Semester 5

S. No.	Course Code	Category	Course Title	Hours per week			Credits	Marks for Sessional	Marks for End Term Examination	Total
				L	T	P				
1	PCC		Dynamics of Machines	**3**	**1**	**0**	**3**	**30**	**70**	**100**
2	PCC		Internal Combustion Engines and Gas Turbines	**3**	**1**	**0**	**3**	**30**	**70**	**100**
3	PCC		Design of machine element-I	**3**	**1**	**0**	**3**	**30**	**70**	**100**
4	PCC		Heat Transfer	3	1	0	3	**30**	**70**	**100**
5	OEC		Open Elective -I	3	0	0	3	**30**	**70**	**100**
6	PEC		Professional Elective-I	3	0	0	3	**30**	**70**	**100**
7	LC		Dynamics of Machines _Lab	**0**	**0**	**2**	**1**	**30**	**70**	**100**
8	LC		Internal Combustion Engines and Gas Turbines _Lab	**0**	**0**	**2**	**1**	**50**	**50**	**100**
9	LC		Heat Transfer Lab	**0**	**0**	2	1	**50**	**50**	**100**
10	PT		Practical Training	**0**	**0**	**2**	**1**	**50**	**50**	**100**
		Total					**22**			**1000**

NOTE :

1. Practical Training: The evaluation will be based on internal evaluation by the examiner. According to performance, the students are awarded grades A, B, C, F. A student who is awarded 'F' grade is required to repeat the course. Excellent: A; Good: B; Satisfactory: C; Not Satisfactory: F
2. Choose any one from Professional Elective Course-I
3. Choose any one from Open Elective Course-I

Professional Elective-I

Sr. No.	Code	Subject	Credit
1		Strength of Material-II	3
2		Welding Technology	3
3		Tribology	3
4		Robotics Engineering	3

Course code					
Course title	Dynamics of Machines				
Category	**Professional Engineering Course**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To understand the student with fundamental knowledge of dynamics of machines so that student can appreciate problems of dynamic force balance, transmissibility of forces, isolation of systems, vibrations.
2. Develop knowledge of analytical and graphical methods for calculating balancing of rotary and reciprocating masses.
3. To understand the Special purpose mechanism (governor, Gyroscope Cam and followers etc.) used in designing of a machine.

UNIT-I

Static and Dynamic Force Analysis: Static force analysis of planer mechanisms, dynamic force analysis including inertia and frictional forces of planer mechanisms.
Dynamics of Reciprocating Engines: engine types, indicator diagrams, gas forces, equivalent masses, inertia forces, bearing loads in a single cylinder engine, crankshaft torque, engine shaking forces.

UNIT-II

Balancing of Rotating Components: static balance, dynamic balance, balancing of rotating masses, two plane balancing, graphical and analytical methods, balancing of rotors, balancing machines, field balancing.
Balancing of Reciprocating Parts: Balancing of single cylinder engine, balancing of multi cylinder; inline, radial and V type engines, firing order.

UNIT-III

Governors: introduction, types of governors, characteristics of centrifugal governors, gravity controlled and spring controlled centrifugal governors, hunting of centrifugal governors, inertia governors.
Dynamometers: types of dynamometers, Prony brake, rope brake and band brake dynamometers, belt transmission dynamometer, torsion dynamometer, hydraulic dynamometer.

UNIT-IV

Gyroscope: gyroscopes, gyroscopic forces and couples, gyroscopic stabilization, ship stabilization, stability of four wheel and two wheel vehicles moving on curved paths.

Course Outcomes (COs): At the end of the course, the student shall be able to:
CO 1- Understand the Static and Inertia Force Analysis.

CO 2- Explore the concept of Balancing of rotating and reciprocating masses.
CO 3- Knowledge of concept of Mechanical Governor.
CO 4- Develop the concept of Gyroscope and its application.
CO 5- Explore the concept of Mechanical Vibration.
CO 6- Analyze and understand the different types of mechanical inversion.

Text Books:

1. Theory of Mechanisms and Machines: Amitabha Ghosh and Ashok kumar Mallik, Third Edition Affiliated East-West Press.
2. Theory of Machine: S.S. Rattan, McGraw Hill Higher Education.

References:

1. Mechanism and Machine Theory: J.S. Rao and R.V. Dukkipati, New age International.
2. Theory of Machines and Mechanisms: Joseph Edward Shigley and John Joseph Uicker, Jr. Second Edition Mc Graw Hill, Inc .
3. Theory of Machines, Beven, Pearson Indian Education Services, Pvt. Ltd.

Course code					
Course title	Internal Combustion Engines and Gas Turbines				
Category	**Professional Engineering Course**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Course Objectives:

1. Familiarize with the terminology associated with IC engines.
2. Understanding the basics of IC engines.
3. Evaluate various parameters and variables affecting it in IC engines.
4. Analyzing about various systems used in IC engines and the type of IC engine required for various applications.
5. Understanding the calculation of efficiency of IC engines.
6. Analyze and evaluate the performance of IC engines.

UNIT-I

Air Standard Cycles: Internal and external combustion engines; classification of I.C. Engines, Cycles of operation in four stroke and two stroke I.C. Engines, Wankel Engines, Assumptions made in air standard cycle; Otto cycle; diesel cycle, dual combustion cycle, comparison of Otto, diesel and dual combustion cycles; sterling and Ericsson cycles; air standard efficiency, specific work output, specific weight; work ratio; mean effective pressure; deviation of actual engine cycle from ideal cycle. Problems.

Carburetion, fuel Injection and Ignition systems: Mixture requirements for various operating conditions in S.I. Engines; elementary carburetor, Requirements of a diesel injection system; types of inject systems; petrol injection, Requirements of ignition system; types of ignition systems ignition timing; spark plugs. Problems.

UNIT-II

Combustion in I.C. Engines: S.I. engines; Ignition limits; stages of combustion in S.I. Engines; Ignition lag; velocity of flame propagation; detonation; effects of engine variables on detonation; theories of detonation; octane rating of fuels; pre-ignition; S.I. engine combustion chambers, Stages of combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.

Lubrication and Cooling Systems: Functions of a lubricating system, Types of lubrication system; mist, wet sump and dry sump systems; properties of lubricating oil; SAE rating of lubricants, engine performance and lubrication, Necessity of engine cooling; disadvantages of overcooling; cooling systems; air-cooling, water cooling; radiators.

UNIT-III

Engine Testing and Performance: Performance parameters: BHP, IHP, mechanical efficiency, brake mean effective pressure and indicative mean effective pressure, torque, volumetric efficiency; specific fuel consumption (BSFC, ISFC), thermal efficiency; heat balance; Basic engine measurements; fuel and air consumption, brake power, indicated power and friction power, heat lost to coolant and exhaust gases; performance curves. Problems.

Air pollution from I.C. Engine and Its remedies: Pollutants from S.I. and C.I. Engines, Methods of emission

control; alternative fuels for I.C. Engines; the current scenario on the pollution front.

UNIT-IV

Rotary Compressors: Root and vane blowers; Static and total head values; Centrifugal compressorsVelocity diagrams, slip factor, ratio of compression, pressure coefficient, pre-whirl; Axial flow compressor- Degree of reaction, polytropic efficincy, surging, choking and stalling, performance characteristics, Problems.

Gas Turbines: Brayton cycle; Components of a gas turbine plant; open and closed types of gas turbine plants; Optimum pressure ratio; Improvements of the basic gas turbine cycle; multi stage compression with intercooling; multi stage expansion with reheating between stages; exhaust gas heat exchanger, Applications of gas turbines. Problems.

Course Outcomes (COs): At the end of the course, the student shall be able to:

CO1: Understand the working principles and thermodynamic cycles of internal combustion engines and gas turbines.

CO2: Analyze the performance characteristics of internal combustion engines and gas turbines, including power output, efficiency, and emissions.

CO3: Develop skills in designing and optimizing internal combustion engines and gas turbines for specific applications and operating conditions.

CO4: Demonstrate proficiency in diagnosing and troubleshooting engine and turbine performance issues and proposing effective solutions.

CO5: Apply knowledge of combustion processes, fuel systems, and heat transfer in the design and operation of internal combustion engines and gas turbines.

CO6: Evaluate the environmental impact of internal combustion engines and gas turbines, and explore alternative fuels and technologies for reducing emissions.

Text Books:

1. Internal Combustion Engines –V. Ganesan, Pub.-Tata McGraw-Hill.
2. Gas Turbines - V. Ganesan, Pub.- Tata McGraw Hill.
3. Engineering fundamental of the I.C.Engine – Willard W. Pulkrabek Pub.-PHI,India

References:

1. Internal Combustion Engines and Air pollution- Obert E.F, Pub.-Hopper and Row Pub., New York
2. Internal Combustion Engines Fundamentals- John B. Heywood, Pub.-McGraw Hill, New York
3. Fundamentals of Internal Combustion Engines-H.N. Gupta, PHI, New Delhi

Course code					
Course title	Design of Machine Element-I				
Category	**Professional Engineering Course**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

This course seeks to provide an introduction to the design of machine elements commonly encountered in mechanical engineering practice, through

1. A strong background in mechanics of materials based failure criteria underpinning the safety-critical design of machine components.
2. An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations.
3. An overview of codes, standards and design guidelines for different elements.
4. An appreciation of parameter optimization and design iteration.
5. An appreciation of the relationships between component level design and overall machine system design and performance

UNIT-I

Design Philosophy: Problem identification- problem statement, specifications, constraints, Feasibility study technical feasibility, economic and financial feasibility, societal and environmental feasibility, Generation of solution field (solution variants), Brain storming, Preliminary design, Selection of best possible solution, Detailed design, Selection of Fits and tolerances and analysis of dimensional chains.

