Course code	Course Name	L-T-P-Credits	Year of Introduction
ME401	DESIGN OF MACHINE ELEMENTS - I	3-1-0-4	2016

Prerequisite: ME201 Mechanics of Solids

Course Objectives:

- To review concepts of statics and strength of materials.
- To introduce fundamental approaches to failure prevention of components.
- To provide knowledge in the design of common machine elements such as fasteners, shafts, springs cotter joints and couplings.

Syllabus

Introduction to Design, Materials and their properties, Theories of Failure, Shock and impact loads,Threaded Joints, Bolted joints, Design of riveted joints, Cotter and Knuckle joints, Design of welded joints, Helical springs, Leaf springs, Shafting, Design of Coupling.

Expected outcome:

The students will be able to

i. Find out various stresses induced in a machine element under different type of loading conditions.
ii. Devise machine components for its conceptual design.

Text Books:

1. Jalaludeen , Machine Design, Anuradha Publications, Chennai,2014
2. R. L. Norton, Machine Design – An Integrated Approach, Pearson Education, 2001
3. V.B.Bhandari, Design of Machine elements, McGraw Hill, 2010

Data books permitted for reference in the final examination:

1. K. Mahadevan, K.Balaveera Reddy, Design Data Hand Book, CBS Publishers & Distributors, 2013
2. NarayanaIyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984
3. PSG Design Data, DPV Printers, Coimbatore, 2012

References Books:

1. J. E. Shigley, Mechanical Engineering Design, McGraw Hill,2003
2. Juvinall R.C & Marshek K.M., Fundamentals of Machine Component Design, John Wiley,2003
3. M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 2006
4. Rajendra Karwa, Machine Design, Laxmi Publications,2006

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Introduction to Design- Definition, steps in design process, preferred numbers, standards and codes in design	4	15%
	Materials and their properties- Elastic and plastic behaviour of metals, ductile and brittle behaviour, shear, bending and torsional stresses, combined stresses, stress concentration factor.	5	
II	Theories of Failure- Guest's Theory, Rankine's Theory, St. Venant's Theory, Haigh's Theory, and Von Mises and Hencky Theory.	5	15%
	Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, factor of safety	6	
FIRST INTERNAL EXAM			
III	Threaded Joints- Terminology, thread standards, types of threads, stresses in screw threads	3	15%
	Bolted joints- effect of initial tension, eccentric loading, design of bolts for static and fatigue loading, gasketed joints, power screws	4	
IV	Design of riveted joints- Material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints	4	15%
	Cotter and Knuckle joints- Gib and Cotter Joint, analysis of knuckle joint.	4	
	Design of welded joints- welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.	4	
SECOND INTERNAL EXAM			
V	Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading, surging, critical frequency, concentric springs, end construction.	5	20%
	Leaf springs- Flat springs, semi elliptical laminated leaf springs, design of leaf springs, nipping	4	
VI	Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity and critical speed, design for static and fatigue loads, repeated loading, reversed bending	5	20%
	Design of Coupling- selection, classification, rigid and flexible coupling, design of keys and pins	3	
END SEMESTER EXAM			

Question paper pattern

Use of approved data book permitted

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

The question paper should consist of three parts

Part A
There should be 3 questions from module I and II and at least 1 question from each module
Each question carries 15 marks
Students will have to answer any 2 questions out of 3 (2X15 marks =30 marks)

Part B
There should be 3 questions from module III and IV and at least 1 question from each module
Each question carries 15 marks
Students will have to answer any 2 questions out of 3 (2X15 marks =30 marks)

Part C
There should be 3 questions from module V and VI and at least 1 question from each module
Each question carries 20 marks
Students will have to answer any 2 questions out of 3 (2X20 marks =40 marks)

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

Course No.	Course Name	L-T-P-Credits	Year of Introduction
ME 402	Design of Machine Elements-II	3-0-0-3	2016

Prerequisite: ME401 Design of Machine Elements-I

Course Objectives:

- To provide basic design methods for clutches, brakes, belt drives, bearings, gears and connecting rod.
- To introduce the design modifications to be considered for ease of manufacturing.

Syllabus

Design of single plate clutches, multiple disc clutches, cone clutch, centrifugal clutch, block brake, band brake, band and block brake, internal expanding shoe brake, rolling contact bearing, sliding contact bearing, spur gear, helical gear , bevel gear, worm and worm wheel, design of flat belt, design of V-belt drives, selection of roller chains, connecting road, design recommendations for forgings, castings, welded products, rolled sections, turned parts, screw machined products, parts produced on milling machines.

Expected outcome:

The students will be able to

1. Apply design procedures for industrial requirements.
2. Design machine components to ease the manufacturing limitations.

Text Books:

1. J. E. Shigley, Mechanical Engineering Design, McGraw Hill,2003
2. Jalaludeen , Machine Dsign, Anuradha Publications, 2016
3. V.B.Bhandari, Design of Machine elements, McGraw Hill, 2016

References Books:

1. Juvinall R.C & Marshek K.M., Fundamentals of Machine Component Design, John Wiley, 2011
2. M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 2006
3. Rajendra Karwa, Machine Design , Laxmi Publications (P) LTD, New Delhi, 2006
4. Siegel, Maleev& Hartman, Mechanical Design of Machines, International Book Company, 1983

Data books permitted for reference in the examination:

1. K. Mahadevan, K.Balaveera Reddy, Design Data Hand Book, CBS Publishers & Distributors, 2013
2. Narayana Iyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill, 1984
3. PSG Design Data, DPV Printers, Coimbatore, 2012

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Clutches – friction clutches, design considerations, multiple disc clutches, cone clutch, centrifugal clutch	2	15%
	Brakes- Block brake, band brake, band and block brake, internal expanding shoe brake	3	
II	Rolling contact bearing- Design of bearings, Types, Selection of a bearing type, bearing life, static and dynamic load capacity, axial and radial loads, selection of bearings, dynamic equivalent load	4	15%
	Sliding contact bearing- lubrication, lubricants, viscosity, Journal bearings, hydrodynamic theory, Sommerfield number, design considerations, heat balance, bearing housing and mountings	4	
FIRST INTERNAL EXAM			
III	Gears- classification, Gear nomenclature, Tooth profiles, Materials of gears, Law of gearing (review only), virtual or formative number of teeth, gear tooth failures, Beam strength, Lewis equation, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, surface durability, heat dissipation – lubrication of gears – Merits and demerits of each type of gears.	3	15%
	Design of spur gear	3	
IV	Design of helical gear	2	15%
	Design of bevel gear	2	
	Design of worm & worm wheel	3	
SECOND INTERNAL EXAM			
V	Design of flat belt- materials for belts, slip of the belts, creep, centrifugal tension	3	20%
	Design of V-belt drives, Advantages and limitations of V-belt drive	3	
	Selection of roller chains, power rating of roller chains, galling of roller chains, polygonal action, silent chain.	3	
VI	Connecting rod – material, connecting rod shank, small end, big end, connecting rod bolts, inertia bending stress, piston	5	20%
	Pressure vessels, thin cylinders, Thick cylinder equation, open and closed cylinders.	2	
END SEMESTER EXAM			

QUESTION PAPER PATTERN

Note : Use of approved data book is permitted

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

The question paper should consist of three parts

Part A
There should be 3 questions from module I and II and at least 1 question from each module
Each question carries 15 marks
Students will have to answer any 2 questions out of 3 (2X15 marks =30 marks)

Part B
There should be 3 questions from module III and IV and at least 1 question from each module
Each question carries 15 marks
Students will have to answer any 2 questions out of 3 (2X15 marks =30 marks)

Part C
There should be 3 questions from module V and VI and at least 1 question from each module
Each question carries 20 marks
Students will have to answer any 2 questions out of 3 (2X20 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
ME403	ADVANCED ENERGY ENGINEERING	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

1. To give an idea about global energy scenario and conventional energy sources
2. To understand solar, wind and Biomass energy
3. To know concepts of other renewable energy sources
4. To create awareness on the impacts of energy conversion and importance of sustainable energy

Syllabus

Global and Indian energy scenario, conventional energy sources, environmental effect of energy conversion, renewable energy sources- solar, wind, biomass, brief account of other renewable energy sources –geothermal, tidal, MHD, hydrogen, fuel cells, small scale hydro power plants. Environmental impact and Sustainability issues.

