DEPARTMENT OF MECHANICAL ENGINEERING

Scheme of Instructions

for

Vth and VIth Semesters

With Effect from academic year

2020-2021

UNIVERSITY COLLEGE OF ENGINEERING
(AUTONOMOUS)
OSMANIA UNIVERSITY
HYDERABAD-500 007, TELANGANA

SCHEME OF INSTRUCTION & EXAMINATION
B.E V Semester (Mechanical Engineering)

S. No.	Code	Name of the Course	No of Hours				Scheme of Examination		Credits
			L	T	P	Contact Hrs/wk	CIE	SEE	
1.	PC501ME	Fluid Mechanics & Hydraulic Machines	3	-	-	3	30	70	3
2.	PC502ME	Heat Transfer	3	-	-	3	30	70	3
3.	PC503ME	Dynamics of Machines	3	-	-	3	30	70	3
4.	PC504ME	Machine Design	3	-	-	3	30	70	3
5.	PC505ME	Metal Cutting & Machine Tools	3	-	-	3	30	70	3
6.	PEME	Professional Elective-I	3	-	-	3	30	70	3
PRACTICALS									
7.	PC551ME	Fluid Mechanics & Hydraulic Machines Lab	-	-	3	3	25	50	1.5
8.	PC552ME	Dynamics of Machines Lab	-	-	3	3	25	50	1.5
9.	PR553ME	Project-I/Summer Internship	-	-	2	2	-	-	1
		Total	18	-	8	26	230	520	22

PROFESSIONAL ELECTIVE COURSE -I	
PE501ME	Production Planning and Control
PE502ME	Powder Metallurgy
PE503ME	Robotic Engineering
PE504ME	Theory of Elasticity
PE505ME	Automobile Engineering

Course Code: PC501ME

FLUID MECHANICS AND HYDRAULIC MACHINES

Credits: 3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To understand the properties of fluids and types of fluids.
- To verify the Bernoulli's theorem and its applications.
- To understand the concepts of fluid flow measurement and flow through pipes.
- To introduce the concepts of the working and design aspects of hydraulic machines like turbines and pumps and their applications.
- To determine the basic principles and characteristic curves of turbines and pumps.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Define the properties of fluids and classify the fluids.	L1
CO2	Apply conservation laws to fluid flow problems in engineering applications and examine the stability of a floating bodies.	L3
CO3	Apply Euler's Equation of motion and Bernoulli's equation for flow measuring devices and hydraulic machines.	L3
CO4	Illustrate the working of Hydraulic machines.	L2
CO5	Analyze the performance of various types of Hydraulic pumps and turbines.	L4

UNIT-I

Fluid Properties: Viscosity of liquids. Newtonian and non-Newtonian fluids. Surface tension, capillary effect, vapor pressure and cavitation. Ideal and real fluids, Incompressible and Compressible flows. Stream lines, Path lines.

Pressures and pressure head: Types of pressures, Pascal's law of pressure at a point, variation of pressure vertically in a fluid under gravity.

Static Forces on Surface and Buoyancy:

Fluid statics, action of fluid pressure on surface, resultant force and center of pressure on a plane surface under uniform pressure. Equilibrium of floating bodies, stability of a submerged body, stability of floating bodies, determination of the metacentric height, determination of the position of the metacentre relative to the center of buoyancy.

UNIT-II

Laws of fluid flow – Continuity equation. Derivation of Euler's and Bernoull's equations. Application of Bernoullis equations. Flow measuring devices-Venturimeter, Orificemeter and Pitot static tube.

Viscous Flow: Reynolds number and Reynolds experiment, flow of viscous fluid through circular pipe- Hagen Poiseuille formula.

Flow through pipes: Head losses in pipes, bends and fittings. Major energy losses, Minor energy losses, Hydraulic gradient and total energy lines, Pipes in series and parallel, Equivalent pipes. Boundary layer theory.

Unit-III

Reciprocating pumps: Classification, working details, theory and terms used for single and double acting pumps. Effect of acceleration head and friction. Indicator diagrams. Effect of cavitation and limiting suction head on pump speed. Variation of pressure inside pump cylinder during suction and delivery strokes. Work done, power required and efficiency. Functions of air vessels. Work

saved and rate of flow from air vessels. Losses and performance curves for reciprocating pumps. Industrial applications. Types of Positive displacement pumps.

Unit-IV

Centrifugal pumps: Working and constructional details of single stage centrifugal pump. Priming – significance and methods of priming. Basic classification of CF pumps. Types of impellers, casings and vane shapes used. Simple and multistage pumps and their applications. Series and parallel operation of CF pumps. Manometric head and its importance. Manometric efficiency and other efficiencies. Losses in CF pumps. Velocity diagrams. Cavitation. Unit quantities, specific speed. Performance and characteristic curves. Methods of balancing of end thrust in CF pump installations.

Unit-V

Hydraulic Turbines: Classification of impulse and reaction turbines and their differences in working. Impulse turbines: Salient features and working details of Pelton wheel installation. Velocity diagrams. Calculation of number of buckets, bucket sizes and power developed. Overall efficiency, speed regulation methods.

Reaction turbines: Constructional details and working of Francis and Kaplan turbines. Draft tube in reaction turbines. Theory, types and efficiency of draft tubes. Velocity diagrams. Power developed and efficiencies, pressure head at inlet of the runner.

Principles of similarity applied to hydraulic turbines. Unit quantities, specific speed and its significance for turbine selection. Performance and characteristic curves for Pelton wheel, Francis and Kaplan turbines. Governing of turbines. Cavitation effects in reaction turbines and remedial measures. Surge tanks.

Suggested Reading:

1. Modi, P.N. & Seth, S.M., "Hydraulics & Fluid Mechanics Including Hydraulics Machines", Standard Book House, 2017
2. A.K.Mohanty. "Fluid Mechanics" , PHI Learning Pvt. Ltd, 1994
3. S.K.Som, Gautam Biswas, S Chakraborty. "Introduction to Fluid Mechanics and Fluid Machines", McGraw Hill Education, 2017
4. Bansal, R. K., "Textbook of fluid mechanics and hydraulic machine" Laxmi Publication, 2011
5. Gupta, V., & Gupta, S. K., "Fluid mechanics and its applications", Tunbridge Wells: New Academic Science, 2012
6. Jagdish Lal, "Hydraulic Machines", Metropolitan Book Co., 1994.
7. N.S. Govind Rao, "Fluid Flow Machines, Tata Mc Graw Hill", 1983.
8. K. Subramanya, "Theory and Applications of Fluid Mechanics", Tata McGraw-Hill Publishing Company Ltd.,1993
9. Vijay Gupta and Santosh K. Gupta, "Fluid Mechanics and its applications", Wiley Eastern Ltd.,1984.
10. K.L. Kumar, "Engineering Fluid Mechanics", Eurasia Publishing House Pvt Ltd., New Delhi, 2009.

Articulation Matrix:

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS O1	PS O2
CO1	3	3	1	1	1	-	-	-	-	-	-	1	1	-
CO2	3	3	3	3	1	-	-	-	-	-	-	1	1	-
CO3	3	3	3	3	1	-	-	-	-	-	-	1	1	-
CO4	3	2	2	2	1	-	-	-	-	-	-	2	1	-
CO5	3	3	3	3	1	-	-	-	-	-	-	2	1	-

Course Code: PC502ME

HEAT TRANSFER

Credits: 3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To develop the fundamental principles and laws of heat transfer and to explore the implications of these principles for system behaviour.
- To formulate the models necessary to study, analyse and design heat transfer systems through the application of these principles.
- To develop the problem-solving skills essential to good engineering practice of heat transfer in real-world applications.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Illustrate the basic modes of heat transfer with its associated laws in simple geometries.	L2
CO2	Solve the problems of steady state and transient heat conduction with simple and multi-layer geometries.	L3
CO3	Analyze heat transfer coefficients for free and forced convection, considering boundary layers.	L4
CO4	Develop relationships for radiation exchange between (Opaque, Diffuse, Gray) Surfaces in an enclosure, Blackbody radiation exchange.	L3
CO5	Analyse heat exchanger performance by using the methods of Log Mean Temperature Difference (LMTD), effectiveness-NTU, and also focus on the knowledge of boiling and condensation.	L4

Unit-I

Heat transfer fundamentals; Basic heat transfer mechanisms (conduction, convection and radiation), Conduction: General conduction equation on plane wall, Cylinders and spheres.
One dimensional steady state conduction through plane walls, hollow cylinders and spheres with and without heat generation. Thermal resistance network, Boundary Conditions, Effect of variable thermal conductivity for one-dimensional steady-state conduction in a plane wall. The critical radius of insulation.

Unit-II

Fins: Heat transfer analysis of a body with negligible internal temperature gradients, fins efficiency and effectiveness.
Lumped system analysis within the body with negligible internal temperature gradients. Transient heat transfer analysis of an infinite slab with specified temperature and connective boundary conditions.
Use of Grover & Heisler charts for solving problems of infinite slabs, cylinders, spheres.

Unit-III

Convection: Physical mechanism of convection, Buckingham pi-theorem and use of dimensional analysis in free and forced convection, Physical significance of different dimensionless numbers. Concept of velocity boundary layer, thermal boundary layer.
Reynolds analogy, Chilton-Colburn analogy for turbulent flow over flat surfaces. Calculation of heat transfer for flow over plates, cylinders and in pipes in free and forced convection using empirical formulae.

Unit-IV

Radiation: Absorptivity, Reflectivity, and Transmissivity, Concept of a blackbody, Emissivity, the Planck Distribution law, Wien's Displacement Law, Stefan-Boltzmann, Kirchhoff's Law. The View factor, View factor relations, View Factors between Infinitely Long Surfaces: The Crossed-Strings Method,Radiation exchange between Opaque, Diffuse, Gray Surfaces in an enclosure: Blackbody radiation exchange, the two-surface enclosure, radiation shields.

Unit-V

Heat Exchangers: Heat exchanger types, overall heat transfer coefficient. Heat exchanger analysis: Use of the Log Mean Temperature Difference (Parallel-Flow, Counter-Flow), the Effectiveness–NTU Method. Heat Exchanger Design and Performance Calculations (LMTD, ε-NTU methods), Selection of heat exchangers.

Boiling: Pool boiling regimes, nucleate pool boiling, and critical heat flux for nucleate pool boiling, minimum heat flux.

Condensation: Physical Mechanisms, Laminar Film Condensation on a Vertical Plate, Turbulent Film Condensation, dropwise condensation.

Suggested Reading:

1. John H Lienhard IV, John H Lienhard V,A"Heat Transfer" Textbook, Fifth Edition, Phlogiston Press, 2019.
2. Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt "Fundamentals of Heat and Mass Transfer", 8th Edition, John willey& Sons, 2018.
3. J.P. Holman, "Heat Transfer", Tenth Edition, McGraw Hill Companies Inc., 2010.
4. Yunus A Cengel, "Heat Transfer A Practical Approach", Second Edition, McGraw-Hill, 2002
5. James R. Welty, Charles Wicks, Robert Wilson, Gregory Rorrer, "Fundamentals of Momentum, Heat and Mass Transfer", 4th Edition, John Wiley and Sons Ltd, 2001

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	-	-	-	-	-	-	1	-	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	-	-
CO3	3	2	2	1	2	-	-	-	-	-	-	1	-	-
CO4	3	2	1	1	2	1	-	-	-	-	-	1	-	-
CO5	3	3	2	2	2	1	-	-	-	-	-	1	1	1

Course Code: PC503ME

DYNAMICS OF MACHINES

Credits: 3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

1. To find static and dynamic forces on planar mechanisms.
2. To know the causes and effects of unbalanced forces in machine members.
3. To determine natural frequencies of undamped , damped and forced vibrating systems of one, two and multi degree freedom systems.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Compare and contrast various methods of static and dynamic analysis of planar and spatial mechanisms.	L2
CO2	Evaluate Gyroscopic effects on Naval ships, Aeroplanes and Automobile.	L4
CO3	Analyze balancing problems in rotating and reciprocating machinery.	L4
CO4	Design systems like governors and flywheels for controlling speed and energy fluctuations.	L4
CO5	Determine natural frequencies and conditions for resonance of single degree and multi degree systems.	L3

Unit-I

Static and Dynamic analysis of planar mechanisms: Graphical and analytical methods, Free body diagrams, Method of superposition, Equivalent offset inertia force, Inertia force in reciprocating engines, Flywheels.

Unit-II

Force analysis of space mechanisms, inertia matrix, Lagrangian and Newton-Euler formulation. Gyroscopic effect in shafts, aero planes, Naval ships, Two & Four wheel automobiles.

Unit-III

Forces on bearings due to rotating shaft carrying several eccentric rotors, balancing of shafts carrying several rotors, determination of balancing masses from the forces on the bearings shaking forces in a single cylinders engine, partial balancing of reciprocating engine. Balancing of a two cylinder locomotive engine, determination of unbalanced forces and couples.

Unit-IV

The role of a centrifugal governor in speed control, Porter and Hartnell type governors, speed vs lift curves, power and stability. Undamped free vibration of a single degree of freedom linear system (axial and torsional), determination of natural frequencies, equivalent system of combination of springs, stepped shafts, gears and rotors. Free response of single degree of freedom damped linear systems, damped natural frequencies, relative damping. Vibration of harmonically forced single degree of freedom systems. Resonance, vibration isolation with coupled damper. Partial differential equation governing free vibration of a simply supported uniform beam. Derivation of natural frequencies.

Unit-V

Natural frequencies of two degree freedom linear systems.Nodes in three rotor systems. Modes of vibration, Determining natural frequencies by Holzer's method for multi-rotor systems. Dunkerley's method , Raleigh's method.

Suggested Reading:

1. S.S. Rathan, "Theory of Machines", Tata-Mc Graw Hill, 1995.
2. Thomas Bevan, "Theory of Machines", 3rd edition, Pearson Education, 2005
3. A. Ghosh and Mallick, "Theory of mechanisms and machines", Affiliated to E-W Press, 1988.
4. John.J.Vicker, Gordon R. Pennock, Joseph E. Shigley, "Theory of Machines & Mechanisms", Oxford University Press, 2003.
5. Robert L. Norton, "Design of Machinery", Tata Mc Graw Hill, 2005.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	-	-	1	-	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	-	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1	-	-
CO4	3	3	2	2	1	-	-	-	-	-	-	1	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	1	-	-

Course Code: PC504ME

MACHINE DESIGN

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- Importance of materials & criteria of failure of general mechanical components like springs, gears, brakes, bearings used in industry
- Importance of the stresses developed under different loading conditions
- Learn to apply design procedures for mechanical components like springs, gears, bearings
- Learn to evaluate the design procedure based on failure theories
- Learn to design components for new applications

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Identify and classify various materials & the corresponding failure theories to be applied in the design of simple mechanical components like springs, gears, bearings, IC engines.	L2
CO2	Illustrate various mechanical components under different loading conditions & constraints.	L2
CO3	Analyse various mechanical components under simple and combined loads.	L3
CO4	Determine (material, dimensions, shape, number) mechanical components subjected to various types of loads, constraints & failure criterions.	L3
CO5	Design mechanical components for specific applications in industry.	L4

Unit-I

Mechanical springs: Introduction. Different types of springs. Materials used for springs. Helical Springs: Whal factor, calculation of stress, Deflection and energy stored in spring. Design for static and fluctuating loads. Leaf Springs: Stress and Deflection. Nipping of Leaf springs. Design for static and fluctuating loads.

Unit-II

Gears: Introduction of gear drives, different types of gears, Materials used for gears. Standards for gears and specifications. Spur Gear Design: Basic analysis of gear tooth-Bending stress-Lewis equation, refined analysis of gear tooth -bending strength-procedure, gear tooth surface fatigue analysis-procedure, spur gear design procedures, Design of Helical, Bevel and Worm gears, concepts of Design for manufacturability.

Unit-III

Bearings: Introduction. Materials used for Bearings. Classification of bearings and mounting of bearings.

Design of sliding contact bearings: Properties and types of Lubricants, Design of Hydrostatic and Hydrodynamic sliding contact bearings. Design of Rolling Contact Bearings: Different types of rolling element bearings and their constructional details, static load carrying capacity. Dynamic load carrying capacity. Load-life relationship, selection of bearing life. Design for cyclic loads and speeds. Selection of Ball and Roller bearings.

Unit-IV

I.C. Engine parts: Introduction. Materials used. Design of piston, connecting rod and crank for I.C. Engines.Fly wheels: Introduction. Design of solid disk type and rimmed fly wheels. Design of

Brakes, Block brake with short shoe & long shoe, Pivoted block brake with long shoe, band brakes, disc brakes, internal expanding shoe, thermal considerations.

Unit-V

Design of curved beams: Introduction stresses in curved beams, expression for radius of curvature of neutral axis for rectangular, circular, trapezoidal and T-sections. Design of crane Hook, C-clamp. Design of chain drives: Power rating of roller chains. Strength of roller chains.

Suggested Reading:

1. Bhandari V.B. "Machine Design", Tata Mc Graw Hill Publications, 1994.
2. Robert C. Juvinall, Kurt M. Marshek, "Fundamentals of Machine Component Design", Wiley publications, 5th edition, 2012.
3. J.E. Shigley , C.R. Misckhe, "Mechanical Engineering Design", Tata Mc Graw Hill Publication, 2003.
4. P. Kannaiah, "Machine Design", Science-Tech Publications, 2003.
5. M.F. Spotts, "Design of Machine Elements", Prentice Hall, 1964.
6. Robert L. Norton, "Machine Design: An Integrated Approach",2/e PearsonEducation, 2000.
7. Nitin Ghokale, "Practical Finite Element Techniques", Altair Publications.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	-	1	1	-
CO2	3	2	1	1	1	-	-	-	-	-	-	1	1	-
CO3	3	2	2	2	2	-	-	-	-	-	-	1	1	-
CO4	3	2	2	2	2	-	-	-	-	-	-	1	1	-
CO5	3	2	1	2	2	-	-	-	-	-	-	1	1	-

Course Code: PC505ME

METAL CUTTING AND MACHINE TOOLS

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course objectives:

- To learn the geometry and mechanics of metal cutting for turning, drilling milling and tool materials.
- To understand the heat distribution, tool wear and tool life
- To know the various machining processes such as lathe, drilling, milling, boring, broaching, grinding etc.
- To know various types of work and tool holding devices for conventional machining.
- To understand the basics of Unconventional Machining processes.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Develop the relations for shear angle, shear strain, forces and temperatures associated with orthogonal cutting.	L3
CO2	Select the cutting fluids, tool materials and coatings to control the tool wear and temperature.	L2
CO3	Evaluate the tool life and economics of machining for maximum production and minimum cost.	L4
CO4	Select the appropriate machine tool and tool & work holding devices for machining of components.	L3
CO5	Illustrate the various finishing techniques and unconventional machining processes.	L2

Unit-I

Basic chip formation process. **Tool geometry:** Nomenclature of single point cutting tool by ASA,ORS and NRS. Geometry of drills, Milling cutters and broaches. Recommended Tool angles. **Chip formation:** Types of chips, BUE, Chip breakers. **Machining:** Orthogonal and oblique cutting, **Mechanics of Orthogonal Cutting**: Merchant's analysis, Friction. **Shear angle:** Shear angle Solutions of Merchant and Lee & Shafer. **Cutting tool materials:** High carbon steel, HSS, Carbides, Ceramics, Coated carbides, Cermets, HPC, cBN & Diamond.

Unit-II

Measurement of Cutting Forces: Lathe tool dynamometers, Drilling, Milling and Grinding Dynamometers. **Thermal aspects of metal cutting:** Sources of heat and heat distribution, various methods of measurement of temperature, Cutting fluids and applications. **Tool wear, Tool life & Machinability:** Types of wear, mechanism of tool wear, Tool life & Machinability. Effects of process parameters on Tool life, Taylor's tool life equation. **Economics of machining:** Tool life for maximum production, minimum cost.

Unit-III

Constructional features and specifications of machine tools: Various operations on Lathe, Types of Lathes and special attachments on a Centre Lathe. Drilling, Milling operations. Indexing methods. Shaper, planer and slotter and their differences. Quick return mechanisms, Automatic feed devices. Jig Boring machines- Differences between horizontal and vertical jig boring machines. Principles of Broaching.

Unit- IV

Abrasive Processes: Grinding machines. Types of grinding, Abrasives and bonds used for grinding wheels. Specification and selection of wheels. Lapping, Honing, Polishing, Buffing, Super finishing and burnishing.

Screws and gear manufacturing: Screw making by tapping, Chasers, Thread rolling, Thread milling, Thread grinding. Gear shaping, Gear hobbing, Gear shaving and grinding.

Unit-V

Jigs and Fixtures: Design principles for location and clamping. Tool holding and work holding devices. Quick clamping devices. Types of Jigs and fixtures.

Unconventional machining: Principles of working and applications of USM, AJM, WJM, EDM, ECM,LBM , EBM and PAM.

Suggested Reading:

1. David A. Stephenson, Johs S. Agapiou, "Metal Cutting Theory and Practice", CRC Press, 3rdEdition, 2016.
2. B.L. Juneja ,Shekhon G.S. and Seth Nitin, "Fundamentals of Metal Cutting & Machine tools", New Age Publishers, 2003.
3. A. Bhattacharyya, "Metal Cutting Theory and Practice", New Central Book Agency (P) Ltd., 2006.
4. Amitabha Ghosh and Ashok Kumar Mallik, "Manufacturing Science", Affiliated East-West Press Pvt. Ltd., 2ndEdition, 2010.
5. Winston A. Knight and Geoffrey Boothroyd, "Fundamentals of Metal Machining & Machine tools", CRC Press, 3rd Edition, 2005.
6. McGeough JA, "Advanced Methods of Machining", Chapman & Hall, 1988.

Articulation Matrix:

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	2	3	1	-	-	-	-	-	-	1	-	-
CO2	3	3	2	2	2	-	1	-	-	-	-	1	-	-
CO3	3	3	2	2	1	-	-	-	-	-	-	1	1	1
CO4	3	2	2	2	2	-	-	-	-	-	-	1	1	1
CO5	3	2	2	2	1	-	-	-	-	-	-	1	1	1

Course Code: PE501ME

PRODUCTION PLANNING & CONTROL

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

1. To understand the importance of PPC in an organization and the role of forecasting in PPC
2. To learn the role of inventory management in PPC and various inventory control techniques
3. To understand the concepts of routing and scheduling
4. To understand the objectives of line balancing and aggregate planning
5. To know the meaning of dispatching and various types of dispatching techniques.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Identify the objectives, functions, applications of PPC and forecasting techniques.	L2
CO2	Apply different Inventory Control Techniques for determining the optimum inventory.	L3
CO3	Solve routing and scheduling problems.	L3
CO4	Illustrate various types of Line Balancing Techniques and Aggregate Planning Strategies.	L2
CO5	Identify various types of dispatching techniques.	L2

Unit I

Introduction:

Definition – Objectives of production Planning and Control – Functions of production planning and control – Elements of production control – Types of production – Organization of production planning and control department – Internal organization of department. Forecasting**:** Importance of forecasting –Types of forecasting, their uses –General principles of Forecasting –Forecasting techniques– qualitative methods- Jury/Expert Method , Survey of Expert opinion method , Sales force composite method, Survey of buyers intention method and quantitative methods-Simple average, moving average, smoothing coefficient, Least Square method.