Selection of Materials: Classification of Engg. Materials, Mechanical properties of the commonly used engg. Materials, hardness, strength parameters with reference to stress-strain diagram, Factor of safety.

UNIT-II

Mechanical Joints: ISO Metric Screw Threads, Bolted joints in tension, Eccentrically loaded bolted joints in shear and under combined stresses, Design of power screws, Design of various types of welding joints under different static load conditions.

Riveted Joints, Cotter and Knuckle Joints: Design of various types of riveted joints under different static loading conditions, eccentrically loaded riveted joints, design of cotter and knuckle joints.

UNIT-III

Belt rope and chain drives: Design of belt drives, Flat and V-belt drives, Condition for Transmission of max. Power, Selection of belt, design of rope drives, design of chain drives with sprockets.

Keys, Couplings and Flywheel: Design of Keys – Flat, Kennedy Keys, Splines, Couplings design – Rigid and Flexible coupling, turning Moment diagram, coefficient of fluctuation of energy and speed, design of flywheel – solid disk and rimmed flywheels.

UNIT-IV

Clutches: Various types of clutches in use, Design of friction clutches – Disc. Multidisc, Cone and Centrifugal, Torque transmitting capacity.
Brakes: Various types of Brakes, Self energizing condition of brakes, Design of shoe brakes – Internal and external expanding, band brakes, Thermal Considerations in brake designing.

Course Outcomes: At the end of the course, the student shall be able to:
CO 1- Exploration of different concepts and considerations of machine design.
CO 2- Understanding design of different types of mechanical joints.
CO 3- Learning of design of different types of keys and couplings.
CO 4- Design procedure of transmission of shafts.
CO 5- Design of different types springs.
CO 6- Analysis of the various types of clutches and brakes.

Text Books:
1. Mechanical Engg. Design - First Metric Editions: Joseph Edward Shigley-MGH, New York.
2. Design of Machine Elements – V.B. Bhandari – Tata McGraw Hill, New Delhi. 5. PSG Design Data Book

References:
1. Engineering design – George Dieter, MGH, New York.
2. Product Design and Manufacturing, A.K.Chitale and R.C.Gupta, PHI.
3. Machine Design An Integrated Approach: Robert L.Norton, Addison Wesley.
4. Machine Design : S.G. Kulkarini - Tata MacGraw Hill.
5. Design of machine elements-C S Sharma, Kamlesh Purohit, PHI.

Course code					
Category	**Professional Engineering Course**				
Course title	Heat Transfer				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. The aim of the course is to build a solid foundation in heat transfer exposing students to the three basic modes namely conduction, convection and radiation.
2. Rigorous treatment of governing equations and solution procedures for the three modes will be provided, along with solution of practical problems using empirical correlations.
3. The course will also briefly cover boiling and condensation heat transfer, and the analysis and design of heat exchangers

UNIT-I

Basics and Laws: Definition of Heat Transfer, Reversible and irreversible processes, Modes of heat flow, Combined heat transfer system and law of energy conservation. Steady State Heat Conduction: Introduction, I-D heat conduction through a plane wall, long hollow cylinder, hollow sphere, Conduction equation in Cartesian, polar and spherical co-ordinate systems, Numericals.

UNIT-II

Steady State Conduction with Heat Generation: Introduction, 1 – D heat conduction with heat sources, Extended surfaces (fins), Fin effectiveness 2-D heat conduction , Numericals. Transient Heat Conduction: Systems with negligible internal resistance, Transient heat conduction in plane walls, cylinders, spheres with convective boundary conditions, Chart solution, Relaxation Method, Numericals.

UNIT-III

Convection: Forced convection-Thermal and hydro-dynamic boundary layers, Equation of continuity, Momentum and energy equations, Some results for flow over a flat plate and flow through tube, Fluid friction and heat transfer (Colburn analogy), Free convection from a vertical flat plate, Empirical relations for free convection from vertical and horizontal o\planes and cylinders, Numericals. Thermal Radiation: The Stephen-Boltzmann law, The black body radiation, Shape factors and their relationships, Heat exchange between non black bodies, Electrical network for radiative exchange in an enclosure of two or three gray bodies, Radiation shields, Numericals.

UNIT-IV

Heat Exchangers: Classification, Performance variables, Analysis of a parallel/counter flow heat exchanger, Heat exchanger effectiveness, Numericals. Winglets, Types of Winglets, Heat Transfer Augmentation Process,

effect of heat treatment augmentation, Application of heat treatment augmentation process, Heat transfer augmentation in a channel flow. Heat Transfer with Change of Phase: Laminar film condensation on a vertical plate, Drop-wise condensation, Boiling regimes, Free convective, Nucleate and film boiling, Numericals

Course Outcome (COs): At the end of the course, the student shall be able to:
CO 1- Understand the basic concept of conduction, convection and radiation heat transfer.
CO 2- Formulation of one dimension conduction problems.
CO 3- Application of empirical correlations for both forced and free convection for determines the value of convection heat transfer coefficient.
CO 4- Expedite basic concept of the radiation heat transfer for black and grey body.
CO 5- Learning of thermal analysis and sizing of Heat exchangers.
CO 6- Understanding the design of heat exchanger.

Text Books:
1. Heat Transfer – J.P. Holman, John Wiley and Sons, New York.
2. Fundamentals of Heat and Mass Transfer–Incropera, F.P. and Dewill, D.P –John Willey New York.
3. Heat Transfer-Principles and Applications-Binay K. Dutta, PHI, New Delhi

References:
1. Conduction of Heat in Solids – Carslow, H.S. and J.C. Jaeger – Oxford Univ. Press.
2. Conduction Heat Transfer – Arpasi, V.S. – Addison – Wesley.
3. Compact Heat Exchangers – W.M. Keys and A.L. Landon, Mc. Graw Hill.
4. Thermal Radiation Heat Transfer – Siegel, R. and J.R. Howell, Mc. Graw Hill.
5. Heat Transmission – W.M., Mc.Adams, Mc Graw Hill.
6. Heat and Mass Transfer, Mohan, Pearson Indian Education Services, Pvt. Ltd. In

Course code					
Course title	Strength of Materials-II				
Category	**PEC-I**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
2. To provide a detailed interpretation of equilibrium phase diagrams
3. Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

UNIT-I

Crystal Structure: Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.

Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength.

UNIT-II

Static failure theories: Ductile and brittle failure mechanisms, Tresca, Von-mises, Maximum normal stress, Mohr-Coulomb and Modified Mohr-Coulomb; Fracture mechanics: Introduction to Stressintensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects of mean stress using the Modified Goodman diagram; Fracture with fatigue, Introduction to non-destructive testing (NDT)

UNIT-III

Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstructural aspects of ledeburite, austenite, ferrite and cementite, cast iron.TTT-curve

UNIT-IV

Heat treatment of Steel: Annealing, tempering, normalizing and spheroidizing, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening

Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons; grey, white, malleable

and spheroidal cast irons- copper and copper alloys; brass, bronze and cupronickel; Aluminum and Al-Cu – Mg alloys-Nickel based superalloys and Titanium alloys

Course Outcomes:
CO1. Student will be able to identify crystal structures for various materials and understand the defects in such structures
CO2. Understand how to tailor material properties of ferrous and non-ferrous alloys
CO3.How to quantify mechanical integrity and failure in materials.
CO4. Interpret the phase diagrams of materials.
CO5. Describe the concept of heat treatment of steels and strengthening mechanisms.
CO6: Develop skills in characterizing and testing materials to determine their mechanical, thermal, electrical, and optical properties.

Text Books:
1. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
3. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 1999.
4. U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.

Course code	

Course title	Welding Technology				
Category	**PEC I**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Corse Objectives:

The objective is to present the mathematical and physical principles in understanding the linear continuum behavior of solids.Apply and use energy methods to find force, stress and displacement in simple structures and springs.Understand and determine the stresses and strains in pressure vessels. Knowledge of stress functions, and calculate stresses in rotating rings, discs, and curved beams.

UNIT-I

Strain Energy & Impact Loading: Definitions, expressions for strain energy stored in a body when load is applied (i) gradually, (ii) suddenly and (iii) with impact, strain energy of beams in bending, beam deflections, strain energy of shafts in twisting, energy methods in determining spring deflection, Castigliano's & Maxwell's theorems, Numericals. Theories of Elastic Failure: Various theories of elastic failures with derivations and graphical representations, applications to problems of 2- dimensional stress system with (i) Combined direct loading and bending, and (ii) combined torsional and direct loading, Numericals.

UNIT-II

Unsymmetrical Bending: Properties of beam cross section, product of inertia, ellipse of inertia, slope of the neutral axis, stresses & deflections, shear center and the flexural axis Numericals. Springs: Stresses in open coiled helical spring subjected to axial loads and twisting couples, leaf springs, flat spiral springs, concentric springs, Numericals.

UNIT-III

Derivation of Lame's equations, Radial & Hoop Stresses in compound spherical shells subjected to internal fluid pressure only, wire wound cylinders, hub shrunk on solid shaft, Numericals. Rotating Rims & Discs: Stresses in uniform rotating rings & discs, rotating discs of uniform strength, stresses in (I) rotating rims, neglecting the effect of spokes, (ii) rotating cylinders, hollow cylinders & solids cylinders. Numericals.

UNIT-IV

Bending of Curved Bars : Stresses in bars of initial large radius of curvature, bars of initial small radius of curvature, stresses in crane hooks, rings of circular & trapezoidal sections, deflection of curved bars & rings, deflection of rings by Castigliano's theorem stresses in simple chain link, deflection of simple chain links, Problems.

Course Outcomes:

After studying this course, students will be able:

CO 1 Apply and use energy methods to find force, stress and displacement in simple structures and springs.

CO 2 Understand and determine the stresses and strains in pressure vessels.