Expected outcome:

The students will be able to

i. Understand energy scenario and the environmental effects of energy conversion.

ii. Become aware of different renewable energy sources and choose sustainable energy for

Text Books:

1. Jefferson W Tester et.al., Sustainable Energy: Choosing Among Options, PHI, 2006
2. P K Nag, Power Plant Engineering, TMH, 2002
3. Tiwari G N, Ghosal M K, Fundamentals of renewable energy sources, Alpha Science International Ltd., 2007

References Books:

1. David Merick, Richard Marshall, Energy, Present and Future Options, Vol.I & II, John Wiley & Sons, 2001
2. Godfrey Boyle, Renewable Energy : Power for a Sustainable Future, Oxford University Press, 2012
3. Roland Wengenmayr, Thomas Buhrke, 'Renewable Energy: Sustainable energy concepts for the future, Wiley – VCH, 2012
4. Twidell J W and Weir A D, Renewable Energy Resources, UK, E&F.N. Spon Ltd., 2006

Course Plan

Module	Contents	Hours	End Sem. Exam Marks
I	Introduction to the course. Global and Indian energy resources. Energy Demand and supply. Components, layout and working principles of steam, hydro, nuclear, gas turbine and diesel power plants	7	15%
II	Solar Energy- passive and active solar thermal energy, solar collectors, solar thermal electric systems, solar photovoltaic systems. Economics of solar power. Sustainability attributes.	7	15%
FIRST INTERNAL EXAM			

III	Wind Energy-Principle of wind energy conversion system, wind data and energy estimation, wind turbines, aerodynamics of wind turbines, wind power economics. Introduction to solar-wind hybrid energy systems	7	15%
IV	Biomass Energy – Biomass as a fuel, thermo-chemical, bio-chemical and agro-chemical conversion of biomass- pyrolysis, gasification, combustion and fermentation, transesterification, economics of biomass power generation, future prospects.	6	15%
SECOND INTERNAL EXAM			
V	Other Renewable Energy sources – Brief account of Geothermal, Tidal , Wave, MHD power generation, Small, mini and micro hydro power plants. Fuel cells – general description, types, applications. Hydrogen energy conversion systems, hybrid systems- Economics and technical feasibility	8	20%
VI	Environmental impact of energy conversion – ozone layer depletion, global warming, greenhouse effect, loss of biodiversity, eutrophication, acid rain, air and water pollution, land degradation, thermal pollution, Sustainable energy, promising technologies, development pathways	7	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
ME404	INDUSTRIAL ENGINEERING	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

- To impart theoretical knowledge about various tools and techniques of Industrial Engineering.
- To create awareness about various safety procedures to be followed in carrying out different types of projects.
- To get acquainted with the Inventory management Principles and Techniques.
- To equip with the theoretical knowledge on Quality control practices and testing methods.

Syllabus

Introduction to Industrial Engineering, Plant layout and Material handling, Methods engineering, Industrial relations, Production planning and control, Quality control and Inspection

Expected outcomes:

The students will be able to

i. Know various tools and techniques in industrial Engineering.
ii. Develop work procedure applying the principles of work study.
iii. Apply inventory control techniques in materials management.
iv. Formulate replacement and purchase decisions and arrive at conclusions

Text Books:

1. B. Kumar, Industrial Engineering Khanna Publishers,2013
2. M Mahajan, Industrial Engineering & Production Management, Dhanpat Rai, 2005
3. Martand Telsang, Industrial Engineering & Production Management, S. Chand, 2006
4. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai, 2010

References:

1. E. S. Buffa, Modern Production management, John Wiley, 1983
2. Grant and Ieven Worth, Statistical Quality Control, McGraw Hill, 2000
3. Introduction to work study – ILO, Oxford And IBH Publishing,2008
4. Ralph M Barnes, Motion and Time Study, Wiley, 1980

Course

Module		Hours	End Sem. Exam Marks
I	Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering Product Development and research- Design function - Objectives of design, - Manufacturing vs purchase- Economic aspects- C-V-P analysis – simple problems-Development of designs- prototype, production and testing - Human factors in design- Value Engineering .	7	15%
II	Plant layout and Material handling- principles of material handling, Types of material handling equipments, Selection and application. Preventive and break- down maintenance - Replacement policy-- Methods of replacement analysis-Method of providing for depreciation- Determination of economic life - Simple problems.	7	15%

FIRST INTERNAL EXAM			
III	Methods engineering: Analysis of work methods using different types of process chart and flow diagrams- Critical examination- Micro motion study and therbligs- Principles of motion economy – Work measurement-Performance rating.-Determination of allowances and standard time. - Job evaluation and merit rating - Objectives and principles of job evaluation--Wages and Incentives- Primary wage systems- Wage incentive plans.	7	15%
IV	Industrial relations- Psychological attitudes to work and working conditions - fatigue- Methods of eliminating fatigue- Effect of Communication in Industry-Industrial safety-personal protective devices-, causes and effects of industrial disputes- Collective bargaining- Trade union - Workers participation in management.	7	15%
SECOND INTERNAL EXAM			
V	Production planning and control- Importance of planning - job, batch and mass production-Introduction and need for a new product- product life cycle. - Functions of production control - Routing , Scheduling, dispatching and follow up- Gantt charts. Inventory Control, Inventory models -Determination of EOQ and reorder level- simple problems- Selective inventory control techniques.	7	20%
VI	Quality control and Inspection- Destructive and non-destructive testing methods- process capability- Statistical quality control – causes of variation in quality- control charts for X and R. Reliability- causes of failures- Bath tub curve.-System reliability- life testing- Introduction to concepts of, TQM, ISO, Six Sigma and Quality circles (Brief description only).	7	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
ME 405	REFRIGERATION AND AIR CONDITIONING	2-1-0-3	2016

Prerequisite: ME205 Thermodynamics

Course Objectives:

1. To introduce vapour compression and vapour adsorption systems
2. To impart knowledge on refrigeration cycles and methods to improve performance
3. To familiarize the components of refrigeration systems
4. To introduce air conditioning systems
5. To know the applications of refrigeration and air conditioning systems

Syllabus

Introduction, Thermodynamics of refrigeration, Air refrigeration systems, Vortex tube refrigeration, Adiabatic demagnetization of paramagnetic salts, Vapour compression systems, Refrigerants and their properties, Application of refrigeration, Refrigeration system components, Air conditioning, Psychrometry, Air conditioning systems.

Expected outcome:

The students will be able to

i. Understand the principles refrigeration of air-conditioning and basic design considerations.
ii. Carry out analysis of refrigeration cycles
iii. Apply the concepts of indoor environmental comfort.
iv. Perform psychrometric calculations, humidity control and analysis of air-conditioning processes
v. Know the various applications of Refrigeration and air conditioning

Text Books:

1. Arora C. P, Refrigeration and Air-Conditioning, McGraw-Hill, 2008
2. Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010
3. Ballaney P. L, Refrigeration and Air-Conditioning, Khanna Publishers, New Delhi, 2014
4. Manohar Prasad, Refrigeration and Air-Conditioning, New Age International, 2011

References Books:

1. ASHRAE Handbook
2. Dossat. R. J, Principles of Refrigeration, Pearson Education India, 2002
3. Stoecker W.F, Refrigeration and Air-Conditioning, McGraw-Hill Publishing Company, 2009

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction – Brief history and applications of refrigeration. Thermodynamics of refrigeration- reversed Carnot cycle- heat pump and refrigeration machines, Limitations of reversed Carnot cycle. Unit of refrigeration- Air refrigeration systems- Reversed Joule cycle, Air craft refrigeration systems, simple bootstrap- Regenerative and reduced ambient system	6	15%

II	Vortex tube refrigeration-Very low temperature refrigeration systems (concept only). Adiabatic demagnetization of paramagnetic salts Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. COP- Effect of operating parameters on COP – methods of improving COP of simple cycle- super- heating , under cooling, Liquid suction heat exchanger, actual cycle.	8	15%
FIRST INTERNAL EXAM			
III	Multi pressure systems - multi compression and multi evaporator, systems. Inter cooling - flash inter cooling and flash gas removal- Different combinations of evaporator and compressor for different applications, Cascade system Refrigerants and their properties-Eco-friendly Refrigerants, mixed refrigerants, selection of refrigerants for different applications Vapour absorption systems - Ammonia – water system - simple system- drawbacks-Lithium Bromide water system- Electrolux-comparison with vapour compression system- steam jet refrigeration.	7	15%
IV	Application of refrigeration- domestic refrigerators- water coolers-ice plants. Cold storages- food preservation methods- plate freezing , quick-freezing. Refrigeration system components- Compressors, condensers, expansion devices, evaporators. Cooling towers- Different types and their application fields- Refrigerant leakage and detection – charging of refrigerant – system controls.	6	15%
SECOND INTERNAL EXAM			
V	Air conditioning – meaning and utility, comfort and industrial air conditioning. Psychometric properties- saturated and unsaturated air, dry, wet and dew point temperature – humidity, specific humidity, absolute humidity, relative humidity and degree of saturation-thermodynamic equations- enthalpy of moisture- adiabatic saturation process -psychrometers. Thermodynamic wet bulb temperature, psychometric chart- Psychometric processes- adiabatic mixing-sensible heating and cooling- humidifying and dehumidifying, air washer – bypass factor- sensible heat factor-RSHF and GSHF line-Design condition- Apparent dew point temperature – Choice of supply condition, state and mass rate of dehumidified air quantity – Fresh air supplied –air refrigeration. Comfort air conditioning- factors affecting human comfort. Effective temperature – comfort chart. Summer air conditioning- factors affecting-cooling load estimation.	8	20%
VI	Air conditioning systems- room air conditioner- split system-packaged system-all air system-chilled water system. Winter air conditioning – factors affecting heating system, humidifiers. Year round air conditioning AC system controls-thermostat and humidistat. Air distribution systems- duct system and design- Air conditioning of restaurants, hospitals, retail outlets, computer center, cinema theatre, and other place of amusement. Industrial applications of air conditioning.	7	20%
END SEMESTER EXAM			

Question Paper Pattern

Use of approved Refrigerant tables permitted

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
ME407	MECHATRONICS	3-0-0- 3	2016

Prerequisite: Nil

Course Objectives:

- To introduce the features of various sensors used in CNC machines and robots
- To study the fabrication and functioning of MEMS pressure and inertial sensors
- To enable development of hydraulic/pneumatic circuit and PLC programs for simple applications

Syllabus

Introduction to Mechatronics, sensors, Actuators, Micro Electro Mechanical Systems (MEMS), Mechatronics in Computer Numerical Control (CNC) machines, Mechatronics in Robotics-Electrical drives, Force and tactile sensors, Image processing techniques, Case studies of Mechatronics systems.