Unit II

Inventory Management : Functions of inventories – relevant inventory costs – ABC analysis – VED analysis – EOQ model – Inventory control systems – P–Systems and Q-Systems Introduction to MRP-I, MRP-II & ERP, JIT inventory, Kanban system

Unit III

Routing & Scheduling : Definition of Routing – Routing procedure –Route sheets – Bill of material – Factors affecting routing procedure. Definition of Scheduling – Activities-Difference with loading, Scheduling types: Forward, Backward scheduling, Job shop scheduling methods – Arrival pattern, processing pattern, number of workers available, machine varieties available, Priority rules for job sequencing FIFO, SPT,SOT, EDD, STR, CR, LISO, Random Orders. Scheduling Techniques Gantt Charts, LOB,Johnson's job sequencing rules- n jobs on 2machines, n jobs on 3 machines, n jobs on m machines.

Unit IV

Line Balancing & **Aggregate Planning:**

Introduction to line balancing, objectives, terms related to line balancing, procedures, simple problems; Introduction to Aggregate Planning, Inputs to aggregate planning, strategies- Line strategy, chase strategy, capacity options, demand options.

Unit V

Dispatching: Centralized and Decentralized Dispatching- Activities of dispatcher – Dispatching procedure – follow-up – definition – Reason for existence of functions – types of follow up, applications of computer in production planning and control.

Suggested Readings:

1. Samuel Eilon, "Elements of Production Planning and Control", Universal Publishing Corporation, 1991.
2. Buffa & Rakesh Sarin , "Modern Production & Operations management", 8th edition, Wiley india Pvt. Ltd, 2009.
3. S.N. Chary, "Production & Operations Management", 6th Edition, McGraw-Hill Education, 2019.
4. Krajewski, L.J., and Ritzman, L. P., "Operations management – strategy and analysis", 6th Edition, Prentice-Hall of India Pvt. Ltd, 2003.
5. S.K Sharma, savita Sharma, "Industrial Engineering and Operations Management", Sk Kataria & Sons, 2002.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	-	-	-	-	-	-	-	-	-
CO2	3	2	1	1	1	-	-	-	-	-	-	-	-	-
CO3	3	3	2	1	1	-	-	-	-	-	-	-	-	-
CO4	3	2	1	1	1	-	-	-	-	-	-	-	-	-
CO5	3	2	1	1	1	-	-	-	-	-	-	-	-	-

Course Code: PE502ME

POWDER METALLURGY

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

1. To know the various powder manufacturing methods
2. To understand the powder characterization techniques
3. To know the sintering and post sintering practices of powders
4. To learn the pressing and compaction tooling for various powders
5. To know the testing and applications of PM parts in industry

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Illustrate basic powder production methods of powder metallurgy.	L2
CO2	Identify and characterize the various powders and their properties.	L2
CO3	Apply the sintering technology to develop various PM products.	L3
CO4	Analyze the pressing and sintering tools for powder making.	L4
CO5	Select the testing methods and applications of industrial products manufactured by PM method.	L1

Unit-I:

Introduction: Importance and advantages of Powder Metallurgy. **Powder Manufacture:** Mechanical methods, Solid state reduction, Electrolytic method, thermal decomposition, and Atomization (water atomization, oil atomization, gas atomization, centrifugal atomization).
Powder Characterization: Powder sampling, Properties, Chemical composition, Particle shape, Particle size, Size distribution and Powder density. Compressibility, Green strength. Powder treatment.

Unit-II:

Powder blending/mixing: Lubricant additives, Binder additives, Blending Equipment. **Compaction:** Die compaction, Pressing operation, Compact presses, Factors affecting tooling design, Tooling materials, Design of sintered part, Powder roll compaction, Powder extrusion, Injection moulding. Cold Iso-Static Pressing and Hot Iso-Static Pressing.

Unit-III:

Sintering: Theory of sintering. Sintering practice – Furnace design, Furnace atmospheres, Vacuum sintering, Solid state sintering, Liquid phase sintering, Activated sintering, and loose powder sintering.

Unit-IV:

Post-Sintering Operations: Sizing and Coining, Machining, Infiltration and Impregnation. Heat treatment, hardening, and tempering, Surface hardening, Electro-plating, and Other coatings, Deburring, Joining.

Unit-V:

Testing of PM Parts: Density, Porosity, Microstructure, Hardness, Strength. **Applications:** Porous bearings and filters, Magnetic Materials, Production of Near-net shapes, Rapidly solidified powders, and Spray forming. Manufacturing of Cutting tools, Forming dies using powder metallurgy.

Suggested Reading:

1. P.C Angelo and R. Subramanian, "Powder Metallurgy", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edn., 2009.
2. E.P. DeGarmo, J.T. Black and R.A. Kohser, "Materials and Processes in Manufacturing", Prentice Hall of India Pvt. Ltd., New Delhi, 8th Edn., 1997.
3. Anish Upadhyaya and G S Upadhyaya, "Powder Metallurgy", Universities Press, Pvt., Ltd., 2013.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", Prentice Hall of India Pvt. Ltd., New Delhi, 4th Edn., 1995.

Articulation Matrix:

CO NO.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	1	1	1	1	-	-	-	1	-	-	1	-	-
CO2	3	3	1	2	2	-	-	-	-	-	-	1	-	-
CO3	3	1	2	1	2	-	-	-	-	-	-	2	-	1
CO4	3	3	1	2	2	-	-	-	-	-	-	2	-	-
CO5	3	1	1	1	2	-	-	-	-	-	-	1	-	1

Course Code: PE503ME

ROBOTIC ENGINEERING

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To provide student with the requisite knowledge of the various sub-disciplines in serial robots such as various robot configurations, kinematics, dynamics, control & manipulation, and computer-based acquisition etc.
- To provide adequate background in both analysis and design of serial robots
- To help students develop robots for needs of industry and society

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Identify and classify various robot configurations with their workspaces and their usage in industry.	L1
CO2	Perform forward and inverse kinematics operations & determine singularity conditions for various robot configurations.	L3
CO3	Compare and contrast various techniques available to find forward and inverse dynamic solutions for various general robot configurations.	L2
CO4	Implement various path planning techniques & control algorithms for computing end effector motions for generalized robotic tasks.	L4
CO5	Interface various hardware and software components to develop robotic systems for industry & Evaluate their performance.	L4

Unit-I

Brief History, Types of robots, Overview of robot subsystems, Robot specifications, joints and its types, types of links,Degrees of freedom of robots,accuracy, precision, resolution and repeatability, Robot classification: kinematic configurations, actuators, control mechanisms, concept of workspace, End effectors and Grippers, Mechanical, Electrical, vacuum and other methods of gripping. Applications of robots, specifications of different industrial robots.

Unit-II

Rotation matrices, Representation of orientation and translation, Euler angle and RPY representation, Homogeneous transformation matrices, Denavit-Hartenberg notation, representation of absolute position and orientation in terms of joint parameters, direct kinematics.

Unit-III

Angular velocity and acceleration of joints & links, skew symmetric matrices, Inverse Kinematics, inverse orientation, inverse locations, Singularities, Jacobian, Static force analysis of RP type and RR type planar robots, Dynamic analysis using Lagrangian and Newton-Euler formulations of RR and RP type planar robots.

Unit-IV

Trajectory Planning: joint interpolation,task space interpolation, executing user specified tasks, Independent joint control, PD and PID feedback, actuator models, nonlinearity of manipulator models, Computed torque control, force control, hybrid control, neural network based control of manipulator, fuzzy control of manipulator, CNN based control of manipulator.

Unit-V

Sensors: types of sensors, tactile & non tactile sensors, sensors to measure Position, velocity & acceleration measurement, Optical encoders. Range and Proximity sensing, acoustic, pneumatic, hall effect sensor, Eddy current sensors, Force and Torque sensors. Different types of End effectors for industrial Robots.

Vision: Image acquisition, types & components of vision system, Image representation, digitisation, binary, gray scale, RGB representation, Image processing, Image segementation, image smoothening, object descriptors, object recognition.

Robots used in general applications like material handling, process applications, assembly operations, inspection applications.

Suggested Reading:

1. Spong and Vidyasagar, "Robot Dynamics & Control", John Wiley and Sons, Ed.,1990
2. Mittal and Nagrath, "Industrial Robotics", Tata McGraw Hill Publications, 2004.
3. Saha & Subirkumarsaha, 'robotics', TMH, India.
4. Asada and Sllotine , "Robot analysis and intelligence", BS Publications , India.
5. Fu. K.S., GonZalez R.C., Lee C.S.G. "Robotics, Control-sensing vision and Intelligence", McGraw Hill, Int. Ed., 1987.
6. Groover M P, "Industrial Robotics", McGraw Hill Publications, 1999.
7. Robotics toolbox in MATLAB.
8. Robotic Operating System (ROS), Open source software, ros.org.com.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	-	1	1	1
CO2	3	3	2	2	2	-	-	-	-	-	-	1	1	1
CO3	3	3	2	2	2	-	-	-	-	-	-	1	1	1
CO4	3	2	2	2	3	-	-	-	-	-	-	1	1	1
CO5	3	2	2	2	3	-	-	-	-	-	-	1	1	1

Course Code: PE504ME

THEORY OF ELASTICITY

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To familiarize stress and strain.
- To distinguish plane stress and plane strain analysis.
- To understand problems on bending, torsion, thin wall, thick wall and columns

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Illustrate the basic concepts in continuum mechanics of solids, including of strain, internal force, stress and equilibrium in solids.	L1
CO2	Implementation of energy principles in solution of strength of materials problems.	L3
CO3	Derivation of constitutive relations of plane stress and strain.	L2
CO4	Derivation of stress-strain relations for linearly elastic solids such as beams and plates, and Torsion of shafts.	L4
CO5	Analyze axisymmetric problems such as cylinders and rotating discs and stability of columns.	L4

Unit-I

Analysis of Stress: Stress tensor, Equilibrium equations in Cartesian coordinates, Two dimensional stress at a point and principal stresses. Three dimensional stress at a point and principal stresses. Stresses on an oblique plane in terms of principal stresses.

Unit-II

Analysis of Strain: Strains in terms of displacements in Cartesian coordinates, Equations of compatibility, Generalized Hook's Law and Lame's constants, Strain energy, Dilatational and distortional energy, St. Venant's principle.

Unit-III

Two dimensional problems: Plane stress, Plane strain problems: Stress function, Bi-harmonic equation, Equilibrium equations, Strain displacement relations and compatibility equations in polar coordinates, Stress concentration.

Unit-IV

Bending of straight beams and curved beams. Torsion of shafts, Membrane analogy. Bending of plates.

Unit-V

Axi-symmetric problems, Thick walled cylinders subjected to internal and external pressures, Stresses in composite tubes, Rotating disks of uniform and variable thickness. General treatment of column stability problems.

Suggested Reading:

1. L.S. Srinath, "Advanced Mechanics of Solids", Tata McGraw Hill Publ. Co., 1970.
2. S. Timeshenko & J.N. Goodier, "Theory of Elasticity", Tata McGraw Hill, 1970.
3. A.C. Uguaral, "Advanced Strength and Theory of Elasticity", Elsevier Publication, 1965.
4. S. Singh, "Theory of Elasticity", Khanna Publishers, 1979.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	-	-	-	-
CO2	3	3	2	2	1	-	-	-	-	-	-	-	-	-
CO3	3	3	2	2	1	-	-	-	-	-	-	-	-	-
CO4	3	2	2	2	1	-	-	-	-	-	-	-	-	-
CO5	3	2	2	2	1	-	-	-	-	-	-	-	-	-

Course Code: PE505ME

AUTOMOBILE ENGINEERING

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To learn about the layout and arrangement of principal parts of an automobile.
- To understand working of different types of Drive train and Transmission Systems
- To learn about different types of Steering , Axle, Wheels and Tyres.
- To understand different types of Suspension and braking systems.
- To learn about Alternative Energy Sources for Automobiles.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Identify principal parts of an automobile and their layout.	L2
CO2	Illustrate the working principles of Drive train and Transmission Systems.	L3
CO3	Enumerate the working principles of Steering, Axle, Wheels and Tyres.	L3
CO4	Examine the functioning of Suspension and braking systems.	L3
CO5	Analyse of alternative Energy Sources for Automobile applications and latest automobiles.	L3

Unit-I

Automobile Body Construction

Automobile history and development, current scenario in Indian auto/ ancillary industries, Classification, types of chassis layout with reference to power source locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitized frame body construction, Loads acting on vehicle frame, details of chassis material.

Unit-II

Drive Train & Transmission

Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission (CVT) , Propeller Shaft, Universal Joint, Differential and final drive

Unit-III

Front & Rear Axle, Steering System, Wheel & Tyres

Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles.
Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering.
Wheel and Tyres: Wheel construction, alloy wheel, wheel alignment and balancing, type of tyres, tyre construction, tyre materials, factors affecting tyre life

Unit-IV

Suspension & Brakes System

Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self leveling suspension (active suspension), damping and shock absorbers Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.

Unit-V

Alternative Energy Sources

Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and Hydrogen in Automobiles- Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with these alternate fuels - Electric and Hybrid Vehicles. Autonomous vehicles –current status of development

Suggested Reading:

1. Kirpal Singh, "Automobile Engineering, Vol I and II",12th Edition, Standard Publishers, 2011
2. S. Srinivasan, "Automotive Mechanics", 2nd Edition, Tata McGraw Hill, 2003.
3. H. Heisler, "Vehicle and Engine Technology", ELBS, 1965.
4. P.L. Kohli, "Automotive Electrical Equipment, Tata McGraw Hill, 1985.
5. William H. Crouse, Donald L. Anglin, "Automotive Mechanics", 10th Ed., Tata Mc Graw Hill, 2007.

Articulation Matrix:

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO3	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO4	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO5	3	2	2	1	-	1	2	1	-	-	-	-	1	1

PC551ME

FLUID MECHANICS AND HYDRAULIC MACHINERY LABORATORY

Credits: 1.5

Instruction: (3P) per week *Duration of SEE: 3 hours*
CIE: 25 Marks *SEE: 50 Marks*

Course Objectives:
The course should enable the students:

- To understand general governing equations for various fluid flows
- To enrich the concept of fluid mechanics and hydraulic machines.
- To demonstrate the classical experiments in fluid mechanics and hydraulic machinery.
- To understand the functioning of various flow measuring devices, pumps and turbines
- To evaluate the performance characteristics of turbines and pumps

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Illustrate the working of Hydraulic machines.	L2
CO2	Apply the Bernoulli's principle in flow measurement used in hydraulic	L3
CO3	Analyze working principles of hydraulic pumps and turbines.	L4
CO4	Evaluate the theoretical concepts and apply them in the functioning of hydraulic machines	L5
CO5	Estimate the performance of pumps and turbines.	L5

List of Experiments:

1. Determination of Cd and Cv of an orifice meter
2. Calibration of a mouth piece
3. Calibration of a Venturi meter
4. Verification of Bernoulli's principle
5. Performance test on Pelton wheel turbine
6. Characteristic curves test on Pelton wheel turbine
7. Performance test on Turgo wheel
8. Characteristic curves test on Turgo wheel
9. Performance test on Francis turbine
10. Characteristic curves test on Francis turbine
11. Performance test on reciprocating pump
12. Study of positive displacement and Rotodynamic pumps with the help of models.
13. Study of the working of Kaplan turbine

Articulation Matrix:

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS O1	PS O2
CO1	2	1	1	1	-	-	-	-	-	-	-	-	-	-
CO2	3	3	1	2	1	-	-	-	-	-	-	-	-	-
CO3	3	3	3	3	2	-	-	-	-	-	-	-	-	-
CO4	3	3	3	3	2	-	-	-	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-	-	1	-

SCHEME OF INSTRUCTION & EXAMINATION
B.E VI Semester (Mechanical Engineering)

S. No.	Code	Name of the Course	No of Hours				Scheme of Examination		Credits
			L	T	P	Contact Hrs/wk	CIE	SEE	
1	PC601ME	Metrology & Instrumentation	3	-	-	3	30	70	3
2	PC602ME	Finite Element Analysis	3	-	-	3	30	70	3
3	PE ME	Professional Elective-II	3	-	-	3	30	70	3
4	PE ME	Professional Elective-III	3	-	-	3	30	70	3
5	HS601MC	Managerial Economics & Accountancy	3	-	-	3	30	70	3
6.	OEC	Open Elective-I	3	-	-	3	30	70	3
PRACTICALS									
7.	PC651ME	Metal Cutting & Metrology Lab	-	-	3	3	25	50	1.5
8.	PC652ME	CAE Lab	-	-	2	2	25	50	1
9.	PR653ME	Project-II	-	-	4	4	25	50	2
		Total	18	-	9	27	255	570	22.5
** At the end of VI semester students should undergo summer Internship - Credits for project III will awarded in VII semester*									

PROFESSIONAL ELECTIVE COURSE-II	
PE601ME	Design of Solar Energy Systems
PE602ME	Refrigeration and Air Conditioning
PE603ME	Control System Theory
PE604ME	Additive Manufacturing Technologies

PROFESSIONAL ELECTIVE COURSE-III	
PE611ME	Mechatronics Systems
PE612ME	Fatigue, Creep and Fracture
PE613ME	Computational Fluid Flows
PE614ME	Non-conventional Machining & Forming Methods

OPEN ELECTIVE COURSE-I	
OE601BM	Engineering Applications in Medicine
OE602CE	Disaster Management
OE603EC	Electronic Instrumentation
OE604EC	Principles of Electronic Communication Systems
OE605ME	3D Printing Technology

Course Code: PC505ME

METROLOGY AND INSTRUMENTATION

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To familiarize with limits and Fits, ISO system and the instruments used to measure these limits.
- To have knowledge of various precision linear and angular measuring instruments
- To learn the importance of form and how to measure form errors
- To understand the working principles of various instrument used for the measurement of strain, pressure, temperature and vibrations.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Illustrate manufacturing process variables.	L1
CO2	Explain the measurement of the physical phenomenon.	L2
CO3	Understand and Apply measurement principles in Industrial requirements.	L3
CO4	Evaluate the methods of measurements affecting Mechanical Engineering	L4
CO5	Design, innovate and modify measuring technology.	L4

Unit-I: Limits and Fits, I.S.O. system. Types of interchangeability. Slip gauges and end bars. Height gauges, Abbe's rule, Types of micrometers. Tomlinson gauges, sine bar, autocollimator, calibration of precision polygons and circular scales. Dial indicator, Sigma mechanical comparator. Free flow and back pressure type Pneumatic comparators. Contact & non-contact tooling, Applications of single and multijet gauge heads; computation and match gauging.

Unit-II: Optical projector-measurement by comparison, movement and translation, chart gauge types and microgauge bridge lines. Tool maker's microscope, Floating carriage diameter measuring machine and Coordinate Measuring Machine. Measurement of straightness & flatness using autocollimator. Roundness measurement with intrinsic datum (V-block, Bench centers) and extrinsic datum (TALYROND).

Unit-III: Taylor's principles for plain limit gauges. Usage and limitations of Ring and Snap gauges. Indicating type limit gauges. Position and receiver gauges, principles of thread gauging. Gauge materials and steps in gauge manufacture. General geometrical tests for machine tools. Surface roughness characteristics and its measurement. Elements of instrumentation system. Static characteristics, Systematic and random errors. Dynamic response of first and second order instruments.

Unit-IV: Strain Measurement: Wire and foil type resistance strain gauges, Evaluation of principal strains with Rosette gauges. Desirable characteristics of gauge material, backing material and adhesive. Ballast and bridge circuits. Lead resistance compensation. Adjacent arm and self temperature compensating methods. Strain gauge calibration. Strain gauge circuits for measuring axial load, bending load and torque.
Measurement of displacement with LVDT and Lasers interferometry.

Unit-V: Force Measurement: Proving ring, Strain gauge load cells, Piezo-electric load cell, Ballastic weighing, Pneumatic and hydraulic force meters. Pressure Measurement: Thermocouple vacuum gauge, High and Low pressure measuring devices. Pirani gauge, Bourdon gauge and Bulk modulus gauge, calibration methods.
Vibration measurement, accelerometers, vibration exciters, calibration of vibrometers.

Temperature measurement: Laws of thermo electricity, types of materials and junctions used in thermocouples, lead and extension wires, ambient temperature compensation, protection tubes, series and parallel circuits. RTD. Total radiation and Optical Pyrometers.

Suggested Reading:

1. R.K. Jain, "Engineering Metrology", Khanna Publications, 1996.
2. I.C. Gupta, "A text book of Engineering Metrology", Dhanpat Rai & Sons, 1984.
3. Bechwith, Marangoni, Lienhard, "Mechanical Measurement", LPE; Pearson Education Asia 2000.
4. D.S. Kumar, "Mechanical Measurements", Metropolitan Book Co., New Delhi, 2001.
5. Rega Rajendra, "Principles of Engineering Metrology", Jaico Publishing House, Mumbai, 2008.

Articulation Matrix:

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO3	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO4	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO5	3	2	2	1	-	1	2	1	-	-	-	-	1	1

Course Code: PC602ME

FINITE ELEMENT ANALYSIS

(Professional Elective-II)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To understand the theory and application of the finite element method for analyzing structural systems.
- To learn Approximation theory for structural problems as the basis for finite element methods
- To learn formulations for a variety of elements in one, two, and three dimensions. Implementations of element formulations will be examined using Matlab.
- To understand modeling and analysis of structures using planar, solid, and plate elements

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Statement	Blooms Level
CO1	Illustrate the concept of Finite Element Method and realize its limitations.	L2
CO2	Construct shape functions for 1D, 2D and 3D linear and higher order elements.	L3
CO3	Applying 1D , 2D and 3D elements to solve different static structural and heat transfer problems.	L3
CO4	Solve 1D and 2D steady state heat transfer, and 1D eigen value and eigen vector problems.	L3
CO5	Analyze time dependent heat transfer problems and review of Finite Element analyses softwares.	L4

Unit-I

Introduction to Finite Element Method, solution method using FEM, discretisation, Boundary conditions, load application, types of elements comparison, Stress and Equilibrium, Boundary conditions. Strain-Displacement relations. Stress-strain relations. Types of elements used.
Convergence requirements and geometric isotropy. Local, natural and global coordinates.
One Dimensional problems: Finite element modeling, coordinates and shape functions.
Potential Energy approach: Assembly of Global stiffness matrix and load vector. Finite element equations, Treatment of boundary conditions. Quadratic shape functions.

Unit-II

Analysis of trusses and frames: Element stiffness matrix for a truss member. Analysis of plane truss with number of unknowns not exceeding two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node.
Analysis of Beams: Element stiffness matrix for two nodded, two degrees of freedom per node beam element.

Unit-III

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions.
Finite element modeling of Axisymmetirc solids subjected to Axisymmetric loading with triangular elements.

Unit-IV

Two dimensional four nodded isoprarametric elements and numerical integration.
Steady state heat transfer analysis: One dimensional analysis of a find and two dimensional analysis of thin plate. Analysis of uniform shaft subjected to torsion.

Unit-V

Dynamic Analysis: Formulation of finite element mode, element matrices, evaluation of Eigen values and Eigen vectors for a stepped bar and a beam.

Time dependent field problems: Application to one dimensional heat flow in a rod. Finite element formation to three dimensional problems in stress analysis. Introduction to Finite Element Analysis Software.