CO 3 Knowledge of stress functions, and calculate stresses in rotating rings, discs, and curved beams.

CO 4 Evaluate the behaviour and strength of structural elements subjected to three dimensional stress system.

CO5 Evaluate the properties and behavior of helical springs

CO6 Develop problem-solving skills by working on numerical examples and exercises

Text Books:

1. Strength of Materials – G.H.Ryder, Third Edition in SI Units 1969 Macmillan, India.
2. Strength of Materials – Sadhu Singh, Khanna Publishers

References:

1. Book of Solid Mechanics – Kazmi, Tata Mc Graw Hill
2. Strength of Materials – D.S. Bedi - S. Chand & Co. Ltd.
3. Strength of Materials – U.C Jindal - Pearson India Ltd.

Course code					
Course title	Tribology				
Category	**PEC I**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To provide the knowledge and importance of Tribology in Design, friction, wear and lubrication aspects of machine components.
2. To select proper grade lubricant for specific application.
3. To understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
4. To introduce the concept of surface engineering and its importance in tribology.
5. To understand the behavior of Tribological components.

UNIT- I

Fundamentals of Tribology: Introduction to tribology and its historical background, Industrial importance, factors influencing Tribological phenomenon. Engineering surfaces- surface characterization, computation of surface parameters. Surface measurement techniques, statistical description.

UNIT- II

Friction of Surfaces: Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction, friction of elastomers, friction of various materials, friction measurement methods, friction of non metallic materials.

UNIT- III

Wear Mechanism: Introduction, types of wear, wear mechanism, minor forms of wear, wear debris analysis, wear testing method, wear of metals, ceramics, polymers, system approach for wear reduction.

UNIT-IV

Theory of Lubrication: Basic principal of lubrication, choice of lubricant type, selection of lubrication oils, oil changing and oil conservation, oil feed system, Greece and anti seizes, gas bearing, lubricating sealing, lubricating testing and specifications, lubrication monitoring, Additives in lubricants.

UNIT- V

Design for Tribological Elements: An overview of engineering materials having potential for tribological application, characterization and evaluation of ferrous materials for tribological requirements/application, selection of ferrous materials for rolling element bearings, Basic Equation for fluid film lubrication, Boundary lubrication, Hydrodynamic lubrication, electrohydrodynamic lubrication.

Course Outcomes:

CO1: Understand the different techniques used to solve mechanical engineering problems.
CO2: Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
CO3: Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
CO4: Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis.
CO5: Use commercial finite element analysis software to solve complex problems in solid mechanics and heat transfer.
CO6: Interpret the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors.

Text Books

1. Moore F Desmond ,Principals and application of Tribology, ,Pergamon press,1975
2. Sahoo Prashant Engineering Tribology, Prentice-Hall of India, New Delhi, 2005
3. Lansdown A R ,Lubrication, A practical Guide to Lubricant selection, Pergamon Press1982
4. Majumdar BC, Introduction to Tribology of Bearings, Wheeler Publishing, New Delhi,1999.

Course code					
Course title	Robotics Engineering				
Category	**PEC I**				
Semester and Credits	L	T	P	**Credits**	Semester V
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

This course introduces the basic concepts, standard terminologies, applications, design specifications, and the mechanical design aspects of robotics related to kinematics, trajectory planning, dynamics, control and simulation of serial industrial robotic manipulators.

UNIT-I

Definition of robot, types and classifications, standard terminologies related to robotics, key design specifications used for selection of serial robotic manipulators for various applications, robotic applications in modern automated industries, research and non-industrial environments.

UNIT-II

Homogeneous co-ordinates and co-ordinate transformations, Forward and inverse kinematics for serial robotic manipulators, the concept of Jacobian, kinematics simulation in MATLAB environment and using Robo Analyser.

UNIT-III

Robot Dynamics: Introduction to Lagrangian formulations for serial robotic manipulators, actuator dynamics.
Trajectory Generation: Joint-Space trajectory generation, Cartesian space trajectory generation, Path generation at run time, simulation of trajectory-related problems.

UNIT-IV

Robot Control: Open-loop and Closed-loop control, Model-based control, Trajectory following control.

Course Outcomes :

The students will be able to:

CO1. Identify and formulate the desired robotic design specifications for a particular application.
CO2. Develop and simulate the forward kinematics model using D-H conventions..
CO3. Develop the inverse kinematics model of a serial manipulator.
CO4. Develop and analyze the mathematical model for robotics trajectory planning, resolved motion rate control and dynamics for a given serial robotic manipulator.
CO5. Apply the joint- and Cartesian-based schemes to control the manipulators in different applications.
CO6. Interpret and analyze the results obtained from Robo Analyser for robot motion and positioning.

Text books:

1. Schilling, R.J., Fundamentals of Robotics Analysis and Control, Prentice Hall of India (2006).
2. Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill (1987).
3. Craig, J.J., Introduction to Robotics: Mechanics and Control, prentice Hall (2004).

Reference Books:

1. Deb, S.R., Robotics and Flexible Automation, McGraw Hill (2004).
2. Saha, S.K., Introduction to Robotics, McGraw Hill (2008).
3. Niku, S.B., Introduction to Robotics: Analysis, system, application, Dorling kingsley (2006).

Course code					
Course title	Dynamics of Machines _Lab (P)				
Category	**Laboratory Course**				
Semester and Credits	L	T	P	**Credits**	Semester V
	0	0	2	1	
Marks for Sessional	50 Marks				
Marks for End term Examination	50 Marks				
Total	`100 Marks				

Note :
1. Ten experiments are to be performed in the Semester.
2. At least seven experiments should be performed from the above list. Remaining three experiments should be performed as designed and set by the concerned Institution as per the scope of the sylLabus.

Course Objectives:
1. To understand the student with fundamental knowledge of dynamics of machines so that student can appreciate problems of dynamic force balance, transmissibility of forces, isolation of systems, vibrations.
2. Develop knowledge of analytical and graphical methods for calculating balancing of rotary and reciprocating masses.

List of Experiments:
1. To perform experiment on Watt and Porter Governors to prepare performance characteristic Curves, and to find stability and sensitivity.
2. To perform experiment on Proell Governor to prepare performance characteristic curves, and to find stability and sensitivity.
3. To perform experiment on Hartnell Governor to prepare performance characteristic Curves, and to find stability and sensitivity.
4. To study gyroscopic effects through models.
5. To determine gyroscopic couple on Motorized Gyroscope.
6. To perform the experiment for static balancing on static balancing machine.
7. To perform the experiment for dynamic balancing on dynamic balancing machine.
8. Determine the moment of inertial of connecting rod by compound pendulum method and triflair suspension pendulum.

Course Outcomes: At the end of the course, the student shall be able to:
CO 1- Understand the various practical demonstrations of forces in mechanism.
CO 2- Knowledge of various Design features of mechanism with practical demonstration.
CO 3- Learning the Special purpose mechanism (governor, Gyroscope Cam and followers etc) used in designing of a machine
CO 4- Prepare practical model using the various linkages.

Course code					
Course title	I.C. ENGINES and GAS TURBINES LAB				
Category	**Laboratory Course**				
Semester and Credits	L	T	P	**Credits**	Semester V
	0	0	2	1	
Marks for Sessional	50 Marks				
Marks for End term Examination	50 Marks				
Total	100 Marks				

NOTE:
1 At least ten experimentsare tobe performed in the Semester.
2 At least seven experiments should be performed from the above list. Remaining three experiments may either be performed from the above list or designed and set by the concerned institution as perthe scope of the sylLabus.

Course Objectives:
After studying this course, students will be able: Understand the how to prepare the graph between bhp, ihp, fhp vs speed by using variable compression test rig. Knowledge of functions of 4 stroke and two stroke engines and Combustion System of IC Engines with Lubrication and Cooling system

List of Experiments:
1. To study the constructional details and working principles of two-stroke/ four stroke petrol engine.
2. To study the constructional detail and working of two-stroke/ four stroke diesel engine.
3. Analysis of exhaust gases from single cylinder/multi cylinder diesel/petrol engine by Orsat Apparatus.
4. To prepare heat balance sheet on multi-cylinder diesel engine/petrol engine.
5. To find the indicated horse power (IHP) on multi-cylinder petrol engine/diesel engine by Morse Test.
6. To prepare variable speed performance test of a multi-cylinder/single cylinder petrol engine/diesel engine and prepare the curves (i) bhp, ihp,fhp, vs speed (ii) volumetric efficiency and indicated specific specific fuel consumption vs speed.
7. To find fhp of a multi-cylinder diesel engine/petrol engine by Willian's line method and by motoring method.
8. To perform constant speed performance test on a single cylinder/multi-cylinder diesel engine and draw curves of (i) bhp vs fuel rate, air rate and A/F and (ii) bhp vs mep, mech efficiency and sfc.
9. To measure CO and Hydrocarbons in the exhaust of 2- stroke / 4-stroke petrol engine.
10. To find intensity of smoke from a single cylinder / multi-cylinder diesel engine.
11. To draw the scavenging characteristic curves of single cylinder petrol engine.
12. To study the effects of secondary air flow on bhp, sfc, Mech. Efficiency and emission of a twostroke petrol engine.

Course Outcomes (COs): After studying this course, students will be able:
CO 1- Understand the how to prepare the graph between bhp, ihp, fhp vs speed by using variable compression test rig.
CO 2- Knowledge of functions of 4 stroke and two stroke engines.

CO 3- Learn Combustion System of IC Engines with Lubrication and Cooling system.
CO 4- Familiarization of the pollution control system.