Expected outcome:

The students will be able to

i. Know the mechanical systems used in mechatronics
ii. Integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems

Text Books:

1. Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
2. Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.
3. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.

References Books:

1. David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.
2. Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998.
3. HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
4. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

Course Plan

Module	Contents	Hours	End Sem. Exam Marks
I	Introduction to Mechatronics: Structure of Mechatronics system. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute, gray coded encoder. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. Principle and types of vibration sensors.	8	15%

II	Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols.	7	15%
FIRST INTERNAL EXAM			
III	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	6	15%
IV	Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Mechatronics elements - Machine structure: guide ways, drives. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing. Re-circulating ball screws, pre-loading methods. Re-circulating roller screws. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.	8	15%
SECOND INTERNAL EXAM			
V	System modeling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Mechatronics in Robotics-Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Force and tactile sensors. Range finders: ultrasonic and light based range finders	6	20%
VI	Robotic vision system - Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, pick and place robot, automatic car park barrier system, automobile engine management system.	7	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 =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
ME409	COMPRESSIBLE FLUID FLOW	2-1-0-3	2016

Prerequisite: ME205 Thermodynamics

Course Objectives:

- To familiarize with behavior of compressible gas flow.
- To understand the difference between subsonic and supersonic flow
- To familiarize with high speed test facilities

Syllabus

Introduction to Compressible Flow, Wave propagation, One dimensional steady isentropic flow, Irreversible discontinuity in supersonic flow, Flow in a constant area duct with friction (Fanno Flow), Flow through constant area duct with heat transfer (Rayleigh Flow), Compressible flow field visualization and measurement, measurement in compressible flow, Wind tunnels

Expected outcome:

The students will be able to

i. Formulate and solve problems in one -dimensional steady compressible flow including: isentropic nozzle flow, constant area flow with friction (Fanno flow) and constant area flow with heat transfer (Rayliegh flow).
ii. Derive the conditions for the change in pressure, density and temperature for flow through a normal shock.
iii. Determine the strength of oblique shock waves on wedge shaped bodies and concave corners
iv. Know the various measuring instruments used in compressible flow

Data book/Gas tables:

1. Yahya S. M., Gas Tables**,** New Age International, 2011
2. Balachandran P., Gas Tables, Prentice-Hall of India Pvt. Limited, 2011

Text Books:

1. Balachandran P., Fundamentals of Compressible Fluid Dynamics, PHI Learning. 2006
2. Rathakrishnan E., Gas Dynamics, PHI Learning, 2014
3. Yahya S. M., Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International Publishers, 2003

References Books:

1. Anderson**,** Modern compressible flow, 3e McGraw Hill Education, 2012
2. Shapiro, Dynamics and Thermodynamics of Compressible Flow – Vol 1., John Wiley & Sons,1953

Course Plan			
Module	**Contents**	**Hours**	**End Sem. Exam Marks**
I	Introduction to Compressible Flow- Concept of continuum-system and control volume approach- conservation of mass, momentum and energy- stagnation state- compressibility-Entropy relations. Wave propagation- Acoustic velocity-Mach number-effect of Mach number on compressibility- Pressure coefficient-physical difference between incompressible, subsonic, sonic and supersonic flows- Mach cone-Sonic boom-Reference velocities- Impulse function-adiabatic energy equation-representation of various flow regimes on steady flow adiabatic ellipse.	8	15%
II	One dimensional steady isentropic flow- Adiabatic and isentropic flow of a perfect gas- basic equations- Area-Velocity relation using 1D approximation-nozzle and diffuser-mass flow rate-chocking in isentropic flow-flow coefficients and efficiency of nozzle and diffuser- working tables-charts and tables for isentropic flow-operation of nozzle under varying pressure ratios –over expansion and under expansion in nozzles.	7	15%
FIRST INTERNAL EXAM			
III	Irreversible discontinuity in supersonic flow- one dimensional shock wave- stationary normal shock- governing equations- Prandtl- Meyer relations- Shock strength- Rankine- Hugoniot Relation- Normal Shock on T-S diagram- working formula- curves and tables-Oblique shock waves - supersonic flow over compression and expansion corners (basic idea only).	7	15%
IV	Flow in a constant area duct with friction (Fanno Flow) – Governing Equations- Fanno line on h-s and P-v diagram- Fanno relation for a perfect gas- Chocking due to friction- working tables for Fanno flow- Isothermal flow(elementary treatment only)	6	15%
SECOND INTERNAL EXAM			
V	Flow through constant area duct with heat transfer (Rayleigh Flow)- Governing equations- Rayleigh line on h-s and P-v diagram- Rayleigh relation for perfect gas- maximum possible heat addition- location of maximum enthalpy point- thermal chocking- working tables for Rayleigh flow.	6	20%
VI	Compressible flow field visualization and measurement- Shadowgraph-Schlieren technique- interferometer- subsonic compressible flow field -measurement (Pressure, Velocity and Temperature) – compressibility - correction factor- hot wire anemometer- supersonic flow measurement- Shock tube-Rayleigh Pitot tube- wedge probe- stagnation temperature probe- temperature recovery factor –Kiel probe - Wind tunnels – closed and open type-	8	20%
END SEMESTER EXAM			

Question Paper Pattern

Use of approved gas tables permitted

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
ME431	MECHANICAL ENGINEERING LAB.	0-0-3-1	2016

Prerequisite : ME302 Heat and mass transfer, ME304 Dynamics of machinery

Course Objectives:

- To conduct the various heat transfer experiments
- To practice calibration of thermometer and pressure gauges
- To do experiments on dynamics

Syllabus

List of experiments:

Hear transfer

1. Determination of LMTD and effectiveness of parallel flow, Counter flow and cross flow heat exchangers(double pipe heat exchanger)
2. Determination of heat transfer coefficients in free convection(free convection apparatus)
3. Determination of heat transfer coefficients in forced convection (forced convection apparatus)
4. Determination of thermal conductivity of solids(composite wall)
5. Determination of thermal conductivity of powder
6. Determination of Thermal conductivity of liquids
7. Determination of emissivity of a specimen (emissivity apparatus)
8. Determination of Stefan Boltzman constant (Stefan Boltzmann apparatus)
9. Study and performance test on refrigeration (Refrigeration Test rig)
10. Study and performance test air conditioning equipment(air conditioning test rig)
11. Performance study on heat pipe(Heat pipe)
12. Calibration of Thermocouples
13. Calibration of Pressure gauge

Dynamics

14. Whirling of shaft
15. Gyroscope
16. Universal governor apparatus
17. Free vibration analysis
18. Forced vibration analysis

Note: Minimum 9 experiments in heat transfer and 3 experiments in dynamics are mandatory

Expected outcome:

The students will be able to

1. Conduct experiments to determine thermal conductivity of materials
2. Determine heat transfer coefficient, LMTD etc..
3. Do calibration of thermometers and pressure gauges
4. Demonstrate the effect of unbalances resulting from rotary motions
5. Visualise the effect of dynamics on vibrations in single and multi degree of freedom system
6. Demonstrate the working principle of governor /gyroscope and demonstrate the effect of forces and moments on their motion

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME461	Aerospace Engineering	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

- To understand the fundamentals of aerospace engineering
- To provide an understanding of flight instruments

Syllabus:

The atmosphere, airfoil theory, 2D, 3D or Finite aero foils Propellers, Aircraft performance, Flight Instruments, stability of aircrafts, wind tunnel testing

Expected Outcomes:

The students will be able to

i. Identify, formulate and solve aerospace engineering problems
ii. Perform analysis of flight dynamics of aircrafts

Text books:

1. A.C. Kermode, Mechanics of flight, Prentice Hall, 2007
2. Anderson, Fundamentals of Aerodynamics, McGraw-Hill, 2010
3. EHJ Pallett, Aircraft Instruments and Integrated systems, Longman,1992