Suggested Reading:

1. Tirupathi R. Chandraputla and Ashok, D. Belgundu" Introduction to Finite Elements in Engineering", Pearson Education, 2002, 3rd Edition.
2. Rao S.S., "The Finite Element Methods in Engineering", pergamon Press, 1989.
3. Segerlind, L.J. "Applied Finite Element Analysis", Wiley Publication, 1984.
4. Reddy J.N., "An Introduction to Finite Element Method", McGraw-Hill Company, 1984.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	--	--	--	--	--	1	--	--
CO2	3	2	2	1	1	1	--	--	--	--	--	1	--	--
CO3	3	3	3	2	2	1	1	--	--	--	--	1	--	--
CO4	3	2	3	2	2	1	1	--	--	--	--	1	--	--
CO5	3	2	2	3	2	2	1	--	1	1	--	1	1	1

Course Code: PE601ME

DESIGN OF SOLAR ENERGY SYSTEMS
(Professional Elective-II)

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To develop the fundamental principle of solar radiation and it's measuring devises.
- To understand the concept of solar cell system and implications of solar cell system for best performance.
- To formulate solar thermal systems and also developsolar hybrid systems for different applications.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Illustrate solar radiation and its physical function of the measuring devices.	L2
CO2	Compare and contract technologies of solar cell fabrication methods.	L2
CO3	Calculate the required size of solar cell systems for maximum output in peak hours.	L3
CO4	Illustrate the solar thermal system for different applications.	L3
CO5	Evaluate the performance of combined solar thermal and solar cell systems.	L4

Unit-I

Solar radiation: Properties of sunlight. Sun-Earth Relationships, Absorption by the atmosphere. Peak sun hours, the declination of the Sun, Determination of Solar time, Solar angle, Solar window. Solar radiation is measuring devices: Pyrheliometers, Pyranometers. Pyrgeometer, Net radiometer, Sunshine recorder, Estimation of Average Solar radiation. Solar irradiance at surfaces

Unit-II

Solar cells and modules: The function of solar cells from semiconductor physics. Different solar cell technologies and fabrication methods. Concepts for increasing efficiency based on loss analysis. Wavelength sensitivity. Series connection and parallel connection of solar cells to modules. Module function and characteristics. Shading of cells and modules.

Unit-III

Solar cell systems: System components and their functions. Calculating output and dimensioning of solar cell systems. Concentrated sunlight and solar power (CSP). Properties of optical concentration systems. Solar cells in concentrated sunlight. Overview of the different components in a CSP system and their functions. Design of Photovoltaic Systems

Unit-IV

Solar thermal: Thermodynamic description of solar collectors. Optical properties of solar collectors and technologies for fabrication. ***Solar thermal systems for different applications***: Solar Water Heating (Active and Passive), Solar Industrial Process Heat, Solar Thermal Power Systems in India and abroad. Storage of solar generated heat.Design of Active Systems by Utilizability Methods, Design of Passive and Hybrid Heating Systems.

Unit-V

Performance Testing of Solar Collectors:
Governing equations for evaluation of performance. Methods of testing, testing procedures, testing of liquid and air flat plate collectors. Cylindrical, parabolic concentrators. Overall performance of heating panels. Selection of materials - Absorbing heat transfer fluids.

Hybrid systems: Combinations of solar thermal and solar cell systems. Overview of different applications.

Suggested Reading:

1. Magal B.S. "Solar Power Engineering", Tata McGraw Hill Publishing Co. Ltd., 1994.
2. Sukhatme S.P.," Solar Energy", 2 Edition, Tata McGraw Hill Publishing Co. Ltd., 2nd ed, 1996.
3. Garg H.P. and Prakash J., "Solar Energy", Tata McGraw Hill Publishing Co. Ltd., 1997.
4. John A. Duffie, William A. Beckman, "Solar Engineering of Thermal Processes", 4th Edition, John Wiley & Sons Inc., 2013.
5. MertensKonrad, “Photovoltaics : Fundamentals, Technology and Practice”, John Wiley & Sons Inc., 2014.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	-	1	1	-
CO2	3	1	2	1	1	-	-	-	-	-	-	1	1	-
CO3	3	3	3	2	2	-	-	-	-	-	-	-	1	1
CO4	3	2	3	2	2	1	-	-	-	-	-	1	1	1
CO5	3	2	2	3	2	1	-	-	-	-	-	1	1	1

Course Code: PE602ME

REFRIGERATION AND AIR CONDITIONING

Credits: 3

Instruction: (3L) per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To understand the basic concepts of refrigeration and air conditioning systems.
- To study the different methods of refrigeration system and their performance.
- To understand conventional and non-conventional refrigeration system.
- To study the psychrometric terms and psychrometric processes.
- To study the lower temperature applications: cryogenics by using cascade systems.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Description	Blooms Level
CO1	Distinguish different types of refrigerants and their properties used in the refrigeration cycle.	L2
CO2	Analyze the performance of vapour compression and vapour absorption system	L4
CO3	Distinguish between conventional and non-conventional refrigeration system.	L2
CO4	Apply the principles of Psychrometrics to estimate the air conditioning loads for the industrial applications.	L3
CO5	Illustrate various methods to obtain cryogenic temperatures.	L2

Unit-I

Definition of Refrigeration & Air Conditioning. Necessity of refrigeration. Applications of refrigeration and air conditioning. Units of refrigeration. Refrigerants classification and desirable properties of refrigerants. Air refrigeration: Carnot refrigeration cycle and its limitation. Air refrigeration cycle operating on Brayton cycle and analysis. Aircraft refrigeration: Necessity.

Advantages of using air cycles for aircraft refrigeration. Refrigeration systems for low and high speed aircrafts.

Unit-II

Vapour compression system: Simple vapour compression cycle: COP, representation of cycle on T-S, P-H and H-S diagrams. Actual vapour compression cycle. Effect of superheating and sub cooling– problems.

Vapour absorption refrigeration systems: Ammonia –water, Lithium Bromide – water systems. Improvements using analyzer and rectifier. Desirable properties of combinations. Electrolux refrigerator – It's working.

Unit-III

Steam jet refrigeration systems: Analysis using T-S and H-S diagrams. Quantity of motive steam required. Use of barometric and evaporative condensers. Limitations and advantages of steam jet systems.

Thermoelectric refrigeration systems: Seebeck effect, Peltier effect and Thompson effect. Analysis of the thermoelectric refrigeration systems using Peltier effect. Expression for COP. Criterion for selecting thermoelectric effects. Vortex tube refrigeration – principle and working.

Unit-IV

Psychrometric properties of air: Psychrometric chart and psychrometric processes and combination of processes. By pass factor. SHR and Room conditioning using SHR with and

without recirculation.Design and classification of Air conditioning systems, RSHF, GSHF, ERSF. Human comfort and tolerances. ASHRAE comfort charts. Effective temperature.

Unit-V

Cryogenics: Limitations of single stage vapour compression systems applied to low temperature applications. Multistage compression and cascade systems for production of low temperature. Joule Thompson effect and coefficient. Inversion curve. Liquification of air using Linde and cloude systems. Liquification of hydrogen and helium. Application of cryogenics in metallurgy, cryobiology and cryosurgery.

Suggested Reading:

1. Arora & Domkundwar, " A Course in Refrigeration and Air conditioning", 8th Edition, Dhanpatrai & Co, 2008.
2. Roy J. Dossat, "Principles of Refrigeration", 5th edition, Pearson Education, 2001
3. R.S. Khurmi & J.K. Gupta, "Refrigeration and air conditioning", 5th revised edition, S Chand & Co, 2008.
4. Jordon & Priester, "*Principles of Refrigeration and Air Conditioning"*, Prentice Hall, India,1988
5. Arora C.P., "Refrigeration and Air Conditioning", Tata McGraw Hill, New Delhi, 1988.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	1	-	-	-	-	1	1	-
CO2	3	3	3	1	1	-	1	-	-	-	-	1	1	1
CO3	3	2	2	1	1	-	-	-	-	-	-	-	-	
CO4	3	3	3	2	2	-	-	-	-	-	-	1	1	1
CO5	3	2	2	1	-	-	1	-	-	-	-	1	1	-

Course Code: PE603ME

CONTROL SYSTEMS THEORY

(Professional Elective-II)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To introduce students to the fundamental of feedback control system theory and use of analytical design methods in designing, analyzing various physical systems and to apply the gained knowledge in developing solutions for real world systems.
- To develop the ability of formulating mathematical models and designing feedback control systems.
- To provide students with necessary tools to analyze linear feedback control systems.
- To introduce the students to the concepts of digital control and modern control.

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO's	Statement	Blooms Level
CO1	Distinguish between open loop and closed systems with examples.	L2
CO2	Develop mathematical models of mechanical, electrical, electro-mechanical systems.	L4
CO3	Evaluate the effects of transient and steady state responses and apply these models to real time systems.	L4
CO4	Apply the time response and frequency response methods to determine the stability of the system.	L3
CO5	Apply the concepts of discrete time control systems. Analyse and design multi input, multi output systems by state space analysis.	L3

Unit-I

Introduction: Classification of control systems. Examples of control systems with applications in Mechanical Engineering. Relationships of components and analogies. Performance characteristics of control system components. Hydraulic and pneumatic control systems. Methods of analysis using standard input functions. Laplace transformation, use of transfer functions.

Derivation of system equations: The simultaneous equation method. Block diagram method and Laplace transform approach. Error sensing devices: Potentiometer, synchros, and AC-DC servomotors, Encoders, Decoders.

Unit-II

Modeling in the time domain. Time Response: Response characteristics of systems Types of input. Transient response of first and second order system for step input. Time domain specification. Types of system, static error coefficients, error series, Routh-Hurwitz criterion of stability.
Root Locus Techniques: Typical systems analyzed by Root Locus Techniques. Effect of location of roots on the system response.

Unit-III

Modeling in the frequency domain. Frequency response analysis: The frequency response of a second order system, effect of numerator factors, zero factors in a transfer function. Bode plots, Gain-Phase plot, Nyquist criterion for stability, Gain Margin and Phase Margin, compensation techniques.

Unit-IV

Discrete Control Analysis: The Z-transformation, digital control, advantages and disadvantages, Digital control system architecture. The discrete transfer function. Z-domain stability. Stability tests. Jury's stability criteria.

Unit-V

State space representation: Concept of state. State variable, state models of linear time invariant systems, derivation of state model from transfer functions and differential equations. State transition matrix, solution of state equations by time domain method.

Suggested Reading:

1. Katsuhiko Ogata, "Modern Control Engineering", Prentice hall, 5th edition, 2010.
2. Norman S Nise, control system engineering', Wiley publications, 6th edition, 2010
3. Francis Raven H. "Automatic Control Engineering", Tata McGraw Hill, 5th Edition, 1995.
4. Peter Dransfield, "Engineering Systems and Automatic Control", Prentice Hall of India,, 1974
5. Gene F. Franklin, J. David Powell, Abbas Emamin Naini, "Feedback control of Dynamic Systems", Pearson Education Pvt. Ltd., 4* Edition, 2004.
6. Benjamin kuo, 'automatic control systems ', 9th edition, wiley, india, 2010.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	-	-	-	-
CO2	3	2	2	2	1	-	-	-	-	-	-	-	-	-
CO3	3	3	3	1	2	-	-	-	-	-	-	-	-	-
CO4	3	2	1	1	1	-	-	-	-	-	-	-	-	-
CO5	3	3	3	2	2	-	-	-	-	-	-	1	1	-

Course Code: PE604ME

ADDITIVE MANUFACTURING TECHNOLOGIES

(Professional Elective-II)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To understand the fundamental concepts of Additive Manufacturing (AM), its advantages, limitations and classifications
- To know the working principle, advantages, disadvantages and applications of VatPhoto Polymerization, Material Jetting, Binder Jetting, Material Extrusion powder bed 3fusion AM Technologies
- To know the various types of STL file errors and other data formats.
- To understand features of various AM software and the concept of Topology optimization in AM
- To understand the diversified applications of AM.

Course outcomes: At the end of the course the student will be able to:

S.No	Statement	Blooms Level
CO1	Interpret the features of Additive Manufacturing (AM) and compare it with conventional CNC Technology.	L2
CO2	Illustrate the working principle, advantages, limitations and applications of various Additive Manufacturing Technologies .	L2
CO3	Interpret various types of errors in STL file and other data formats used in AM and identify the role of Topology optimization in AM.	L3
CO4	Analyze different types of software's used in 3D Printing Technology.	L4
CO5	Apply the knowledge of various AM technologies for developing innovative applications.	L3

Unit – I

Introduction: Additive Manufacturing fundamentals: Need for time compression in product development, Need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies. Role of AM in Industry 4.0.

Unit – II

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies:

VatPhotopolymerization AM Systems: Photopolymers, photo polymerization Stereo lithography Apparatus (SLA), Direct Light Processing (DLP) and Continuous Direct Light Processing (CDLP). **Material Jetting AM Systems:** Material Jetting, Nano particle jetting and Drop-On-Demand (DOD) material jetting, Polyjet **Binder Jetting AM Systems:** Three dimensional Printing (3DP). **Material Extrusion AM Systems**: Fused Deposition Modeling (FDM)

Unit – III

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies:

Powder Bed Fusion AM Systems: Selective laser sintering (SLS), Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM).

Direct Energy Deposition (DED) AM Systems: Laser Engineered Net Shaping (LENS).

Sheet Lamination AM Systems: Laminated Object Manufacturing (LOM) and Ultrasonic Additive Manufacturing (UAM).

Unit – IV

AM Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Slicing Algorithms:

Design for AM: Topology optimization and Additive Manufacturing.

AM Software's: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3 D Rhino, 3 D doctor, Flash Print, Object Studio, Cura, ITK Snap, 3-matic, Simplant, 3-matic, Simplant, MeshLab, Ansys for Additive Manufacturing.

Unit –V

Additive Manufacturing Applications: AM Applications in Design, Engineering Analysis and Planning, Aerospace, Automotive, Jewelry, Coin, GIS, Arts, Architecture. Medical and Bioengineering Applications, Forensic Science, Anthropology, Visualization of Biomolecules, Electronic industry and Disaster Management.

Suggested Readings:

1. Chee Kai Chua and Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" Fifth Edition, World Scientific Publications, 2017
2. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Springer, Second Edition, 2010.
3. Frank W.Liou, "Rapid Prototyping & Engineering Applications", CRC Press, Taylor & Francis group, 2011.
4. RafiqNoorani, **"**Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley & Sons, 2006.
5. NPTEL Course on Rapid Manufacturing. https://nptel.ac.in/courses/112/104/112104265/

Articulation Matrix:

SNO	PO1	PO2	PO3	PO4	PO5	PO6	P07	P08	P09	P010	P011	P012	PSO1	PSO2
CO1	3	2	2	2	1	--	--	--	--	--	--	--	1	--
CO2	3	3	2	1	1	--	--	--	--	--	--	1	1	1
CO3	3	2	2	1	2	--	--	--	--	--	--	1	1	1
CO4	2	2	2	1	2	--	--	--	--	--	--	1	1	
CO5	3	2	3	1	2	--	--	--	--	--	--	1	1	1

Course Code: PE611ME

MECHATRONICS SYSTEMS
(Professional Elective-III)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives

- Learn the architecture of mechatronic systems
- Introduce concept of sensors & actuators to measure & control various physical quantities like volume, pressure, temperature
- Learn to design simple control systems
- Learn PLC programming to build simple control systems

Course outcomes: At the end of the course the student will be able to:

S.No	Statement	Blooms Level
CO1	Illustrate the architecture of mechatronic systems.	L2
CO2	Design some simple measurement systems using different sensors.	L4
CO3	Demonstrated ability to design basic control systems using different actuators.	L3
CO4	Execute PLC programs for industrial Applications.	L4
CO5	Demonstrate an understanding of analogue and digital interfacing.	L3

Unit 1:
Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach.

Unit II:
Review of fundamentals of electronics. Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs.

Unit III:
Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems.

Unit IV:
Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. Description

Unit V:
Description of PID controllers. CNC machines and part programming. Industrial Robotics.

Suggested Readings:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. G.W. Kurtz, J.K. Schueller, P.W. Claar . II, Machine design for mobile and industrial applications, SAE,1994.
3. T.O. Boucher, Computer Automation in Manufacturing - an Introduction, Chappman and Hall, 1996.
4. Devdas Shetty, Richard Klok "Mechatronic system design", 2nd edition, Cengage Learning,
5. Boltan, W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", Longman, Singapore, 1999

6. Krishna Kant; Computer Based Industrial Control ; Prentice Hall of India Pvt. Ltd. 1999.
7. Herbert Taub & Donald Schilling : Digital Integrated Electronics, McGraw Hill International Edition, 1977.
8. David Alciatoare, Michael Histand, "Introduction to Mechatronics and Measurement Systems",McGraw Hill, 2002.
9. Haxkworth, "Programmable Logic Controllers-Programming Methods and its Applications", Pearson India Ltd., 2011.

Articulation Matrix:

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

Course Code: PE612ME

FATIGUE CREEP AND FRACTURE

(Professional Elective-III)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*

CIE: 30 Marks *SEE: 70 Marks*

Course Objectives

- Learn the concepts of fatigue design and testing.
- Understand the factors affecting fatigue strength.
- Conceptualize the theory of brittle fracture and understand the modes of fracture and its measurement.
- Learn the mechanism of creep and its importance in design.

Course outcomes: At the end of the course the student will be able to:

S.No	Statement	Blooms Level
CO1	Enumerate the design philosophy and recognize formulate fatigue design.	L2
CO2	Illustrate the factors affecting fatigue and methods to improve fatigue strength.	L2
CO3	Evaluate ductile and brittle fracture.	L4
CO4	Predict the stress field at the crack tip.	L4
CO5	Calculate and measure creep deformation.	L3

Unit I:

Design philosophy : Infinite life, Safe life, Fail safe and Damage tolerant design concepts.

Fatigue Design : Cyclic stress and stress reversals, Fatigue and progressive fracture, Endurance limit, Fatigue Tests : Cantilever and Beam type of Fatigue Tests, Axial Fatigue Tests. Influence of mean stress on fatigue : Gerber, Goodman and Soderberg's criteria. Effect of compressive cyclic stress on fatigue. Fatigue design formula for axial, bending, torsional and combined loading.

Unit II:

Fatigue controlling factors: Effect of frequency, Temperature, size, form, stress concentration factors, Notch, sensitivity & surface conditions, residual stresses. Improvement of fatigue strength by chemical/metallurgical processes such as nitriding, flame hardening, case carburizing. Fatigue strength enhancement by mechanical work : cold rolling, peening, shot peening.

Unit III:

Effect of environment : Corrosion Fatigue, Concept of cumulative fatigue damage Fracture Mechanics : Ductile and brittle fracture Theoretical cohesive strength of metals, Griffith Theory of brittle Fracture, Oruron's modification to Griffith Theory.

Unit IV: Modes of fracture :

Mode-I, -II and -III, fatigue crack growth, Behaviour of metals, Linear Elastic Fracture Mechanics (LEFM), Stress Intensity Factor(SIF), Stress field near the crack tip, Critical SIF and Fracture Toughness, Experimental determination of fracture toughness K_{IC} , COD gauges and standard ASTM Tests.

Strain Energy Release Rates (SERR), Elasto-Plastic Fracture Mechanics (EPFM), Plastic zone size and its evaluation, J-Integral Method.

Unit V: Creep Analysis :

Definition, Constant stress and constant, strain creep tests. Uniaxial creep tests : Baily's Power Law, Creep relaxation : strain hardening and time hardening creep relaxation. Introduction to Creep bending and deflection of simple problems.

Suggested Reading

1. George E. Dieter, Mechanical Metallurgy, - Mc Graw Hill, NY,1988
2. Joseph Marin, Mechanical Behaviour of Engg. Materials, - Prentice Hall of India, 1966
3. Stephens, R.I. and Fuchs, H.O., Metal Fatigue in Engg. ,- Wiley, NY 2001
4. Finnie, I. and Heller, W.R., Creep of Engg. Materials, - Mc Graw Hill Book Co.,1959
5. Prasant Kumar, Fracture Mechanics

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	--	--	--	--	--	--	--	--	--
CO2	3	2	2	1	1	--	--	--	--	--	--	--	--	--
CO3	2	1	1	1	1	--	--	--	--	--	--	--	--	--
CO4	3	3	2	2	1	--	--	--	--	--	--	--	--	--
CO5	3	2	3	2	1	--	--	--	--	--	--	--	--	--

Course Code: PE613ME

COMPUTATIONAL FLUID FLOWS
(Professional Elective-III)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To understand the equations of fluid flow.
- To learn Finite difference method with heat transfer equations and grid generation.
- To learn Finite volume method and staggered grid.

Course outcomes: At the end of the course the student will be able to:

S.No	Statement	Blooms Level
CO1	Establish the governing equations for different types of fluid flow systems.	L3
CO2	Illustrate method of averaging of turbulent flow properties and classify second order partial differential equations.	L2
CO3	Devise finite difference equations based on accuracy, type of differencing and analyse their stability.	L4
CO4	Solve equations using FDM and numerical methods on discretised domain.	L3
CO5	Apply Finite volume method for basic equations of heat transfer and fluid flow problems.	L3

Unit-I

Review of basic equations of fluid dynamics: Continuity, Momentum and Energy equations- Navier Stokes equations, Reynolds and Favre averaged N-S equations. Heat transfer conduction equations for steady and unsteady flows. Steady convection-diffusion equation.

Unit-II

Introduction to turbulence, Mixing length model, K-ε turbulence Model.
Classification of PDEs-Elliptic, parabolic and hyperbolic equations. Initial and boundary value problems.

Unit-III

Concepts of Finite difference methods- forward, backward and central difference. Finite difference solutions-Parabolic partial differential equations. Euler, Crank Nicholson,Implicit methods. Higher order difference methods. Errors, consistency. stability analysis- von Neumann analysis. Convergence criteria.

Unit-IV

Numerical Methods– Jacobi, Gauss Seidel and ADI methods. 1D and 2D Elliptic partial differential equations Problems. Viscous incompressible flow, Stream function- Vorticity method. Introduction to Grid Generation- Types of grid- O,H,C.

Unit- V

Introduction to finite volume method. Finite volume formulations for diffusion equation, convection diffusion equation. Solution algorithm for pressure velocity coupling in steady flows, Staggered grid, SIMPLE Algorithm.

Suggested Reading

1. Muralidhar K, Sundararjan T, *Computational Fluid Flow and Heat transfer*, Narosa Publishing House, 2003.
2. Chung, T J, *Computational Fluid Dynamics*, Cambridge University Press, 2002.
3. Patankar, S V, *Numerical Heat transfer and Fluid flow*, Hemisphere Publishing Company, New York, 1980.

4. John D Anderson, *Computational Fluid Dynamics*, Mc Graw Hill, Inc., 1995.
5. Pradip Niyogi, Chakrabartty S K, Laha M K, *Introduction to Computational Fluid Dynamics*, Pearson Education, 2005.

Articulation Matrix:

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	3	3	2	1	1	-	-	-	-	-	-	-	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	-	-
CO3	3	3	3	3	2	-	-	-	-	-	-	-	-	-
CO4	3	3	3	3	2	-	-	-	-	-	-	1	1	-
CO5	3	3	3	3	2	-	-	-	-	-	-	1	1	-

Course Code: PE614ME

NON-CONVENTIONAL MACHINING & FORMING METHODS

(Professional Elective-III)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To know the various unconventional methods of machining and forming techniques.
- To understand the principles, advantages and applications of unconventional machining and forming processes.
- To know the various process parameters and their effect on machining and forming.

