Course code	Course Name	L-T-P-Credits	Year of Introduction
ME302	Heat and Mass Transfer	3-1-0-4	2016

Prerequisites : ME203 Mechanics of fluid

Course Objectives:

- To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems
- To provide useful information concerning the performance and design of simple heat transfer systems
- To introduce mass transfer

Syllabus:

Modes of Heat Transfer: Conduction: Most general heat conduction equation, One dimensional steady state conduction with and without heat generation, Critical radius of insulation, Elementary ideas of hydrodynamics and thermal boundary layers, Convection heat transfer: Newton's law of cooling, Dimensionless numbers, Dimensional analysis, Problems. Fins: Types of fins : Fin efficiency and effectiveness. Boiling and condensation heat transfer, Introduction to heat pipe. Transient heat conduction. Heat exchangers, LMTD and NTU methods. Radiation: laws of radiation, Electrical analogy, Radiation shields. Mass Transfer :Mass transfer by molecular diffusion, Convective mass transfer.

Expected outcome:

The students will be able to

1. Apply principles of heat and mass transfer to engineering problems
2. Analyse and obtain solutions to problems involving various modes of heat transfer
3. Design heat transfer systems such as heat exchangers, fins, radiation shields etc..

Text Books:

1. Sachdeva R C, Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009
2. R.K.Rajput. Heat and mass transfer, S.Chand& Co.,2015
3. Nag P K., Heat and Mass Transfer, McGraw Hill,2011
4. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2006

Data Book:

- Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanya, New age International publishers,2014

References Books:

1. Yunus A Cengel, Heat Transfer: A Practical Approach, McGraw Hill,2015
2. Holman J P, Heat Transfer, McGraw Hill, 2011
3. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons, 2011

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Modes of Heat Transfer: Conduction: Fourier law of heat conduction-Thermal conductivity of solids, liquids and gases-Factors affecting thermal conductivity- Most general heat conduction equation in Cartesian, cylindrical and spherical coordinates One dimensional steady state conduction with and without heat generation conduction through plane walls, cylinders and spheres-variable thermal conductivity conduction shape factor- heat transfer through corners and edges. Critical radius of insulation.	12	15%
II	Elementary ideas of hydrodynamics and thermal boundary layers-Thickness of Boundary layer-Displacement, Momentum and Energy thickness (description only). Convection heat transfer: Newton's law of cooling- Laminar and Turbulent flow, Reynolds Number, Critical Reynolds Number, Prandtl Number, Nusselt Number, Grashoff Number and Rayleigh's Number. Dimensional analysis Buckingham's Pi theorem- Application of dimensional analysis to free and forced convection- empirical relations- problems using empirical relations	10	15%
FIRST INTERNAL EXAMINATIONEXAM			
III	Transient heat conduction-lumped heat capacity method. Fins: Types of fins - Heat transfer from fins of uniform cross sectional area- Fin efficiency and effectiveness. Boiling and condensation heat transfer(elementary ideas only),Introduction to heat pipe.	8	15%
IV	Combined conduction and convection heat transfer-Overall heat transfer coefficient - Heat exchangers: Types of heat exchangers, AMTD, Fouling factor, Analysis of Heat exchangers- LMTD method, Correction factor, Effectiveness-NTU method, Special type of heat exchangers (condenser and evaporator, simple problems only)	8	15%
SECOND INTERNAL EXAMINATION			
V	Radiation- Nature of thermal radiation-definitions and concepts- monochromatic and total emissive power-Intensity of radiation- solid angle- absorptivity, reflectivity and transmissivity-Concept of black body- Planck' law- Kirchoff's law- Wein's displacement law-Stefan Boltzmann's law- black, gray and real surfaces-Configuration factor (derivation for simple geometries only)- Electrical analogy- Heat exchange between black/gray surfaces- infinite parallel plates, equal and parallel opposite plates-perpendicular rectangles having common edge- parallel discs (simple problems using charts and tables). Radiation shields(no derivation).	10	20%

VI	Mass Transfer :Mass transfer by molecular diffusion- Fick's law of diffusion- diffusion coefficient Steady state diffusion of gases and liquids through solid- equimolar diffusion, Isothermal evaporation of water through air- simple problems. Convective mass transfer- Evaluation of mass transfer coefficient- empirical relations- simple problems- analogy between heat and mass transfer.	8	20%
END SEMESTER EXAM			

Question Paper Pattern

Use of approved data book permitted

Total marks: 100, Time: 3 hrs

The question paper should consist of three parts

Part A

There should be 2 questions each from module I and II

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B

There should be 2 questions each from module III and IV

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C

There should be 3 questions each from module V and VI

Each question carries 10 marks

Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME304	DYNAMICS OF MACHINERY	2-1-0-3	2016

Prerequisite: ME301 Mechanics of Machinery

Course Objectives:

- To impart knowledge on force analysis of machinery, balancing of rotating and reciprocating masses, Gyroscopes, Energy fluctuation in Machines.
- To introduce the fundamentals in vibration, vibration analysis of single degree of freedom systems.
- To understand the physical significance and design of vibration systems with desired conditions

Syllabus

Force analysis of machinery - static and dynamic force analysis of plane motion mechanisms. Flywheel analysis - static and dynamic balancing - balancing of rotating masses, gyroscopic couples. Vibrations – free vibrations of single degree freedom systems, damping, forced vibration, torsional vibration.

Expected outcome:

The students will be able to

1. Develop the design and practical problem solving skills in the area of mechanisms
2. Understand the basics of vibration and apply the concepts in design problems of mechanisms.

Text Books:

1. Ballaney P.L. Theory of Machines, Khanna Publishers,1994
2. S. S. Rattan, Theory of Machines, Tata McGraw Hill, 2009
3. V. P. Singh, Theory of Machines, Dhanpat Rai,2013

References :

1. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education, 2003
2. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press, 2003
3. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education, 4e, 2012
4. Holowenko, Dynamics of Machinery, John Wiley, 1995
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,1995
6. W.T.Thompson, Theory of vibration, Prentice Hall,1997