Reference books:

1. Houghton and brock, Aerodynamics for Engineering Student, Hodder & Stoughton,1977

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	The atmosphere-characteristics of troposphere , stratosphere , thermosphere, and ionosphere- pressure, temperature and density variations in the atmosphere. Application of dimensional analysis – aerodynamic force – model study and similitude. 2D aero foils -Nomenclature and classification- pressure distribution in inviscid and real flows- momentum and circulation theory of aerofoil- characteristics.	8	15%
II	3D or Finite aero foils – effect of releasing the wingtips- wing tip vortices- replacement of finite wing by horse shoe vertex system, lifting line theory-wing load distribution – aspect ratio, induced drag calculation of induced drag from momentum considerations. Skin friction and from drag- changes in finite wing plan shape	7	15%
FIRST INTERNAL EXAMINATION			

III	Propellers – momentum and blade element theories –propeller coefficients and charts. Aircraft performance-straight and level flight –power required and power available graphs for propeller and jet aircraft	**6**	**15%**
IV	Gliding and climbing –rate of climb-service and absolute ceilings-gliding angle and speed of flattest glide takeoff and landing performance – length of runway required- aircraft ground run- circling flight – radius of tightest turn-jet and rocket assisted take –off high lift devices-range and endurance of airplanes-charts for piston and jet engine aircrafts.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Flight Instruments-airspeed indicator, calculation of true air speed-altimeter, gyrohorizon -direction indicator-vertical speed indicator –turn and back indicator-air temperature indicator. (Brief description and qualitative ideas only). Ideas on stability-static and dynamic stability- longitudinal, lateral and directional stability- controls of an aero plane- aerodynamic balancing of control surfaces- mass balancing (Qualitative ideas only).	**7**	**20%**
V1	Principles of wind tunnel testing –open and closed type wind tunnels-wind tunnel balances supersonic wind tunnels. Study of subsonic, Transonic, and supersonic aircraft engines (Description with figures Only).Elementary ideas on space travel-calculation of earth orbiting and escape velocities ignoring air resistance and assuming circular orbit.	**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
ME462	Propulsion Engineering	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

- To give an overview of various air craft engines, rocket engines and their applications.
- To provide knowhow on tools to analyze various rocket propulsion.
- To know the testing of rocket engines .

Syllabus:

Fundamentals of Propulsion, Types of propulsive devices, Efficiencies, Thermodynamics analysis of turbojet, Turbojet engine components, Rocket propulsion, Types of rockets, Flight Performance, Testing of rockets

Expected Outcomes:

The students will be able to

i. Perform thermodynamic analysis of aircraft engines
ii. Carry out performance analysis of aircraft systems and components
iii. Formulate and solve rocket engine problems

Text books:

1. K Ramamurthi, Rocket Propulsion, Laxmi Publications, 2016
2. Saeed Farokhi, Aircraft Propulsion, Wiley, 2e, 2014

Reference books:

1. G. P. Sutton and Oscar Biblarz, Rocket Propulsion elements- John Wiley & Sons, 2013
2. J Mattingly, H von Ohain, Elements of Propulsion: Gas Turbines and Rockets, AIAA, 2006
3. Philip Hill, Carl Peterson: Mechanics and Thermodynamics of Propulsion, Pearson, 2014
4. Ronald D Flack, Fundamentals of Jet Propulsion with Applications, Cambridge University Press, 2005

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Fundamentals of Propulsion- Classification types of propulsive devices-Airscrew, Turbojet, Turboprop, turbofan, Turboshaft, Ramjet, Scramjet, Pulsejet and Rocket engines. Comparative study of performance characteristics applications.	7	15%
II	Theory of propulsion – Thrust, thrust power and efficiencies of turbojet engine. Thermodynamics analysis of turbojet engine cycle, Propellers: Types of propellers	7	15%
FIRST INTERNAL EXAMINATION			

III	Turbojet engine components- air intakes, Compressors, Combustion chambers, turbines, nozzles turbine and compression matching – Thrust augmentation.	**7**	**15%**
IV	Rocket propulsion- general operating principles of chemical, electrical nuclear and solar rockets. Chemical Rockets- Classification. Performance parameters for chemical rockets and their relationship, Energy and efficiencies, simple problems, Solid propellants- Types- burning rate- grain Configurations, - Classification- Typical fuels and oxidizers, properties and specifications, Selection.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Liquid propellant feed systems, injectors, Starting and ignition, Igniters liquid propellant, Precautions in propellant handling. Hybrid Rockets combustion processes in SPR and LPR combustion instability- Control of instabilities –Cooling of Rocket motors	**7**	**20%**
V1	Flight Performance- Velocity and attitude in simplified vertical Refractory staging of rockets. Rocket Testing- Test facilities and safeguards. Measurement System Terminology, Flight Testing.	**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.


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Course code	Course Name	L-T-P-Credits	Year of Introduction
ME463	Automobile Engineering	3-0-0-3	2016

Pre requisites: Nil

Course objectives

- To know the anatomy of automobile in general
- To understand the working of different automotive systems and subsystems
- To update the latest developments in automobiles

Syllabus:- Engine, clutch, transmission, steering, brakes, suspension and aerodynamics

COURSE OUTCOMES:

The students will be able to:

i. Practically identify different automotive systems and subsystems.
ii. Understand the principles of transmission, suspension, steering and braking systems of an automobile
iii. Develop a strong base for understanding future developments in the automobile industry

Text Books

1. Gupta R.B. Auto design , Satya Prakash, New Delhi, 2015
2. Heinz Heisler, Advanced engine technology, Butterworth-Heinemann,1995
3. Heinz Heisler, Advanced vehicle technology, Society of Automotive Engineers Inc, 2002
4. Hillier and Peter Coobes, Fundamentals of motor vehicle technology, Nelson Thornes, 2004
5. Tom Denton, Automobile mechanical and electrical systems, Butterworth-Heinemann, 2011

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Piston: - material for piston, clearances, piston rings, types, need for two compression rings, oil control ring, piston pin.	1	15%
	Piston for IC engine, piston rings, piston pin, connecting rod, crank shaft, crank pin, cam shaft, valves, fly wheel, fluctuation of energy and size of fly wheel, hub and arms, stress in a fly wheel rim, simple problems.	1	
		1	
	Petrol fuel injection systems: - comparison petrol injection and carbureted fuel supply systems- comparison –multiport fuel injection (MPFI) and common rail direct injection (CRDI) systems.	1	
		1	
	Super charging systems: fundamentals, naturally aspirated engines and supercharged engines– Turbo charger, turbo lag.	1	

	Hybrid cars, safety overview -Formula-I engine technology: overview, electrical technology, brakes, transmission technology.	1	
II	Friction clutch:- fundamentals, driven plate inertia, driven plate transmitted torque, driven plate wear –angular driven plate cushioning and torsional damping, clutch friction materials, when clutch is worn out.	1	**15%**
	Pull type diaphragm clutch, multiple diaphragm clutch, multi-plate hydraulically operated automatic transmission clutch, semi centrifugal clutch, fully automatic centrifugal clutch, and integral single plate diaphragm clutch.	1	
		1	
	Need of gear box, resistance to vehicle motion, power to weight ratio, speed operating range-five speed and reverse sliding mesh, constant mesh, and synchromesh gear boxes:- gear synchronization and engagement.	1	
		1	
	Over drives – hydrodynamic fluid couplings: - efficiency and torque capacity – fluid friction coupling- torque converters.	1	
		1	
FIRST INTERNAL EXAMINATION			
III	Steering:-basic principle of a steering system:- swinging beam system – Ackermann –over steer and under steer – slip angle, camber, caster etc.	1	**15%**
		1	
	Swivel axis inclination: centre point steering, camber, king pin inclination, negative offset, caster, toe-in and toe-out	1	
	Steering gear box: - fundamentals screw and nut steering gear mechanism-worm and roller type steering gear box – Re-circulating ball nut and rocker lever, re-circulating ball rack and sector steering gear box– need of power assisted steering.	1	
		1	
		1	
	External direct coupled and rack and pinion and integrated steering power cylinder, power assisted steering lock limitations	1	
IV	Suspension: - suspension geometry, terminology- Macpherson strut friction and spring offset - suspension roll centers:-roll centers, roll axis, roll centre height, short swing and long arm suspension, transverse double wishbone, parallel trailing double arm and vertical pill strut suspension, Macpherson strut suspension, semi-trailing arm rear suspension, telescopic suspension.	1	**15%**
		1	
	High load beam axle leaf spring, sprung body roll stability. Rear axle beam suspension- body roll stability analysis:- body roll couple, body roll stiffness, body over turning couple	1	