Course outcomes: At the end of the course the student will be able to:

S.No	Statement	Blooms Level
CO1	Illustrate the basic principles of non-conventional machining techniques.	L3
CO2	Select non-conventional machining techniques for various materials.	L2
CO3	Illustrate principles of non-conventional forming techniques.	L3
CO4	Select modern forming processes to various metals.	L2
CO5	Analyze the process parameters of non-conventional machining and forming techniques.	L4

Unit-I

Ultrasonic Machining (USM): Process description, abrasive slurry, Abrasive materials and their characteristics.

Functions of liquid medium in slurry. Types of Transducers, effect of process parameters, applications and limitations.

Abrasive Jet Machining (AJM): Principle of operation, process details, process variables and their effect on MRR and accuracy. Equation for MRR. Advantages, disadvantages and applications.

Water Jet Machining (WJM): Schematic diagram, equipment used, advantages and applications.

Unit-II

Electro Discharge Machining (EDM): Process description with schematic diagram, process parameters, functions and characteristics of dielectric medium, dielectric fluids, over cut and side taper Flushing, Mechanism of metal removal, crater volume, types of power supply circuits, mathematical analysis of metal removal rate (MRR), characteristics of spark eroded surfaces, advantages, disadvantages and applications, wire electro-discharge machining principles and description.

Electro-Chemical Machining (ECM): Schematic of the process, process parameters, function and characteristics of electrolyte, chemistry of the process. Equation for specific MRR and electrode feed rate, advantages, limitations and applications.

Rotary Machining, Hot machining, high speed machining, description of each process, process parameters, advantages and applications.

Unit-III

LASER Beam Machining (LBM): Principle of LASER Beam production, materials used, thermal analysis of the process, process parameters, equations for power density and machining rate, advantages, limitations and applications.

Plasma Arc Machining (PAM): Equipment used, process description and parameters, types of plasma arc: Transferred arc and non-transferred arc and process applications.

Electron Beam Machining (EBM): Schematic of the process, process parameters, principle of production of Electron beam, equipment used, Advantages, disadvantages and applications. ION Etching: Process description and applications.

Hybrid Machining Processes: Principle and applications of Electro chemical discharge

machining, electro chemical abrasive finishing, electro discharge abrasive grinding.

Unit-IV

Rubber Pad Forming: Principle of the process, process details, process variants - Guerin, wheelon, Marforming and Hydro forming processes and applications.
High Energy Rate Forming (HERF): Advantages of high energy rate forming, Explosive forming: Explosive materials, standoff operation and contact operation, advantages and applications. Electro-Hydraulic Forming (EHF): Schematic of the process, description and its applications. Electro-Magnetic Forming (EMF): Process details and parameters, materials used and applications. HERF hammers.

Unit- V

Stretch Forming: Introduction, types of stretch forming: stretch draw forming, rotary stretch forming or stretch wrapping, compression forming, radial draw forming. Stretch forming equipment and accessories, accuracy and surface finish, process variables and limitations.
Tube spinning: Introduction, methods of tube spinning, Backward spinning, Forward spinning, machines and tools used. Machine variables, speeds and feeds, effect of tube spinning on work metal properties and applications.
Hydrostatic Forming: Process principle description and applications.
Water Hammer Forming (WHF): Schematic diagram of the process, principle of operation, process variable, work materials, process limitations and applications.

Suggested Reading:

1. Pandey PC. and Shah H.S., "Modern Machining Process", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1980
2. Bhattacharya A., "New Technology", the Institution of Engineers, India, 1984.
3. Davies and Austin, "Developments in High Speed Metal Forming". The Machinery Publishing Co. Ltd., 1985
4. Mikell. P. Groover "Principles of Modern Manufacturing" Wiley India Pvt. Ltd., New Delhi, 2014.
5. Hassan Abdel-Gawad El-Hofy, Advanced Machining Processes, Nontraditional and Hybrid Machining Processes, McGraw Hill Publishing Co. Ltd.

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS O1	PS O2
CO1	3	2	1	1	1	-	-	-	-	-	-	-	-	-
CO2	3	3	2	2	1	1	-	-	-	-	-	-	-	-
CO3	3	2	1	1	1	-	-	-	-	-	-	-	-	-
CO4	3	2	2	2	1	1	-	-	-	-	-	-	-	-
CO5	3	3	1	1	2	-	-	-	-	-	-	-	-	-

Course Code: OE601BM

ENGINEERING APPLICATIONS IN MEDICINE

(Open Elective-I)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- Provide a basic knowledge of human physiology to engineering graduate students.
- Understand the applications of various branches of engineering in Medicine.

Course outcomes: At the end of the course the student will be able to:

1. Importance and evolution of medical health care
2. Applications of solid and fluid mechanics in bio medical systems
3. Evaluation of Brain machine interface based systems
4. understand the characteristics and design challenges in signal processing of bio-mechanical systems
5. Choose replacement materials for various implants

UNIT-I

Evolution of Modern healthcare, Major organ systems- Cardiovascular, Respiratory, Nervous, Skeletal, Muscular. Homeostasis. Physiological signals and their diagnostic importance.

UNIT-II Solid mechanics-Analysis of muscle force and joint reaction force for the limb joints. Fluid mechanics-Factors governing and opposing blood flow, Wind-Kessel model, Application of HagenPoiseuille flow to blood flow.

UNIT-III Brain-Computer Interface: Brain signals for BCIs, Generic setup for a BCI, Feature extraction and Feature translation involved in BCIs. Typical applications-Word forming, Device control.

UNIT-IV Bioelectricity-Excitable cells, Resting potential, Action potential, Accommodation, Strength-Duration Curve, Propagation of impulses in myelinated and unmyelinated nerves. Medical Instrumentation system-Functions, Characteristics, Design Challenges. Signal Processing-QRS detection.

UNIT-V Materials and Tissue Replacements-Types of Biomaterials- Metals, Polymers, Ceramics and Composites and their applications in Soft and Hard tissue replacements. Implants-Manufacturing process, Design, fixation.

Suggested Reading:

1. John Enderle,Susan m. Blanchard and Joseph Bronzino, Introduction to Biomedical Engineering, Second Edition, Elsevier, 2005.
2. Joseph D.Bronzino, Biomedical Engineering Fundamentals, 3rd Edition, CRC press, 2006
3. Ozkaya, Nordin. M, Fundamentals of Biomechanics, Springer International Publishing, 4th Edition, 2017.

Course Code: OE 602 CE

DISASTER MANAGEMENT

(Open Elective-I)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

• To provide students an exposure to disasters, their significance and types.
• To ensure that students begin to understand the relationship between vulnerability, disasters, disaster prevention and risk reduction
• To gain a preliminary understanding of approaches of Disaster Risk Reduction (DRR)
• To enhance awareness of institutional processes in the country and
• To develop rudimentary ability to respond to their surroundings with potential disaster response in areas where they live, with due sensitivity

Course Outcomes:

• The students will be able to understand impact on Natural and manmade disasters.
• Able to classify disasters and destructions due to cyclones
• Able to understand disaster management applied in India

UNIT-I

Introduction to Disasters: Concepts and definitions of Disaster, Hazard, Vulnerability, Resilience, Risks. Natural and Manmade disasters, impact of drought, review of past disasters and drought in India, its classification and characteristics. Classification of drought, causes, Impacts (including social, economic. political, environmental, health, psychosocial, etc.).

UNIT-II

Disaster: Classifications, Causes, Impacts including social, economic, political, environmental, health, psychosocial etc. □□ Differential Impacts - in terms of caste, class, gender, age, location, disability Global trends in disasters, urban disasters, pandemics, complex emergencies, climate change. Cyclones and Floods: Tropical cyclones & Local storms, Destruction by tropical cyclones and local storms, Cumulative atmospheric hazards/ disasters, Cold waves, Heat waves, Causes of floods, Rood hazards in India.

UNIT-III Approaches to Disaster Risk Reduction: Disaster cycle - its analysis, Phases, Culture of safety, prevention, mitigation and preparedness community based DRR, Structuralnonstructural sources, roles and responsibilities of community, Panchayati Raj Institutions/Urban Local Bodies (PRis/ULBs), states, Centre, and other stake-holders.

UNIT-IV Inter-relationship between Disasters and Development: Factors affecting Vulnerabilities, differential impacts, impact of development projects such as darns, embankments, changes in Land-use etc. Climate Change Adaptation, Relevance of indigenous knowledge, appropriate technology and local resources.

UNIT-V Disaster Risk Management in India: Hazard and Vulnerability profile of India Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, Waste Management Institutional

arrangements (Mitigation, Response and Preparedness, OM Act and Policy, other related policies, plans, programmes and legislation) Field Work and Case Studies: The field work is meant for students to understand vulnerabilities and to work on reducing disaster risks and to build a culture of safety. Projects must be conceived creatively based on the geographic location and hazard profile of the region where the college is located.

Suggested Reading :

1. Sharma V. K. (1999). Disaster Management, National Centre for Disaster Management, IIPE, Delhi.
2. Gupta Anil K, and Sreeja S. Nair. (2011). Environmental Knowledge for Disaster Risk Management, NIDM, New Delhi.
3. Nick. (1991). Disaster Management: A Disaster Manager's Handbook. Asian Development Bank, Manila Philippines.
4. Kapur, et al. (2005). Disasters in India Studies of grim reality, Rawat Publishers, Jaipur.
5. Pelling Mark, (2003). The Vulnerability of Cities: Natural Disaster and Social Resilience Earthscan publishers, London.

Course Code: OE 603EC

ELECTRONIC INSTRUMENTATION

(Open Elective-I)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

1. To familiarize with various measurement parameters and Standards of measurement.
2. To learn the working principles of various types of Microphones and Hygrometers.
3. To understand the operation and applications of CRO.
4. To understand about the operation of various transducers.
5. To understand the importance of biomedical instrumentation and Virtual instrumentation.

Course Outcomes:

1. Analyze the various characteristics of measurement parameters and Standards of measurement.
2. Evaluate the operation and application of microphones
3. Use the CROs for various applications and explore its features.
4. Explore various types of Transducers and their characteristics.
5. Analyze the operation of various biomedical instruments and the features of Virtual Instrumentation.

UNIT – I

Measurement parameters: History of instrumentation. Error in Measurement, Types of Errors, Statistical analysis of errors, Limiting errors, Standards of measurement, IEEE and ISO standards.

UNIT – II

Microphones and Hygrometers: Microphones: Microphones and their types, Humidity measurement, resistive, capacitive, aluminium-oxide and crystal Hygrometer types – Operation and applications.

UNIT – III CRO: Basic Principle of CRT, its features, Block diagram and operation of CRO, Oscilloscope Controls, Waveform display, Measurement of frequency and Phase using Lissajous method, Applications and Advantages of CRO.

UNIT –IV Transducers: Introduction, Electrical Transducer, Factors for Selecting a Transducer, Active and Passive Transducers, Operation and applications of Resistive transducers, Strain gauges and Thermistors.

UNIT –V Biomedical and Virtual Instrumentation: Biomedical instrumentation, Bio-potential electrodes, Principles of operation and applications of ECG, EEG, EMG, X-ray machines, CT scanners and Introduction to virtual instrumentation.

Suggested Reading:

1. Albert D.Helfrick and William D.Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Prentice-Hall of India Private Limited, New Delhi, 1996.

2. H S Klasi, “Electronic Instrumentation”, Tata McGraw-Hill Company Limited, New Delhi, 2004.
3. David A.Bell, “Electronic Instrumentation and Measurements”, 2nd Edition, PrenticeHall of India Private Limited, New Delhi, 1994.
4. R.S.Khandpur, “Handbook of biomedical Instrumentation”, Tata McGraw- Hill publishing company Limited, New Delhi, 2000.

Course Code: OE 604EC

PRINCIPLES OF ELECTRONIC COMMUNICATION SYSTEMS

(Open Elective-I)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

1. Provide an introduction to fundamental concepts in the understanding of communications systems.
2. Provide an introduction to network model and some of the network layers including physical layer, data link layer, network layer and transport layer.
3. Provide an introduction to the evolution of wireless systems and current wireless technologies.

Course Outcomes: Student will be able to

CO1 Understand the working of analog and digital communication systems
C02 Understand the OSI network model and the working of data transmission
CO3 Understand the concepts of modulation and demodulations
CO4 Understand the evolution of communication technologies from traditional telephony systems to modern wireless communication systems.
CO5 Understand the principles of optical communications systems

UNIT- I

Introduction to communication systems: Electromagnetic Frequency Spectrum, Signal and its representation, Elements of Electronic Communications System, Types of Communication Channels, Signal Transmission Concepts-Baseband transmission and Broadband transmission, Communication parameters-Transmitted power, Channel bandwidth and Noise, Need for modulation Signal Radiation and Propagation-Principle of electromagnetic radiation, Types of Antennas, Antenna Parameters and Mechanisms of Propagation.

UNIT- II

Analog and Digital Communications: Amplitude modulation and demodulation, FM modulation and demodulation, Digital converters, Digital modulation schemes – ASK, FSK, PSK, QPSK, Digital demodulation.

UNIT- III

Data Communication and Networking: Network Models, OSI Model, Data Link Layer – Media Access control, Ethernet, Network Layer – Internet Protocol (IPv4/IPv6), Transport Layer – TCP, UDP.

UNIT- IV

Telecommunication Systems: Telephones, Telephone system, Paging systems, Internet Telephony. Optical Communications: Optical Principles, Optical Communication Systems, Fiber –Optic Cables, Optical Transmitters & Receivers, Wavelength Division Multiplexing.

UNIT- V

Wireless Communications: Evolution of Wireless Systems: AMPS, GSM, CDMA, WCDMA, And OFDM. Current Wireless Technologies: Wireless LAN, Bluetooth, PAN and ZigBee, Infrared wireless, RFID communication, UWB, Wireless mesh networks, Vehicular adhoc networks.

Suggested Readings:

1. Louis E. Frenzel, “Principles of Electronic Communication Systems”, 3e, McGraw Hill publications, 2008.
2. Behrouz A. Forouzan, “Data Communications and Networking”, 5e TMH, 2012. 3. Kennady, Davis, “Electronic Communications systems”, 4e, TMH, 1999.

Course Code: OE605ME

3D PRINTING TECHNOLOGY

(Open Elective-I)

Credits:3

Instructions: (3L) hrs per week *Duration of SEE: 3hours*
CIE: 30 Marks *SEE: 70 Marks*

Course Objectives:

- To understand the fundamental concepts of 3D Printing, its advantages and limitations.
- To know the working principle, advantages, disadvantages and applications of liquid, solid and Powder based 3D Printing Technologies.
- To know the various types of STL file errors and other data formats used in 3D Printing Technology.
- To know the features of various 3D Printing software's.
- To know diversified applications of 3D Printing Technologies.

Course outcomes: At the end of the course the student will be able to:

S.No	Statement	Blooms Level
CO1	Interpret the features of 3D Printing and compare it with conventional methods.	L2
CO2	Illustrate the working principle of liquid, solid and powder based 3D Printing Technologies.	L2
CO3	Identify various types of errors in STL file and other data formats used in 3D Printing Technology.	L3
CO4	Select suitable software used in 3D Printing Technology.	L2
CO5	Apply the knowledge of various 3D Printing technologies for developing innovative applications.	L3

Unit-I

Introduction: Prototyping fundamentals: Need for time compression in product development, Historical development, Fundamentals of 3D Printing, 3D Printing Process Chain, Advantages and Limitations of 3D Printing, 3D Printing wheel, Commonly used Terms, Classification of 3D printing processes, Fundamental Automated Processes: Distinction between 3D Printing and Conventional Machining Processes.

Unit-II

Liquid-based 3D Printing Systems: Stereo Lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages, Case studies. Polyjet: Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies

Solid-based 3D Printing System: Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

Unit-III

Powder Based 3D Printing Systems: Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following 3D Printing Technologies like Selective laser sintering (SLS), Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS), Laser Engineered Net Shaping (LENS), Electron Beam Melting (EBM),

Unit-IV

3D Printing Data Formats & Software: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. 3D Printing Software's Features: Magics, Mimics, Solid View, View Expert, 3 D Rhino, 3 D doctor, Flash Print, Object Studio, Cura, ITK Snap, 3-matic, Simplant, 3-matic, Simplant, MeshLab, Ansys for Additive Manufacturing.

Unit-V

Applications of 3D Printing : Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Electronic Industry, Jewellery Industry, Coin Industry, GIS application, Arts and Architecture. RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Biomolecules. Biopolymers, Packaging, Disaster Management, Entertainment and Sports industry.

Suggested Readings:

1. Chee Kai Chua and Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" Fifth Edition, World scientific
2. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing- Ian Gibson, David W Rosen, Brent Stucker, Springer, Second Edition, 2010.
3. Rapid Prototyping & Engineering Applications – Frank W.Liou, CRC Press, Taylor & Francis Group, 2011.
4. RafiqNoorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.
5. NPTEL Course on Rapid Manufacturing. https://nptel.ac.in/courses/112/104/112104265/

Articulation Matrix:

SNO	PO1	PO2	PO3	PO4	PO5	PO6	P07	P08	P09	P010	P011	P012	PSO1	PSO2
CO1	3	2	2	2	1	-	-	-	-	-	-	-	-	-
CO2	3	3	2	1	1	-	-	-	-	-	-	1	1	1
CO3	3	2	2	1	2	-	-	-	-	-	-	1	1	1
CO4	2	2	2	1	2	-	-	-	-	-	-	1	1	-
CO5	3	2	3	1	2	-	-	-	-	-	-	1	1	1

FACULTY OF ENGINEERING

Scheme of Instruction & Examination

(AICTE Model Curriculum for the Academic Year 2020-2021)

and

Syllabi

B.E. V and VI Semester

of

Four Year Degree Programme

in

Automobile Engineering

(With effect from the academic year 2020 – 2021)

(As approved in the faculty meeting held on - -2020)

Issued by

Dean, Faculty of Engineering

Osmania University, Hyderabad – 500 007

2020

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Automobile Engineering) V – SEMESTER

S.No.	Course Code	CourseTitle	Schemeof Instruction				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC501AE	Internal Combustion Engines	3	-	-	3	30	70	3	3
2	PC502AE	Automotive Transmission	3	-	-	3	30	70	3	3
3	PC503AE	Design of MachineComponents	3	-	-	3	30	70	3	3
4	PC503ME	Dynamics of Machines	3	-	-	3	30	70	3	3
5	PC505ME	Heat Transfer	3	-	-	3	30	70	3	3
LaboratoryCourse										
6	PC591AE	Automotive Engineering Lab	-	-	2	2	25	50	3	1
7	PC592AE	Fuels, Lubricants & Engine Testing Lab	-	-	2	2	25	50	3	1
8	PC592ME	Dynamics of Machines Lab	-	-	2	2	25	50	3	1
		Total	15	-	06	21				18

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Automobile Engineering) VI – SEMESTER

S.No.	Course Code	Course Title	Scheme of Instructions				Scheme of Examination			Credits
			L	T	P/D	Contact Hours/Week	CIE	SEE	Duration in Hours	
Theory Course										
1	PC601AE	Design of Automotive Components	3	-	-	3	30	70	3	3
2	PC602AE	Computer Aided Design, Analysis & Manufacturing	3	-	-	3	30	70	3	3
3	PC603AE	Production Technology	3	-	-	3	30	70	3	3
4	PE-I	Professional Elective – I (PTAV, MHEMV, EH Vehicles)	3	-	-	3	30	70	3	3
5	OE-1	Open Elective – 1	3	-	-	3	30	70	3	3
6	OE-2	Open Elective – 2	3	-	-	3	30	70	3	3
Laboratory Course										
7	PC691AE	CAD/CAM/CAE Lab	-	-	2	2	25	50	3	1
8	PC692AE	Production Technology Lab	-	-	2	2	25	50	3	1
9		Summer Internship*								2
		Total	18	00	04	22				22

Open Elective - 1 (OE601ME) : Entrepreneurship (Not for Mechanical / Prod. / Automobile)
Open Elective - 2 (OE602ME) : Industrial Robotics (Not for Mechanical / Prod. / Automobile)

PROFESSIONAL ELECTIVE - I	
PE611AE	**Performance And Testing Of Automotive Vehicles**
PE612AE	**Material Handling and Earth Moving Vehicles**
PE613AE	**Electric and Hybrid Vehicles**

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

* *At the end of VI semester students should undergo summer Internship - Credits for Summer Internship will be awarded in VII semester*

Course Code	Course Title						Core/Elective
PC501AE	**Internal Combustion Engines**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives:

- To understand air standard cycles and basic principle of operation of petrol and diesel engines.
- To understand the working of fuel supply systems of I C Engines.
- To understand the working of ignition, cooling and lubrication systems of IC Engines.
- To understand combustion process in IC engines and know different combustion chambers, supercharging and turbocharging
- To understand the performance and emission characteristics of I C Engines and latest developments in engine technology.

Course Outcomes

The student is able to

1. Calculate efficiency of air standard cycles and demonstrate working principle I C Engines.
2. Distinguish between fuel supply systems used for I C Engines.
3. Select suitable ignition, cooling and lubrication systems for any I C Engine.
4. Explain combustion phenomenon in IC engines & select combustion chamber, supercharging/ turbocharging method for the engines
5. Evaluate the performance and emission characteristics of I C Engines and explain latest developments in engine technology.

UNIT – I

BASIC THEORY

Otto Cycle, Diesel Cycle and dual cycles. Derivation for efficiency and problems solving. Constructional details of I C engines,working principles of two stroke and four stroke petrol and diesel engines. Comparison of two stroke and four stroke engines. Valve timing and port timing diagrams.

UNIT – II

FUEL SUPPLY SYSTEMS

Carburettor-Requirements, Working principle, starting, idling, acceleration and normal circuits of carburettors. Fuel feed systems- mechanical and electrical fuel feed pumps. Petrol injection, MPFI. Requirements of fuel injection, functions of components, jerk and distributor type pumps, common rail system, PTFI system pressure waves, injection lag, unit injector, mechanical and pneumatic governors, fuel injector, types of injection nozzles.

UNIT – III

Ignition System

Working of battery and magneto ignition systems, relative merits and demerits, centrifugal and vacuum advance mechanisms. Types and construction of spark plugs, electronic ignition systems.

Cooling and Lubrication System

Need for cooling system, Types of cooling system: air cooling system, liquid cooling system, forced circulation system, pressure cooling system. Lubrication system; mist, wet sump lubrication system. Properties of lubricants.

UNIT – IV

Combustion and Combustion Chambers

Combustion in SI engine: stages of combustion, flame propagation, rate of pressure rise, abnormal combustion, detonation, effect of engine variables on knock, knock rating. Types of Combustion chambers for Si Engines.

Combustion in CI Engine: Stages of combustion, delay period, factors affecting delay period, knock in CI engines. Comparison of knock in CI & SI engines. Combustion chambers- design requirements, direct and indirect injection combustion chambers.

SUPERCHARGING AND TURBOCHARGING

Importance of Supercharger and Turbocharger. Types of supercharging and Turbo charging, Limitations, Effect of Supercharging and Turbo charging on power output & efficiency of engine.

UNIT – V

ENGINE TESTING AND PERFORMANCE

Automotive and stationary engine testing and related emission standards. Engine performance and emission characteristics, variables affecting engine performance and emission, methods to improve engine performance, heat balance, performance maps. Introduction to Stratified charge engine, LHR engines, HCCI and RCCI engines, Problems.

Suggested Reading

1.Ganesan."*Internal Combustion Engines*", Tata McGraw-Hill Publishing Co., New Delhi, 2003.

2.M.L.Mathur and R. P.Sharma "*A course in Internal Combustion Engines*", DhanpatRai and Sons, 2002.