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Introduction to force analysis in mechanisms - static force analysis (four bar linkages only) - graphical methods	4	15%
	Matrix methods - method of virtual work - analysis with sliding and pin friction	3	
II	Dynamic force analysis: Inertia force and inertia torque. D'Alemberts principle, analysis of mechanisms (four bar linkages only), equivalent dynamical systems	4	15%
	Force Analysis of spur- helical - bevel and worm gearing	3	
FIRST INTERNAL EXAM			
III	Flywheel analysis - balancing - static and dynamic balancing - balancing of masses rotating in several planes	4	15%
	Balancing of reciprocating masses - balancing of multi-cylinder in line engines - V engines - balancing of machines	3	
IV	Gyroscope – gyroscopic couples	3	15%
	Gyroscopic action on vehicles-two wheelers, four wheelers, air planes and ships. Stability of an automobile – stability of a two wheel vehicle –Stabilization of ship.	4	
SECOND INTERNAL EXAM			
V	Introduction to vibrations – free vibrations of single degree freedom systems – energy Method	2	20%
	Undamped and damped free vibrations – viscous damping – critical damping - logarithmic decrement - Coulomb damping – harmonically excited vibrations	3	
	Response of an undamped and damped system – beat phenomenon - transmissibility	2	
VI	Whirling of shafts – critical speed - free torsional vibrations – self excitation and stability analysis - vibration control - vibration isolation – vibration absorbers	4	20%
	Introduction to multi-degree freedom systems - vibration measurement - accelerometer – seismometer – vibration exciters	3	
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME306	ADVANCED MANUFACTURING TECHNOLOGY	3-0-0-3	2016

Pre requisite: ME 220 Manufacturing Technology, ME303 Machine Tools and Digital Manufacturing

Course Objectives

1. To introduce machining principles and processes in the manufacturing of precision components and products that use conventional and nonconventional technologies.
2. To give basic understanding of the machining capabilities, limitations, and productivity of advanced manufacturing processes.
3. To describe how PLC's operate and how they control automated equipment and systems
4. To demonstrate tool path simulations with CNC powered equipment
5. To introduce CNC programming

Syllabus:-

Powder Metallurgy- Programmable Logic Controllers- CNC- non-traditional and micro machining process - high velocity forming of metals-material additional process.

Expected outcome:

The students will be able to

i. Become conversant with the non- traditional machining process and to appreciate the effect of process parameters on the surface integrity aspects during the non- traditional machining process.
ii. Appreciate the use of an EDM as a non traditional method of machining complex and hard materials.
iii. Prescribe a laser materials processing technique suitable for a given product with material, size, precision, and surface quality requirements.
iv. Program and operate a CNC mill and lathe.
v. Select the tool material and machining process parameters.

Text books/References

1. ASTME, High velocity forming of metals, PHI, 1968.
2. Davies K and Austin E.R, Developments in high speed metal forming, the machinery publishing Co, 1970.
3. Ibrahim Zeid, R Sivasubrahmanian CAD/CAM: Theory & Practice, McGraw Hill Education, 2009
4. Jain V.K., Introduction to Micromachining, Narosa publishers,2014
5. M.P. Groover, E.M. Zimmers, Jr. CAD/CAM; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
6. Petruzella Frank.D., Programmable logic controllers,McGraw Hill,2016
7. Yoram Koren, Computer control of manufacturing systems, TMH,2006

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam. Marks**
I	Introduction: Need and comparison between traditional, non-traditional and micro & nano machining process.	1	**15%**
	Powder Metallurgy: Need of P/M - Powder Production methods:- Atomization, electrolysıs, Reduction of oxides, Carbonyls (Process parameters, characteristics of powder produced in each method).	1	
	Powder characteristics: properties of fine powder, size, size distribution, shape, compressibility, purity etc.	1	
	Mixing – Compaction:- techniques, pressure distribution, HIP & CIP.	1	
	Mechanism of sintering, driving force for pore shirking, solid and liquid phase sintering - Impregnation and Infiltration Advantages, disadvantages and specific applications of P/M.	1	
	Programmable Logic Controllers (PLC): need – relays - logic ladder program –timers, simple problems only.	1	
	Point to point, straight cut and contouring positioning - incremental and absolute systems – open loop and closed loop systems - control loops in contouring systems: principle of operation.	1	
II	DDA integrator:-Principle of operation, exponential deceleration –liner, circular and complete interpolator.	1	**15%**
	NC part programming: part programming fundamentals - manual programming –	1	
	NC coordinate systems and axes — sequence number, preparatory functions, dimension words, speed word, feed world, tool world, miscellaneous functions –	1	
	Computer aided part programming:– CNC languages – APT language structure: geometry commands, motion	1	
	commands, postprocessor commands, compilation control commands	1	
	Programming exercises: simple problems on turning and drilling etc - machining centers- 5 axis machining **(*At least one programming exercise must be included in the end semester University examination).***	2	
	FIRST INTERNAL EXAMINATION		

III	Electric Discharge Machining (EDM):- Mechanism of metal removal, dielectric fluid, spark generation, recast layer and attributes of process characteristics on MRR, accuracy, HAZ etc, Wire EDM, applications and accessories.	3	**15%**
	Ultrasonic Machining (USM):-mechanics of cutting, effects of parameters on amplitude, frequency of vibration, grain diameter, slurry, tool material attributes and hardness of work material, applications.	2	
	Electro chemical machining (ECM):- Mechanism of metal removal attributes of process characteristics on MRR, accuracy, surface roughness etc, application and limitations.	1	
IV	Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma arc Machining (PAM), Ion beam Machining(IBM) - Mechanism of metal removal, attributes of process characteristics on MRR, accuracy etc and structure of HAZ compared with conventional process; application, comparative study of advantages and limitations of each process.	3	**15%**
	Abrasive Jet Machining (AJM), Abrasive Water Jet Machining **(AWJM)** - Working principle, Mechanism of metal removal, Influence of process parameters, Applications, Advantages & disadvantages.	3	
	SECOND INTERNAL EXAMINATION		
V	High velocity forming of metals:-effects of high speeds on the stress strain relationship steel, aluminum, Copper – comparison of conventional and high velocity forming methods- deformation velocity, material behavior, stain distribution.	3	**20%**
	Stress waves and deformation in solids – types of elastic body waves- relation at free boundaries- relative particle velocity.	2	
	Sheet metal forming: - explosive forming:-process variable, properties of explosively formed parts, etc.	2	
	Electro hydraulic forming: - theory, process variables, etc, comparison with explosive forming.	1	
V1	Micromachining: Diamond turn mechanism, material removal mechanism, applications.	1	**20%**
	Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing.	2	
	Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining.	3	
	Material addition process:- stereo-lithography, selective laser sintering, 3D Printing, fused deposition modeling, laminated object manufacturing, , laser engineered net-shaping, laser welding, LIGA process.	2	

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME308	COMPUTER AIDED DESIGN AND ANALYSIS	3-0-0-3	2016

Prerequisite: ME201 Mechanics of solids

Course Objectives:

1. To impart basic knowledge on Computer Aided Design methods and procedures
2. To introduce the fundamentals of solid modelling
3. To introduce the concepts of finite element analysis procedures.