	Body weight transfer, body direct weight transfer couple, body roll couple distribution, body roll weight transfer, lateral force distribution.	1	
	Anti roll bars and roll stiffness:- anti roll bar function, operating principle, anti roll bar action caused by the body rolling, single wheel lift -rubber spring bumper:-bump stop function and characteristics, axis inclination.	1	
	Rear suspension: - live rigid axle suspension, non drive rear suspension- swing arm rear wheel drive independent suspension.	1	
	Low pivot split axle coil spring wheel drive independent suspension, trailing and semi trailing arm rear wheel drive independent suspension.	1	**15%**
	Transverse double link arm rear wheel drive independent suspension, De Dion axle rear wheel suspension - Hydrogen suspension, hydro-pneumatic automatic height correction suspension.	1	
SECOND INTERNAL EXAMINATION			
V	Brakes:- mechanical and hydraulic brakes (review only) – properties of friction lining and pad materials, efficiency, stopping distance, theory of internal shoe brake, equations –	1	**20%**
	effect of expanding mechanism of shoes on total braking torque, equations.	1	
	Braking vehicles:- brakes applied on rear, front and all four wheels, equations –calculation of mean lining pressure and	1	
	heat generation during braking operation, equations. – braking of vehicle moving on curved path, simple problems.	1	
	Anti Lock Braking system (ABS):- need and advantages of ABS – hydro-mechanical ABS - hydro-electric ABS - air-electric ABS.	1	
	Brake servos: - operating principle, vacuum servo - direct acting suspended vacuum assisted brake servo unit operation - hydraulic servo assisted brake systems.	1	
	Pneumatic operated disc brakes – air operated brake systems: - air over hydraulic brake system - Three line brake system-– electronic-pneumatic brakes.	1	
V1	Aerodynamic drag: pressure drag, air resistance, opposing motion of a vehicle, equations, after flow wake, drag	1	**20%**
	coefficients, various body shapes, base drag, vortices, trailing vortex drag, attached transverse vortices.	1	
	Aerodynamic lift:-lift coefficients, vehicle lift, underbody floor height versus aerodynamic lift and drag, aerofoil lift	1	
	and drag, front end nose shape.	1	
	Car body drag reduction:-profile edge chamfering, bonnet	1	

	slope and wind screen rake, roof and side panel chamfering, rear side panel taper, underbody rear end upward taper, rear end tail extension, underbody roughness.		
	Aerodynamic lift control:- underbody dams, exposed wheel air flow pattern, partial enclosed wheel air flow pattern, rear end spoiler, negative lift aerofoil wings.	1	
	After body drag: - square back drag, fast back drag, hatch back drag, notch back drag.	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
ME464	Robotics and Automation	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

- To provide the concepts of vision system and image processing
- To equip students to write programs for automatic functioning of a robot
- To familiarise various robot sensors and their perception principles that enable a robot

Syllabus:

Definition ,Co-ordinate Systems, Work Envelope, types and classification, Robot drive systems, End Effectors, Grippers, Sensors and machine vision, Robot kinematics and robot programming, Application of robots in machining.

Expected Outcomes:

The students will be able to

i. Become familiar with the history, concept, development and key components of robotics technologies
ii. Classify and characterize the robots based on the configuration and work volume
iii. Solve the problems related to robot design and control

Text books:

1. Industrial Robots, Yu.Kozyrev, Mir Publishers
2. Janakiraman.P.A., Robotics and Image Processing, Tata McGraw-Hill, 1995
3. M.P.Groover, Industrial Robotics – Technology, Programming and Applications, McGraw-Hill, 2001
4. Yoram Koren, Robotics for Engineers, McGraw-Hill Book Co., 1992

References:

1. Fu.K.S. Gonzalz.R.C., and Lee C.S.G., Robotics Control, Sensing, Vision and Intelligence, McGraw-Hill Book Co., 1987
2. K.S.Fu., R.C.Gonalez, C.S.G.Lee, Robotics Control sensing, Vision andIntelligence, McGraw Hill International Edition, 1987
3. Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, Robotic engineering-An Integrated Approach , Prentice Hall Inc, 1989

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Definition – Co-ordinate Systems, Work Envelope, types and classification – Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load – Basic robot motions - Point to point control, Continuous path control. Robot Parts and Their Functions – Need for Robots Different Applications.	7	15%
II	Robot drive systems: Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications	7	15%

	and Comparison of all these Drives.		
FIRST INTERNAL EXAMINATION			
III	End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations	**7**	**15%**
IV	Sensors and machine vision: Requirements of a sensor, Principles and Applications of the following types of sensors – Position of sensors (Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders), Range Sensors (Triangulation Principle, Structured, Lighting Approach, Laser Range Meters).	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Proximity Sensors(Inductive, Capacitive, and Ultrasonic), Touch Sensors, (Binary Sensors, Analog Sensors), Wrist Sensors, Compliance Sensors, Slip Sensors. Camera, Frame Grabber, Sensing and Digitizing Image Data – Signal Conversion, Image Storage, Lighting Techniques. Robot kinematics and robot programming: Forward Kinematics, Inverse Kinematics and Differences; Forward Kinematics and Reverse Kinematics of Manipulators with Two Degrees of Freedom (In 2 Dimensional) – Deviations and Problems.	**7**	**20%**
V1	Teach Pendant Programming, Lead through programming, Robot programming Languages –VAL Programming – Motion Commands, Sensor Commands, End effecter commands, and Simple programs. Industrial Applications: Application of robots in machining, welding, assembly, and material handling.	**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: in all parts each question can have a maximum of four sub questions

Course code	Course Name	L-T-P-Credits	Year of Introduction
ME465	Industrial Hydraulics	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

1. To introduce various fluid power systems
2. To get knowledge on fluid power circuits

Syllabus:

Introduction to fluid power, Properties of fluids. Selection of fluids, Pumps, Hydraulic cylinders and rams, Fluid power pumping systems and components, Hydraulic Actuators, Fluid temperature control, Piping systems, Control circuits

Expected Outcomes:

The students will be able

1. To understand the various components used in fluid power systems
2. To select the suitable system for a particular application
3. To know the various fluid circuits used in hydraulic systems

Text books:

1. B. Lall, Oil Hydraulics, International Literature Association
2. D. A. Pease, Basic Fluid Power, Prentice Hall,1986
3. J. J. Pipenger, Tyler Gregory Hicks, Industrial Hydraulics, McGraw Hill,1979
4. Pinches, Industrial Fluid Power, Prentice Hall,1989
5. R.K. Bansal, Fluid Mechanics, Laxmi Publication (P) Ltd.,2017

Reference:

1. ISO - 1219, Fluid Systems and components, Graphic Symbols
2. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier ,1999
3. Michael J. Prinches and Ashby J. G, Power Hydraulics, Prentice Hall,1988
4. Yeaple, Fluid Power Design Handbook, CRC Press,1995

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction to fluid power – Hydraulics and Pneumatics systems – Fluid power systems – Fundamentals of fluid mechanics , Properties of fluids. Selection of fluids, additives, effect of temperature and pressure on hydraulic fluids , Measurement of physical parameters – Hydraulic symbols	7	15%
II	Pumps: Types , classification , principle of working & constructional details of vane pump, gear pumps, radial and axial plunger pumps, Power and efficiency calculations, char, Curves, selection of pumps for hydraulic power transmission	7	15%
FIRST INTERNAL EXAMINATION			

III	Hydraulic cylinders and rams – Fluid power pumping systems and components. Pressure accumulators – Functions – Fluid reservoirs – Filter in hydraulic circuits. Loading and replacement of filter elements – Materials for filters.	**7**	**15%**
IV	Hydraulic Actuators (i) Linear and Rotary. (ii) Hydraulic motors - Types- Vane, Gear, Piston types, radial piston. (iii) Methods of control of acceleration, deceleration. (iv) Types of cylinders and mountings. (v) Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads. (vi) Design considerations for cylinders. Cushioning of cylinders.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Fluid temperature control – Fluid pressure control –control valves – Sequence -valve – Counterbalance valve-unloading valve – Friction control valve – Servo systems, Hoses & Pipes : Types , materials , pressure drop in hoses/pipes. Hydraulic piping connections.	**7**	**20%**
V1	Simple reciprocating, Regenerative, Speed control (Meter in, Meter out and bleed off), Sequencing, Synchronization, transverse and feed, circuit for riveting machine, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, circuit for hydraulic press, unloading circuit (Numerical treatment), motor breaking circuit	**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
ME466	Computational Fluid Dynamics	3-0-0-3	2016

Prerequisite : ME203 Mechanics of fluids

Course Objectives: :

- To introduce governing equations of viscous fluid flows
- To introduce numerical modelling and its role in the field of fluid flow and heat transfer
- To enable the students to understand the various discretization methods, solution procedures and turbulence modelling.
- To create confidence to solve complex problems in the field of fluid flow and heat transfer using high speed computers.