3.Dr.K.K.Ramalingam "*Internal Combustion Engines Theory and Practice*", Scitech Publications (India), Pvt. Ltd., Chennai 600 017, 2002.

4.Heywood.J.B "*Internal Combustion Engine Fundamentals*", McGraw-Hill Book Co., 1988.

5.Pulkrabek "*Engineering Fundamentals of the Internal Combustion Engines*", Practice Hall of India ,2003

Course Code	Course Title						Core/Elective
PC502AE	**Automotive Transmission**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand working principle of Clutches.
- To understand construction, working and classification of gear box and troubleshooting aspects
- To understand construction working, of fluid flywheel and torque converter
- To know about automatic transmission systems and their applications.
- To know the concepts of hydrostatic drive and electric drive

Course Outcomes:

After completing this course, the student will be able to

1. To know construction, working and types of clutches with trouble shooting aspects.
2. To know and analyze the construction, working and classification of gear box with trouble shooting aspects
3. Explain the working, scope and significance of fluid flywheel and torque converter.
4. Understand the scope and working of automatic transmission systems.
5. Understand hydrostatic drive And electric drive and there application

UNIT-I

CLUTCH: Need of clutch, requirements, materials, different types of clutches, principle of friction clutches, single plate, multi-plate, diaphragm, cone, centrifugal clutch, method of actuation; electromagnetic, hydraulic, vacuum, adjustment, wet and dry friction clutches clutch trouble shooting diagnosis, numerical problems

Unit-II

GEAR BOX: Functions of transmissions, necessity of gear box, gears, gear ratio and torque, types of transmission; manual and automatic transmission, sliding-mesh gear box, constant-mesh gear box, synchromesh gear box, transfer box, transaxle. Selector mechanism and; types and interlock devices, gearbox lubrication. Calculation of gear ratios for vehicles, performance characteristics in different gears. Switches and sensors - Transmission Controlled Spark (TCS), troubleshooting diagnosis and servicing and maintenance of manual transmission and transaxle.

UNIT-III

Hydrodynamic Transmission Fluid Coup Understand **ling**: Fluid coupling- principles- performance characteristics- advantages and limitations, construction details, torque capacity, slip in fluid coupling, performance characteristics.

Torque Converter

Principal of torque conversion, single, multi stage and poly phase torque converters, Automobile Torque Converter Arrangements, performance characteristics, constructional and operational details of typical hydraulic transmission drives

UNIT-IV

Automatic Transmission: Spur and internal gear type planetary gearboxes, Relative merits and demerits when compared to conventional transmission, automatic control of gears, study of typical automatic transmissions, Ford and Chevrolet drive, and automatic control of gear box. Continuously Variable Transmission (CVT)-types-Operations.

UNIT-V

HYDROSTATIC DRIVES: Principle of hydrostatic drives, different systems of hydrostatic drives, types of pumps, advantages and limitations, typical hydrostatic drives.

ELECTRIC TRANSMISSION: General arrangement and description of electric transmission, their working principle and control mechanisms and limitations

Suggested Reading

1. Heldt P.M - *Torque converters*- Chilton Book Co.-1992.
2. Newton and Steeds - *Motor Vehicle*- Illiffee Publisher- 2000
3. *Design Practices, passenger Car Automotive Transmissions*- SAE Hand book- 1994
4. K.M. Gupta, *Automobile Engineering*,, Volume 1, Umesh Publications, 2001
5. Crouse & Anglin, "*Automotive Mechanics*" McGraw hill, 10th edition

Course Code	Course Title						Core/Elective
PC503AE	**Design of Machine Components**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- To know the mechanical properties of materials used in mechanical systems; Component manufacturing consideration; stresses in different types of loading,
- To understand the significance of theories of failure for safe design; fatigue-factors affecting and design for fatigue. S-N diagram, Soderberg and Modified Goodman's diagrams for fatigue design. Cumulative fatigue – Miner's rule
- To understand the design principles for various load conditions for the design of components such as Shafts- solid, hollow and splined; Standard types of couplings
- To understand the design principles for various load conditions for the design of joints, joining members like bolts, weldments and rivets; Power transmission – pulleys, chains
- To understand the use of above principles for various load conditions for the design of power screws differential and Compound Screws. Design of riveted and welded joints under direct and eccentric loads

Course Outcomes

After completing this course, the student will be able to:

1. Formulate and analyze stresses and strains in machine elements andstructures in 3-D subjected to various loads. Apply multidimensional static failure criteria in the analysis and design of mechanical components.
2. Gain knowledge of fatigue failure and load-life relation
3. Analyze and design power transmission shafts carrying various elements with geometrical features. Design and analyze shafts with different geometrical features under various loading conditions. Calculate critical speed of shafts and make the design decisions accordingly.
4. Design and analyze detachable joints (bolts, keys, pins, etc.) under various loading conditions.
5. Design machine elements like power screws and screw jack considering: allowable load, materials, mode of failure, operating conditions and required life. Stresses in power screw. Design procedure of a power screw, differential and compound screws

UNIT-I

Design considerations of Machine Elements

Materials used in machine design and their specifications according to Indian Standards. Codes and standards used in design. Important mechanical properties of materials used in design. Preferred numbers. Manufacturing considerations in design. Review of types of loads and simple stresses. Stresses due to Biaxial and Triaxal loads. Factor of safety. Theories of failure. Design of components subjected to impact loading.

UNIT-II

Design for Fatigue

Fluctuating stresses, fatigue strength and endurance limit, Stress concentration factor and Notch sensitivity. Factor effecting fatigue strength. S-N diagram, Soderberg and Modified Goodman's diagrams for fatigue design. Cumulative fatigue – Miner's rule.

UNIT-III

Design of shafts

Solid, hallow and splined shafts under torsion and bending loads. Design of keys.

Design of couplings

Muff, Split muff, Flange, Flexible, Marine type couplings and slip couplings.

UNIT-IV

Design of Joints

Cotter and Knuckle joints. Design of pulleys. Design of chains drives linked and laminated chains. Design of bolts and nuts, Locking devices for nuts, Bolts of uniform strength. Bolted joints under eccentric loads. Design of gasket joints.

UNIT-V

Design of Power Screws And Screw Jack

Differential and Compound Screws. Design of riveted and welded joints under direct and eccentric loads.

Suggested Reading

1. M.F. Spotts, *Design of Machine Elements,* Pearson Edu, 7th Ed. 2003.
2. V.B. Bhandari, *Machine Design,* Tata McGraw – Hill Publ, 2004.
3. P.C. Sharma & D.K. Aggarwal, *Machine Design,* S.K. Kataria & Sons, 10th ed, 2003.
4. P. Kannaiah, *Machine Design,* Scu-Tech Publ., 2003
5. J.E.. Shigley & Charles R. Mischke, *Mechanical Engineering Design,* Tata McGraw-Hill, 6th ed., 2003.

Course Code	Course Title						Core/Elective
PC503ME	DYNAMICS OF MACHINES						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
Kinematics of Machines	3	--	--	--	30	70	3

Course Objectives:

- To know effect of inertia of links, and external forces on the input torque, and forces developed at joints in typical mechanisms in motion; understand the gyroscopic couple and its effect on vehicles in motion.
- To know the working principles and characteristics of typical governors, as also the function of flywheels.
- To know the concept of unbalancing rotating and reciprocating masses in single and multi-cylinder in line and radial engines.
- To understand the phenomena of free of free and forced, including the effect of damping for single dof systems, and concepts of isolating vibration.
- To determine natural frequencies of undammed, damped and forced vibrating systems of one, two and multi degree freedom systems.

Course Outcomes:

- Analyse static and dynamic forces in slider crank and other mechanisms; determine the magnitude of gyroscopic couple and its effect on vehicles in motion.
- Evaluate the performance of various types of governors and design flywheels considering speed and energy fluctuation
- Analyse problems of balancing in rotating and reciprocating machinery.
- Evaluate the natural frequencies of single and two degree of freedom systems in free and forced vibration mode, also considering the effect of damping.
- Determine the natural frequencies and mode shapes of multi degree of freedom systems, including by Dunkerley, Raleigh and Holzer methods.

UNIT-I

Static and Dynamic Force Analysis: *Static equilibrium:* Constraint and Applied forces, Static Force analysis of Single slider crank mechanism without Friction, Principle of Superposition.

Dynamic Equilibrium: d'Alambert's Principle, Equivalent offset inertia force, Dynamic force Analysis of Slider Crank Mechanism,

Engine Force Analysis: Piston effort, Force along connecting rod, thrust on sides of cylinder, crank effort. Thrust on bearing. Dynamically Equivalent System for Connecting Rod.

Gyroscope: Gyroscopic Couple, gyroscopic effects on aeroplanes, naval ships.

Stability of two wheel vehicle only.

UNIT-II

Governors: Working principle of governor, Classification & types of governors, analysis of Watt, Porter, and Hartnell governors. Characteristics of governors:

Controlling Force, Stability, Isochronism, Sensitivity, Power and Effort of governors.

Flywheels: Functions, Differences between flywheel and governor, turning moment diagrams, flywheel analysis for I-C Engines and presses.

UNIT - III

Balancing: Static balancing, Dynamic balancing, balancing of several masses rotating in several planes, consideration of bearing forces, balancing of reciprocating masses, primary balancing shaking forces in single cylinder engine, partial balancing and its effects, secondary balancing.

UNIT - IV

Vibrations: Vibrations of Single degree freedom system (axial, transverse and torsional), Equivalent system of combination of springs, Stepped shaft, Whirling speed of shafts.

Damped Vibrations: Types of damping, Vibrations with viscous damping

Forced Damped Vibrations: Magnification factor, Resonance, Vibration isolation and Transmissibility.

UNIT –V

Vibration Analysis of Multi Degree Freedom Systems: Torsional Vibrations of Two rotor, three rotor and Geared systems. Natural frequencies of two degree freedom systems Modes of vibration approximate methods for determining natural frequencies: Dunkerley's method, Rayleigh's method. Holzer's method (only Theory).

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. Thomas Bevan, the Theory of Machines, CBS Publishers & Distributors, 2004.
3. John J.Uicker, Jr. Gordon, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
4. J.S. Rao and Gupta, Theory and Practice of Mechanical Vibrations, Prentice Hall, 1984.
5. R.L.Nortan, "Kinematics and Dynamics of Machinery", Tata McGraw Education Pvt. Ltd , New Delhi, 2009.
6. Ghosh and Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press, 1988.

Course Code	Course Title						Core/Elective
PC505ME	**HEAT TRANSFER**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
FLUID MECHANICS	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- The basic concepts of heat transfer Obtaining centroids and moments of inertia for various regular and irregular areas.
- The concepts of conduction, convection, radiation and heat exchangers applicable for commercial and industrial use
- The applications of various experimental heat transfer correlations in engineering applications.
- Thermal analysis and sizing of heat exchanger.
- solving problems on different modes of heat transfer which are related to thermal power plants, refrigeration and air conditioning

Course Outcomes

After completing this course, the student will be able to:

1. To understand the basic concepts of heat transfer.
2. To understand the concepts of heat transfer through extended surfaces.
3. To Familiarize with time dependent heat transfer and compute convective heat transfer coefficients in forced, natural convection.
4. To understand radiation heat transfer
5. To understand , heat exchangers and mechanism involved in boiling and condensation.

UNIT – I

Conduction: Modes of Heat Transfer, Laws of Heat Transfer - Fourier, Newton, Stefan-Boltzmann General conduction equation in cartesian, cylindrical and spherical coordinates, One dimensional steady state conduction through slabs, hollow cylinders and spheres with and without heat generation, Effects of variable thermal conductivity in heat transfer of one dimensional steady state conduction of plate, cylinders and spheres, Steady state heat transfer through composite slabs, cylinders and spheres, Critical radius of insulation.

UNIT – II

Fins: Heat transfer analysis of tips with heat dissipation environment - rectangular straight and pin fins, Application of fin to temperature measurement, unsteady state conduction, Lumped parameter, analysis of a body with negligible internal temperature gradients, Transient heat transfer analysis of finite slab with specified temperature and convective boundary conditions, Use of Grober and Heisler charts for solving problems of infinite slabs, cylinders and spheres.

UNIT-III

Free and forced convection: Dimensional analysis and its use in free and forced convection, Buckingham theorem, Physical significance of different dimensionless numbers, Application of Von-Karman integral equation for the analysis of thermal boundary layer in forced convection of flat plate, Reynold's analogy for flow over plane surfaces, calculation of heat transfer for flow over plates, cylinders and for flow through tubes in free and forced convection using empirical formulae.

UNIT –IV

Radiation: Definition of absorptivity, reflectivity and transmissivity, Concept of black-body and emissivity. Kirchoffs law, Planck's black body spectral distribution, Wien's and Steffan Boltzmann law, Monochromatic and total emissive power, radiant heat exchange between two gray surfaces, Shape factor, Thermal circuit for radiant heat exchange between infinite parallel plates and between concentric, cylinders, Enclosures with black and gray surfaces, Radiation shields and re-radiation surfaces.

UNIT – V

Heat Exchangers: Classification and applications of heat exchangers in industry, Analysis and design of counter flow and parallel flow heat exchanger, Fouling factors, solving problems for multi pass heat exchanger using non dimensional parameter plots.

Change of Phase: Boiling-pool boiling regimes nucleate pool boiling, effect of surface wettability on bubble contact angle, Critical heat flux, boiling in forced convection, Condensation: Film condensation, Drop wise condensation, Condensation film thickness, Heat transfer coefficient in film condensation.

Suggested Readings:

1. Holman, J.P., "Heat Transfer", McGraw Hill Publication, New Delhi, 2010 2.
2. Rajput, R.K., "Heat and Mass Transfer", S. Chand & Company Ltd, New Delhi, 2004.
3. Yadav, R., Sanjay. and Rajay., "Heat and Mass Transfer ', Central Publishing House, Allahabad, 2004
4. Sachdeva,R.C., "Fundamentals of Engineering Heat and Mass Transfer ", New Age International (P) Ltd Publishers, New Delhi,
5. Arora, S.C. and Domkandwar., "A course in Heat and Mass Transfer ", DhanpatRai& Sons, New Delhi, 2004.

Course Code	Course Title						Core/Elective
PC591AE	**Automotive Engineering Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To understand the special tools used in the lab.
- To understand the different components of the engine and its functions.
- To make the students how to assemble and dissemble the parts of engine components like piston, connecting rod, crank shaft, timing gear, timing chain, cylinder head assembly, lubrication system and cooling system.
- To understand working of cooling system, lubrication system, ignition system and SI engine fuel system.
- To measure the Ovality and taper of cylinder bore and crankshaft Run out.

Course Outcomes

Aftercompletingthis course, thestudentwillbe ableto:

- Use the special tools and identify different components of the engine..
- Assemble and dissemble different engine components
- Demonstrate the working of cooling system, lubricating system ignition and fuel supply systems of SI Engine.
- Determine ovality and cylinder bore and crank shaft run out.

List of Experiments

1. Disassembling of 4 cylinder petrol engine
2. Assembling of 4 cylinder petrol engine
3. Disassembling of 6 cylinder diesel engine
4. Assembling of 6 cylinder diesel engine
5. Study of oil filter, fuel filter, fuel injection system, carburetor, MPFI
6. Study of ignition system components – coil, magneto and electronic ignition systems
7. Study of engine cooling system components
8. Study of engine lubrication system components
9. Ovality and taper measurement of cylinder bore and comparison with standard specifications
10. Ovality and taper measurement of engine crank shaft and comparison with standard specification

Suggested Reading

1. Ganesan. V "*Internal Combustion Engines*", Tata McGraw-Hill Publishing Co., New Delhi, 2003
2. M.L.Mathur and R.P.sharma "*A course in Internal Combustion Engines*", DhanpatRai and Sons, 2002
3. Dr.KK. Ramalingam "*Internal Combustion Engines Theory and Practice*", Scitech publications (India) Pnt. Ltd., Chennai 600 017, 2002

Course Code	Course Title						Core/Elective
PC592AE	**Fuels, Lubricants and Engine Testing Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To evaluate the properties of fuels and lubricants
- To know the actual Valve Timing and Port Timing Diagrams
- To understand the performance of SI and CI engines
- To prepare Heat Balance Sheet for SI and CI engines

Outcomes

Aftercompletingthis course, thestudentwillbe ableto:

1. Demonstrate the experiment to measure viscosity, flash and fire points of the given oils.
2. Explain the actual vale timing and port timing diagrams for ic engines.
3. Evaluate the performance of the engines
4. Estimate different ways of energy utilization in the engines.

List of Experiments

1. Temperature dependence of viscosity of lubrication oil by Redwood Viscometer.
2. Viscosity index of lubricating oil by Saybolt Viscometer.
3. Flash and Fire points of fuels.
4. Flash and Fire points of lubricants.
5. Valve Timing and Port Timing Diagrams.
6. Performance test on two wheeler SI engine.
7. Performance test on automotive multi-cylinder SI engine.
8. Performance test on automotive multi-cylinder CI engine.
9. Retardation test on I.C. Engine.
10. Heat Balance test on automotive multi-cylinder SI engine.
11. Heat Balance test on automotive multi-cylinder CI engine.
12. Morse test on multi-cylinder SI engine.

Note: Minimum ten experiments should be conducted in the semester.

Suggested Reading

1. Ganesan. V "*Internal Combustion Engines*", Tata McGraw-Hill Publishing Co., New Delhi, 2003
2. M.L.Mathur and R.P.sharma "*A course in Internal Combustion Engines*", DhanpatRai and Sons, 2002
3. Er. R. K. Rajput "Thermal Engineering", Laxmi Publications (P) Ltd.New DelhiNinth Edition,2013.

Course Code	Course Title						Core/Elective
PC592ME	**DYNAMICS OF MACHINES LAB**						**Core**
Prerequisite	**Contact Hours per week**				**CIE**	**SEE**	**Credits**
	L	**T**	**D**	**P**			
Theory of Machines	**--**	**--**	**--**	**2**	**25**	**50**	**1**

Course Objectives:

- To understand the effects and importance of kinematic and dynamic analysis of mechanisms
- To understand effects and analysis of Single degree freedom vibration systems
- To study the gyroscope, governors and cams
- To carry out the static and dynamic analysis of four bar mechanisms and drives

Course Outcomes:

- To experimentally quantify the effect of inertia forces in systems like flywheel, gyroscope and governors.
- To evaluate vibrational characteristics of various systems experimentally.
- To Synthesize balancing method of multi plane rotating masses.

List of Experiments

1. Centrifugal Governors: Experiment on Performance Characteristic Curves.
2. Estimation of Gyroscopic Couple & Understanding of Gyroscopic Effects on a rotating disc.
3. Static and Dynamic Balancing of Rotating Masses.
4. Determination of Moment of Inertia of Connecting Rod by compound pendulum method.
5. Damped and Undamped Torsional Vibrations of Single and Double Rotor System.
6. Single DOF (Degrees of Freedom) of Spring Mass Damper System. (Damped and Undamped Systems).
7. Free and Forced Vibration of Simply Supported Cantilever Beam.
8. Dunkerley Method to Find Fundamental Frequencies.
9. Critical Speed of Shaft.
10. Modal Analysis of Beam.
11. Cam Analysis of Cams.
12. Any Experiment explaining dynamic aspects of mechanical systems.

Additional Experiments Suggested

1. Determination of Moment of Inertia of Flywheel.
2. Experiment with Bifilar System.

Demonstration Experiments (Can't be allocated in final exams)

1. Velocity Ratios of Simple, Compound, Epicyclic and Differential Gear Trains.
2. Virtual Lab Experiment I – Governors.
3. Virtual Lab Experiment II – Natural Frequency of Cantilever beam.

Note: Minimum ten experiments should be conducted in the semester.

Course Code	Course Title						Core/Elective
PC601AE	**Design of Automotive Components**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce the theoretical concepts involved and help in the development of design procedures, under various loading conditions, for the most commonly occurring components in mechanical equipments.
- To know the application of kinematic principles and design concepts for design and sizing of components of an IC engine.
- To understand the applications of
    a. springs- helical and leaf Elliptical and semi elliptical;
    b. Bearings- sliding and rolling contact of different types;
    c. Transmission elements-belts,chains, gears of different types
- To know the automotive gear box, over drive, drive line and differential.

Course Outcomes

After completing this course, the student will be able to understand and realize,

1. The concepts of designing different automotive engine components.
2. The concepts of design and design considerations for springs used in automotives like coil springs, leaf springs and the associated accessories.
3. The concepts of design and design considerations for sliding & rolling contact bearings.
4. The concepts of design and design considerations different power transmission elements like belts & belt-drives, ropes & rope-drives, chain & chain-drives and gears & gear-drives, gear-box, differential, drives like Hotchkiss drive, torque tube drive

UNIT-I

Types of cylinder, piston and valves. Design of cylinder, piston, piston pin, piston rings, tappets, push rod, rocker arms, valves. Design of connecting rod, whipping stress in connecting rod.

Design of crank shaft: Centre crank shaft, Overhung crank shaft.

UNIT-II

Springs

Introduction, Different types of springs, materials used for springs, Helical springs, Whal's factor, calculation of stress, deflection and energy stored in springs, design for static and fluctuating loads. Elliptical and semi elliptical springs: stress and deflection, Nipping of leaf springs.

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UNIT –III

Bearings

Introduction materials used for bearings, Classification of bearings, Viscosity of lubricants, theory of hydrostatic and hydrodynamic lubrication. Design of sliding contact bearings, Design of aerostatic bearings and applications.

Rolling contact bearings

Types of rolling element bearings and their constructional details, static load carrying capacity, dynamic load carrying capacity. Load life relationship, selection of bearing life. Design of cyclic loads and speeds.

UNIT – IV

Design of Transmission Elements-Belts

Stress calculation in flat belt-selection criteria for V-Belt-& Design of Pulleys. Chains: Length and Pitch calculation.

Gears: Introduction to gear drives, different types of gears, materials used for gears. Spur gear design: beam strength of gear tooth, Lewis equation, wear strength of gear tooth, dynamic loads on gear tooth- Buckingham equation. Basic design of Helical, Bevel and worm gears.

UNIT –V

Design of automotive gear box

Selection of type of gears-type of gear train-design of gear shaft& corresponding bearings.

Design of over drive

Gear ratio calculations.

Design of drive line

Hotchkiss drive-Torque tube drive – Torque & Force calculations.

Differential

Speed ratio and torque calculations.

Suggested Reading

1. V.Bhandari, "*Machine Design"*, Tata McGraw Hill publication,
2. R.K. Jain, *"Machine Design",* Khanna Publishers, New Delhi, 1997.
3. P.C.Sharma and D.K.Aggarwal, "*Machine Design"*, S.K.Kataria & sons, 2003
4. A.Kolchin and V.Demidov, *"Design of Automotive Engines"*, MIR Publishers, Moscow, 1984.
5. J.E.Shigley , C.R.Mischke, *"Mechanical Engineering Design"* Tata Mc Graw hill publications.

Course Code	Course Title						Core/Elective
PC602AE	**Computer Aided Design Analysis And Manufacturing**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To know the basic design process design criteria to find alternative solution understand parametric representation of cubic spline, Bezier and B-spline curves along with concepts of NURBS.
- To understand the concepts of surface modeling, analytical surface, solid modeling and threir different approaches like C- rep and B-rep along with mass property calculations mechanical tolerance.
- To know the principals of CAD database and its structure and learn the different neutral formats, like IGES and PDES and basics of FEA.
- To know the different types of numerical control machine tools, its features and elements, CAD/CAM integration and rapid prototyping concepts.