Course code					
Category	Professional Engineeringcourse				
Course title	Heat Transfer Lab				
Semester and Credits	L	T	P	**Credits**	Semester V
	0	0	2	1	
Classwork	50 Marks				
Exam	50 Marks				
Total	100 Marks				

Note: 1. At least ten experiments are to be performed in the semester. 2. At least seven experiments should be performed from the above list. Remaining three experiments may either be performed from the above list or designed and set by the concerned institute as per the scope of the sylLabus.

Courses Objectives:

(1) The aim of the course is to build a solid foundation in heat transfer exposing students to the three basic modes namely conduction, convection and radiation.

(2) The course will also briefly cover boiling and condensation heat transfer, and the analysis and design of heat exchangers.

List of Experiments:

1. To determine the thermal conductivity of a metallic rod.
2. To determine the thermal conductivity of an insulating power.
3. Measurement of heat transfer rate in a channel flow using winglets.
4. To determine the thermal conductivity of a solid by the guarded hot plate method.
5. To find the effectiveness of a pin fin in a rectangular duct natural convective condition and plot temperature distribution along its length.
6. To find the effectiveness of a pin fin in a rectangular duct under forced convective and plot temperature distribution along its length.
7. To determine the surface heat transfer coefficient for a heated vertical tube under natural convection and plot the variation of local heat transfer coefficient along the length of the tube. Also compare the results with those of the correlation.
8. To determine average heat transfer coefficient for a externally heated horizontal pipe under forced convection and plot Reynolds and Nusselt numbers along the length of pipe. Also compare the results with those of the correlations.
9. To measure the emmisivity of the gray body (plate) at different temperature and plot the variation of emmisivity with surface temperature.
10. To find overall heat transfer coefficient and effectiveness of a heat exchange under parallel and counter flow conditions. Also plot the temperature distribution in both the cases along the length of heat of heat exchanger.
11. To verify the Stefen-Boltzmann constant for thermal radiation.
12. To demonstrate the super thermal conducting heat pipe and compare its working with that of the best conductor i.e. copper pipe. Also plot temperature variation along the length with time or three pipes.
13. To study the two phases heat transfer unit.
14. To determine the water side overall heat transfer coefficient on a cross-flow heat exchanger.
15. Design of Heat exchanger using CAD and verification using thermal analysis package eg. IDeas etc.

Course Outcomes (COs): At the end of the course, the student shall be able to:

CO 1- Understanding the conduction heat transfer coefficient.

CO 2- Design and analyze heat transfer system with practical demonstration.
CO 3- Selection of equipments and their practical demonstration in heat transfer design.
CO 4- Knowledge of development about mass transfer

Course code	

Course title	Practical Training				
Category	**PT**				
Semester and Credits	L	T	P	**Credits**	Semester V
	0	0	2	0	
Marks for Sessional					
Marks for End term Examination					
Total					

PRACTICAL TRAINING VIVA-VOCE:

1) Assessment of Practical Training-I, undergone at the end of IV semester, will be based on seminar, viva-voce, report and certificate of practical training obtained by the student from the industry/ Professional organization/ Research Laboratory with the prior approval of the Director-Principal/ Mechanical Software /Automobile Workshop.

   According to performance letter grades A, B, C, F are to be awarded:
   1)Excellent : A ; Good : B ; Satisfactory : C ; Not satisfactory : F. A student who has been awarded ' F' grade will be required to repeat the practical training.
   2) Each student has to undergo practical training of 4/6 weeks during summer vacation and its evaluation shall be carried out in the V semester.

Course Objectives:

1. Achieving the objectives of the University and its colleges and departments in practical training.
2. Providing students with practical skills, which match the requirements of the job market and allow them to directly enter the work community in a serious and constructive manner.
3. Providing students with experience to help them take decisions pertaining to their future career objectives.
4. Providing college students the full opportunity to apply theoretical knowledge (gained during their studies) in a real work environment at a later stage of their studies
5. Developing the student's understanding of the needs of the job market and reaching this understanding successfully.

Semester 6

S. No.	Course Code	Category	Course Title	Hours per week			Credits	Marks for Sessional	Marks for End Term Examination	Total
				L	T	P				
1	HSC		Entrepreneurship Development	**3**	**0**	**0**	**3**	**30**	**70**	**100**
2	PCC		Fluid Machines	**3**	**0**	**0**	**3**	**30**	**70**	**100**
3	PCC		Design of machine element-II	**3**	**0**	**0**	**3**	**30**	**70**	**100**
4	PCC		Operation Research	**3**	**0**	**0**	**3**	**30**	**70**	**100**
5	OEC		Open Elective-II	**3**	**0**	**0**	**3**	**30**	**70**	**100**
6	PEC		Elective-I	**3**	**0**	**0**	**3**	**30**	**70**	**100**
7	PEC		Elective-II	**3**	**0**	**0**	**3**	**30**	**70**	**100**
8	LC		Fluid Machines _Lab	**0**	**0**	**2**	**1**	**50**	**50**	**100**
9	HSMC		Economics for Engineers	**2**	**0**	**0**	**0**	**30**	**70**	**100**
10	PROJ-1		Project_I	**0**	**0**	**2**	**2**	**30**	**70**	**100**
		Total					**24**			**1000**

NOTE

1. The examination of the regular students will be conducted by the concerned college/Institute internally. Each student will be required to score a minimum of 40% marks to qualify in the paper. The marks will not be included in determining the percentage of marks obtained for the award of a degree.
2. Choose any one from each of the Professional Elective Course-II and III .
3. Choose any one from Open Elective Course-II

Professional Elective-II

Sr. No.	Code	Subject	Credit
1		Power Plant Engineering	3
2		Solar Energy Engineering	3
3		Artificial Intelligence and Machine Learning	3
4		Automobile Engineering	3

Professional Elective-III

Sr. No.	Code	Subject	Credit
1		Additive Manufacturing	3
2		Finite Element Method	3
3		System Modelling And Simulation	3
4		Noise and Vibrations	3
		Hydraulics and Pneumatics	3

Course code					
Course title	Entrepreneurship Development				
Category	**HSC**				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

The objectives of the course are to

1. Introduce various qualities required for entrepreneurship
2. Explain various entrepreneurship models
3. Organize interaction with successful entrepreneurs
4. Introduce to various tools as Six hat techniques, Five S.

UNIT-I

Entrepreneurship : Concept and Definitions; Entrepreneurship and Economic Development; Types of Entrepreneurs; Factor Affecting Entrepreneurial Growth – Economic, Non-Economic Factors; EDP Programmes; Entrepreneurial Training; Traits/Qualities of an Entrepreneurs; Manager Vs. Entrepreneur, types of entrepreneurships, Entrepreneurial myths.

UNIT-II

Opportunity Identification and Product Selection: Entrepreneurial Opportunity Search and Identification; Criteria to Select a Product; Conducting Feasibility Studies; Sources of business ideas, launching a new product; export marketing, Methods of Project Appraisal, Project Report Preparation; Project Planning and Scheduling. Sources of finance for entrepreneurs.

UNIT-III

Small Enterprises and Enterprise Launching Formalities : Definition of Small Scale; Rationale; Objective;Scope; SSI; Registration; NOC from Pollution Board; Machinery and Equipment Selection , Role of SSI in Economic Development of India; major problem faced by SSI,MSMEs – Definition and Significance in Indian Economy; MSME Schemes, Challenges and Difficulties in availing MSME Schemes.

UNIT-IV

Role of Support Institutions and Management of Small Business : Director of Industries; DIC; SIDO;SIDBI; Small Industries Development Corporation (SIDC); SISI; NSIC; NISBUD; State Financial Corporation SIC; Venture Capital : Concept, venture capital financing schemes offered by

various financial institutions in India, Legal issues – Forming business entity, considerations and criteria, requirements for formation of a Private/Public Limited Company.

Course Outcomes: At the end of the course, the student shall be able to:

CO1 - Students will be able understand who the entrepreneurs are and what competences needed

CO2 - Students will be able to understand insights into the management, opportunity search, identification of a product, market flexibility studies, project finalization etc. required for small business enterprise.

CO3- Students will be able to write a report and do oral presentation on the topics such as product identification, business ideas, export marketing etc.

CO4 - Students will be able to know the different financial and other assistance avaiLable for establishing small industrial units.

CO5- Analyze and evaluate the legal and regulatory frameworks relevant to entrepreneurship and business establishment.

CO6- ColLaborate in multidisciplinary teams to develop and pitch entrepreneurial ideas, fostering creativity, teamwork, and leadership skills.

Text Books and Reference Books :

1. "Entrepre neurship deve lopme nt sma ll bus iness enterprises", Pearson, Poornima M Charantimath,2013.
2. Roy Rajiv, "Entrepreneurship", Oxford University Press, 2011.
3. "Innovation and Entrepreneurship",Harper business- Drucker.F, Peter, 2006.
4. "Entre preneurship", Tata Mc-graw Hill Publishing Co. ltd new Delhi- Robert D. Hisrich, Mathew J. Manimala, Michael P Peters and Dean A. Shepherd, 8th Edition, 2012
5. Enterpreneurship Development- S.ChandandCo.,Delhi- S.S.Khanka 1999
6. Small-Scale Industries and Entrepreneurship. Himalaya Publishing House, Delhi –Vasant Desai 2003.
7. Entrepreneurship Management -Cynthia, Kaulgud, Aruna, Vikas Publishing House, Delhi, 2003.
8. Entrepreneurship Ideas in Action- L. Greene, Thomson Asia Pvt. Ltd., Singapore, 2004.

Course code					
Course title	Fluid Machines				
Category	**Professional Core Course**				
Semester and Credits	L	T	P	**Credits**	Semester
	3	0	0	3	VI
Marks for Sessional	30 Marks				
Marks for End term Examination	70 Marks				
Total	100 Marks				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

The students completing this course are expected to understand the theory of boundary layer, working and performance characteristics of various hydraulic machines like pumps and turbines.