Syllabus:

Introduction to CFD, Governing equations, Steady and unsteady flows, Analytical solution of a one dimensional convection diffusion equation, Statistical representation of turbulent flows, Different types of turbulence models, Grid generation, Pressure-velocity decoupling for incompressible flows, Typical results of CFD analysis

Expected Outcomes:

The students will be able to

i. Grasp numerical modelling and its role in the field of fluid flow and heat transfer
ii. Apply the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems
iii. Know established engineering methods to solve complex engineering problem

Text books:

1. Patankar Suhas V., Numerical Heat Transfer and Fluid Flow, Taylor &Francis,1980
2. Versteeg H.K. &Malalasekera W., An introduction to Computational Fluid Dynamics, Longman,2008

Reference books:

1. Anderson Dale A., Tannehill John C. &Pletcher Richard H., Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, 2016
2. Fletcher C.A.J., Computational Techniques for Fluid Dynamics I, Springer Verlag,1984

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction to CFD, Historical background, applications, advantages. Basic steps of CFD. Meshes, Structured and unstructured mesh, Classification of structured grids. Governing equations: continuity and momentum equations. Equation of transport of a scalar. Potential, Euler and Navier-Stokes equations	7	15%
II	Steady and unsteady flows. Typical boundary conditions such as Dirichlets and Neumann conditions. TDMA method., Numerical	7	15%

	problem up to four unknowns using TDMA. Cell centred finite volume discretisation of terms of governing equations such as time derivative, convective and diffusion.		
FIRST INTERNAL EXAMINATION			
III	Analytical solution of a one dimensional convection diffusion equation. Upwind, central and blended difference approximations for convection term, QUICK scheme. Implicit, explicit and Crank-Nicolson schemes	**7**	**15%**
IV	Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Turbulence modeling, Different types of turbulence models: advantages and disadvantages. Structured Grid generation – Unstructured Grid generation– Mesh refinement – Adaptive mesh	**7**	**20%**
VI	Pressure-velocity decoupling for incompressible flows - SIMPLE and PISO algorithms. Density based solutions for compressible flow, TVD and Van-leerschemes for compressible flow. Typical results of CFD analysis. Stream lines, method for generating stream line, velocity contours and pressure contours, Method of drawing a velocity vector. Solution of Lagrangian coordinates of a fluid particle. Commercial CFD packages.	**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
ME467	Cryogenic Engineering	3-0-0-3	2016

Prerequisite : NIL

Course Objectives: :

- To provide the knowledge of evolution of low temperature science
- To provide knowledge on the properties of materials at low temperature
- To familiarize with various gas liquefaction systems and to provide design aspects of cryogenic storage and transfer lines

Syllabus:

Introduction to Cryogenics, Applications of Cryogenics, Properties of materials at cryogenic temperature, Liquefaction systems, Gas liquefaction systems, Cryogenic Refrigeration systems, Cryogenic fluid storage and transfer systems, Cryogenic instrumentation, heat exchangers used in cryogenic systems

Expected Outcomes:

The students will be able to

i. Understand properties of material at cryogenic temperatures.
ii. Know about various liquefaction systems
iii. Get ideas on cryogenic refrigeration systems, cryogenic instrumentation and cryogenic heat exchangers

Text books

1. J. H. Boll Jr, Cryogenic Engineering
2. R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 1959
3. Randal F.Barron, Cryogenic systems, McGraw Hill, 1986

Reference books:

1. Klaus D.Timmerhaus and Thomas M.Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989.

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction to Cryogenic Systems, Historical development, Low Temperature properties of Engineering Materials, Mechanical properties- Thermal properties- Electric and magnetic properties – Cryogenic fluids and their properties. Applications of Cryogenics: Applications in space, Food Processing, super conductivity, Electrical Power, Biology, Medicine, Electronics and Cutting Tool Industry. Low temperature properties of engineering materials	8	15%
II	Liquefaction systems ideal system, Joule Thomson expansion, Adiabatic expansion, Linde Hampson Cycle, Claude & Cascaded System, Magnetic Cooling, Stirling Cycle Cryo Coolers.	7	15%
FIRST INTERNAL EXAMINATION			

III	Gas liquefaction systems: Introduction-Production of low temperatures-General Liquefaction systems- Liquefaction systems for Neon. Hydrogen and Helium –Critical components of Liquefaction systems	**6**	**15%**
IV	Cryogenic Refrigeration systems: Ideal Refrigeration systems-Refrigeration using liquids and gases as refrigerant- Refrigerators using solids as working media;,	**6**	**15%**
SECOND INTERNAL EXAMINATION			
V	Cryogenic fluid storage and transfer systems: Cryogenic Storage vessels and Transportation, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems.	**8**	**20%**
V1	Cryogenic instrumentation, Pressure flow-level and temperature measurements. Types of heat exchangers used in cryogenic systems(only description with figure) Cryo pumping Applications	**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
ME468	Nanotechnology	3-0-0-3	2016

Prerequisite : Nil

Course Objectives:

- To introduce nanotechnology and nanostructures
- To introduce fabrication and characterization techniques used in nanotechnology

Syllabus:

Introduction and scope, nanostructures Effect of Nanoscale dimensions on various properties, Fabrication methods, Characterisation methods, Applications of Nanotechnology (nano materials and devices), Nanomachines, Nanofluids, Nanoswitches, nano computers, nanofilters

Expected Outcomes:

The students will be able to

i. Understand properties of materials at nanoscale
ii. Know the fabrication and characterization methods used in nanotechnology
iii. Acquaint with the various applications of nanotechnology

Text books:

1. A.K. Bandyopdhyay, Nanomaterials, , New age international publishers,2008
2. Bharat Bhushan, Springer Handbook of Nanotechnology, 2010
   Charles P Poole, Frank J Owens, Introduction to Nanotechnology, John Wiley and Sons, 2003
3. Jeremy Ramsden,Nanotechnology, William Andrew, Elsevier, 2011
4. T Pradeep, Nano: The essentials, McGraw – Hill education,2 007
5. V.S.Muralidharan, A Subramnya,Nano science and Technology, Ane books Pvt Ltd

Reference books:

1. Gregory Timp, Nanotechnology, Springer-Verlag, 2009
2. John Mongillo, Nano Technology, Greenwood Press, 2007
3. Kelsall Robert. W, Ian Hamley, MarkGeoghegan, Nanoscale Science and Technology, Wiley Eastern,2005

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction and scope-Classification of nanostructures: Quantum dots, quantum wires, quantum wells, nanoclusters, nanotubes, super lattices, nanocrystalline materials-Effects of nanometer length scale – Changes to the system total energy, changes to the system structures.	7	15%
II	Effect of Nanoscale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties.	7	15%
FIRST INTERNAL EXAMINATION			

III	Fabrication methods: Top down and bottom up approaches-Top down processes: Milling, Lithographics, machining process, pulsed laser methods- Bottom up processes: Vapour phase deposition methods, PVD, CVD, electro deposition, plasma assisted deposition process, MBE, chemical methods, colloidal and solgel methods	**7**	**15%**
IV	Characterisation methods: General classification of characterization methods, Microscopy techniques: Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy, Diffraction Techniques-Spectroscopy Techniques – Raman Spectroscopy, Surface analysis and depth profiling- Mechanical Properties-Magnetic and Thermal properties.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Applications of Nanotechnology (nano materials and devices)-Applications of nanocomposites, nanocrystalline materials, nano layered structures, nanomagnetic materials-magneto resistance-Carbon nanotubes: SW, MW, nanostructured coatings- nano sensors: order from chaos, characterization, perception, nano sensor based on quantum size effect, Electrochemical sensors, Sensors based on physical properties, Nanobiosensors, smart dust	**7**	**20%**
V1	Nanomachines: covalent and non covalent approaches, Molecular motors and machines, molecular devices, single molecular devices, practical problems with molecular device- Nanofluids: nanoparticles, preparation of nanofluids, thermophysical properties of nanofluids in comparison with base fluid. Nanoswitches - nano computers- nanofilters	**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
ME469	FINITE ELEMENT ANALYSIS	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

1. To learn the mathematical background of finite element methods.
2. To understand the basics of finite element formulation.
3. To practice finite element methodologies through structural and heat transfer problems.

Syllabus

Introduction; Brief history; Review of elasticity; Direct approach;1D bar element; Analogous problems; Beam elements; Plane truss; Coordinate transformations; Interpolation functions; Shape functions; Variational methods; Strong and weak form; Rayleigh Ritz method; FE formulation using minimization of potential; Consistent nodal loads; Higher order elements; Iso parametric elements; Weighted residual methods; FEA software packages.