Course Outcomes

After completing this course, the student will be able to:

1. Basic design process and geometric elements.
2. Different 2D transformations like translation, scaling, rotation, shearing and reflection.
3. CAD DATA base,basics of FEA, features and elements of numerical control machines.
4. Computer numerical control and Industrial Robots.
5. Computer aided inspection and quality control

UNIT-I

Design Processes

Computer Aided Design and Computer Aided Manufacturing, Design Process, Product life cycle. Design criteria, CAD Hardware and Workstation.

Geometric Modeling

Wire frame entities and their definition, Interpolation and Approximation curves. Concept of parametric and non-parametric representation of a circle and helix curves, properties of splines.

Synthetic Curves

Parametric representation of cubic spline, Bezier and B-spline curves, properties and characteristics. Concept of NURBS.

UNIT-II

Surface Modeling

Analytic surfaces: Definitions of planar, surface of revolution, Tabulated cylinder, synthetic surfaces: Cubic and Bezier surfaces, coons surface.

Solid Modeling

C-rep and B-rep approaches, feature based and parametric modeling.

2D Transformations

Translation, Scaling and Rotation about arbitrary points, Shearing and Reflection.

UNIT-III

Design Applications

Mass property calculations, Mechanical tolerancing, Finite Element Analysis, Design Review.

CAD Database and Data exchange

CAD Database and structure, CAD Exchange format: IGES, STEP and STL format.

Introduction to Finite element analysis
Introduction, basic concepts, discretization, element types, nodes and degrees of freedom mesh generation, constraints, loads, preprocessing, and application to static analysis.

UNIT-IV
Numerical Control Machine Tools
Features and elements of NC, Positional, paraxial and contouring types. Definitions of axes. Definitions of interpolation, post-processor, preparatory and miscellaneous functions, Canned cycles, Tool length and cutter radius compensation. Manual and computer aided part programming (APT) for simple components, programming with MACROS.
Computer Numerical Control
CNC, DNC and Adaptive control systems. Typical configurations and relative features. Machining centers.

UNIT-V
Industrial Robots
Robot Anatomy, Configurations, Controls, Drivers, Programming methods and Applications.
CAPP
Variant and Generative process planning.
FMS&CMS
Building blocks of Flexible Manufacturing systems and their control, Elements of CIMS.
Computer Aided Inspection and QC
Coordinate Measuring Machine, Non contact inspection: Machine vision, Scanning Laser Beam Devices, Quality control.
CAD/CAM Integration, Turkey CAD/CAM Systems, Introduction to Rapid Prototyping Technique, Reverse Engineering.

Suggested Reading
1. Arvid R. Eide, Roland D. Jenison, Lane H. Mashaw, Larry: / Mprtji[. *"Introduction to Engineering Desingg'* McGraw Hill, 1998.
2. Ibrahim Zeid, *CAD/CAM, Theory and Practice,* McGraw Inc. New York, 1991.
3. Grover, MP and Zimmeers E.W. *CAD/CAM,* Prentice Hall of India, 1989.
4. Rao, P.N/ *CAD/CAM: Principles and applications,* 2nd Edition, Tata McGraw Hill, New Delhi, 2004.
5. Yoram Koren, *Computer Control of Manufacturing Systems,* McGraw Hill Int., New York, 1994.

Elanchezhian, C. Sunder Selwyn, T. Shanmuga Sunder, G. *computer Aided Manufacturing,* Laxmi Publications (P) Ltd., 2nd Edition, New Delhi, 2007

Course Code	Course Title						Core/Elective
PC603AE	**Production Technology**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- To know the different manufacturing processes required to develop mechanical components and identify various process parameters and their effect on defined process characteristics.
- To understand the effect of sand properties on the sand mould and the development of products using casting methods;
- To understand the welding process and the different methods used for joining the similar and dissimilar metals.

  To know the metal forming concepts and the methods used in obtaining mechanical components; Selection of cutting tools and process parameters for obtaining desired machining characteristics.

Course Outcomes

After completing this course, the student will be able to:

1. Understand the basic working principles of casting, forming and welding.
2. Select manufacturing processes for engineering applications and identify plastics for different applications
3. Analyze problems in Forging, Rolling, Drawing and Extrusion.
4. Select suitable machining process for suitable materials

UNIT-I

Metal Casting

Moulding sand, properties, moulding methods, moulding machines, patterns, types of patterns, pattern materials, pattern allowances, steps involved in making a casting.

Special Casting Processes

Shell moulding, CO_2 process, Continuous casting, die casting, investment casting, centrifugal casting, centrifuging, Defects in casting, causes and remedies.

UNIT-II

Metal Joining

Classification of welding process, Electrode and its specification, Oxy acetylene gas welding, types of flames, oxy acetylene gas cutting.

Arc welding processes

SMAW, SAW, GMAW, TPA, atomic hydrogen welding, plasma arc welding.

Solid State Welding Processes

Friction welding, forge welding, explosive welding, ultrasonic welding.

Resistance Welding Processes

Spot, projection, seam, butt, upset and flash welding process. Introduction to soldering, brazing, braze welding. Defects in welding, causes and remedies.

UNIT-III

Metal Forming: Stress,Strain in elastic and plastic deformation, hot working, cold working.

Rolling

Principle of rolling, types of rolling mill, two high rolling mill, three high rolling mill, cluster rolling mill, planetary roll mill, advantages and limitations of rolling.

Forging

Principle of forging, forging operations, types of forging – Smith forging, drop forging, press forging, machine forging, advantages and limitations of forging.

Extrusion

Principle of extrusion, forward extrusion, backward extrusion, tube extrusion, hydrostatic extrusion, impact extrusion.

Drawing

Principle of drawing, wire drawing, tube drawing.

Sheet Metal Working

Blanking, piercing, bending and deep drawing.

Processing of plastics - Blow moulding and injection moulding.

UNIT-IV

Metal Cutting and Machine Tools

Elements of cuttingprocess, cutting tool materials and its properties, nomenclature and geometry of single point cutting tool, chip formation, types of chips, chip breakers.

Machining

Orthogonal and oblique cutting, Merchant analysis, tool life, cutting fluids, Machinability.

UNIT-V

Machine Tools

Lathe- Principle of working, specification, types, operations performed. Lathe attachments, work holding and tool holding devices, taper turning methods – tail stock set over method, compound swivel method, special attachment method,. Capstan and turret lathes.

Types – Specification, working principle, operations performed in shaping, slotting, milling, planning, drilling and boring machines. Introduction to lapping, honing and super finishing operations.

Suggested Reading

1. P.N. Rao, *Manufacturing Technology,* Tata McGraw Hill Publishers, 2nd Edition, 1990
2. Amitaba Ghosh, Malik, *Manufacturing Science,* Assoc. East West Press Pvt. Limited, 4th Edition, 1991.
3. Roy A Lindberg, *Materials & Processes of Manufacturing,* Prentice Hall of India, 5th Edition, 1992.
4. Serope Kalpakjain, *Manufacturing Engineering and Technology,* Addison Wesley Publishing Company.

P.N. Rao, *Manufacturing Technology – Metal Cutting & Machine Tools*, Tata Mc.Graw Hill Publishers, 2nd Edition, 1990.

Course Code	Course Title						Core/Elective
PE611AE	**Performance And Testing Of Automotive Vehicles**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To know the estimation of power requirements considering factors such as power train, vehicle accelerations, terrain, and ambient conditions.
- To understand the engine performance characteristics, and parameters affecting efficiency and fuel economy; characteristics of clutches and gear transmission; Steering and brake controls and suspension features
- To understand the testing procedures for major components like suspension, brakes, engine vibrations, fuel economy and road handling including durability, maximum speed, brake testing on roads, hill climbing and ride comfort.

Course Outcomes

After completing this course, the student will be able to:

1. To Develop Basic Interest About Vehicle Performance
2. Identify The Differences Between Various Transmissions.
3. An Ability To Identify, Formulate & Solve Engine Performance Problems.
4. To Identify Formulate & Solve Related Vehicle Control System Problems
5. To Provide Students With Sound Foundation In Vehicle Components Like Clutch, Suspension, Braking, Steering & Engine.

UNIT-I

Vehicle Performance Estimation & Prediction

Aerodynamic drag, methods of estimation of resistance to motion, power requirement for propulsion, power plant characteristics. Transmission related requirements, arrangement of power train. Vehicle controls, vehicle acceleration, maximum speed, and gradiability drive systems comparison, hill climbing, handling and ride characteristics on different road surfaces. Effect of pressure, temperature and humidity on power output.

UNIT-II

Vehicle Transmission Performance

Characteristics & features of friction clutches, mechanical gear transmission & Epicyclic gear boxes.

UNIT-III

Operational Performance

Engine performance & operating characteristics, Operation at full load and part load conditions, fuel economy, effect of vehicle condition, tyre and road condition, traffic condition and driving habits on fuel economy, vehicle safety.

UNIT-IV

Control Systems

Braking arrangements & Characteristics, weight transfer, steering arrangements, rigid & independent suspension, roll centre, torsion bar, stabilizer, radius bar.

UNIT-V

Vehicle Performance Testing: Laboratory Testing

Testing of major components of vehicle like clutch, suspension, braking, steering etc., Engine testing – noise, vibrations, emission, power & fuel consumption, Vehicle testing on chassis dynamometers, Road and Track Testing, Initial inspection, running in and durability, extensive driving, maximum speed & acceleration, Brake testing on the road, Hill climbing, handling & ride characteristics on different road surfaces, ride comfort. Corrosion testing, fault finding tests.

Suggested Reading

1. Gousha H. M., "Engine Performance Diagnosis & Tune Up Shop Manual"
2. J. G. Giles, "Vehicle Operation & Performance".
3. W. H. Crouse & D. L. Anglin, "Motor Vehicle Inspection".
4. SAE Transactions Papers – 831814 / 820346 / 820367 / 820371 / 820375
5. CIRT & VRDE Manuals

Course Code	Course Title						Core/Elective
PE612AE	**Material Handling and Earth Moving Vehicles**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Introduced the heavy earth moving vehicles and material handling equipments
- To know the working of different types of off road vehicles
- To understand the working and construction of the hoisting equipment
- Classify the off road vehicle

Course Outcomes

After completing this course, the student will be able to:

1. Students able to distinguish the on road and off road vehicle and understand the complexity in off road vehicles.
2. Understand Working and construction of the machines and equipment
3. Maintain and repair condition of working machines and equipment, for scheduling to maintenance

UNIT-I

MATERIAL HANDLING SYSTEMS

Design and construction of various components of mechanical handling conventional belt conveyors, high angle conveyors, cable belt conveyor, chain conveyors, stackers, Re-claimers, wagon loaders, wagon tipplers, bucket elevators, bins, bunkers, silos, selection, productivity and power calculations conveyors.

UNIT-II

HOISTING EQUIPMENTS

Mobile jib cranes–different types, EOT cranes, pillar cranes, lower cranes, gantry cranes, radial cranes. Hoist, Travel and slew mechanisms of mechanical handling equipment. Stability of mobile cranes. Programmable and flexible load handling devices, automation in the handling of material

UNIT-III

CLASSIFICATION AND REQUIREMENTS OF OFF ROAD VEHICLES

Land clearing machines Earth moving machines shovels - drag lines - ditchers - capacity of shovels. Land clearing machines: Bush cutter, tree dozer, rippers.

UNIT-IV

TRANSPORT EQUIPMENT

Powered equipment, Tractors and Trailers, Platform lift trucks, Fork lift trucks, containers and Supports. Hauling equipment: Types of dump trucks, On-high way vehicles, Off high way vehicles. Tractors,*Applications of tractors, Rating of Tractors, Wheeled and Crawler tractor, recent trends in* tractor design

UNIT-V

EARTH MOVING MACHINES

Bulldozers, cable and hydraulic dozers. Crawler track, running and steering gears, scrapers, drag and self-Powered types - dump trucks and dumpers - loaders, singlebucket, multi bucket and rotary types - power and Capacity of earth moving machines .Scrapers, elevating graders, self-powered scrapers and graders. Shovels and Ditchers: Power shovel, revolving and stripper

Suggested Reading

1. *Material Handling Equipment; N Rudenko*
2. *Conveyors and Related Equipment, Spivakovosky, V. Dyachk*
3. *Abrosimov. K. Bran berg.A. and Katayer.K., Road making Machinery, MIR Publishers,*
4. *Moscow, 1971*
5. *Wang.J.T., Theory of Grand vehicles, John Wiley & Sons, New York, 1987.*
6. *Off the road wheeled and combined traction devices - Ashgate Publishing Co. Ltd. 1998*
7. *R.L. Peurifoy, Construction Planning Equipment and Methods, McGraw Hill Publishers, 1956*
8. *Mahesh Varma, Construction Equipment and its Planning and Applications, Metropolitan Books Co., Delhi, 2004*
9. *Materials Handling Equipment, MPAlexand Rov, MIR Publishers.*

Good year hand book of belting, conveyor and elevator

Course Code	Course Title						Core/Elective
PE613AE	**Electric and Hybrid Vehicles**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course objectives:

- To Understand electric vehicle technology
- To Understand electric vehicle battery technology and control systems
- To know the classification drives in hybrid vehicles their principles and merits
- To know different power sources used in hybrid vehicles
- To know Electric propulsion systems and fuel cells

Course Outcomes:

After completing this course, the student will be able to

1. Know-how of power plants used in Electric vehicles and their significance.
2. To provide exposure to electric vehicle battery technology and control systems.
3. Able to classify drives in hybrid vehicles their principles and merits
4. Understand different power sources used in hybrid vehicles
5. Understand Electric propulsion systems and fuel cells

UNIT - I

INTRODUCTION: Electric vehicles; early systems, charging techniques for lead acid batteries, charging techniques for nickel based batteries, charging techniques for non aqueous batteries, Battery state of charge measurement, battery management, connection methods, battery exchange. Economic and environmental comparison of alternative vehicle options. Electric vehicles; configuration of EVs, performance, traction motor characteristics, tractive effort and transmission requirements.

UNIT- II

BATTERIES: Storage batteries; advanced lead acid, metal foil lead acid, nickel - iron, nickel - zinc, nickel - cadmium, sodium - sulphur, sodium - nickel chloride, lithium - iron sulphide, lithium - solid polymer, lithium - ion, aluminum - air and zinc - air.

ELECTRIC PROPULSION SYSTEMS: DC motor drives, chopper control of DC motors. Drive train configuration and design objectives, control strategies. EV conversion process. Controller; overview, solid state controller,

UNIT - III

HYBRID DRIVES: Introduction, features , functional classification, start/stop system, mild hybrid, full hybrid, plug-in-hybrid, batteries for hybrid vehicles, optimization of hybrid configurations. Changing modes for conductive charging. Super capacitor, fuels cells, solar cells, the flywheel, the hydraulic accumulator, compressed air storage, thermal energy storage, non battery energy sources.

UNIT - IV

HYBRID ELECTRIC VEHICLES(HEVS) AND DRIVE STRUCTURES: Concept of electric drive train, architecture of hybrid electric drive train, series hybrid drive, parallel hybrid electrical drive train, parallel hybrid drive train with torque coupling, power split hybrid drive, speed coupling, hybrid drive train with torque and speed coupling. Control of hybrid vehicles.

UNIT - V

FUEL CELLS: Fundamentals, operating principles of fuel cells, fuel cell system characteristics, fuel cell technologies, non-hydrogen fuel cells, fuel cell hybrid electric drive train design,

Electric and Hybrid Vehicles - Case Studies: Honda Insight, Chevrolet Volt, GM EV1, Nissan Leaf, Toyota RAV 4 EV and Ford; Think City

Suggested Reading

1. Iqbal Husain, "Electic and Hybrid vehicles Design Fundamentals" , CRC Press, second enition 2013
2. James Larminie, John Lowry, "Electric vehicle techonology Explained" 2nd Ed.,Wiley 2012
3. Vehicular Electrical Power Systems – Emadi, Ehasni, Mercel (Marcel Dekker)
4. Electronic Engine Controls – Steve V Hatch(Cengage learning)
5. Electric and Hybrid vehicles – Pistoia (Elsevier)
6. Fuel cells principles and applications - B.Vishwanath, M. Aulice Scibion (University Press)
7. Electrical vehicle machine and drives – K.T.Chau (Wiley).

Course Code	Course Title						Core / Elective
OE601ME	**Entrepreneurship**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation
- To understand the behavioural aspects of entrepreneurs and time management

Course Outcomes

At the end of the course, the students will be able to

1. Understand Indian Industrial Environment, Entrepreneurship and Economic growth, Small and Large Scale Industries, Types and forms of enterprises.
2. Identify the characteristics of entrepreneurs, Emergence of first generation entrepreneurs, Conception and evaluation of ideas and their sources.
3. Practice the principles of project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis.
4. Apply the concepts of Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques
5. Understand the Behavioural aspects of entrepreneurs, Time Management, Various approaches of time management, their strengths and weakness. The urgency addiction and time management matrix.

UNIT-I

Indian Industrial Environment-competence, Opportunities and Challenges. Entrepreneurship and Economic growth. Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs. Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas and their sources. Choice of Technology - Collaborative interaction for Technology development.

UNIT-III

Project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis, project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management. Assessment of tax burden.

UNIT-V

Behavioural aspects of entrepreneurs: Personality - determinants, attributes and models. Leadership concepts and models. Values and attitudes. Motivation aspects. Change behaviour. Time

Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management",* Himalaya Publishing House, 1997
2. Prasanna Chandra, *"Project-Planning, Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd. 1995.
3. Stephen R. Covey and A. Roger Merrill, *"First Things First",* Simon and Schuster Publication, 1994.
4. G.S. Sudha, *"Organizational Behaviour",* 1996.
5. Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005.

Course Code	Course Title						Core / Elective
OE602ME	**INDUSTRIAL ROBOTICS**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**0**	**0**	**0**	**30**	**70**	**3**

Course Objectives

- To familiarize the student with the anatomy of robot and their applications.
- To provide knowledge about various kinds of end effectorsusage.
- To equip the students with information about various sensors used in industrial robots.
- To make the student understand the importance of spatial transformation of robots using forward and inverse kinematics.
- To specify and provide the knowledge of techniques involved in robot vision in industry.
- To equip students with latest robot languages implemented in industrial manipulators.

Course Outcomes

- Able to demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics and have an understanding of the functionality and limitations of robot actuators and sensors.
- Able to demonstrate an ability to apply spatial transformation to obtain forward/Inverse kinematics equation of robot manipulators using analytical/numerical/simulation tools.
- Able to apply knowledge and choose the best & economically suitable sensors/end effectors required for specific applications.
- Able to understand the importance of robot vision and apply the learnt techniques to get the required information from input images.
- Able to design and develop a industrial robot for a given purpose economically.
- Appreciate the current state and potential for robotics in new application areas.

UNIT – I

Introduction to Robotics: Basic structure of Robots. Degree of freedom of Robots, Work envelope, Classification of Robots based on Drive Technology, Work-Envelope and motion control methods. Application of Robots in Industry, Repeatability, Precision and Accuracy as applied to Robots, Specifications of robots used for various applications. End effectors, Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers, Two fingered and three fingered grippers, internal grippers and external grippers, Selection and design considerations.

UNIT – II

Requirements of a Sensor: Principles and Applications of the following types of sensors- Position of sensors (Piezo electric sensor, LVDT, Resolvers, Optical encoders, Pneumatic position sensors), Range sensors (Triangulation principle, Structured, Lighting approach, Time of flight range finders, Laser range meters), Proximity sensors (Inductive, Hall effect, Capacitive, Ultrasonic and Optical proximity sensors), Touch sensors (Binary sensors, Analog sensors), Wrist Sensors, Compliance Sensors, Slip Sensors.

UNIT – III

Kinematic Analysis of Robots: Rotation matrix. Homogeneous transformation matrix, Denavit&Hartenberg representation, Euler and RPY angles representation. Representation of absolute position and orientation in terms of joint parameters, Direct Kinematics of manipulators, Inverse kinematics of Robot arm for position and orientation. Redundancy in Robots, Static force analysis

UNIT-IV

Introduction to Techniques used in Robot Vision: Image acquisition, illumination techniques, imaging geometry, basic relationship pixels, preprocessing, segmentation & description of 3-dimensional structures, their recognition and interpretation. Types of Camera, frame grabbing, sensing and digitizing image data, Signal conversion, Image Storage, Lighting techniques, Image processing and analysis, Data reduction, Segmentation, Feature extraction, Object recognition, and various algorithms, Applications, Inspection, identification, visual serving and navigation.

UNIT – V

Robot Programming Languages: Characteristics of robot level languages, task level languages. Teach pendant programming, Lead through programming, Robot programming languages, VAL programming, Motion commands, Sensor commands. End effecter commands, Simple programs. RGV, AGV, Implementation of robots in industries, various steps, Safety considerations for robot operations. Economic analysis of robots, Pay back method, EUAC method and Rate of return method

Suggested Readings:

1. Groover M P, **"Industrial Robotics"**, McGraw Hill Publications,1999.
2. Fu. K.S., GonZalez R.C., Lee C.S.G. "**Robotics, Control-sensing vision and Intelligence**", McGraw Hill, Int. Ed.,1987.
3. Spong and Vidyasagar, "**Robot Dynamics & Control**", John Wiley and Sons,Ed.,1990.
4. Mittal and Nagrath, "**Industrial Robotics**", Tata McGraw Hill Publications,2004.
5. Saha&Subirkumarsaha, '**Robotics'**, TMH,India.

Course Code	Course Title						Core/Elective
PC691AE	**CAD/ CAM/ CAE LAB**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To become familiar with Full-Scale CAD Software systems designed for geometric modelling of engineering components.
- Gaining knowledge of Analysis of mechanical components under static conditions using Finite Element Techniques.
- Becoming familiar with CNC machine tools, Its features and elements, practice manual part programming using miscellaneous and preparatory functions (M & G codes).
- Getting exposed to the manufacturing process through flexible manufacturing Systems.

Course Outcomes

After completing this course, the student will be able to:

1. Apply CAD software for the geometric modelling of components
2. Analyse mechanical components by using Finite Element techniques
3. Apply M & G codes in part programming used for CNC machine tools.
4. Demonstrate flexible manufacturing system.

List of Experiments

CAD

1. Practice in the use of some of the packages like: Pro-E / I-DEAS / Solid works / MDT / Inventor / CATIA etc., for Geometric modeling of simple parts (sketching).
2. Part modeling and assembly of simple parts using any of the above packages.
3. Mass properties and Sectional properties of a part and Assembly.

CAE

4. Static Analysis of Plane Truss and 2D beam for different type of loads using ANSYS / NASTRAN / ADINA etc
5. Static analysis of 2D beam for different types of loads using beam elements

CAM

6. Facing, Turning, Step turning, Taper turning on CNC Lathe
7. Pocketing and Contouring on CNC milling
8. Programming for integration of various CNC machines, robots and material handling systems

Course Code	Course Title						Core/Elective
PC692AE	**Production Technology Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To understand different manufacturing processes required to develop mechanical components and identify various process parameters and their effect on defined process characteristics.
- To gain knowledge about different metal cutting operations on varied machines, selection of cutting tools and process parameters for obtaining desired machining characteristics.
- To appreciate the effect of sand properties on the sand mould and the development of products using casting methods; phenomenon of welding process and the different methods used for joining the similar and dissimilar metals.
- To understand Metal forming concepts and the methods used in obtaining mechanical components.