Syllabus

Introduction to CAD/CAM, Basics of geometric and solid modeling, transformation, representation points, lines, surfaces and solid models. Introduction to finite element analysis, solution procedures, interpolation, isoparametric formulation, applications.

Expected outcome:

The students will be able to

1. Gain a basic knowledge on Computer Aided Design methods and procedures
2. Understand the fundamentals of solid modelling
3. Have a basic knowledge in finite element analysis procedures.

Text Books:

1. M.P. Groover, E.M. Zimmers, Jr.CAD/CAM; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
2. T. R. Chandrupatla and A. D. Belagundu, Introduction to Finite Elements in Engineering, Pearson Education, 2001

References:

1. Chris Mcmahon and Jimmie Browne - CAD/CAM – Principle Practice and Manufacturing Management, Addision Wesley England,1998
2. D. F. Rogers and J. A. Adams, Mathematical Elements in Computer Graphics, McGraw-Hill,1990
3. Daryl Logan, A First course in Finite Element Method, Thomson Learning,2007
4. David V Hutton, Fundamentals of Finite Element Analysis, THM,2003
5. Donald Hearn, M. Pauline Baker and Warren Carithers, Computer Graphics with open GL, Pearson Education,2001
6. Grigore Burdea, Philippe Coiffet, Virtual Reality Technology, John Wiley and sons,2003
7. Ibrahim Zeid, CAD/ CAM Theory and Practice, McGraw Hill,2007
8. P. Radhakrishnan and S. Subramanyan, CAD / CAM / CIM, New Age Int. Ltd.,2008

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Introduction to CAD , Historical developments, Industrial look at CAD, Comparison of CAD with traditional designing, Application of computers in Design	2	15%
	Basics of geometric and solid modeling, Packages for CAD/CAM/CAE/CAPP	1	
	Hardware in CAD components, user interaction devices, design database, graphic Standards, data Exchange Formats, virtual Reality.	4	
II	Transformation of points and line, 2-D rotation, reflection, scaling and combined transformation, homogeneous coordinates, 3-D scaling.	4	15%
	Shearing,rotation, reflection and translation, combined transformations, orthographic and perspective projections, reconstruction of 3-D objects.	3	
FIRST INTERNAL EXAM			
III	Algebraic and geometric forms, tangents and normal, blending functions, reparametrization, straight lines, conics, cubic splines, Bezier curves and B-spline curves.	4	15%
	Plane surface, ruled surface, surface of revolution, tabulated cylinder, bi-cubic surface, bezier surface, B-spline surfaces and their modeling techniques.	3	
IV	Solid models and representation scheme, boundary representation, constructive solid geometry.	3	15%
	Sweep representation, cell decomposition, spatial occupancy enumeration, coordinate systems for solid modeling.	4	
SECOND INTERNAL EXAM			
V	Introduction to finite element analysis - steps involved in FEM- Preprocessing phase – discretisation - types of elements	2	20%
	Formulation of stiffness matrix (direct method, 1-D element) - formulation of load vector - assembly of global equations - implementation of boundary conditions - solution procedure - post processing phase	3	
	Simple problems with axial bar element (structural problems only)	2	
VI	Interpolation – selection of interpolation functions - CST element - isoparametric formulation (using minimum PE theorem) – Gauss-quadrature	4	20%

	Solution of 2D plane stress solid mechanics problems (linear static analysis)	3	
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME312	METROLOGY AND INSTRUMENTATION	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

- To understand the working of linear and angular measuring instruments.
- To familiarize with the working of optical measuring instruments and fundamentals of limits and limit gauges.
- To give basic idea about various methods for measurement of screw thread and surface finish parameters.
- To give an exposure to advanced measuring devices and machine tool metrology.
- To provide students an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.
- To provide basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

Syllabus

Introduction to Metrology - Errors in Measurement- Basic standards of length - Linear Measurement, Comparators - Angular Measurement - Limits and Limit gauges - Optical Measuring Instruments - Screw thread measurement - Measurement of surface texture - Machine tool metrology - Coordinate Measuring Machine (CMM) and Machine Vision.
Introduction to Mechanical Measurement - Motion and Dimension measurement, Strain and Stress Measurement - Measurement of Force, Torque and Temperature Measurement.

Expected outcome:

The students will be able to

i. Understand the working of linear and angular measuring instruments.
ii. Know the fundamentals of limits and limit gauges, various methods for measurement of screw thread and surface roughness parameters and the working of optical measuring instruments.
iii. Get an exposure to advanced measuring devices and machine tool metrology.
iv. Acquire an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.
v. Get basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

Text books

1. Anand K Bewoor, Vinay A Kulkarni, Metrology & Measurement, McGraw-Hill, 2009
2. Ernest O. Doebelin, Dhanesh N. Manik, Measurement Systems Application and Design, McGraw-Hill, 2004
3. Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS,1990
4. Thomas G. Beckwith, John H. L., Roy D. M., Mechanical Measurements, 6/E , Pearson Prentice Hall, 2007

Reference books

1. ASME, Hand book of Industrial Metrology,1998
2. Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.,1990
3. J.P.Holman, Experimental Methods for Engineers,Mcgraw-Hill, 2007
4. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.,1958

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Concept of measurement:-Introduction to Metrology; Need for high precision measurements; Terminologies in Measurement-Precision, accuracy, sensitivity, calibration.	1	15%
	Errors in Measurement, types of errors, Abbe's Principle.	1	
	Basic standards of length- Line standard, End standards, Wavelength standard; Various Shop floor standards.	1	
	Linear Measurement – Slip gauges, wringing, grades; Surface plate; Dial indicators; Height gauges and Vernier calipers.	1	
	Comparators- mechanical, electrical, optical and pneumatic.	1	
	Angular Measurement – Bevel protractor; Sine Bar, principle and use of sine bar, sine centre; Angle gauges.	1	
	Sprit level; Angle Dekkor; Clinometers.	1	
II	Limits and Limit gauges – Making to suit, selective assembly, systems of limits and fits; Types of fits; Hole basis system and Shaft basis system.	1	15%
	Standard systems of limits and fits; Shaft and Hole system; Tolerance, allowance and deviation (as per BIS).	1	
	Simple problems on tolerance and allowance, shaft and hole system.	1	
	Limit Gauges – GO and NO GO gauges; types of limit gauges.	1	
	Gauge design - Taylor's principle of gauging; Gauge tolerance, disposition of gauge tolerance, wear allowance.	1	
	Optical Measuring Instruments: - Benefits of using light waves as standards; Monochromatic light; Principle of Interference.	1	
	Interference band using optical flat, application in surface measurement.	1	
	Interferometers – NPL flatness interferometer, Pitter-NPL gauge interferometer.	1	
	FIRST INTERNAL EXAMINATION		
	Screw thread measurement – Screw thread terminology; Measurement of major diameter; Measurement of minor or root diameter.	1	
	Measurement of pitch; Measurement of effective diameter with two wire method and three wire method.	1	
	Measurement of flank angle and form by profile projector and	1	