1. Study working of different types of hydraulic machines and their design principles.
2. Study the development of hydropower and its advantages over other types of power development.

UNIT-I

Impact of free jets: Impulse – momentum principle, jet impingement - on a stationary flat plate, inclined plate and a hinged plate, at the center of a stationary vane, on a moving flat plate, inclined plate, a moving vane and a series of vanes, Jet striking tangentially at the tip of a stationary vane and moving vane(s), jet propulsion of ships, Problems.

Impulse Turbines: Classification – impulse and reaction turbines, water wheels, component parts, construction, operation and governing mechanism of a Pelton wheel, work done, effective head, avaiLable head and efficiency of a Pelton wheel, design aspects, speed ratio, flow ratio, jet ratio, number of jets, number of buckets and working proportions, Performance Characteristics, governing of impulse turbines, Problems.

UNIT-II

Francis Turbines: Component parts, construction and operation of a Francis turbine, governing mechanism, work done by the turbine runner, working proportions and design parameters, slow, medium and fast runners, degree of reaction, inward/outward flow reaction turbines, Performance Characteristics, Problems.

Propeller and Kaplan turbines: Component parts, construction and operation of a Propeller, Kaplan turbine, differences between the Francis and Kaplan turbines, draft tube - its function and different forms, Performance Characteristics, Governing of reaction turbine, Introduction to new types of turbine, Deriaz (Diagonal), Bulb, Tubular turbines, Problems.

UNIT-III

Dimensional Analysis and Model Similitude: Dimensional homogeneity, Rayleigh's method and Buckingham's πtheorem, model studies and similitude, dimensionless numbers and their significance. Unit quantities, specific speed and model relationships for turbines, scale effect, cavitations – its causes, harmful effects and prevention, Thomas cavitation factor, permissible installation height, Problems.

Centrifugal Pumps: Classification, velocity vector diagrams and work done, manometric efficiency, vane

shape, head capacity relationship and pump losses, pressure rise in impeller, minimum starting speed, design considerations, multi-stage pumps. Similarity relations and specific speed, net positive suction head, cavitation and maximum suction lift, performance characteristics. Brief introduction to axial flow, mixed flow and submersible pumps, Problems.

UNIT-IV

Reciprocating Pumps: Construction and operational details, discharge coefficient, volumetric efficiency and slip, work and power input, effect of acceleration and friction on indicator diagram (pressure – stroke length plot), separation, air vessels and their utility, rate of flow into or from the air vessel, maximum speed of the rotating crank, characteristic curves, centrifugal vs reciprocating pumps, brief introduction to screw, gear, vane and radial piston pumps, Problems.

Hydraulic systems: Function, construction and operation of Hydraulic accumulator, hydraulic intensifier, hydraulic crane, hydraulic lift and hydraulic press, Fluid coupling and torque converter, Hydraulic ram, Problems.

Course Outcomes (COs): At the end of the course, the student shall be able to:

CO 1- Application of momentum equation and its application.
CO 2- Understand the construction, working principle and design analysis of hydraulic turbines.
CO 3- Expedite construction, working principle and design analysis of pumps.
CO 4- Knowledge of the design of a prototype on the basis of dimensional analysis.
CO 5- Understanding of use of different fluid flow measuring devices.
CO 6- Apply appropriate equations and principles to analyze pipe flow problems.

Text Books:

1. Fluid Mechanics and Hydraulic Machines – Mahesh Kumar, Pearson Indian Education Service Pvt. Ltd. India.
2. Hydraulics and Fluid Mechanics – Modi and Seth, Pub. - Standard Book House, N.Delhi
3. Hydraulic Machines – Jagdish Lal, Metropolitan

References:

1. Fluid Mechanics and Hydraulic Machines – S S Rattan, Khanna Publishers
2. Introduction to Fluid Mechanics and Fluid Machines – S K Som and G Biswas, Tata McGraw Hill
3. Fluid Mechanics and Fluid Power Engineering – D S Kumar, S K Kataria and Sons.

Course code					
Category	Professional Core course				
Course title	Design of Machine Element -II				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. Develop an ability to apply knowledge of mechanics and materials
2. Develop an ability to design a system / component to meet desired needs within realistic constraints using suitable design methodology.
3. Utilize various standards and methods of standardization.
4. Apply the concept of design and validation by strength analysis.

UNIT-I

Design for Production ; Erogonomic and value engineering considerations in design, Role of processing in design, Design considerations for casting, forging and machining. Variable Loading : Different types of fluctuating/ variable stresses, Fatigue strength considering stress concentration factor, surface factor, size factor, reliability factor etc., Fatigue design for finite and infinite life against combined variable stresses using Goodman and Soderberg‟s Criterion, Fatigue design using Miner‟s equation, Problems.

UNIT-II

Shafts: Detailed design of shafts for static and dynamic loading, Rigidity and deflection consideration. Springs: Types of Springs, Design for helical springs against tension and their uses, compression and fluctuating loads, Design of leaf springs, Surging phenomenon in springs, Design Problem.

UNIT-III

Bearings: design of pivot and collar bearing, Selection of ball and roller bearing based on static and dynamic load carrying capacity using load-life relationship, Selection of Bearings from manufacturer's catalogue, types of lubrication – Boundary, mixed and hydrodynamic lubrication, Design of journal bearings using Raimondi and Boyd's Charts, Lubricants and their properties, Selection of suitable lubricants, Design Problems.

UNIT-IV

Gears : Classification, Selection of gears, Terminology of gears, Force analysis, Selection of material for gears, Beam and wear strength of gear tooth, Form or Lewis factor for gear tooth, Dynamic load on gear teeth -Barth equation and Buckingham equation and their comparison, Design of spur, helical, bevel and worm gear including the Consideration for maximum power transmitting capacity, Gear Lubrication, Design Problems

Course Outcomes (COs): At the end of the course, the student shall be able to:

CO 1- Expose the students to the Design for Production and for variable loading.

CO 2- Impart in depth knowledge of designing of screws and different types of fasteners.

CO 3- Design bearings, selection of bearings for different aspects and lubricants with their properties.
CO 4- Knowledge of gears, design of different types of gears with consideration of maximum power transmission and gear lubrication.
CO 5- Learn in depth knowledge of flywheels and their design.
CO 6-Experties in the gear and gear train design.

Text Books:

1. Mechanical Engg. Design- Joseph Edward Shigley-Mc Graw Hill Book Co.
2. Design of Machine Elements – V.B. Bhandari – Tata McGraw Hill, New Delhi.

Reference Books :

1. Engineering design – George Dieter, McGraw Hill, New York.
2. Product Design and Manufacturing –: A.K.Chitale and R.C.Gupta, PHI, New Delhi.
3. Machine Design An Integrated Approach: Robert L.Norton,Second Edition –Addison Wisley Longman 8. Machine Design : S.G. Kulkarni , TMH , New Delhi.

Course code					
Category	Professional Core course				
Course title	Operation Research				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives :

To provide knowledge and training in using optimization techniques under limited resources for the engineering and business problems.

UNIT I

The phase of an operation research study – Linear programming – Graphical method– Simplex algorithm – Duality formulation – Sensitivity analysis.

UNIT II

Transportation Assignment Models –Traveling Salesman problem-Networks models – Shortest route – Minimal spanning tree – Maximum flow models –Project network – CPM and PERT networks – Critical path scheduling – Sequencing models.

UNIT III

Inventory models – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

UNIT IV

Queueing models - Queueing systems and structures – Notation parameter – Single server and multi server models – Poisson input – Exponential service – Constant rate service – Infinite population – Simulation.

UNIT V

Decision models – Game theory – Two person zero sum games – Graphical solution- Algebraic solution– Linear Programming solution – Replacement models – Models based on service life – Economic life– Single / Multi variable search technique – Dynamic Programming – Simple Problem.

Course Outcomes :

Upon completion of this course, the students can able

1. optimization techniques for use engineering and Business problems
2. Understand the simplex algorithm and its application in solving linear programming problems.
3. Analyze project networks using CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique)
4. Comprehend stochastic inventory models and their application in uncertain demand scenarios
5. Analyze queueing models with Poisson input and exponential service times

6. Analyze replacement models based on service life, economic life, and other relevant factors

Text Book:

1. Hillier and Libeberman, “Operations Research”, Holden Day, 2005
2. Taha H.A., “Operations Research”, Sixth Edition, Prentice Hall of India, 2003

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References:

1. Bazara M.J., Jarvis and Sherali H., “Linear Programming and Network Flows”, John Wiley, 2009.
2. Budnick F.S., “Principles of Operations Research for Management”, Richard D Irwin, 1990.
3. Philip D.T. and Ravindran A., “Operations Research”, John Wiley, 1992. 4. Shennoy G.V. and Srivastava U.K., “Operation Research for Management”, Wiley Eastern, 1994.

Course code					
Category	**Professional Elective Course-II**				
Course title	Power Plant Engineering				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. Basic knowledge of Different types of Power Plants, site selection criteria of each one of them.
2. Understanding of Thermal Power Plant Operation, turbine governing, different types of high pressure boilers including supercritical and supercharged boilers, Fluidized bed combustion systems.
3. Design of chimney in thermal power plants, knowledge of cooling tower operation, numerical on surface condenser design.
4. Basic knowledge of Different types of Nuclear power plants including Pressurized water reactor, Boiling water reactor, gas cooled reactor, liquid metal fast breeder reactor.
5. Understanding of Power Plant Economics, Energy Storage including compressed air energy and pumped hydro etc.
6. Discussing environmental and safety aspects of power plant operation

UNIT I

Introduction-Analysis of steam cycles, optimization of reheat pressure and degree of regeneration, coupled cycles and combined plants, process heat and power. Fuels and their properties, stoichiometric and actual air requirements, flue gas analysis.