Expected outcome

The students will be able to

i. understand the mathematical background of FEM .
ii. solve real life problems using finite element analysis

Text Books:

1. Chandrupatla T R., Finite Element Analysis for Engineering and Technology, University Press, 2004
2. Hutton D V., Fundamentals of Finite Element Analysis, Tata McGraw-Hill, 2005
3. Logan D L., A first course in the Finite Element Method, Thomson-Engineering, 2012
4. Seshu P., Text Book of Finite Element Analysis, PHI Learning Pvt. Ltd., 2003

References Books:

1. Cook R D., Malkus D S., Plesha M E.,Witt R J., Concepts and Analysis of Finite Element Applications, John Wiley & Sons,1981
2. Reddy J N., An introduction to the Finite Element Method, McGraw- Hill, 2006

Course

Module	Contents	Hours	End Sem. Exam Marks
I	Introduction to Finite Element Method (FEM)- Brief history- Application of FEA- Advantages and disadvantages. Review of elasticity- Strain displacement relations- Compatibility-Stress strain relations- Boundary conditions- Plane stress, plane strain and axisymmetry.	2	15%

	Direct approach-1D bar element- element stiffness- Assembly of elements- properties of [K] matrix- Treatment of boundary conditions- Stress computation.	4	
II	Analogous problems of torsion, heat conduction and laminar pipe flow. Beam elements- FE formulation-element stiffness matrix- boundary conditions.	4	20%
	Plane truss- Element formulation-Co ordinate transformation- Local and global co ordinates- Stress calculations.	4	
FIRST INTERNAL EXAMINATION			
III	Interpolation functions-Shape functions- Lagrange interpolation- 1D linear and quadratic element	3	15%
	Variational methods: Functionals- Strong and weak form- Essential and natural boundary conditions.	3	
IV	Principle of stationary potential energy- Rayleigh Ritz method.	3	20%
	FE formulation using minimization of potential- B matrix- Element matrices for bar element- Consistent nodal loads.	4	
SECOND INTERNAL EXAMINATION			
V	Higher order elements- Quadratic and cubic elements-Pascal's triangle-Serendipity elements.	3	15%
	Iso parametric elements, Natural coordinates, Area co ordinates-Quadrilateral elements-Jacobian matrix-Gauss quadrature.	5	
VI	Weighted residual method: Galerkin FE formulation. Axially loaded bar-Heat flow in a bar	5	15%
	Structure of FEA software package. Introduction to Modal analysis, non linear analysis and coupled analysis.	2	
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
ME471	Optimization Techniques	3-0-0-3	2016

Prerequisite - ME372 Operations Research

Course Objective:

- To learn the various optimization techniques for effective decision making.

Syllabus:

Linear programming – integer programming– network models – goal programming – dynamic programming – nonlinear programming – nontraditional optimization.

Expected Outcome:

- The students will be able to understand optimization techniques and apply them in solving practical problems

Text Books:

1. Miller, D. M. and Schmidt, J. W., Industrial Engineering and Operations Research, John Wiley & Sons, Singapore, 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. 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
5. Srinivasan, G. "Operations Research-Principles and Applications", latest edition, PHI Pvt. Ltd.

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Review of linear programming– revised simplex method	1	15%
		1	
	Dual simplex method	1	

		1	
	Sensitivity analysis – changes affecting feasibility – changes affecting optimality	**1**	
		1	
		1	
II	Integer programming – importance – applications	**1**	**15%**
	Branch and bound technique	**1**	
		1	
	Gomory's cutting plane method	**1**	
		1	
	Solution to travelling salesman problem	**1**	
		1	
FIRST INTERNAL EXAMINATION			
III	Network models – minimal spanning tree problem	**1**	**15%**
	PRIM's algorithm	**1**	
	Kruskal's algorithm	**1**	
	Shortest route problem –applications	**1**	
	Systematic method	**1**	
	Dijkstra's algorithm	**1**	
	Floyd's algorithm	**1**	
IV	Goal programming – goal programming formulation-application.	**1**	**15%**
		1	
	Simplex method for solving goal programming	**1**	
		1	
	Dynamic programming – terminologies – forward and backward recursion –applications	**1**	
	Shortest path problems	**1**	
		1	
SECOND INTERNAL EXAMINATION			
V	Nonlinear programming – convex, quasi-convex, concave and unimodal functions – theory of constrained optimization	**1**	**20%**
		1	
		1	
	Lagrangean method	**1**	
		1	
	Kuhn-Tucker conditions	**1**	
		1	
VI	Nontraditional optimization – computational complexity- Introduction to metaheuristics – areas of application	**1**	**20%**
		1	
	Genetic algorithm (GA) – terminologies – steps and examples	**1**	
	Tabu search (TS) – steps and examples	**1**	
	Simulated annealing (SA) – steps and examples	**1**	
	Ant colony optimization (ACO) – steps and examples - Particle Swarm Optimization (PSO)-Steps and examples	**1**	
		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
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
ME472	FAILURE ANALYSIS AND DESIGN	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

1. To understand the failure modes and theories of failure.
2. To include the effect of cyclic loading, fatigue and endurance limit in design.
3. To understand the methods for lifecycle prediction.

Syllabus

Material failure modes and their identification. Static loading, combined stress, theories of failure. Fatigue loading, high cycle fatigue, fatigue testing, S-N-P curves, endurance diagrams, influence factors, stress concentration factors and notch sensitivity, fatigue design for combined stress, cumulative damage and life prediction, low cycle fatigue, fracture mechanics principles in design practice, contact fatigue, high temperatures, corrosion. Shock and impact loading.

Expected outcome

The students will be able to

i. analyze real life failure modes and use of theories for failure prediction
ii. design for fatigue and cyclic loading
iii. make comprehensive life cycle prediction of designed products

Text Books:

1. Collins. J. A., Failure of Materials in Mechanical Design, John Wiley & Sons, 1993
2. Suresh S, Fatigue of Materials, Cambridge University Press, 1998

References Books:

1. Prashant Kumar, Elements of Fracture Mechanics, Wheeler Publishing, 1999
2. Withered C. E., Mechanical Failure Avoidance Strategies and Techniques, McGraw-Hill, 1994

Course Plan

Module	Contents	Hours	End Sem. Exam Marks
I	Introduction to material failure modes- Identification of failure modes	3	15%
	Combined stresses –Theories of failure	5	

II	Fatigue loading, high cycle fatigue, fatigue testing, S-N-P curves-factors affecting S-N-P curve- endurance diagrams	6	20%
FIRST INTERNAL EXAM			
III	Cumulative damage and life prediction- Fracture control	5	15%
	Fatigue design for combined stress	2	
IV	Low cycle fatigue – Cumulative damage in low cycle fatigue	4	20%
	Influence factors- Stress concentration factors and notch sensitivity	4	
SECOND INTERNAL EXAM			
V	Fracture mechanics principles in design practice	6	15%
VI	Contact fatigue, high temperatures, corrosion	4	15%
	Shock and impact loading.	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
ME474	Micro and Nano Manufacturing	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

1. To give awareness of different techniques used in micro and nano manufacturing
2. To give in-depth idea of the conventional techniques used in micro manufacturing
3. To introduce Non-conventional micro-nano manufacturing and finishing approaches
4. To introduce Micro and Nanofabrication Techniques and other processing routes in Micro and nano manufacturing
5. To know different techniques used in Micro Joining and the metrology tools in micro and nano manufacturing.

Syllabus

Introduction to Precision engineering- Bulk micromachining – Micro-energy -Carbon Nanotubes - Molecular Logic Gates and Nanolevel Biosensors - Conventional Micro Machining - Non-conventional micro-nano manufacturing and finishing approaches - Micro and Nano Finishing Processes - Micro and Nanofabrication Techniques - Micro Joining - Characterization and metrology tools.

Expected outcome

The students will

1. get an awareness of different techniques used in micro and nano manufacturing.
2. get in-depth idea of the conventional techniques used in micro manufacturing.
3. become aware about non-conventional micro-nano manufacturing and finishing approaches.
4. get awareness on micro and nano finishing processes.
5. understand micro and nanofabrication techniques and other processing routes in micro and nano manufacturing.
6. know about different techniques used in micro joining and the metrology tools in micro and nano manufacturing.

References:

1. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006.
2. Mark. J. Jackson, Micro-fabrication and Nano-manufacturing - Pulsed water drop micromachining CRC Press 2006.
3. Nitaigour Premchand Mahalik, Micro-manufacturing and Nanotechnology, 2006.
4. V.K.Jain, Micro-manufacturing Processes, CRC Press, 2012.