III	microscope.		**15%**
	Measurement of surface texture – Meaning of surface texture, roughness and waviness; Analysis of surface traces, peak to valley height, R.M.S. value, Centre Line Average and R_a value, Rt, Rz etc.	**1**	
	Methods of measuring surface roughness – Stylus probe, Tomlinson surface meter, Talysurf; Terms used in surface roughness measurement – assessment length, roughness width cut-off, sampling length and evaluation length.	**1**	
	Interference method for measuring surface roughness – using optical flat and interferometers.	**1**	
	Autocollimator, principle and use of autocollimator.	**1**	
IV	Machine tool metrology – Alignment testing of machine tools like lathe, milling machine, drilling machine.	**1**	**15%**
	Advanced measuring devices – Laser interferometers.	**1**	
	Coordinate Measuring Machine (CMM) – Introduction to CMM; Components and construction of CMM.	**1**	
	Types of CMM; Advantages and application of CMM	**1**	
	CMM probes, types of probes – contact probes and non contact probes	**1**	
	Machine Vision – Introduction to machine vision, functions, applications and advantages of machine vision.	**1**	
	Steps in machine vision	**1**	
	SECOND INTERNAL EXAMINATION		
V	Introduction to Mechanical Measurement – significance of mechanical measurement; Fundamental methods of measurement; Classification of measuring instrument.	**1**	**20%**
	Stages in generalized measuring system – Sensor-Transducer stage, Signal-Conditioning stage, Readout-Recording stage; Types of input quantities; Active and Passive transducers.	**1**	
	Performance characteristic of measuring devices – Static characteristics – Accuracy, Precision, Repeatability, Sensitivity, Reproducibility, Drift, Resolution, Threshold, Hysteresis, Static calibration.	**1**	
	Dynamic characteristics- different order systems and their response-, Measuring lag, Fidelity, Dynamic error; Types of errors in measurement.	**1**	
	Transducers – Working, Classification of transducers.	**1**	
	Motion and Dimension measurement – LVDT – Principle, applications, advantages and limitations.	**1**	
V1	Strain and Stress Measurement - Electrical resistance strain gauge - Principle, operation.	**1**	
	Measurement of Force and Torque – Strain-Gauge Load Cells, Hydraulic and Pneumatic load cells – basic principle and three component force measurement using piezoelectric quartz crystal.	**1**	
	Torque Measurement – Dynamometers – Mechanical, Hydraulic and Electrical.	**1**	
	Vibration measurement – Vibrometers and Accelerometers – Basic principles and operation.	**1**	

	Temperature Measurement – Use of Thermal Expansion – Liquid-in-glass thermometers, Bimetallic strip thermometer, Pressure thermometers.	**1**	**20%**
	Thermocouples – Principle, application laws for Thermocouples, Thermocouple materials and construction, measurement of Thermocouple EMF.	**1**	
	Resistance Temperature Detectors (RTD); Thermistors; Pyrometers (Basic Principles).	**1**	
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME362	Control System Engineering	3-0-0-3	2016

Course Objectives: :

1. To introduce the concepts of controls and modelling of physical systems.
2. To give idea on system response analysis and stability of systems.
3. To use different methods to analyse stability of control systems

Syllabus:

Control systems and components, Mathematical models, Block diagrams, Signal Flow graphs, Transient and Steady state response analysis, Stability , Routh's stability criterion, Root locus method. Frequency response analysis using polar plots ,Bode plots, Nyquist stability criterion

Expected Outcomes: At the end of the course students will be able

1. To model and analyse physical systems.
2. To analyse the stability of feedback control systems

Text books:

1. Kuo, B. C., Automatic Control Systems, Prentice Hall,2012
2. Thaler and Brown, Analysis and Design of Feedback Control Systems, McGraw Hill, 1960.
3. Nagrath I J and Gopal M, Control Systems Engineering, New Age India Pvt Limited, 2009

References:

1. Ogata, K., Modern Control Engineering, Pearson Education, 2004
2. NPTEL courses, http//nptel.iitm.ac.in/courses.php, web and video courses on Control Engineering

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction to control systems. Elementary ideas on types of control systems- Open loop and closed loop systems, Servo systems, Automatic regulating systems, Process control systems, Adaptive control systems, Learning control systems, Discrete control systems, Multivariable control systems, Linear and Non-linear systems. Elementary ideas on types of controls- proportional, integral, proportional integral, proportional integral derivative controls. Direct and indirect controls. Mathematical models of physical systems – typical examples of mechanical, thermal, electrical, hydraulic and pneumatic systems.	7	15%
II	Block diagram, transfer function, reduction of block diagrams, signal flow graphs :Manson's gain formula. Control system components – servomotors, stepper motor, synchros, hydraulic pumps and motors, hydraulic valves, pneumatic bellows, pneumatic valve, pneumatic relay, pneumatic actuator, gyroscopes (elementary ideas only. No derivations)	7	15%

	FIRST INTERNAL EXAMINATION		
III	System response- Time response of first and second order systems, steady state errors and error constants, specifications in time domain. Effect of pole locations, Concept of stability, Routh's stability criterion	**7**	**15%**
IV	Root locus method of analysis and design. Lead and lag compensation	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Frequency response analysis- relationship between time & frequency response, Bode's plot, stability in frequency domain, gain margin and Phase margin	**7**	**20%**
V1	Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin.	**7**	**20%**
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME364	Turbomachinery	3-0-0-3	2016

Prerequisite : ME205 Thermodynamics

Course Objectives: :

1. To know the principle of operation of turbomachines
2. To provide students thorough understanding of velocity triangles, turbomachinery
3. To introduce students to fans, turbines, pumps etc..

Syllabus:

Definition of turbomachine, Application of first and second laws of thermodynamics to turbomachines, Efficiencies, Centrifugal fans and blowers, Centrifugal Compressors, Axial flow compressors, Axial and radial flow turbines

Expected Outcomes:

The students will be able to

1. Understand the operation of turbomachines
2. Gain ideas on performance characteristics, governing and selection of turbomachinery.