UNIT II

Boilers- Different types of boilers, boiler mountings, feed water treatment, boiler loading and manner of operation. boiler energy balance, draft system. Different types of furnaces for burning coal, fuel oil and gas. Circulation theory, down-comers and risers, economizers and super-heaters, air pre-heater, drum and its internals.

UNIT III

Steam Turbines- Convergent and convergent-divergent nozzles - theory and design. Impulse and reaction turbines, compounding of turbines, optimum velocity ratio, reheat factor and condition line, parallel exhaust, losses in steam turbines, steam turbine governing.

UNIT IV

Plant Components- Theory and design of condensers, air ejector and cooling towers. Types and applications.

UNIT V

Power Plant Economics & Environmental Considerations- Plant energy studies: concepts and resources, procedures and implementation. Energy accounting. Various thermal systems and energy management.

Electrical load management. Economic analysis. Waste heat recovery. Multi objective energy management-conservation, pollution control and evaluation of alternative energy sources. Cost of energy management and payback.

Course Outcomes:

CO 1: Understand the principles of power generation and the different types of power plants, including thermal, hydroelectric, nuclear, and renewable energy sources.
CO 2: Analyze the components and systems of power plants, including boilers, turbines, generators, and electrical systems, and their operation and maintenance requirements.
CO 3: Develop skills in designing and optimizing power plant layouts and configurations to maximize efficiency, reliability, and safety.
CO 4: Demonstrate knowledge of environmental considerations and regulatory requirements related to power plant operations, emissions control, and waste management.
CO 5: Apply engineering principles to solve power plant engineering problems, such as heat transfer, fluid mechanics, thermodynamics, and control systems.
CO 6: Evaluate the economic feasibility of power plant projects, including cost analysis, energy efficiency assessment, and risk management.

Text/Reference Books:

1. Nag.P.K. Power plant engineering: Tata McGraw-Hill.
2. Arora, S. C., & Domkundwar, S. A course in power plant engineering: Dhanpat Rai.
3. Elanchezhian, C. Power Plant Engineering: I.K. International Pub. House.

Course code					
Category	**Professional Elective Course-II**				
Course title	Solar Engineering				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To provide a fundamental understanding of solar energy principles and technologies for effective engineering and design.
2. To develop the skills necessary to assess, analyze, and optimize solar energy systems for maximum efficiency and sustainability.
3. To equip students with the knowledge and tools to design and manage solar energy projects, considering site-specific factors and integration into existing energy systems.
4. To explore and stay updated with the latest advancements and emerging trends in solar energy engineering, fostering innovation and problem-solving in the field.

UNIT-I

Solar Radiation: Introduction, solar system – sun, earth and earth-sun angles, time, derived solar angles, estimation of solar radiation (direct and diffuse), measurement systems – pyrheliometers and other devices. Effect of Solar radiation upon structures: Steady state heat transmission, solar radiation properties of surfaces, shading of surfaces, periodic heat transfer through walls and roofs.

UNIT-II

Solar Collectors: Flat plate and concentrating – comparative study, design and materials, efficiency, selective coatings, heliostats. Heating Applications of Solar Energy: Air and Water heating systems, thermal storages, solar bonds, solar pumps, solar lighting systems, solar cookers, solar drying of grains.

UNIT-III

Cooling Applications of Solar Systems: Continuous and Intermittent vapour absorption systems for cooling applications, absorbent – refrigerant combination, passive cooling systems.

UNIT-IV

Solar Electric Conversion Systems: Photovoltaics, solar cells, satellite solar power systems. Effects on Environment, economic scenario, ozone layer depletion, greenhouse effect, global warming, Remedial measures by international bodies.

Course Outcomes:

CO 1: Understand the principles of solar energy and its conversion into usable forms of power, including photovoltaic (PV) systems and solar thermal technologies.

CO 2: Analyze the design, installation, and operation of solar energy systems, including PV arrays, solar collectors, energy storage, and grid integration.
CO 3: Develop skills in assessing site suitability, solar resource estimation, and system sizing for efficient utilization of solar energy.
CO 4: Demonstrate proficiency in modeling and simulating solar energy systems using software tools and techniques.
CO 5: Apply knowledge of electrical and electronic engineering principles to optimize the performance and reliability of solar energy systems.
CO 6: Evaluate the economic viability and environmental impact of solar energy projects, considering factors such as cost analysis, life cycle assessment, and policy frameworks.

Text Books:

1. Solar Energy – S P Sukhatme, Tata McGraw Hill
2. Solar Energy Process – Duffie and Bechman, John Wiley

References Books:

1. Applied Solar Energy – Maniel and Maniel, Addison Wiley
2. Solar Energy: Fundamentals and Applications – R P Garg and Jai Prakash, TMH.

Course code					
Category	**Professional Elective Course-II**				
Course title	Artificial Intelligence and Machine Learning				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. Acquaint with fundamentals of artificial intelligence and machine learning.
2. Llearn feature extraction and selection techniques for processing data set.
3. Understand basic algorithms used in classification and regression problems.
4. Outline steps involved in development of machine learning model.
5. Familiarize with concepts of reinforced and deep learning.
6. Implement and Analyze machine learning model in mechanical engineering problems

UNIT-I

History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning

UNIT-II

Feature extraction: Statistical features, Principal Component Analysis. Feature selection: Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering

UNIT-III

Classification: Decision tree, Random forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.

UNIT-IV

Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions

UNIT-V

Characteristics of reinforced learning; Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Mechanical Engineering

Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning

of control algorithms.

Course Outcomes:

On completion of the course, learner will be able to

CO1. Demonstrate fundamentals of artificial intelligence and machine learning.
CO2. Apply feature extraction and selection techniques.
CO3. Apply machine learning algorithms for classification and regression problems.
CO4. Devise and develop a machine learning model using various steps.
CO5. Explain concepts of reinforced and deep learning.
CO6. Simulate machine learning model in mechanical engineering problems

Text Books:

1.Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
4. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003

Reference Books:

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

Course code					
Category	**Professional Elective Course-II**				
Course title	Automobile Engineering				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To provide a comprehensive understanding of automobile engineering principles, including vehicle design, manufacturing, and operation.
2. To develop the skills necessary to analyze and optimize automotive systems, considering factors such as performance, efficiency, and safety.
3. To equip students with the knowledge and tools to design and innovate automobile components and systems, incorporating emerging technologies and sustainable practices.
4. To foster an understanding of industry trends and advancements in automobile engineering, preparing students for the dynamic and evolving automotive sector.

UNIT-I

Vehicle Structure and Engines-Types of Automobiles, Vehicle Construction – Chassis, Frame and Body ,Aerodynamics, Components of Engine – Their forms, Functions and Materials, Review of Cooling and Lubrication systems in Engine, Turbo Chargers, Engine Emission Control by 3–Way Catalytic Controller, Electronic Engine Management System.

UNIT-II

Engine Auxiliary Systems- Carburettor–working principle, Electronic fuel injection system – Mono-point and Multi - Point Injection Systems, Electrical systems – Battery generator – Starting Motor and Drives – Lighting and Ignition (Battery, Magneto Coil and Electronic Type)- Regulators-cut outs.

UNIT-III

Transmission Systems-Clutch – Types and Construction, Gear Boxes-Manual and Automatic, Simple Floor Mounted Shift Mechanism, Over Drives, Transfer Box Fluid flywheel- Torque convertors, Propeller shaft – Slip Joint – Universal Joints, Differential and Rear Axle, Hotchkiss Drive and Torque Tube Drive.

UNIT-IV

Steering, Brakes and Suspension- Wheels and Tires – Wheel Alignment Parameters ,Steering Geometry and Types of steering gear box, Power Steering, Types of Front Axle – Suspension systems. Braking Systems – Types and Construction – Diagonal Braking System – Antilock Braking System.

UNIT-V

Alternative Energy Sources-Use of Natural Gas, LPG, Biodiesel, Gasohol and Hydrogen in Automobiles, Electric and Hybrid Vehicles, Fuel Cells.

Course Outcomes:

CO1: Understand the fundamental principles of automobile engineering, including vehicle dynamics, powertrain systems, and vehicle design.

CO2: Analyze and evaluate the performance characteristics of automotive components and systems, such as engines, transmissions, suspension, and braking systems.

CO3: Develop skills in designing and optimizing vehicle structures and systems for improved safety, fuel efficiency, and environmental sustainability.

CO4: Demonstrate proficiency in using computer-aided design (CAD) and simulation tools to model and analyze automotive systems.

CO5: Apply knowledge of automotive engineering principles to diagnose and troubleshoot common vehicle problems and propose effective solutions.

CO6: Evaluate the impact of emerging technologies, such as electric and autonomous vehicles, on the future of automobile engineering and transportation systems.

Text/Reference Books:

1. Crolla, D. Automotive Engineering: Powertrain, Chassis System and Vehicle Body: Butterworth-Heinemann.
2. Heisler, H. Advanced vehicle technology: Butterworth-Heinemann.
3. Happian-Smith, J. An introduction to modern vehicle design: Butterworth-Heinemann.
4. Newton, Steeds and Garet, Motor vehicles, Butterworth Publishers.
5. Crouse, W. H., and Anglin, D. L. Automotive Mechanics, Study Guide: McGraw-Hill.

Course code					
Category	**Professional Elective Course-III**				
Course title	Additive Manufacturing				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications

Unit I

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM and CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. Vat Photo polymerization AM Processes: Stereo lithography (SL), Materials, Process Modelling, SL resin curing process, SL scan patterns, Micro-stereo lithography, Mask Projection Processes, Two-Photon vat photo polymerization, Process Benefits and Drawbacks, Applications of Vat Photo polymerization, Material Jetting and Binder Jetting AM Processes.

