra, Alessandro Vinciarelli, “Machine Learning for Audio, Image and Video Analysis: Theory and Applications”, Springer 2015.

5. M. Tekalp ,”Digital video Processing”, Prentice Hall International

6. Relf, Christopher G.,"Image acquisition and processing with LabVIEW", CRC press

7 Chris Solomon, Toby Breckon ,"Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab", John Wiley & Sons,

8. Yao wang, Joem Ostarmann and Ya – quin Zhang, ”Video processing and communication “,1st edition , PHI

Course Level Assessment Questions

Course Outcome1 (CO1):

1. Illustrate how the image is digitized by sampling and quantization.
2. Let V = {1,2} and compute the length of the shortest 4-, 8-, and m path between p and q. If a particular path does not exist between these two points explain why.

3	1	2	1q
2	2	0	2
1	2	1	1
p 1	0	1	2

Course Outcome 2(CO2):

1. Determine whether the given matrix is unitary or not:

$$A = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}.$$

2. Explain any five properties of 2D Fourier Transform.

Course Outcome 3(CO3):

1. Discuss how restoration is done in digital images.
2. Explain with examples the different morphological operations applied to images.

Course Outcome 4(CO4): .

1. With suitable examples, clearly bring out the need for compression in images and videos.
2. Discuss any one method for finding motion vectors.

Course Outcome 5(CO5):

1. Explain any one technique used for segmenting a video.
2. Compare and contrast analog video and digital video in multimedia.

Model Question Paper

QP CODE:

Reg No: _______________

Name: _________________ **PAGES : 3**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: AIT 398

Course Name: Image and Video Processing

Max. Marks : 100 **Duration: 3 Hours**

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Explain bit plane slicing and contrast stretching.

2. Discuss about pixel relationships.

3. Find the 4 order forward and inverse DFT for the following image segment:

1	1	1	1
1	1	1	1
1	1	1	1
1	1	1	1

4. Define DCT. Write the properties of DCT.

5. Discuss hit or miss transformation with appropriate examples.

6. Explain about the morphological operation dilation.

7. Explain the significance of image compression.

8. Distinguish between lossy and lossless compression.

9. Discuss the significance of change detection.

10. Explain how transform coding is used in compression algorithms.

(10x3=30)

Part B

(Answer any one question from each module. Each question carries 14 Marks)

11. (a) Perform histogram specification of the following 3 bit gray scale image whose gray level distribution is given as follows. **(9)**

Input image

Gray level	0	1	2	3	4	5	6	7
No. of Pixels	8	10	10	2	12	16	4	2

Target image

Gray Level	0	1	2	3	4	5	6	7
No. of Pixels	0	0	0	0	20	20	16	8

(b) Design Laplacian filter for image enhancement in spatial domain. **(5)**

OR

12. (a) What is histogram equalization? Explain the procedure for histogram equalization. **(7)**

(b) Explain the gray level transformation functions: a) image negatives and b) log transformation c) power law transformation. **(7)**

13. (a) Compute the 2D DFT of the 4 X 4 grayscale image given below. **(4)**

(b) Explain about smoothing and sharpening frequency domain filters. **(10)**

OR

14. (a) Explain Butterworth filters for image smoothening and image sharpening. **(4)**

(b) Explain the steps followed in frequency domain filtering? **(5)**

15. (a) Apply opening and closing operation on the image sample A given below with structuring element B **(10)**

$$A=\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \quad \text{and} \quad B=\begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

(b) Explain Morphological operations a) opening b) closing with suitable examples. **(4)**

OR

16. (a) Discuss about different noise models. **(7)**

(b) Explain how periodic noise reduction can be done using frequency domain filtering. **(7)**

17. (a) Comment on JPEG compression standard. **(8)**

(b) Discuss on run-length encoding with the help of an example. **(6)**

OR

18. (a) Explain LZW coding with the help of a suitable example. **(8)**

(b) Illustrate the concept of arithmetic coding. **(6)**

19. (a) Compare and contrast MPEG video coding and H.261 standard. **(7)**

(b) Explain video segmentation with an example. **(7)**

OR

20. (a) Illustrate how motion compensation is used in video compression. **(7)**

(b) With the help of a neat block diagram explain predictive coding methods. **(7)**

Teaching Plan

No	Contents	No. of Lecture Hours (44 hrs)
Module – 1 (7 hours)		
1.1	Fundamentals of Image processing: Basic steps of Image processing system, Sampling and quantization of an Image.	1 hour
1.2	Basic relationship between pixels and connectivity.	1 hour
1.3	Image Enhancement: Gray level transformations	1 hour
1.4	Histogram, Histogram Equalization	1 hour
1.5	Histogram specification	1 hour
1.6	Fundamentals of Spatial Filtering	1 hour
1.7	Smoothing Spatial filters	1 hour
1.8	Sharpening Spatial filters	1 hour
Module-2 (8 hours)		
2.1	Image Transforms: Unitary transforms.	1 hour
2.2	2D Discrete Fourier Transform	1 hour

2.3	Discrete Cosine Transform (DCT)	1 hour
2.4	Discrete Wavelet transforms	1 hour
2.5	Basics of filtering in frequency domain	1 hour
2.6	Image smoothing	1 hour
2.7	Image sharpening	1 hour
2.8	Homomorphic filtering.	1 hour
	Module-3 (9 hours)	
3.1	**Image Restoration:** Image degradation/Restoration model	1 hour
3.2	Noise models	1 hour
3.3	Restoration basics	1 hour
3.4	Restoration in presence of noise only - spatial filtering	1 hour
3.5	Periodic Noise reduction by frequency domain filtering.	1 hour
3.6	Morphological Operations: basics	1 hour
3.7	Erosion, Dilation, Opening, Closing	1 hour
3.8	Hit-or-miss transformation	1 hour
3.9	Boundary extraction.	1 hour
	Module-4 (10 hours)	
4.1	Image compression fundamentals - Coding Redundancy	1 hour
4.2	Spatial and temporal redundancy.	1 hour
4.3	Compression models : Lossy and Lossless	1 hour
4.4	Huffman coding	1 hour

4.6	Arithmetic coding	1 hour
4.7	LZW coding	1 hour
4.8	Run length coding	1 hour
4.9	Bit Plane coding,	1 hour
4.10	JPEG standards	1 hour
	Module-5 (10 hours)	
5.1	Basics of Video Processing: Analog video, Digital Video.	1 hour
5.2	Video segmentation: Introduction to video segmentation	1 hour
5.3	Change detection.	1 hour
5.4	Introduction to video compression	1 hour
5.5	Video compression based on motion compensation	1 hour
5.6	Search for motion vectors	1 hour
5.7	Transform coding	1 hour
5.8	Predictive coding	1 hour
5.9	MPEG standards	1 hour
5.10	H.261 standard	1 hour