Text books

1. Bruneck, Fans, Pergamom Press, 1973.
2. Dixon, S.I, Fluid Mechanics and Thermodynamics of Turbomachinery , Pergamom, Press, 1990.
3. Ganesan .V, Gas Turbines , Tata McGraw Hill Pub. Co., New Delhi, 1999.
4. Stepanff, A.J, Blowers and Pumps , John Wiley and Sons Inc., 1965.
5. Yahya, S.H, Turbines, Compressor and Fans , Tata Mc Graw Hill, 1996.

Reference books

1. Earl Logan, Jr, Hand book of Turbomachinery, Marcel Dekker Inc, 1992.
2. Shepherd, D.G, Principles of Turbomachinery , Macmillan, 1969.

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Definition of turbomachine, parts of turbomachines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies.	7	15%
II	Application of first and second laws of thermodynamics to turbomachines, Efficiencies of turbomachines. Stage velocity triangles, work and efficiency for compressors and turbines	7	15%
FIRST INTERNAL EXAMINATION			

III	Centrifugal fans and blowers : Types, stage and design parameters, flow analysis in impeller blades, volute and diffusers, losses, characteristics curves and selection, fan drives and fan noise.	**7**	**15%**
IV	Centrifugal Compressors: Construction details, types, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Axial flow compressors : Stage velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, work done factor, simple stage design problems and performance characteristics.	**7**	**20%**
V1	Axial and radial flow turbines : Stage velocity diagrams, reaction stages, losses and coefficients blade design principles, testing and performance characteristics.	**7**	**20%**
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME366	ADVANCED METAL JOINING TECHNOLOGY	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To expose the students to the fundamental concepts of advanced welding technologies and their relevance

Syllabus

Radiant energy welding, Electron beam and Laser beam welding, Plasma arc welding, Micro plasma welding, Magnetically impelled arc butt welding, Underwater welding, Explosive welding, Adhesive bonding, Friction welding, Friction stir welding, Friction stir processing, Diffusion welding, Cold Pressure welding, Ultrasonic welding, Vacuum brazing.

Expected outcome

- The students will be able to understand the advancements in welding technologies and processes, their significance, application areas etc. leading to the development of products and processes.

References Books:

1. ASM Metals Hand Book "Welding and Brazing", Vol. 6, ASM, Ohio, 1988.
2. Parmar R.S., "Welding Processes and Technology", Khanna Publishers, Delhi, 1998.
3. Parmer R. S., Welding Engineering and Technology", Khanna Publishers, 1997
4. Rossi, Welding Engineering, McGraw Hill, 1954.
5. Schwartz M.M., "Metals Joining Manual", McGraw-Hill Inc., 1979.
6. Udin et al., Welding for Engineers, John Wiley & Sons, New York, 1967.
7. Welding Engineers Hand Book- ASHE Vol . I, II, III and IV.

Course Plan

Module	Contents	Hours	End Sem. Exam Marks
I	Radiant energy welding: Electron Beam Welding- Background of the Process, Guns, Weld Environment, Welding in Different Degrees of Vacuum, Equipment and Safety, Joint Design, Applications, Laser Beam Welding, Physics of Lasers, Types of Lasers, Process Parameters, Applications and Limitations.	7	15%

II	Diffusion Welding- theory and Principle of Process, Key Variables, Intermediate Materials, Deformation Welding, Equipment and Tooling, Joint Design, Economics, Advantages and Limitations, Materials and Applications, Cold Pressure Welding- Process, Equipment and Setup, Applications	6	15%
FIRST INTERNAL EXAM			
III	Explosive Welding- theory and Key Variables, Parameters, Weld Quality, Equipment and Tooling, Advantages and Limitations, Joint Design, Materials and Applications, Adhesive Bonding- theory and Key Parameters, Physical Characteristics, Metal Adhesive, Equipment, Design, Economics of Process, Materials and Applications.	7	15%
IV	Ultrasonic welding-Principles of operation, Process Characteristics and Applications, Vacuum brazing- Theory, Mechanisms and Key Variables, Equipment and Tooling, Stop-Off and Parting Agents, Advantages, Limitations, Economics Materials and Applications.	6	15%
SECOND INTERNAL EXAM			
V	Plasma arc welding: Plasma Arc Welding- theory and Principles, Transferred arc and Non-Transferred arc Techniques, Equipment and Tooling, Joint Design Advantages, Disadvantages, Economics, Materials and Applications, Needle Arc Micro Plasma Welding - Characteristics of Process, Operating Characteristics, Fixturing and Joint Design, Shielding, Weld Penetration and Shape, Applications, Magnetically impelled arc butt (MIAB) welding, Under Water Welding- Wet and Dry Under Water Welding	8	20%
VI	Friction Welding- Basic Principles, Process Variants, Different Stages of Friction Welding, Mechanism of Bonding, Influence of Process Parameters, Weld Quality and Process Control, Joining of Dissimilar Materials, Advantages, Limitations and Applications, Friction Stir Welding-Metal flow phenomena, tools, process variables and applications, Friction Stir Processing- Process, Application	8	20%
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3x10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3x10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4x10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME368	Marketing Management	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

- To introduce the concept of market and marketing
- To give idea about launching a new product
- To introduce the various marketing strategies

Syllabus:

Introduction to marketing, Social and Marketing planning, Consumer behavior, Marketing communication, Designing the message, New trends in marketing

Expected Outcomes:

The students will be able to

i. state the role and functions of marketing within a range of organizations.
ii. describe key marketing concepts, theories and techniques for analyzing a variety of marketing situations.
iii. identify and demonstrate the dynamic nature of the environment in which marketing decisions are taken
iv. synthesize ideas into a marketing plan

Text books:

1. Majumdar R., Marketing Research, Text, Applications and Case Studies, New Age International (P), 1991
2. Ramaswamy V.S. & Namkumari S, Marketing Management: Planning, Implementation and Control, Macmillan India Limited, 2002
3. Robert, Marketing Research, Prentice Hall of India,1999
4. T N Chabra and S K Grover : Marketing management, Dhanpat Rai, 2007

Reference books:

1. Kotler P, Marketing Management: Analysis, Planning, Implementation and Control, Prentice Hall of India,1993
2. Stanton W.J., Etzel M.J. & Walker B.J, Fundamentals of Marketing, McGraw Hill International Edition, 1994

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction to marketing - concept of market and marketing – marketing environment - controllable factors - factors directed by top management - factors directed by marketing - uncontrollable factors - demography, economic conditions, competition.	7	15%
II	Social and Marketing planning - marketing planning process - Boston consultancy group model - marketing mix - marketing mix variables. Developing, testing and launching of new products .	7	15%

	FIRST INTERNAL EXAMINATION		
III	Market segmentation and market targeting - introduction to segmentation - targeting and product positioning. Marketing research - need and scope - marketing research process – research objectives, developing research plan, collecting information, analysis, and findings.	**7**	**15%**
IV	Consumer behaviour - factors influencing consumer behaviour - perceived risks Product life cycle - marketing strategies for different stages of product life cycle	**6**	**15%**
SECOND INTERNAL EXAMINATION			
V	Marketing communication - marketing mix variables - steps in developing effective communication - identification of target audience - determination of communication objectives	**7**	**20%**
V1	Designing the message - selecting the communication channels - promotion mix evaluation - advertising and sales promotion - factors in advertising - sales promotion tools. New trends in marketing- Brand management - significance of branding to consumers and firms	**8**	**20%**
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME372	Operations Research	3-0-0-3	2016

Prerequisite -Nil

Course Objectives:

- To understand the role of operation research in decision making
- To impart the various operation research techniques for effective problem solving.

