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

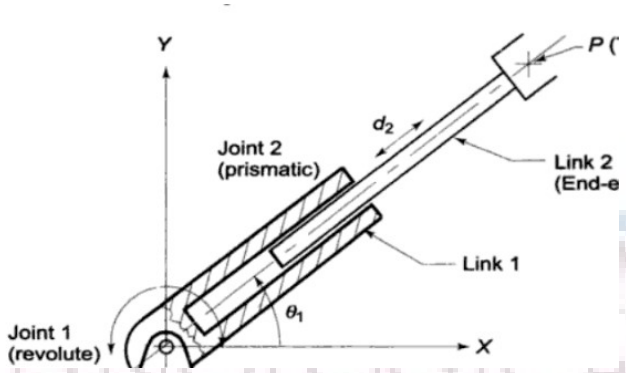
13	a)	How will you choose appropriate sensor for a robotic application?	(8)
	b)	Mention the applications of vision sensor	(6)
14	a)	Outline the method of varying position using servo motor and stepper motor.	(8)
	b)	Explain the working of typical hydraulic actuator.	(6)

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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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)

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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. 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

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)

***

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

RAD481	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini 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 Robotics and Automation 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;
- Preparing a Written Report on the Study conducted for presentation to the Department;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
2	Project Guide	**30**
3	Final Seminar evaluation by the committee	**30**
4	The report evaluated by the evaluation committee	**20**
	Total	**100**
	Minimum required to pass	**50**

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

RAD482	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini 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 Robotics and Automation 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:

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Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

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