Course Outcomes:

After completing this course, the student will be able to:

1. Develop mechanical components by using different manufacturing processes
2. Select cutting tools and process parameters for metal cutting operations.
3. Develop casting products by using different casting methods.
4. Demonstrate metal forming process.

List of Experiments

Metal Cutting

1. Perform Step turning & Taper turning operations for a given dimension on Lathe Machine.
2. Perform Thread Cutting & Knurling operation s for a given dimension on Lathe Machine.
3. Perform drilling & tapping operations on the PCD of a given cylindrical component on Radial Drilling Machine.
4. Develop a gear for a given dimension on milling Machine.

Foundry

5. Single piece pattern making with wood as material considering allowances (Draft, Shrinkage and Machining).
6. Green sand mould making processes with complete sprues, gates ,riser design.
7. Testing of green sand properties.
8. Melting ad casting of aluminum metal

Welding

9. Prepare a butt joint using arc welding process and determine deposition efficiency of electrodes.
10. Exercises using TIG and MIG welding processes.

Forming

11. Evalution of formability using Erichsen Cupping test.
12. Performing blanking and piercing operations using Mechanical / fly presses.
13. Manufacturing of simple component using Plastic Injection Moulding machine

Suggested Reading:

P.N. Rao, Manufacturing Teachnology, Tata McGraw Hill Publishers,2nd Edition, 1990

2.Amitaba Ghosh, Malik, Manufacturing Science, Assoc. East West Press Pvt. Limited, 4th Edition,1991.

3.Roy A Lindberg, Materials & Processes of Manufacturing, Prentice Hall of India, 5th Edition,1992.

4.P.N.Rao,Manufacturing Technology-Metal Cutting $& Machine Tools, Tata Mc.Graw Hill Publishers, 2nd Edition,1990.

Note: Minimum ten experiments should be conducted in the semester

FACULTY OF ENGINEERING

Scheme of Instruction & Examination

(AICTE Model Curriculum for the Academic Year 2020-2021)

and

Syllabi

B.E. V and VI Semester

of

Four Year Degree Programme

in

Mechanical Engineering

(With effect from the academic year 2020– 2021)

(As approved in the faculty meeting held on - -2020)

Issued by

Dean, Faculty of Engineering

Osmania University, Hyderabad – 500 007

2020

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Mechanical Engineering) V – SEMESTER

S.No.	Course Code	CourseTitle	SchemeofInstructions				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC501ME	Fluid Mechanics and Hydraulic Machinery	3	-	-	3	30	70	3	3
2	PC502ME	Design of Machine Elements	3	-	-	3	30	70	3	3
3	PC503ME	Dynamics of Machines	3	-	-	3	30	70	3	3
4	PC504ME	Metal Cutting and Machine Tools	3	-	-	3	30	70	3	3
5	PC505ME	Heat Transfer	3	-	-	3	30	70	3	3
LaboratoryCourse										
6	PC591ME	Thermal Engineering Lab-2	-	-	2	2	25	50	3	1
7	PC592ME	Dynamics of Machines Lab	-	-	2	2	25	50	3	1
8	PC593ME	Fluid Mechanics and Hydraulic Machinery Lab	-	-	2	2	25	50	3	1
		Total	15	-	06	21				18

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Mechanical Engineering) VI – SEMESTER

S.No.	Course Code	CourseTitle	SchemeofInstructions				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC601ME	Machine Design	3	-	-	3	30	70	3	3
2	PC602ME	Metrology and Instrumentation	3	-	-	3	30	70	3	3
3	PC603ME	Finite Element Analysis	3	-	-	3	30	70	3	3
4	PEME	Professional Elective – I	3	-	-	3	30	70	3	3
5	OEC - 1	Open Elective – 1	3	-	-	3	30	70	3	3
6	OEC - 2	Open Elective – 2	3	-	-	3	30	70	3	3
LaboratoryCourse										
7	PC691ME	Metrology and Machine Tools Lab	-	-	2	2	25	50	3	1
8	PC692ME	Computer Aided Engineering Lab	-	-	2	2	25	50	3	1
9		Summer Internship*								2
		Total	18	00	04	22				22

Open Elective - 1 (OE601ME) : Entrepreneurship (Not for Mechanical / Prod. / Automobile)
Open Elective - 2 (OE602ME) : Industrial Robotics (Not for Mechanical / Prod. / Automobile)

PROFESSIONAL ELECTIVE - I	
PE611ME	CAD/CAM
PE612ME	Automobile Engineering
PE613ME	Modern Machining and Forming Methods

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

* *At the end of VI semester students should undergo summer Internship - Credits for Summer Internship will be awarded in VII semester*

Course Code	Course Title						Core/Elective
PC501ME	**Fluid mechanics & Hydraulic machines**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Mathematics& mechanics-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

It is intended to make the students to

1. Know various fluid properties, concepts and methods of fluid measurement.
2. Understand the basic concepts and principle of fluid flow.
3. Study different equations of fluid motion and fluid dynamics.
4. Analyze different flow characteristics of laminar flows.
5. Understand the working principle of hydraulic turbines and pumps and their performance**.**

Course Outcomes

After completing this course, , the student is able to

1. Distinguish the properties of the fluids and different types of pressure and measure them.
2. Explain different types of flows and analyze them.
3. Analyze the flow between parallel plates and in pipes and also calculate drag and lift coefficients.
4. Demonstrate the working principles of various hydraulic turbines and estimate their performance.
5. Demonstrate the working principles of various hydraulic pumps and estimate their performance.

UNIT – I

Basic Concepts and Properties of Fluid

Definition, distinction between solid and fluid, , Properties of fluids, density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension, units and dimensions.

Fluid statics

Concept of fluid static pressure, absolute and gauge pressures, pressure measurements by manometers and pressure gauges.

UNIT-II

Fluid Kinematics

Flow visualization, lines of flow, types of flow, velocity field and acceleration, Continuity equation (one and three-dimensional differential forms), Equation of streamline, stream function, velocity potential function, circulation, flow net**.**

Fluid Dynamics

Equations of motion, Euler's equation along a streamline, Bernoulli's equation, applications. Venturi meter, Orifice meter, Pitot tube.

UNIT-III

Incompressible Fluid Flow

Viscous flow, Shear stress-pressure gradient relationship, laminar flow between parallel plates, Laminar flow through circular tubes (Hagen poiseulle's), Hydraulic and energy gradient lines**.**

Flow through pipes

Darcy- Weisback's equation, pipe roughness, friction factor, minor losses, flow through pipes in series and in parallel, power transmission, Boundary layer flows, boundary layer thickness, boundary layer separation, drag and lift coefficients.

UNIT IV

Hydraulic Turbines

Definition and classifications, Pelton turbine, Francis turbine, propeller turbine, Kaplan turbine, working principles, velocity triangles, work done, specific speed. Efficiencies, performance curve for turbines.

UNIT V

Hydraulic Pumps

Pumps: definition and classifications, Centrifugal pump: classifications, working principles, velocity triangles, specific speed, efficiency and performance curves. Reciprocating pump: classification, working principles, indicator diagram, performance curves, cavitation in pumps, Rotary pumps: working principles of gear and vane pumps.

Suggested Reading

1. **Streeter, V.L., and Wylie, E.B., "Fluid Mechanics", McGraw-Hill, 1983.**
2. **Modi & Seth "Hydraulic and Fluid Mechanics" – standard book house, 2002.**
3. **Bansal, R.K., "Fluid Mechanics and Hydraulics Machines", (5th edition), Laxmi publications (P) Ltd. Delhi, 1995.**
4. **Kumar D. S., "Fluid Mechanics and Fluid Power Engineering", S. K. Kataria & Sons.**
5. **White, F.M., "Fluid Mechanics", Tata McGraw-Hill, 5th Edition, New Delhi, 2003.**
6. **Som, S.K., and Biswas, G., "Introduction to fluid mechanics and fluid machines", Tata McGraw-Hill, 2nd edition, 2004.**

Course Code	Course Title						Core/Elective
PC502ME	DESIGN OF MACHINE ELEMENTS						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
	3	--	--	--	30	70	3

Course Objectives:

- Importance of codes, materials, manufacturing processin design of mechanical components
- Importance of theories of failure and effects of fatigue and stress concentration on the life of the component
- Learn the concepts required to design machine components like keys, shafts, couplings
- Will learn to determine size of rivets, welds and cotter joints for specific applications
- Will Understand the concepts used for designing machine components like cotters, bolts, nuts

Course Outcomes:

- Identify & Use codes and standards, selection proper material & perform static design.
- Analyze cyclic loading conditions and provide fatigue design of components
- Analyze machine elements like keys, shafts and couplings,
- Evaluate various joining techniques like welding, riveting and cotter joints.
- Synthesize an d design screw threads for fasteners and power screw applications.

UNIT-I

Steps involved in Design, Design considerations of Machine Elements, Materials used and their specifications. Codes and standards used in design. Practice of using Design data book. Concept of Aesthetics & Ergonomics in design, Preferred numbers. Manufacturing considerations in design. Concept of Value analysis, Principles of concurrent design,

Types of loads and simple stresses. Principal stresses, Stresses due to Biaxial and Triaxial loads. Stress concentration effects, Factor of safety. Theories of failures. Design of components subjected to impact loading.

UNIT-II

Design for Fatigue: Fluctuating stresses, fatigue strength and endurance limit Stress concentration factor and Notch sensitivity. Factors affecting fatigue strength. S-N diagram, Soderberg and Modified Goodman's diagrams for fatigue design, Cumulative fatigue - Miner's rule.

UNIT-III

Design of shafts: solid, hollow and splined shafts under torsion and bending loads. Design of keys. Design of couplings – Industrial Flange coupling, Flexible rubber bush couplings.

UNIT-IV

Design of Joints: Cotter and Knuckle joints. Design of rivetted and welded joints under direct and eccentric loads.

UNIT-V

Design of Screw threads: Design of bolts and nuts, Locking devices for nuts, Bolts of uniform strength. Design of gasket joints, Bolted joints under eccentric loads, Differential and Compound Screws, Design of power Screws and screw jack.

Suggested Reading:

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw-Hill Publ, 3rd Edn. 2010.
2. J.E. Shigley & Charles R. Mischke "Mechanical Engineering Design", Tata McGraw-Hill.,6th ed.2010.
3. P. Kannaiah, Machine Design, Sci-Tech Publ., 2009.
4. P.C. Sharma & D.K. Aggarwal, "Machine Design", S.K. Kataria & Sons, 10th edn, 2003
5. V. B. Bhandari, "Design Data Book " 2nd edition, ", Tata McGraw-Hill Publ, 2019

Note : Solution of Numerical problems using Design data book should be practiced.

Course Code	Course Title						Core/Elective
PC503ME	DYNAMICS OF MACHINES						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
Kinematics of Machines	3	--	--	--	30	70	3

Course Objectives:

- To know effect of inertia of links, and external forces on the input torque, and forces developed at joints in typical mechanisms in motion; understand the gyroscopic couple and its effect on vehicles in motion.
- To know the working principles and characteristics of typical governors, as also the function of flywheels.
- To know the concept of unbalancing rotating and reciprocating masses in single and multi-cylinder in line and radial engines.
- To understand the phenomena of free of free and forced, including the effect of damping for single dof systems, and concepts of isolating vibration.
- To determine natural frequencies of undammed, damped and forced vibrating systems of one, two and multi degree freedom systems.

Course Outcomes:

- Analyse static and dynamic forces in slider crank and other mechanisms; determine the magnitude of gyroscopic couple and its effect on vehicles in motion.
- Evaluate the performance of various types of governors and design flywheels considering speed and energy fluctuation
- Analyse problems of balancing in rotating and reciprocating machinery.
- Evaluate the natural frequencies of single and two degree of freedom systems in free and forced vibration mode, also considering the effect of damping.
- Determine the natural frequencies and mode shapes of multi degree of freedom systems, including by Dunkerley, Raleigh and Holzer methods.

UNIT-I

Static and Dynamic Force Analysis: *Static equilibrium:* Constraint and Applied forces, Static Force analysis of Single slider crank mechanism without Friction, Principle of Superposition.

Dynamic Equilibrium: d'Alambert's Principle, Equivalent offset inertia force, Dynamic force Analysis of Slider Crank Mechanism,

Engine Force Analysis: Piston effort, Force along connecting rod, thrust on sides of cylinder, crank effort. Thrust on bearing. Dynamically Equivalent System for Connecting Rod.

Gyroscope: Gyroscopic Couple, gyroscopic effects on aeroplanes, naval ships.

Stability of two wheel vehicle only.

UNIT-II

Governors: Working principle of governor, Classification & types of governors, analysis of Watt, Porter, and Hartnell governors. Characteristics of governors:

Controlling Force, Stability, Isochronism, Sensitivity, Power and Effort of governors.

Flywheels: Functions, Differences between flywheel and governor, turning moment diagrams, flywheel analysis for I-C Engines and presses.

UNIT - III

Balancing: Static balancing, Dynamic balancing, balancing of several masses rotating in several planes, consideration of bearing forces, balancing of reciprocating masses, primary balancing shaking forces in single cylinder engine, partial balancing and its effects, secondary balancing.

UNIT - IV

Vibrations: Vibrations of Single degree freedom system (axial, transverse and torsional), Equivalent system of combination of springs, Stepped shaft, Whirling speed of shafts.

Damped Vibrations: Types of damping, Vibrations with viscous damping

Forced Damped Vibrations: Magnification factor, Resonance, Vibration isolation and Transmissibility.

UNIT –V

Vibration Analysis of Multi Degree Freedom Systems: Torsional Vibrations of Two rotor, three rotor and Geared systems. Natural frequencies of two degree freedom systems Modes of vibration approximate methods for determining natural frequencies: Dunkerley's method, Rayleigh's method. Holzer's method (only Theory).

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. Thomas Bevan, the Theory of Machines, CBS Publishers & Distributors, 2004.
3. John J.Uicker, Jr. Gordon, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
4. J.S. Rao and Gupta, Theory and Practice of Mechanical Vibrations, Prentice Hall, 1984.
5. R.L.Nortan, "Kinematics and Dynamics of Machinery", Tata McGraw Education Pvt. Ltd , New Delhi, 2009.
6. Ghosh and Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press, 1988.

Course Code	Course Title						Core/Elective
PC504ME	**METAL CUTTING & MACHINE TOOLS**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

- To learn the tool material, geometry and mechanics of metal cutting for turning, drilling and milling.
- To know the heat distribution, tool wear, tool life, and machinability
- To learn the principle and working of various machine tools like lathe, shaper, planer, milling, drilling and grinding machines etc.
- To learn various types of fixtures, conventional and unconventional machining processes.

Course Outcomes:

- Understand the cutting tool geometry, mechanism of chip formation and mechanics of orthogonal cutting.
- Understand the thermal aspects of metal cutting, influence of tool wear on tool life and machinability.
- Identify basic parts and operations of machine tools including lathe, shaper, planer, milling, drilling, and boring machines.
- Design locating and clamping devices to produce a component.
- Understand the principles of various finishing processes and gear manufacturing processes
- Understand the principle and working of various unconventional machining processes.

UNIT-I

Cutting Tool Materials: High carbon steel, HSS, Stellites, Carbides, Coated carbides, Diamonds, Tool material properties; **Tool Geometry:** Nomenclature of single point cutting tool by ASA & ORS systems. Geometry of drills, milling cutters; **Chip Formation:** Types of chips, BUE, Chip breakers; **Machining:** Orthogonal and oblique cutting, Mechanics of metal cutting, Merchant's analysis, Shear angle, Solutions of Merchant and Lee & Shafer.

UNIT-II

Thermal Aspects of Metal Cutting: Sources of heat and heat distribution, various methods of measurement of temperature, Cutting fluids and applications; **Tool Wear, Tool Life and Machinability:** Types of wear, mechanism of tool wear, Tool life & Machinability, Machinability index. Taylor's tool life equation; **Economics of Machining:** Tool life for maximum production, minimum cost.

UNIT-III

Machine Tools: Constructional features and specifications of machine tools, various operations on Lathe, Types of Lathes - capstan and turret Lathes; Drilling, Milling and Boring machines. Indexing methods, differences between shaper, planer and slotter, Tool holding and work holding devices Quick return mechanisms.

UNIT-IV

Grinding Machines: Types of grinding, Abrasives and bonds used for grinding wheels. Specification and selection of grinding wheels; Broaching, Lapping, Honing, Polishing, Buffing, Super Finishing and Burnishing.

Screws and Gear Manufacturing: Tapping, Chasers, Thread rolling, Thread milling, Thread grinding. Gear shaping, Gear hobbing, Gear shaving and grinding.

UNIT-V

Jigs and Fixtures: Design principles for location and clamping. Quick clamping devices Types of Jigs and fixtures. Applications of Jigs and Fixtures.

Unconventional Machining: Principle of working, merits, demerits and applications of USM, AJM, EDM, ECM, LBM and EBM

Suggested Reading:

1. B.L. JuneJa and Shekon, "Fundamentals of Metal Cutting & Machines Tools", Wiley Eastern Ltd. 1987.
2. P.N. Rao, "Manufacturing Technology – Metal Culling & Machine Tools", Vol. 2, Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Amitab Ghosh and Mallick, "Manufacturing Science", Affiliated East West Press 1985.
4. P.K Misha, "Non Traditional Machining Processes", Narosa Publications, 2006.
5. V.K.Jain “Advanced Machining Processes“ Allied Publishers, Hyderabad, 2011.
6. A. Bhattacharyya, “Metal Cutting Theory and Practice” New Central Book Agency (P) Ltd. Calcutta, 1996.
7. Stephan Radavich, “Gear Manufacturing”, CRC Press, ,1 Edn,2011

Course Code	Course Title						Core/Elective
PC505ME	**HEAT TRANSFER**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
FLUID MECHANICS	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- The basic concepts of heat transfer Obtaining centroids and moments of inertia for various regular and irregular areas.
- The concepts of conduction, convection, radiation and heat exchangers applicable for commercial and industrial use
- The applications of various experimental heat transfer correlations in engineering applications.
- Thermal analysis and sizing of heat exchanger.
- solving problems on different modes of heat transfer which are related to thermal power plants, refrigeration and air conditioning

Course Outcomes

After completing this course, the student will be able to:

1. To understand the basic concepts of heat transfer.
2. To understand the concepts of heat transfer through extended surfaces.
3. To Familiarize with time dependent heat transfer and compute convective heat transfer coefficients in forced, natural convection.
4. To understand radiation heat transfer
5. To understand , heat exchangers and mechanism involved in boiling and condensation.

UNIT – I

Conduction: Modes of Heat Transfer, Laws of Heat Transfer - Fourier, Newton, Stefan-Boltzmann General conduction equation in cartesian, cylindrical and spherical coordinates, One dimensional steady state conduction through slabs, hollow cylinders and spheres with and without heat generation, Effects of variable thermal conductivity in heat transfer of one dimensional steady state conduction of plate, cylinders and spheres, Steady state heat transfer through composite slabs, cylinders and spheres, Critical radius of insulation.

UNIT – II

Fins: Heat transfer analysis of tips with heat dissipation environment - rectangular straight and pin fins, Application of fin to temperature measurement, unsteady state conduction, Lumped parameter, analysis of a body with negligible internal temperature gradients, Transient heat transfer analysis of finite slab with specified temperature and convective boundary conditions, Use of Grober and Heisler charts for solving problems of infinite slabs, cylinders and spheres.

UNIT-III

Free and forced convection: Dimensional analysis and its use in free and forced convection, Buckingham theorem, Physical significance of different dimensionless numbers, Application of Von-Karman integral equation for the analysis of thermal boundary layer in forced convection of flat plate, Reynold's analogy for flow over plane surfaces, calculation of heat transfer for flow over plates, cylinders and for flow through tubes in free and forced convection using empirical formulae.

UNIT –IV

Radiation: Definition of absorptivity, reflectivity and transmissivity, Concept of black-body and emissivity. Kirchoffs law, Planck's black body spectral distribution, Wien's and Steffan Boltzmann law, Monochromatic and total emissive power, radiant heat exchange between two gray surfaces, Shape factor, Thermal circuit for radiant heat exchange between infinite parallel plates and between concentric, cylinders, Enclosures with black and gray surfaces, Radiation shields and re-radiation surfaces.

UNIT – V

Heat Exchangers: Classification and applications of heat exchangers in industry, Analysis and design of counter flow and parallel flow heat exchanger, Fouling factors, solving problems for multi pass heat exchanger using non dimensional parameter plots.

Change of Phase: Boiling-pool boiling regimes nucleate pool boiling, effect of surface wettability on bubble contact angle, Critical heat flux, boiling in forced convection, Condensation: Film condensation, Drop wise condensation, Condensation film thickness, Heat transfer coefficient in film condensation.

Suggested Readings:

1. Holman, J.P., "Heat Transfer", McGraw Hill Publication, New Delhi, 2010 2.
2. Rajput, R.K., "Heat and Mass Transfer", S. Chand & Company Ltd, New Delhi, 2004.
3. Yadav, R., Sanjay. and Rajay., "Heat and Mass Transfer ', Central Publishing House, Allahabad, 2004
4. Sachdeva,R.C., "Fundamentals of Engineering Heat and Mass Transfer ", New Age International (P) Ltd Publishers, New Delhi,
5. Arora, S.C. and Domkandwar., "A course in Heat and Mass Transfer ", DhanpatRai& Sons, New Delhi, 2004.

Course Code	Course Title						Core/Elective
PC591ME	**THERMAL ENGINEERING Lab - II**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- Determining thermal conductivity of an insulating powder in composite slab or cylinder. The concepts of conduction, convection, radiation and heat exchangers applicable for commercial and industrial use
- Evaluating the heat transfer coefficients under natural convection and forced convection phenomena Thermal analysis and sizing of heat exchanger.
- determining the necessary constants pertaining to radiation
- understanding the working principles of axial flow fan and its overall efficiency
- estimating overall efficiency of a centrifugal compressors and pressure distribution over cylinder and an aerofoil section on turbo machines.

Course Outcomes

Aftercompletingthis course, thestudentwillbe ableto:

1. Interpret the link between refrigeration effects, work done and COP of the system, describe different methods adopted to evaluate COP, list the different psychrometric processes and describe how those processes can be maintained
2. Calculate the overall efficiency of centrifugal blower and axial flow fan at different volume flow rates, show the variation of overall efficiency with load and speed graphically To understand radiation heat transfer, heat exchangers and mechanism involved in boiling and condensation.
3. . Identify the various components of low speed wind tunnel, plot a graph showing variation of pressure over the entire length of aerofoil blade and also evaluate the lift and drag coefficient values for a given aerofoil blade at different angle of assign
4. Describe the modes of heat transfer, calculate thermal conductivity, heat transfer coefficient subjected to natural and forced convection environment and Stefan Boltzmann constant value of thermal radiation.
5. Express the working principle of heat exchangers and its application in real life, calculate the LMTD and effectiveness of a given heat exchanger for both parallel and counter flows.

List of Experiments:

1. Determination of thermal conductivity of metal bar
2. Determination of thermal conductivity of composite wall.
3. Determination of the efficiency of pin-fin subjected to natural and forced convection
4. Determination of effectiveness of parallel flow and counter flow heat exchanger

5. Determination of emissivity of given test plate
6. Determination of Stefan Boltzmann constant.
7. Determination of COP of the Air conditioning system
8. Determination of percentage relative humidity and study of humidification and dehumidification process in Air Conditioning systems
9. .Determination of COP of refrigeration systems using capillary tube/ thermostatic expansion valve
10. Determination of overall efficiency of centrifugal blower
11. Determination of overall efficiency of axial flow fan
12. Pressure distribution on symmetrical and non-symmetrical specimen in wind tunnel
13. Measurement of lift and drag force of the models in wind tunnel test section

Note: At least ten experiments should be conducted.