Syllabus:

Operations research models, linear programming, transportation problem, assignment problem, sequencing problem, network analysis, queuing theory, inventory control, decision theory, game theory – simulation.

Expected Outcome:

- The students will be able to understand operations research techniques and apply them in solving practical problems in industry.

Text Books:

1. Miller, D. M. and Schmidt, J. W., Industrial Engineering and Operations Research, John Wiley & Sons, Signapore, 1990.
2. Paneerselvam, R., Operations Research, Prentice Hall of India, New Delhi, 2008.
3. Pannerselvam, R., Design and Analysis of Algorithms, Prentice Hall of India, New Delhi, 2007.
4. Srinivasan, G. "Operations Research-Principles and Applications", Latest edition, PHI Pvt. Ltd., 2010.
5. Taha, H. A., Operations Research, Pearson, 2004.

Reference Books:

1. Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M., Discrete-Event System Simulation, Third Edition, Pearson Education, Inc., 2001.
2. Goel, B. S. and Mittal, S. K., Operations Research, Pragati Prakashan, Meerut, 1999.
3. Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Willey & Sons, 1987.

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Basics of operations research–OR models–applications.	1	15%
	Linear programming – problem formulation	1	
	Graphical method	1	
	Simplex method	1	

	Big-M method	**1**	
	Two–phase method	**1**	
	Duality in linear programming	**1**	
II	Transportation problem – formulation – balanced & unbalanced transportation problems	**1**	**15%**
	North west corner rule – least cost method	**1**	
	Vogel's method –stepping stone method	**1**	
	MODI method	**1**	
	Assignment problem – formulation – optimal solution, Hungarian algorithm	**1**	
	Variants of assignment problems	**1**	
	Traveling salesman problem.	**1**	
FIRST INTERNAL EXAMINATION			
III	Sequencing problem– terminology and notations – assumptions – problems with *n* jobs through two machines	**1**	**15%**
	Problems with *n* jobs through three machines	**1**	
	Problems with *n* jobs through *m* machines.	**1**	
	Network analysis – basic terms – network construction – time analysis	**1**	
	Critical path method (CPM)	**1**	
	Programme evaluation and review technique (PERT)	**1**	
	Cost considerations in network analysis – crashing	**1**	
IV	Introduction to queuing theory–terminologies– classification of queuing models	**1**	**15%**
	Single server problems	**1**	
	Multi server problems	**1**	
	Inventory control – variables – deterministic inventory models – purchasing model without shortages	**1**	
	Manufacturing model without shortages	**1**	
	Purchasing model with shortages	**1**	
	Manufacturing model with shortages	**1**	
SECOND INTERNAL EXAMINATION			
V	Decision theory – steps in decision theory approach – decision making conditions	**1**	**20%**
	Decisions under conditions of risk	**1**	
	Decisions under uncertainty conditions	**1**	
	Decision tree analysis	**1**	
	Game theory – games with saddle points	**1**	
	Games without saddle points – 2 x 2 games	**1**	

	Graphical method for m x 2 & 2 x n games	**1**	
VI	Simulation – types of simulation – phases of simulation – applications– advantages and disadvantages	**1**	**20%**
	Design of simulation, models & experiments, model validation	**1**	
	Generation of random numbers	**1**	
	Monte Carlo simulation	**1**	
	Queuing simulation model	**1**	
	Inventory simulation model	**1**	
	Simulation languages	**1**	

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
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Each question carries 10 marks
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Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3x10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4x10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code.	Course Name	L-T-P-Credits	Year of Introduction
ME374	THEORY OF VIBRATIONS	3-0-0-3	2016

Prerequisite: ME304 Dynamics of machinery

Course Objectives

- To understand the principles of vibration theory.
- To introduce techniques for solving vibration problems.
- To enable development of mathematical model for engineering problems in vibrations.

Syllabus

Introduction to mechanical vibrations; Analysis of free, forced single degree of freedom systems; Damping; Vibration measuring instruments; Multi degree of freedom systems; Eigen value problems; Lagrange's equation; Vibration of continuous systems; Transient vibrations; Introduction to non linear and random vibrations.

Expected outcome

The students will be able to

i. formulate differential equations of motion of mechanical systems
ii. determine the natural frequencies of multi degree of freedom systems
iii. understand non linear and random vibrations.

Text Books:

1. Graham Kelly S, Schaum's outline of Mechanical Vibrations, Schaum's Outlines,1996
2. Singiresu S Rao, Mechanical Vibrations, Pearson, 2016
3. Thomson, W T , Theory of Vibration with Applications., Prentice Hall India,1981

References Books:

1. Den Hartog, J P, Mechanical Vibrations, McGrawHill, 1956.
2. Leonard Meirovitch, Elements of Vibration Analysis,McGraw Hill,1975.

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Introduction to mechanical vibrations- Simple harmonic motion- Natural frequency -Equation of motion-- Energy method-Rayleigh method	2	20%
	Free vibration of single degree of freedom (DOF) systems with damping- Viscous damping- Logarithmic decrement. Coulomb damping-Energy dissipated by damping- Structural damping -Equivalent viscous damping.	4	
II	Forced harmonic vibration- Magnification factor-Transmissibility-Vibration isolation-Base excitation-Rotating unbalance- whirling of shafts- Resonance Vibration measuring instruments. Seismometer-Accelerometer	5	15%
FIRST INTERNAL EXAM			
III	Two degree of freedom systems-Normal mode vibration-Principal co-ordinates-Coordinate coupling.	3	15%
	Beat phenomenon-Undamped vibration absorbers- Vibration dampers.	2	
IV	Multi degree of freedom systems- Matrix formulation- Influence coefficients-Flexibility matrix-Stiffness matrix	5	20%
	Eigen Value problem:Eigen value and Eigen vectors-Frequency mode shape -Modal analysis.	4	
SECOND INTERNAL EXAM			
V	Lagrange's equation- Solution to problems using Lagrange's equation.	4	15%
	Vibration of continous systems-Vibrating strings- Longitudinal vibration of rods—Torsional vibration of rods	6	
VI	Transient vibrations- Impulse excitation- Convolution integral.	4	15%
	Introduction to non linear vibrations and random vibrations	3	
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME376	Maintenance Engineering	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

- To enable the student to understand the principles, functions and practices of maintenance activities.
- To develop ability in formulating suitable maintenance strategies to achieve reliable manufacturing system.
- To introduce the different maintenance categories and failure analysis tools.
- To equip with essential system diagnosis techniques so as to identify and take appropriate actions on error symptoms and causes of failures.
- To illustrate the techniques used for maintenance management.
- To empower with the skills to manage a manufacturing system to achieve continuous system availability for production.