Unit II

Extrusion - Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, BioExtrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes. Sheet Lamination AM Processes: Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

Unit III

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process 11 Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Unit IV

Directed Energy Deposition AM Processes: Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structureproperties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. Materials science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of nonequilibrium structure, microstructural studies, Structure property relationship.

Unit V

Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques. Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.

Course Outcomes:

CO1: Understand the working principle and process parameters of AM processes
CO2: Explore the applications of AM processes in various fields
CO3: Select the suitable material and process for fabricating a given product
CO4: Apply the knowledge in Material science in Additive Manufacturing Components.
CO5: Design and develop a product for AM Process.
CO6: Expertise in the field of 3D modelling and printing.

Text Books:

1. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015.
2. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004.

Reference Books:

1. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles and Applications", 4th Edition, World Scientific, 2015.
2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
3. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley and Sons, 2006.

Course code					
Category	**Professional Elective Course-III**				
Course title	Finite Element Method				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To provide a solid foundation in the principles and concepts of the finite element method (FEM) for numerical analysis and simulation of engineering problems.
2. To develop the skills necessary to discretize and model complex engineering systems using FEM, allowing for accurate prediction of structural behavior and performance.
3. To equip students with the knowledge and tools to analyze and optimize engineering designs through FEM, considering factors such as stress distribution, deformation, and heat transfer.
4. To explore advanced applications of FEM, such as nonlinear analysis, dynamic response, and multiphysics simulations, enabling students to tackle real-world engineering challenges.

Unit I

Basic concepts- The standard discrete system, Finite elements of an elastic continuum displacement approach, Generalization of the finite element concepts- weighted residual and variational approaches.

Unit II

Element Types- Triangular, rectangular, quadrilateral, sector, curved, iso-parametric elements and numerical integration. Automatic mesh generation schemes.

Unit III

Application to structural mechanics problems- Plane stress and plane strains, Axisymmetric stress analysis, three dimensional stress analyses, bending of plates.

Unit IV

FEM in Steady State Field Problems- Introduction, heat conduction, fluid flow and nonlinear material problems, plasticity, creep etc. Computer procedures for Finite element analysis.

Course Outcomes:

CO1: Understand the theoretical foundations and mathematical principles of the finite element method (FEM) for solving engineering problems.
CO2: Develop skills in constructing finite element models and discretizing complex geometries for structural and thermal analysis.
CO3: Demonstrate proficiency in using FEM software tools to solve linear and nonlinear problems, including static and dynamic structural analysis.
CO4: Apply FEM techniques to analyze and optimize the behavior of engineering structures and components under various loading and boundary conditions.
CO5: Evaluate the accuracy and reliability of FEM results through verification and validation techniques, including convergence studies and comparison with experimental data.
CO6: Evaluate and interpret FEM results to assess structural integrity, optimize designs, and make informed engineering decisions.

Text/Reference Books:

1. Chandrupatla T.R., and Belegundu A.D., Introduction to Finite Elements in Engineering, Pearson Education
2. David V Hutton, Fundamentals of Finite Element Analysis McGraw-Hill Int. Ed.
3. Rao S.S. The Finite Element Method in Engineering, Pergammon Press.
4. Logan D.L., A First course in the Finite Element Method, Third Edition, Thomson Learning,
5. Robert D.Cook., David.S, Malkucs Michael E Plesha , Concepts and Applications of Finite Element Analysis.
6. Reddy J.N, An Introduction to Finite Element Method, McGraw-Hill International Student Edition
7. O.C.Zienkiewicz and R.L.Taylor, The Finite Element Methods, Vol.1. The basic formulation and linear problems, Vol.1, Butterworth Heineman.

Course code					
Category	**Professional Elective Course-III**				
Course title	System Modelling And Simulation				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To provide a comprehensive understanding of system modeling and simulation techniques for analyzing and predicting the behavior of complex systems.
2. To develop the skills necessary to create mathematical models of systems and simulate their dynamic behavior using appropriate simulation tools and software.
3. To equip students with the knowledge and tools to analyze and optimize system performance, considering factors such as efficiency, reliability, and cost-effectiveness.
4. To foster an understanding of the application of system modeling and simulation across various disciplines, including engineering, business, and healthcare, enabling students to tackle diverse real-world problems.

Unit I

Introduction-Systems, System types, System Modeling, Types of system modelling, Classification and comparison of simulation models, attributes of modelling, Comparison of physical and computer experiments, Application areas and Examples.

Unit II

Mathematical and Statistical Models- Probability concepts, Queuing Models, Methods for generating random variables and Validation of random numbers.

Unit III

Language-System modelling, programming languages, comparison of languages, Identifying and selection of programming language, feasibility study of programming language for the given application.

Unit IV

Experiments-Simulation of different systems, Analysis, validation and verification of input and output simulated data, study of alternate techniques.

Unit V

Case study-Developing simulation model for information centers, inventory systems and analysis of maintenance systems.

Course Outcomes:

CO1: Understand the principles and techniques of system modeling and simulation for representing and analyzing complex systems.
CO2: Develop skills in selecting appropriate modeling methodologies and simulation tools based on system characteristics and objectives.
CO3: Apply mathematical and computational modeling techniques to represent system behavior, dynamics, and interdependencies.
CO4: Demonstrate proficiency in using simulation software to create and execute system models, analyzing system performance and behavior under different scenarios.
CO5: Evaluate the validity and reliability of simulation results through verification and validation techniques, including sensitivity analysis and comparison with real-world data.
CO6: ColLaborate effectively in multidisciplinary teams to design and conduct system simulations, interpret results, and make informed decisions for system optimization and improvement.

Text Books:

1. Geoffrey Gordon, “System Simulation”, Second edition, Prentice Hall, India, 2002.
2. Jerry Banks and John S.Carson, Barry L.Nelson, David M.Nicol, “Discrete Event System Simulation”, Third edition, Prentice Hall, India, 2002.

Reference Books:

1. Robert E. Shannon, “System Simulation The art and science”, , Prentice Hall, New Jersey, 1995.
2. D.S. Hira, “System Simulation”, S.Chand and company Ltd, New Delhi, 2001.

Course code					
Category	**Professional Elective Course-III**				
Course title	Noise and Vibrations				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objectives:

1. To provide a comprehensive understanding of noise and vibration principles, their generation mechanisms, and their effects on human health and the environment.
2. To develop the skills necessary to measure, analyze, and mitigate noise and vibration problems in various engineering applications.
3. To equip students with the knowledge and tools to design and implement effective noise and vibration control strategies in engineering systems and structures.
4. To foster an understanding of relevant regulations and standards related to noise and vibration, ensuring compliance and promoting sustainable and comfortable environments.

UNIT-I

Introduction: Periodical motion, harmonic motion, period, cycle, circular frequency, amplitude and phase angles of vibration motion, non-harmonic periodic motions. classification of vibration: free and forced vibration, undamped and damped vibration, linear and non linear vibration Harmonic analysis, the vector method of representing vibrations, displacement, velocity and acceleration in harmonic motion, super position of simple harmonic, beats, work done in harmonic motion.

UNIT-II

System with One Degree of Freedom: System having single degree of freedom, free vibration of systems without damping, equilibrium and energy method for determining natural frequency. Raleigh's method, equivalent systems (systems with compound spring, shafts of different dia. Equivalent length, effect of mass of springs and shaft). Free vibration of systems with viscous, coulomb and structural damping. Equations of motions-discussion of solutions. Forced vibrations of systems with and without viscous and coulomb damping,, frequency response plots, Phase shift plots, Equivalent viscous damping, power consumption of vibration systems, forced isolation, commercial isolators, transmissibility.

UNIT-III

Systems with Two Degree of Freedom: System having two degree of freedom system, Normal mode of vibrations, Torsional systems, undamped and damped vibration in two degree of freedom system with free and forced vibration. Vehicle suspension, Undamped dynamic vibration absorber. Centrifugal absorber, friction damper. Vibration Instruments: Principle of frequency, Amplitude, Velocity and acceleration measuring instruments, Analysis of vibration records. Electrical Analogies: Electric circuit principles, equivalent circuits.

UNIT-IV

Whirling of Shafts: Whirling of light flexible shaft with an unbalance disk at the Centre of its length with and without damping, discussion of speeds above and below the critical speed, Uniform shaft with and without unbalanced masses attached along its length (by Rayleigh method) for simple supported and fixed ends.

UNIT-V

Noise Control: Noise and its causes, sound pressure /intensity/ power level and their interrelation, Decibel scale, Loudness and equal loudness contours, Sound spectra and octave band analysis. Background noise. Weighted networks. Measurement of noise, effect of machine/ process noise on operators, employees and local resident's, standard of noise level and exposure limits. Methods of industrial noise control.

Course Outcomes:

CO1: Understand the principles and theories of noise and vibration generation, transmission, and control in engineering systems.
CO2: Analyze and evaluate the sources and characteristics of noise and vibrations in mechanical, electrical, and structural components.
CO3: Develop skills in designing and implementing effective noise and vibration control strategies to minimize their adverse effects.
CO4: Demonstrate proficiency in using measurement and analysis tools to quantify and assess noise and vibration levels in various environments.
CO5: Apply knowledge of acoustics and vibration engineering to solve real-world problems in industries like automotive, aerospace, and construction.
CO6: ColLaborate in multidisciplinary teams to develop innovative solutions for noise and vibration reduction, improving overall product performance and user experience.

Text Books:

1. Ambekar A.G. "Mechanical Vibrations and Noise Engineering" Prentice-Hall of India, New-Delhi, 2e, 2006.
2. Singh V.P., "Mechanical Vibration" Dhanpat Raiand Co.(p)Ltd., Delhi, 3e, 2001
3. Thomson W.T "Theory of Vibration with Application" CBS Publishers and Distriburors, Delhi, 3e, 1990. Grover G.K."Mechanical Vibrations" Nem Chand and Brothers, 2e, 2007.
4. Pujara K. " Vibration and Noise for Engineers", Dhanpat Rai and Sons, Delhi, 2e,1992.