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks
I	Introduction to Precision engineering, macro milling and micro drilling, Micro-electromechanical systems – merits and applications, Micro phenomenon in Electro-photography – applications	1	15%

	Introduction to Bulk micromachining, Surface micromachining-steps, Micro instrumentation – applications, Micro Mechatronics, Nanofinishing – finishing operations.	**1**	
	Laser technology in micro manufacturing- Practical Lasers, application of technology fundamentals	**1**	
	Introduction to Micro-energy and chemical system (MECS), Space Micro-propulsion, e-Beam Nanolithography – important techniques, Introduction to Nanotechnology	**1**	
	Carbon Nano-tubes – properties and structures, Molecular Logic Gates and Nano level Biosensors - applications	**1**	
II	Introduction to mechanical micromachining, Micro drilling – process, tools and applications	**1**	**15%**
	Micro turning- process, tools and applications, Diamond Micro turning – process, tools and applications	**1**	
	Micro milling and Micro grinding – process, tools and applications	**1**	
	Micro extrusion- process and applications	**1**	
	micro bending with Laser	**1**	
	Nano- Plastic forming and Roller Imprinting	**1**	
	FIRST INTERNAL EXAMINATION		
III	Introduction to Non-conventional micro-nano manufacturing	**1**	**15%**
	Process, principle and applications – Abrasive Jet Micro Machining, WAJMM	**1**	
	Micro EDM, Micro WEDM, Micro EBM – Process principle, description and applications	**1**	
	Micro ECM, Micro LBM - Process principle, description and applications	**1**	
	Focused ion beams - Principle and applications	**1**	
IV	Introduction to Micro and Nano Finishing Processes	**1**	**15%**
	Magnetorheological Finishing (MRF) processes, Magnetorheological abrasive flow finishing processes (MRAFF) – process principle and applications	**1**	
	Force analysis of MRAFF process,	**1**	
	Magnetorheological Jet finishing processes	**1**	
	Working principle and polishing performance of MR Jet Machine	**1**	
	Elastic Emission Machining (EEM) – machine description, applications	**1**	
	Ion Beam Machining (IBM) – principle, mechanism of material removal, applications	**1**	
	Chemical Mechanical Polishing (CMP) – Schematic diagram, principle and applications	**1**	
	SECOND INTERNAL EXAMINATION		
V	Introduction to Micro Fabrication: basics, flowchart, basic chip	**1**	**20%**

	making processes		
	Introduction to Nanofabrication, Nanofabrication using soft lithography – principle, applications – Examples (Field Effect Transistor, Elastic Stamp)	**1**	
	Manipulative techniques – process principle, applications	**1**	
	Introduction to Carbon nano materials – CN Tubes	**1**	
	CN Tubes – properties and applications	**1**	
	CN Tube Transistors – Description only	**1**	
	Diamond - Properties and applications	**1**	
	CVD Diamond Technology	**1**	
	LIGA Process	**1**	
V1	Laser Micro welding – description and applications, Defects	**1**	**20%**
	Electron Beam Micro-welding – description and applications	**1**	
	Introduction to micro and nano measurement, defining the scale, uncertainty	**1**	
	Scanning Electron Microscopy – description, principle	**1**	
	Scanning White-light Interferometry – Principle and application	**1**	
	Optical Microscopy – description, application	**1**	
	Scanning Probe Microscopy, scanning tunneling microscopy- description, application	**1**	
	Confocal Microscopy - description, application	**1**	
	Introduction to On-Machine Metrology	**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
ME476	Material Handling & Facilities Planning	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

- To understand the overall facilities planning process
- To educate product, process and schedule design and their effects on the facility layout
- To introduce concepts of material handling and safety in industries.

Syllabus:

Design of layout of factories, General equipment for amenities of working people, Computer applications in layout designs, Environmental aspects, Plant safety, Economical aspects

Expected Outcomes:

The students will be able to

i. Assess the value of facility planning on the strategy of a firm
ii. Develop a systematic plant layout
iii. Know the environmental and economical aspects in facilities planning
iv. Understand various material handling systems

Text books/Reference books:

1. A W Peymberton, Plant layout and Material Handling, John Wiley
2. James A Apple, Plant layout and Material Handlin, Krieger Pub Co,1998
3. John A Sehbin, Plant layout and Material Handling-
4. K C Arora & Shinde, Aspects of Material handling, Lakshmi Publications.
5. P B Mahapatra, Operations Management, PHI, 2010

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Design of layout of factories, Office, Storage area etc. on consideration of facilities of working people, Storage facilities and general equipment for amenities of working people – Product, Process and combination layout –Systematic layout planning, Design of Assembly lines, Line balancing methods.	8	15%
II	Computer applications in layout designs, Environmental aspects like lighting, Ventilation, dust control, humidity. Different type of Plant services like steam compressed air etc.	6	15%
	FIRST INTERNAL EXAMINATION		
III	Plant safety, Elements off Industrial safety- Causes and prevention of accidents – Pollution and environmental consideration.	6	15%
IV	Introduction, Material Handling systems, Material Handling principles, Classification of Material Handling Equipment, Relationship of material handling to plant layout.	8	15%

SECOND INTERNAL EXAMINATION			
V	Basic Material Handling systems: Selection, Material Handling method- path, Equipment, function oriented systems.	**7**	**20%**
V1	Methods to minimize cost of material handling- Maintenance of Material Handling Equipments, Safety in handling, Ergonomics of Material Handling equipment. Design, Miscellaneous equipment	**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
ME482	Energy Conservation and Management	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

1. To enable analysis of the energy data of industries, energy accounting and balancing
2. To know energy audit and methodologies for energy savings
3. To understand utilization of the available resources in optimal ways

Syllabus:

Energy, Power, Past & Present scenario of World; National Energy consumption Data, Components of EB billing, Boilers, Furnaces and Thermic Fluid Heaters, Pumps, Fans, Blowers, Energy audit, Energy Economics

Expected Outcomes:

The students will be able to

i. carryout energy accounting and balancing
ii. suggest methodologies for energy savings

Text books:

1. Callaghn, P.W. Design and Management for Energy Conservation, Pergamon Press, Oxford,1981.
2. Witte. L.C., P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, 1988.

References:

1. Dryden. I.G.C., The Efficient Use of Energy Butterworths, London, 1982
2. Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website of Bureau of Energy Efficiency (BEE), A statutory body under Ministry of Power, Government of India, 2004.
3. Murphy. W.R. and G. Mc KAY, Energy Managemen", Butterworths, London 1987.
4. Turner. W.C., Energy Management Hand book, Wiley, New York, 1982.

Module	Contents	Hours	End Sem. Exam. Marks
I	Energy - Power – Past & Present scenario of World; National Energy consumption Data – Environmental aspects associated with energy utilization –Energy Auditing: Need, Types, Methodology and Barriers. Role of Energy Managers. Instruments for energy auditing	7	15%

II	Components of EB billing – HT and LT supply, Transformers, Cable Sizing, Concept of Capacitors, Power Factor Improvement, Harmonics, Electric Motors - Motor Efficiency Computation, Energy Efficient Motors, Illumination – Lux, Lumens, Types of lighting, Efficacy, LED Lighting and scope of Encon in Illumination.	**7**	**15%**
FIRST INTERNAL EXAMINATION			
III	Stoichiometry, Boilers, Furnaces and Thermic Fluid Heaters – Efficiency computation and encon measures. Steam: Distribution &Usage: Steam Traps, Condensate Recovery, Flash Steam Utilization, Insulators & Refractories	**7**	**15%**
IV	Energy efficiency in Pumps, Fans, Blowers, Compressed Air Systems, Refrigeration and Air Conditioning Systems – Cooling Towers – D.G. sets	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, Bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution, energy audit instruments and metering	**7**	**20%**
V1	Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Net Present Value, Life Cycle Costing –ESCO concepts	**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
ME484	Finite Element Analysis	3-0-0-3	2016

Prerequisite : Nil

Course Objectives: :

1. To introduce the concepts of Mathematical Modeling of Engineering Problems.
2. To appreciate the use of FEA to a range of Engineering Problems.

Syllabus:

Historical Background, Mathematical Modeling of field problems in Engineering ,Governing Equations, Basic concepts of the Finite Element Method, Solution of problems from solid mechanics and heat transfer, Fourth Order Beam Equation, Second Order 2D Equations involving Scalar Variable Functions, Equations of elasticity, Natural co-ordinate systems

Expected Outcomes:

- The students will be able to understand different mathematical techniques used in FEM analysis and use them in Structural and thermal problems

Text books:

1. Reddy. J.N., An Introduction to the Finite Element Method, 3rd Edition, Tata McGraw-Hill, 2005
2. Seshu, P, Text Book of Finite Element Analysis, Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.

Reference books:

1. Bhatti Asghar M, Fundamental Finite Element Analysis and Applications, John Wiley & Sons,2005 (Indian Reprint 2013)
2. Chandrupatla & Belagundu, Introduction to Finite Elements in Engineering, 3rd Edition, Prentice Hall College Div, 1990
3. Logan, D.L., A first course in Finite Element Method, Thomson Asia Pvt. Ltd., 2002
4. Rao, S.S., The Finite Element Method in Engineering, 3rd Edition, Butterworth Heinemann, 2004
5. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley Student Edition, 2002.

COURSE PLAN

Module	Contents	Hours	End Sem. Exam. Marks
I	Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique	7	15%
II	Basic concepts of the Finite Element Method. One Dimensional	7	15%

	Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices		
FIRST INTERNAL EXAMINATION			
III	Solution of problems from solid mechanics and heat transfer Longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation –Transverse deflections and Natural frequencies of beams.	**7**	**15%**
IV	Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements – Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Torsion of Non circular shafts –Quadrilateral elements – Higher Order Elements.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects – Stress calculations - Plate and shell elements.	**7**	**20%**
V1	Natural co-ordinate systems – Isoparametric elements – Shape functions for iso parametric elements – One and two dimensions – Serendipity elements – Numerical integration and application to plane stress problems - Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software.	**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.