Syllabus:

Maintenance – reliability – maintainability – availability – maintenance systems – condition monitoring – monitoring systems – failure analysis – maintenance effectiveness – quality assured maintenance – maintenance planning and scheduling – maintenance organization – maintenance costs – maintenance budgeting – human factor in maintenance – computer-aided maintenance management system – maintenance integration.

Expected outcome:

The students will be able to

i. Understand the relationship of key concepts in reliability engineering and application to maintenance strategies in a manufacturing environment.
ii. Establish maintenance strategies according to system characteristics and design transition programs to implement these strategies.
iii. Manage the manufacturing organization with highest possible availability.

Text Books:

1. Gupta A. K., Reliability, Maintenance and Safety Engineering, University Science Press, New Delhi, 2009.

2. Rao S. S., Reliability-Based Design, McGraw-Hill, Inc, New York, 1992.
3. Srivastava S. K., Maintenance Engineering and Management, S. Chand & Company Ltd., New Delhi, 1998.

4. Venkataraman, Maintenance Engineering and Management, Prentic-Hall of India Pvt. Ltd., New Delhi, 2007.

Reference Books:

1. Davies, Handbook of Condition Monitoring, Chapman & Hall, 1996.

2. Garg M. R., Industrial Maintenance, S. Chand & Co., 1986.

3. Higgins L. R., Maintenance Engineering Hand book, McGraw Hill, 5th Edition, 1988.

4. Mishra R. C. and Pathak K., Maintenance Engineering and Management, PHI Learning Pvt. Ltd., New Delhi, 2009.

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Maintenance – basic concepts, purpose, functions and objectives of maintenance.	1	15%
	Principles, benefits and effects of maintenance	1	
	Inter-relationship between productivity, quality, reliability and maintainability – maintenance productivity – quality in maintenance.	1	
	Reliability – basic concepts – bathtub curve – failure rate – mean time before failure.	1	
	System reliability – reliability of series and parallel systems.	1	
	Maintainability – mean time to failure – mean time to repair.	1	
	Availability – inherent, achieved and operational availability – reliability, availability and maintainability (RAM).	1	
II	Maintenance strategies / systems – types – basis for selection. Breakdown maintenance – corrective maintenance	1	15%
	Preventive maintenance – process flow – frequency in preventive maintenance.	1	
	Predictive maintenance – components – advantages and disadvantages.	1	
	Condition based maintenance and condition monitoring – monitoring systems.	1	
	Performance monitoring – visual, tactile and aural monitoring – leakage monitoring.	1	
	Temperature monitoring – thermography – advantages.	1	
	Thickness monitoring – acoustic monitoring – smell/odour monitoring.	1	
FIRST INTERNAL EXAMINATION			
III	Vibration monitoring – vibration fundamentals – vibration analysis.	1	15%
	Vibration transducers – types.	1	
	Machinery vibration trouble shooting – machinery vibration standard, severity chart and acceptable limits.	1	
	Lubricant monitoring – components and techniques – filter debris analysis & filtergrams.	1	
	Ferrography – spectroscopic oil analysis program.	1	

	Crack monitoring – techniques.	**1**	
	Corrosion monitoring – techniques.	**1**	
IV	Reliability centered maintenance (RCM) – steps – flow diagram – basic guidelines.	**1**	**15%**
	Defect and failure – definitions – basics of failures – failure generation – failure analysis.	**1**	
	Fault tree analysis (FTA)	**1**	
	Event tree analysis (ETA)	**1**	
	Root cause analysis (RCA)	**1**	
	Failure modes and effects analysis (FMEA)	**1**	
	Failure mode effect criticality analysis (FMECA)	**1**	
SECOND INTERNAL EXAMINATION			
V	Terotechnology – definitions – terotechnology system – terotechnology process – strategies.	**1**	**20%**
	Total productive maintenance (TPM) – features –methodology – basic systems of TPM – TPM and terotechnology.	**1**	
	Six sigma maintenance.	**1**	
	Lean maintenance – 5-zero maintenance concept – 5-S maintenance concept.	**1**	
	Business centered maintenance (BCM) – six pillars – success factors.	**1**	
	Maintenance effectiveness – overall equipment effectiveness – key performance indicators – maintenance performance measuring indices.	**1**	
	Quality assured maintenance – need – maintenance work quality – use of c-chart for quality control in maintenance.	**1**	
VI	Maintenance planning and scheduling.	**1**	**20%**
	Maintenance organization – objectives and characteristics – centralized and decentralized maintenance.	**1**	
	Maintenance costs – classification of maintenance costs – maintenance cost analysis – cost effectiveness analysis.	**1**	
	Maintenance budgeting – types of maintenance budget – preparation of maintenance budget.	**1**	
	Human factor in maintenance – manpower planning for maintenance – objectives and stages of manpower planning – training for maintenance personnel.	**1**	
	Computer-aided maintenance management system (CMMS) – functions, applications and advantages of CMMS.	**1**	
	Maintenance integration – various steps in integration – scheme of integration of maintenance function with other functions.	**1**	

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
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Note: Each question can have a maximum of four sub questions, if needed.

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME332	COMPUTER AIDED DESIGN AND ANALYSIS LAB	0-0-3-1	2016

Prerequisite: ME308 Computer aided design and analysis

Course Objectives:

- To provide working knowledge on Computer Aided Design methods and procedures
- To impart training on solid modelling software
- To impart training on finite element analysis software

Syllabus

Introduction to solid modeling and Finite Element Analysis software.