Course Code					
Category	**Professional Elective-III**				
Course Title	**Hydraulic & Pneumatics**				
Semester and Credits	L	T	P	Credits	Semester – VI
	3	0	0	3	
Class Work	50 Marks				
Examination	50 Marks				
Total	100 Marks				
Duration of Exams	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have seven parts of 2 marks each from all units, and the remaining eight questions of 14 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, the first being compulsory and selecting one from each unit.

Course Objective

Students will able to understand the basic concepts of fluid power, including hydraulic and pneumatic systems, their components, and their advantages and limitations. They will be studying the properties of fluids, including viscosity, pressure, flow rate, and temperature, and their impact on fluid power systems amd will able to explore the hydraulic components such as pumps, actuators, valves, and reservoirs, as well as hydraulic circuit design and analysis.

Unit-I

Fluid Power Principles and Fundamentals and Hydraulic motors

Introduction to fluid power, Advantages and applications, Fluid power systems, Types and Properties of Hydraulic fluids, Basics of hydraulics, Principles of flow, Work, Power and Torque, Reynolds number, Influence of temperature on viscosity, High water based fluid, Fluid preparation, Common fire resistant fluid, Biodegradable oils. Vane Motor, Gear Motor, Piston motor, Selection of hydro motor, Hydraulic or electrical motor, Hydraulic motor in circuits, Types of hydraulic transmission, Pump motor combination, Open loop and close loop system, Application of hydrostatic transmission

Unit II

Hydraulic Linear Actuators

Hydraulic cylinder, Construction of cylinders, Seals in cylinders, Cylinder reliability, Cylinder force, Acceleration and losses, Calculation of cylinder forces, Flow velocity, Cylinder efficiency, Sizing of cylinder tubes, Piston rod design, Mounting style of cylinders, Cushioning of hydraulic cylinder, Hydraulic cylinder and their characteristic application.

Unit III

Hydraulic Circuits

Hydraulic circuits, Manual or Automatic Hydraulic systems, Regenerative circuits, Use of check Valve in hydraulic circuits, Standards in circuit diagram representation, Speed variation in cylinder motion, Some basic circuits, Functional diagram, Application of functional diagram, Electrical control of hydraulic system.

UNIT IV

Hydro Pneumatic

Compressibility, Solution, Types of hydro Pneumatic systems, Hydraulic check unit, Hydro pneumatic cylinder, Parallel check unit, Integral air oil cylinder, Types of feed, Intensifier, Comparison of Hydro pneumatic, Hydraulic and pneumatic system. Maintenance need of Pneumatic systems, Common problems in Pneumatic system, Maintenance schedule of Pneumatic system

Course Outcomes:

CO1 Develop the ability to design and analyze hydraulic and pneumatic circuits
CO2 Gain insights into real-world applications of fluid power technology across various industries
CO3 Develop critical thinking and problem-solving skills to identify and resolve challenges related to fluid power systems
CO4 understanding of fluid power principles, including the properties and behavior of fluids

Suggested Books:

1. S.R. Majumdar, **Oil Hydraulic Systems-Principles and Maintenance**, Tata McGraw Hill.
2. S.R. Majumdar, **Pneumatic Systems-Principles and Maintenance**, Tata McGraw Hill.
3. Farel Bradbury, **Hydraulic Systems and Maintenance,** Butterworth & Co (Publishers) Ltd.
4. R. Srinivasan, **Hydraulic and Pneumatic Controls**, Vijay Nicole.
5. Anthony Esposito, **Fluid Power with Applications**, PHI/Pearson Education.

Course code					
Course title	Fluid Machines _Lab				
Category	**Laboratory Course**				
Semester and Credits	L	T	P	**Credits**	Semester
	0	0	2	1	VI
Marks for Sessional	50 Marks				
Marks for End term Examination	50 Marks				
Total	`100 Marks				

NOTE:
1. At least ten experiments are to be performed in the Semester.
2. At least seven experiments should be performed from the above list. Remaining three experiments may either be performed from the above list or designed and set by the concerned institution as per the scope of the sylLabus.

List of Experiments:
1. To study the constructional details of a Pelton turbine and draw its fluid flow circuit.
2. To draw the following performance characteristics of Pelton turbine-constant head, constantspeed and constant efficiency curves.
3. To study the constructional details of a Francis turbine and draw its fluid flow circuit.
4. To draw the constant head, constant speed and constant efficiency performance characteristics of Francis turbine.
5. To study the construction details of a Kaplan turbine and drawits fluid flow circuit.
6. To drawthe constant head, speed and efficiency curves for a Kaplan turbine.
7. To study the constructional details of a Centrifugal Pump and draw its characteristic curves.
8. To study the constructional details of a Reciprocating Pump and draw its characteristics curves.
9. To study the construction details of a Gear oil pump and its performance curves.
10. To study the constructional details of a Hydraulic Ram and determine its various efficiencies..
11. To study the constructional details of a Centrifugal compressor.
12. To study the model of Hydro power plant and draw its layout.

Course Objectives:
(1) To understand the principles and performance characteristics of flow and thermal devices.
(2) To know about the measurement of the fluid properties.
(3) To understand the theory, working and performance characteristics of various hydraulic machines like pumps and turbines.

Course Outcomes (COs): At the end of the course, the student shall be able to:
CO 1- Understand the concept of momentum equation.
CO 2- Knowledge of construction, working principle and performance of hydraulic turbines.
CO 3- Learn construction, working principle and performance of pumps.

CO4- Explore construction, working principle and performance of hydraulic ram.

Course code					
Category	Management Course				
Course title	Economics for Engineer				
Semester and Credits	L	T	P	**Credits**	Semester VI
	3	0	0	3	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Course Objectives:
To teach students different tools to optimize profits, minimize costs, analyze various scenarios, forecast fluctuations in business cycles, and more

Unit I

Economic Decisions Making – Overview, Problems, Role, Decision making process.
Engineering Costs and Estimation – Fixed, Variable, Marginal and Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types Of Estimate, Estimating Models - Per-Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement and Learning Curve, Benefits. Case Study - Price and Income Elasticity of Demand in the real world.

Unit II

Cash Flow, Interest and Equivalence: Cash Flow – Diagrams, Categories and Computation, Time Value of Money, Debt repayment, Nominal and Effective Interest

Unit III

Cash Flow and Rate Of Return Analysis – Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate Of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing An Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity And Breakeven Analysis. Economic Analysis In The Public Sector - Quantifying And Valuing Benefits and drawbacks. Case Study – Tata Motors

Unit IV

Inflation And Price Change – Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In Engineering Economic Analysis, Cash Flows that inflate at different Rates. Case Study – Competition in the Advertise Segment in India
Present Worth Analysis: End-Of-Year Convention, Viewpoint Of Economic Analysis Studies, Borrowed Money Viewpoint, Effect Of Inflation and Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives

Course Outcomes:

CO-1 Describe the principles of economics that govern the operation of any organization under diverse market conditions

CO-2 Comprehend macroeconomic principles and decision making in diverse business set up

CO-3 Explain the Inflation and Price Change as well as Present Worth Analysis

CO-4 Apply the principles of economics through various case studies

CO-5 Apply knowledge of economic policies and regulations to understand the impact on engineering projects and industry competitiveness.

CO-6 ColLaborate in multidisciplinary teams to consider economic perspectives and trade-offs in engineering project planning, design, and implementation.

Reference Books:

1. James L.Riggs,David D. Bedworth, Sabah U. Randhawa : Economics for Engineers 4e , Tata McGraw-Hill

2. Donald Newnan, Ted Eschembach, Jerome Lavelle : Engineering Economics Analysis, OUP

3. John A. White, Kenneth E.Case,David B.Pratt : Principle of Engineering Economic Analysis, John Wiley

4. Sullivan and Wicks: Engineering Economy, Pearson 5. R.Paneer Seelvan: Engineering Economics, PHI 6. Michael R Lindeburg : Engineering Economics Analysis, Professional Pub

Course code					
Category	Project				
Course title	Project-I				
Semester and Credits	L	T	P	**Credits**	Semester VI
	0	0	2	2	
Classwork	30 Marks				
Exam	70 Marks				
Total	100 Marks				

COURSE OBJECTIVE

1. To prepare the student to gain major design and or research experience as applicable to the profession
2. Apply knowledge and skills acquired through earlier coursework in the chosen project.
3. Make conversant with the codes, standards, application software and equipment
4. Carry out the projects within multiple design constraints
5. Incorporate multidisciplinary components
6. Acquire the skills of comprehensive report writing

Students will be assigned projects (Applications/Research based) individually or in a group of not more than 3 students depending on the efforts required for completion of the project.

The project will have 4 stages: (*Marks for internal evaluation are given in brackets)

1. Synopsis submission (5 marks),
2. 1st mid-term progress evaluation (Literature Survey in case of research project) (5 marks)
3. 2nd mid-term progress evaluation (Paper Publishing/acceptance in a reputed Journal or Conference acceptance/ Presenting) (5 marks)
4. Final submission evaluation

The external examiner will evaluate the project on the basis of idea/quality of project, implementation of the project, project report and/or publication and viva.

Course outcomes

On successful completion of the course students will be able to:

CO1. Demonstrate a sound technical knowledge of their selected project topic.

CO2. Undertake problem identification, formulation and solution.
CO3. Design engineering solutions to complex problems utilising a systems approach.
CO4. Conduct an engineering project.
CO5. Communicate with engineers and the community at large in written an oral forms.
CO6. Demonstrate the knowledge, skills and attitudes of a professional engineer.