Exercises on modeling and assembly.

a. Creation of higher end 3D solid models.(minimum 3 models)

b. Creation of assembled views of riveted joints, cotter joints and shaft couplings. (minimum 3 models)

Exercises on the application of Finite Element Method/Finite Volume Method to engineering systems:-

a. Structural analysis. (minimum 3 problems)

b. Thermal analysis. (minimum 2 problems)

c. Fluid flow analysis. (minimum 1 problem)

Expected outcome:

The students will be able to

i. Gain working knowledge in Computer Aided Design methods and procedures

ii. Solve simple structural, heat and fluid flow problems using standard software

Points to note:

- Any appropriate solid modeling software (like CATIA, Solids Works, ProE, IDEAS, Siemens Solid Edge and NX, free software, etc.) and package (like ANSYS, Comsol Multi Physics, NASTRAN, ABAQUS, ADINA, Siemens Femap Nastran,free software etc.) may be used.
- **Evaluation**

  Class exercises 60 marks
  Regular class viva 10 marks
  Final internal exam using software 30 marks
  All the above three evaluations are mandatory.

References Books:

1. Daryl Logan, A First course in Finite Element Method, Thomson Learning, 2007
2. David V Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill,2003
3. Ibrahim Zeid, CAD/ CAM Theory and Practice, McGraw Hill, 2007
4. Mikell P. Groover and Emory W. Zimmer, CAD/ CAM – Computer aided design and manufacturing, Pearson Education,1987
5. T. R. Chandrupatla and A. D. Belagundu, Introduction to Finite Elements in Engineering, Pearson Education, 2012

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME334	MANUFACTURING TECHNOLOGY LABORATORY – II	0-0-3-1	2016

Prerequisite: ME312 Metrology and Instrumentation

Course Objectives:

- To provide programming practice on CNC machine tools
- To impart knowledge on the fundamental concepts and principles of metrology
- To explain the need of various modern measuring instruments and precision measurements

List of Experiments/Exercises:	Sessions
Exercise on grinding machine	1
Study and preparation of program, simulation and exercise on CNC lathe:-turning, step turning, taper turning, thread cutting, ball and cup turning etc.	2
Study and preparation of program, simulation and exercise on CNC milling machine: - surface milling, pocket milling, contour milling etc.	2
Basics for mechanical measurements Calibration of vernier caliper, micrometer and dial gauge etc. Determination of dimensions of given specimen using vernier caliper, micrometer, height gauge, bore dial gauge etc. Determination of dimensions of a rectangular, square, cylindrical specimens using slip gauges and comparing with height gauge/vernier caliper etc	1
Experiments on Limits, Fits and Tolerance Determine the class of fits between given shaft and hole. etc.	
Linear measurements Study of different linear measuring instruments. Calibration of LVDT using slip gauges.	1
Straightness error measurement Study of different straightness error measuring instruments – basic principle of auto collimator and spirit level. Measurement of straightness error of a CI surface plate using auto collimator and comparing with sprit level. laser interferometer used to determine straightness error To check straightness error of a straight edge by the wedge method using slip gauges.	1
Angle measurements Angular measurements using bevel protractor, combination sets, clinometers, angle dekkor etc. Measurement of angle and width of a V-block and comparing with combination sets. Measurement of angle using sine bar of different samples.	1

Out of roundness measurement Study of different methods used for measurement out of roundness Measurement of out of roundness using form measuring instrument Measurement of out of roundness using V-block and dial gauge Measurement of out of roundness using bench centre and dial gauge etc.	**1**
Screw thread measurement Measurement of screw thread parameters using two wire and three wire method. Measurement of screw thread parameters using tool maker's microscope etc. Measurement of screw thread parameters using thread ring gage, thread plug gage, thread snap gage, screw thread micrometer, optical comparator etc.	**1**
Bore measurement Measurement of a bore by two ball method. Measurement of a bore by four ball method. Bore measurement using slip gauges and rollers. Bore measurement using bore dial gauge etc.	**1**
Calibration and determination of uncertainties Strain measurement using strain gauge load cells. Calibration of a cantilever strain gauge load cell. **Rotation measurement** Determination of rpm using tachometer, optical tachometer and stroboscope, etc.	**1**
Area determination Study of planimeter and Green's theorem Determination of given irregular area using planimeter.	**1**
Gear metrology Types of gears – gear terminology – gear errors - study of Profile Projector. Measurement of profile error and gear parameters using profile projector etc. **Use of Comparators** Exercise on comparators: mechanical, optical, pneumatic and electronic comparators.	**1**
Use of Tool makers microscope Study of tool maker's microscope – use at shop floor applications. Measurement of gear tooth parameters using tool maker's microscope. Measurement of different angles of single point cutting tool using tool maker's microscope.	**1**
Surface roughness measurement Measurement of surface roughness using surface profilometer /roughness measuring machine of turned, milled, grounded, lapped and glass etc specimens.	**1**
Squareness measurement Determination of squareness of a trisquare using angle plate and slip gauges.	**1**
Flatness measurement Study of optical flat and variation of fringe patterns for different surfaces. Determination of parallelism error between micrometer faces. Compare given surface using optical flat with interpretation chart**.**	**1**
Vibration measurement Measurement of displacement, velocity and acceleration of vibration.	**1**

Use of Pneumatic comparator Checking the limits of dimensional tolerances using pneumatic comparator Calibration using air plug gauge etc	**1**

Reference books

1. Collett, C.V. and Hope, A.D, Engineering Measurements, Second edition, ELBS/Longman,1983
2. Sharp K.W.B. and Hume, Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd, London,1958
3. Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, London,1990
4. Yoram Koren, Numerical Control of Machine Tools, McGraw-Hill,1983

A minimum of 12 experiments are mandatory but the experiments/exercises in CNC machines are mandatory.

The academic evaluation shall be carried out by faculty.

Course code	Course Name	L-T-P - Credits	Year of Introduction
**352	Comprehensive Examination	0-1-1-2	2016
Prerequisite : Nil			

Course Objectives

- To assess the comprehensive knowledge gained in basic courses relevant to the branch of study
- To comprehend the questions asked and answer them with confidence.

Assessment

Oral examination – To be conducted by the college (@ three students/hour) covering all the courses up to and including V semester– 50 marks

Written examination - To be conducted by the Dept. on the date announced by the University– common to all students of the same branch – objective type (1 hour duration)– 50 multiple choice questions (4 choices) of 1 mark each covering the six common courses of S1&S2 and six branch specific courses listed – questions are set by the University - no negative marks – 50 marks.

Note: Both oral and written examinations are mandatory. But separate minimum marks is not insisted for pass. If a students does not complete any of the two assessments, grade I shall be awarded and the final grade shall be given only after the completion of both the assessments.

The two hours allotted for the course may be used by the students for discussion, practice and for oral assessment.

Expected outcome.

- The students will be confident in discussing the fundamental aspects of any engineering problem/situation and give answers in dealing with them