Course Code	Course Title						Core/Elective
PC592ME	**DYNAMICS OF MACHINES LAB**						**Core**
Prerequisite	**Contact Hours per week**				**CIE**	**SEE**	**Credits**
	L	**T**	**D**	**P**			
Theory of Machines	**--**	**--**	**--**	**2**	**25**	**50**	**1**

Course Objectives:

- To understand the effects and importance of kinematic and dynamic analysis of mechanisms
- To understand effects and analysis of Single degree freedom vibration systems
- To study the gyroscope, governors and cams
- To carry out the static and dynamic analysis of four bar mechanisms and drives

Course Outcomes:

- To experimentally quantify the effect of inertia forces in systems like flywheel, gyroscope and governors.
- To evaluate vibrational characteristics of various systems experimentally.
- To Synthesize balancing method of multi plane rotating masses.

List of Experiments

1. Centrifugal Governors: Experiment on Performance Characteristic Curves.
2. Estimation of Gyroscopic Couple & Understanding of Gyroscopic Effects on a rotating disc.
3. Static and Dynamic Balancing of Rotating Masses.
4. Determination of Moment of Inertia of Connecting Rod by compound pendulum method.
5. Damped and Undamped Torsional Vibrations of Single and Double Rotor System.
6. Single DOF (Degrees of Freedom) of Spring Mass Damper System. (Damped and Undamped Systems).
7. Free and Forced Vibration of Simply Supported Cantilever Beam.
8. Dunkerley Method to Find Fundamental Frequencies.
9. Critical Speed of Shaft.
10. Modal Analysis of Beam.
11. Cam Analysis of Cams.
12. Any Experiment explaining dynamic aspects of mechanical systems.

Additional Experiments Suggested

1. Determination of Moment of Inertia of Flywheel.
2. Experiment with Bifilar System.

Demonstration Experiments (Can't be allocated in final exams)

1. Velocity Ratios of Simple, Compound, Epicyclic and Differential Gear Trains.
2. Virtual Lab Experiment I – Governors.
3. Virtual Lab Experiment II – Natural Frequency of Cantilever beam.

Note: Minimum ten experiments should be conducted in the semester.

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. John J.Uicker, J r. G o r d o n, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
3. Lab manual supplied by department.

Course Code	Course Title						Core/Elective
PC593ME	**Fluid mechanics & Hydraulic machines laboratory**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

Students able to understand

1. **the working of pumps of different kinds and their behaviour.**
2. **the working of turbines of different kinds and their behaviour.**
3. **the theory of working of various flow measuring devices and their utility in industry.**

Course Outcomes

Aftercompleting this course, thestudentwillbe ableto:

1. Practice and experiment on different types of turbines and analyse their performance at rated and off design conditions.
2. Investigate through experimentation different types of pump models and estimate their performance.
3. Apply the priniciple of different flow measuring instruments and their adoptability to the industry.
4. Develop the hydraulic circuits to cater the needs of the industry.

List of Experiments:

1. **Performance and characteristic curves of Self Priming pump**
2. **Performance and characteristic curves of Centrifugal/ Submergible pump**
3. **Performance and characteristic curves of Reciprocating pump**
4. **Performance and characteristic curves of Gear pump**
5. **Impact of Jets on Vanes**
6. **Performance and characteristic curves of Pelton Wheel**
7. **Performance and characteristic curves of Francis Turbine**
8. **Performance and characteristic curves of Kaplan Turbine**
9. **To determine coefficient of discharge of venturi meter**
10. **To determine coefficient of discharge of orifice meter**
11. **Study of Hydraulic Circuits**
12. **Study of pneumatic Circuits**

Course Code	Course Title						Core/Elective
PC601ME	MACHINE DESIGN						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
DMM	3	--	--	--	30	70	3

Course Objectives:

- Importance of helical coil springs and leaf springs in mechanical systems
- Understand the design of gears such as spur, Helical and bevelgears
- How to apply design concepts in bearing design
- Importance of design procedure in designing IC engine components
- Utilization of curved beams on mechanical components

Course Outcomes:

- Analyze helical coil springs and leaf springs for mechanical systems
- Evaluate kinematic transmission systems using gears
- Select bearing system for specific applications
- Design various IC engine components
- Determine load carrying capacity of curved beams

Note: Standard Design data book is allowed in University exam.

UNIT-I

Mechanical Springs: function of springs, Types of springs and materials used. Design of helical coil springs based on strength deflection and energy considerations. End preparation of coil springs, Design for fluctuating loads. Principles of limit design, Concentric springs

Leaf Springs: Stresses and Deflection.Nipping of Leaf springs

UNIT-II

Gears: Types of gears and materials used. Standards for gear specifications. design of spur gears, Helical and Bevel Gears basedstrength criterion -Lewis equation, Wear considerations, dynamic tooth load, Types of gear tooth failure and preventive measures.

UNIT-III

Bearings: Materials used for Bearings. Classification of Bearings. Viscosity of Lubricants Theory of Hydrostatic and Hydrodynamic lubrication. Design of sliding contact bearings - for axial and thrust loads

Rolling Contact Bearings: Different types of rolling element bearings and their constructional details.Static and Dynamic load carrying capacity, Load-life relationship, Design of deep groove ball bearing and roller bearing only, Design for cyclic loads,

UNIT-IV

I.C. Engine Parts: Design of piston, connecting rod and crank shafts. Design of Flywheels for I.C. Engines and Presses

UNIT-V

Curved beams: Theory of bending of members with initial curvature - rectangular, circular and Trapezoidal sections. Design of crane Hooks, Machine frames and C-clamps.

Design of chain drives: types of chain drives, polygonal effect, power rating of roller chains, design of roller and bush type chain, silent chain.

Suggested Reading:

1. V. B. Bhandari, “Design of Machine Elements”, Tata McGraw-Hill Publ, 3rd Edn. 2010.
2. J.E. Shigley & Charles R. Mischke “Mechanical Engineering Design”, Tata McGraw-Hill.,6th ed.2010.
3. P. Kannaiah, Machine Design, Sci-Tech Publ., 2009.
4. P.C. Sharma & D.K. Aggarwal, "Machine Design", S.K. Kataria & Sons, 10th edn, 2003
5. V. B. Bhandari, “Design Data Book ” 2nd edition, ”, Tata McGraw-Hill Publ, 2019

Note : Solution of Numerical problems using Design data book should be practiced.

Course Code	Course Title	Core/Elective

PC602ME	METROLOGY & INSTRUMENTATION						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- To familiarize with Limits & fits, I.S.O. system and the instruments used to measure these limits.
- To have knowledge of various precision linear and angular measuring instruments.
- To learn the importance of form and how to measure form errors.
- To understand the working principles of various instruments used for the measurement of strain, forces, pressure, temperature and vibrations.

Course Outcomes

After completing this course, the student will be able to:

6. To understand limits, fits and tolerances and their applications. Linear and angular measurements and measuring instruments.
7. To understand the design of limit gauges, evaluate roughness and its measurement.
8. To understand basic measuring system, static and dynamic characteristics of instruments
9. To understand various principles to measure pressure, temperature, displacement, force, torque and vibrations.

UNIT – I

Introduction to Limits, Fits,Tolerances as per ISO, types of interchangeability and limit gauges.Taylor's Principle of guage design, Uses of Plug, Ring and Snap gauges. Introduction to Linear and Angular measurements – Slip gauges and End bars – Gauge materials, Different types of Micrometers, Height gauges Tomlinson gauges. Precision polygon, Sine bar, Auto collimator**.**

UNIT – II

Comparators: Dial indicators, Mechanism of Dial indicators, Mechanical comparators, Pneumatic comparators, Optical comparators, Electrical comparators, Tool maker's Microscope and its applications. Measurement of Straightness and Flatness Roundness measurement with bench centers and talyround.

UNIT-III

Introduction to Surface Roughness Measurements, Profilometer, Taylor Hobson Talysurf. Application of Thread metrology - 2 wire and 3 wire methods, Gear measurement - Gear tooth thickness, Parkinson gear tester, General geometric tests for testing machine tools – Lathe, drill and Mill.

UNIT –IV

Introduction to Elements of instrumentation - Static and Dynamic characteristics, Types of errors, Transducers, LVDT, Strain measurement -Wire and foil type resistance strain gauges. Rosette Gauges,Bonding procedure Lead resistance compensation. Proving ring, Strain gauge load cells, measurement of axial load and torsion by strain gauges, Piezo-electric load cell.

UNIT – V

Introduction to Seismic Transducers -displacement and acceleration measurement, Pressure measurement -Bourdon pressure gauge, pirani gauge. Temperature measurement by thermo couples and its law.Types of materials used in thermocouples Protection tubes. Extension wire- Series and parallel circuit's compensation.

Suggested Readings:

1. I.C. Gupta – "Engineering metrology", Dhanpat Rai Publications, New Delhi.
2. Rega Rajendra, "Principles of Engineering Metrology", Jaico Publishing House, Mumbai.
3. RK Jain, "Engineering Metrology", Khanna Publications, 1996.
4. Doeblin,"Measurement Systems Application and Design", Tata Mc¬Graw Hill,5th ed., 2004.
5. Beckwith, Buck, Lienhard, Mechanical Measurements, Paerson education india.
6. P. Donald Echman, "Industrial Instrumentation", John Wiley and Sons, 1996.
7. Hume, "Engineering Metrology", Kalyani Publications, 1985.

Course Code	Course Title						Core/Elective
PC603ME	FINITE ELEMENT ANALYSIS						Core
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
EM, MOM, HT	3	-	-	-	30	70	3

Course Objectives:

1. Equip the students with the Finite Element Analysis fundamentals and formulations
2. Enable the students to formulate the axial, truss, beam and 2d problems
3. Enable the students to formulate the heat conduction and dynamics problems
4. Able to understand use of numerical integration and Gaussian quadrature
5. Enable the students to perform engineering simulations using FE software (ANSYS)

Course Outcomes:

1. Summarize basic equations of elasticity and formulate finite element modeling of one dimensional element using Potential energy approach.
2. Formulate finite element modeling of truss and frame elements along with the concepts of transformation from local to global matrices.
3. Interpolate Hermitian shape function of beam element in natural coordinate system.
4. Develop stiffness matrix for a plane stress & plane strain conditions on a CST, Axisymmetric elements by interpolating shape functions in natural coordinate system.
5. Formulate finite element model to steady state heat transfer analysis using one & two dimensional elements.
6. Formulate mass and stiffness matrices of 1D & beam elements to establish Eigen values &Eigen vectors using Lagarangian and Hamilton principles.

UNIT-I

Introduction to Finite Element Method for solving field problems, Stress and Equilibrium, Boundary conditions, Strain, Displacement, Stress-Strain relations.

One dimensional problems: Finite element modeling coordinates and shapes functions, Potential Energy approach: Assembly of Global stiffness matrix and load vector, Finite element equations, Treatment of boundary conditions, Galerkin's approach, Quadratic shape functions.

UNIT-II

Analysis of trusses and frames: Element stiffness matrix for a truss member, Analysis of plane truss with two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node, Analysis of Beams: Element stiffness matrix for two nodes (two degrees of freedom per node).

UNIT-III

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Finite element modeling of axi-symmetric solids subjected to axi-symmetric loading with triangular elements.

UNIT-IV

Two dimensional four noded iso-parametric elements and numerical integration. Steady state heat transfer analysis: One dimensional analysis of a fin and two dimensional analysis of thin plate, Analysis of circular shaft subjected to torsion.

UNIT-V

Dynamic Analysis: Formulation of finite element model, element matrices, Evaluation of Eigen values and Eigen vectors for a stepped bar and a beam, Time dependent field problems: Application to one dimensional heat flow in a rod **Convergence requirements.** Introduction to Finite Element Analysis Software.

Suggested Reading:

1. G.Ramamurthy, Applied Finite Element Analysis, I.K. International Publishing House Pvt.Ltd., New Delhi, 2009.
2. Tirupathi R, Chandraputla and Ashok D Belagundu, Introduction to Finite Elements in Engineering, Prcatice Hall of India,1997.
3. Rao S S, The Finite Element Method in Engineering, Pergamon Press, 1989.

4. Segerlind L J, Applied Finite Element Analysis, Wiley Eastern, 1984.
5. Reddy JN, An Introduction to Finite Element Method, McGraw-Hill, 1984.

Course Code	Course Title	Core/Elective

PE611ME	**CAD/CAM**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives:

- To introduce the concepts of CAD and advanced modeling techniques
- To help the students in understanding the functioning of computer numerical control machine tools and also in writing programs for operating this machines.
- To help the student in understanding advanced manufacturing concepts like Group technology, flexible manufacturing systems, Computer aided Process Planning, Computer aided quality control, Artificial Intelligence etc.

Course Outcomes:

The Students will be able to

- Understand the fundamental applications of computer in design, manufacturing and geometric transformation techniques in CAD
- Develop mathematical Model for curves, surfaces, solid models and understand the fundamental concepts of Finite Element Analysis
- Write CNC Part program for manufacturing components
- Understand the concepts of Machining Centres, adaptive control and as well as fundamentals knowledge of robotics
- Understand the working of various components of an modern manufacturing systems

Unit-I

CAD Fundamentals, Product life cycle in conventional and computer based manufacturing system, Hardware integration and networking. CAD Software: Definitions of system software and application software. Graphic Standards and Exchange Formats. CAD database and structure. Automatic 2-D facilities such as Fillets, Chamfers, Hatching, Dimensioning, Editing, Windowing & Zooming. 2-D & 3-D Geometric Transformations.

Unit-II

Geometric modeling: 3-D wire frame modeling: wire frame entities and their definitions, Interpolation and approximation of curves, synthetic curves and curve fitting. Definitions of cubic, Bezier, and B-spline curves.

Surface modeling: Definitions of basic surfaces, surface of revolution, blends, intersection, and Cubic, Bezier, B-spline surfaces.

Solid Modeling: Solid entities, Boolean operations, B-rep and C-rep approaches. Feature based modeling: Concepts and applications, Assembly modeling.

Finite element modeling: Introduction, modeling, Meshing, Characteristics of different elements, different solvers and post processing.

Unit-III

Numerical Control of machine Tools: Features and elements of NC. Positional, paraxial and contouring types. Definitions of axes, punched type, formats of tape preparation. Definitions of interpolation, post-processor, preparatory and miscellaneous functions, canned cycles, tool length and cutter radius compensation. Manual and computer aided part programming (APT) for simple components. Programming with MACROS.

Unit-IV

Computer Control in NC and Robots: Machining centers, CMC, DNC and adaptive control systems. Their types, typical configurations and relative features. Industrial Robots: Classification based on manipulator configurations, relative characteristics, Online and offline programming methods, controls and drives, applications.

Unit-V

Group Technology: Organization, G.T. layout, part classification and coding, CAPP: Variant and Generative approaches and their relative features. Computer Aided Quality Control: Computer in quality control, Contact and non contact inspection, optical and non optical computer aided testing. Basic concepts of FMS, Experts systems. Artificial intelligence, CAD/CAM integration, Introduction to 3D Printing: Process chain, Classification , description about SLA, SLS and FDM processes.

Suggested Reading:

1. Ibrahim Zeid, "CAD/CAM, theory and practice", McGraw Hill Inc, N.Y.1991.
2. Grover, MP and Zimmers E.W., "CAD/CAM", Prenctice Hall of India 1989.
3. Rao P.N., Tiwari N.K., Kundra T.K., "Computer Aided Manufacturing", Tata McGraw Hill, New Delhi, 1993.
4. Radhakrishnan. P, Subramanyan. S, Raju. V, "CAD/CAM/CIM", New Age international (P) Ltd., 2nd Edn., 2004.

Course Code	Course Title						Core/Elective
PE612ME	**AUTOMOBILE ENGINEERING**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Understand the Working of Fuel, Ignition, and cooling Systems.
- Understand the Working of Lubrication and Electrical Systems
- Understand the Working of Suspension, Steering and Braking Systems.
- Understand the Working of Power Transmission.
- Understand the Necessity of Pollution Control and Maintenance.

Course Outcomes

After completing this course, the student will be able to:

1. Generalize the different types of automobiles, list the engine components, describe the functioning of IC engines and classify the fuel supply system for S.I and C.I engines
2. Differentiate the types of lubrication system; identify different lubrication and cooling systems used in vehicles. Classify ignition system and describe the functioning of battery and automobile air conditioning system.
3. List the salient features of different steering mechanisms, describe the importance of wheel alignment and wheel balancing, describe the importance of different suspension systems and shock absorbers used in an automobile
4. Identify different components in power transmission system design a system, components, or process to meet desired needs with in realistic constrains such as economic, environmental, health and safety, describe about braking system
5. Adapt techniques, skills and modern engineering tools necessary to control the pollution, record the automobile parts maintenance, design and build components and system to reduce pollution of automobile vehicles

UNIT – I

Types of automobiles: Normal, Hybrid and Hydrogen fuel vehicles. Engine location and its components, chassis layout, crank shaft proportion, firing order, piston and piston rings, cylinder liners, valves and operation mechanism, inlet and exhaust manifolds, carburetion and fuel injection system, mechanical fuel injection system & electronic fuel injection system.

UNIT – II

Lubricating systems: Wet sump, dry sump and petrol systems, and Cooling systems: Water pumps, radiators, thermostat control anti freezing compounds. Types of Ignition systems, modern ignition systems, types of batteries and charging systems, starting motors, lighting and electrical accessories, automobile air-conditioning.

UNIT-III

Steering systems: Linkage arrangements and its components modified Ackerman linkage, wheel alignment, caster and camber. Rack and pinion assembly – recent trends Wheel and tyres: Tyre construction, specification. Tyre wear and causes, wheel balancing, types of suspension system, independent suspension coil and leaf springs, torsion bar, shock absorbers.

UNIT –IV

Power Train: Clutches, gear and gearbox manual, semi-automatic and automatic gearboxes. Torque converter, propeller shaft, universal coupling differential, four-wheel drive system.Brake systems: Description and operation of hydraulic brake, leading and trailing shoe layout, disc brakes, master cylinder, hand brake linkage, recent trends.

UNIT – V

Maintenance: Pollution control, trouble shooting and servicing procedure overhauling, engine tune up, tools and equipment for repair and overhaul, testing equipment, pollution control technologies used for petrol and diesel engines, types and study of catalytic converters, Euro norms 2 & 3 and Bharat Norms – recent trends.

Suggested Readings:

1. Crouse & Anglin, 'Automotive Mechanics' Tata McGraw Hill, Publishing Co., Ltd., New Delhi, Tenth edition - 2004..
2. Kirpal Singh, "Automobile Engineering", Vol I & II Standard Publishers, Delhi.
3. Joseph Heitner, 'Automotive Mechanics', Affiliated East West Pvt., Ltd.,
4. C.P. Nakra, "Basic Automobile Engineering", Dhanpat Rai Publishing Co.(P) Ltd., New Delhi, 2003

Course Code	Course Title						Core/Elective
PE613ME	**MODERN MACHINING AND FORMING METHODS**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

To know the importance of unconventional machining and forming processes.

To learn the working principle of various modern machining and forming processes.

To understand the advantages, limitations and applications of various modern machining and forming processes.

To know the relationship between process parameters and performance of various processes.

To know the suitability of processes for various engineering materials and applications.

Course Outcomes:

Students will be able to:

- Understand the evolution, classification and need of nontraditional machining technology in modern manufacturing
- Understand the principle, description, the parametric effect on process performance and material removal mechanics of USM, AJM, WJM and AWJM processes.
- Understand the principle, description, the parametric effect on process performance and material removal mechanics of EDM, EDG, ECM and CHM processes.
- Understand the principle, description, the parametric effect on process performance and material removal mechanics of LBM, EBM, PAM and Ion machining processes.
- Compare conventional & high energy rate forming methods
- Understand the principle, working and applications of various types of high energy rate forming methods.

UNIT-I

Introduction: Need for nontraditional machining processes, selection, classification & comparative study of different processes; **Ultrasonic Machining (USM):** Introduction, process description, abrasive slurry, Abrasive materials and their characteristics. Functions of liquid medium in slurry, Types of Transducers, effect of process parameters, applications and limitations; **Abrasive Jet Machining (AJM):** Principle of operation, process details, process variables and their effect on MRR and accuracy. Equation for MRR Advantages, disadvantages and applications; **Water Jet Machining (WJM):** Schematic diagram, equipment used, advantages and applications; **Abrasive Water Jet Machining (AWJM):** Schematic diagram, equipment used, advantages and applications.

UNIT-II

Electro Discharge Machining (EDM): Process description with schematic diagram, process parameters, functions and characteristics of dielectric medium, dielectric fluids, over cut and side taper' Flushing, Mechanism of metal removal, crater volume, types of power supply circuits, mathematical analysis of metal removal rate (MRR), characteristics of spark eroded surfaces, advantages, disadvantages and applications.

Wire EDM: Process description and applications; **Electro Discharge Grinding:** Process description and applications; **Electro-Chemical Machining (ECM):** Schematic of the process parameters, function and characteristics of electrolyte, chemistry of the process, Equation for specific MRR and electrode feed rate, advantages, limitations and applications; **Electro Chemical Grinding:** Process description and applications.

UNIT-III

LASER Beam Machining (LBM): Principle of LASER Beam production, materials used, thermal analysis of the process, process parameters, equations for power density and machining rate, advantages, limitations and applications; **Plasma Arc Machining (PAM):** Introduction equipment used, process description and parameters, types of plasma arc - Transferred arc and non transferred arc; advantages, disadvantages and applications; **Electron Beam Machining (EBM):** Schematic of the process, process parameters, principle of production of Electron beam, equipment used, Advantages, disadvantages and applications; **Ion Etching:** Process description and applications.

UNIT-IV

High Energy Rate Forming (HERF): Introduction, comparison of conventional & high energy rate forming methods. Types of high energy rate forming methods; **Explosive Forming:** principle, Explosive materials, types of explosive forming - standoff operation and contact operation, advantages, disadvantages and applications; **Electro-Hydraulic forming (EHF):** Schematic of the process description and its applications; **Electro-Magnetic Forming (EMF):** Schematic of the process description and its applications; **Rubber Pad Forming:** Principle, process details and its types; Guerin, wheel on, Marfoming and Hydro forming processes and applications.

UNIT-V

Stretch Forming: Introduction, types of stretch forming - stretch draw forming, rotary stretch forming or stretch wrapping, compression forming and radial draw forming, Stretch forming equipment and accessories, accuracy and surface finish, process variables, limitations and applications; **Tube spinning:** Introduction, methods of tube spinning - backward spinning, Forward spinning; machines and tools used, machine variables - speeds and feeds; effect of tube spinning on work metal properties and applications; **Hydrostatic Forming:** Process principle, description and applications; **Water Hammer Forming (WHF):** Schematic diagram of the process, principle of operation, process variables, work materials, process limitations and applications.

Suggested Reading:

1. P.K.Mishra "Non Traditional Machining processes" Narosa Publications, New Delhi, 2001.
2. V.K Jain "Advanced Machining Processes" Allied Publishers, Hyderabad.
3. Davies and Austin, Developments in High Speed Metal Forming, The Machinery Publishing Co. Ltd., 1985.
4. HMT Production Technology, Tata McGraw Hill Publications, 1995.

Course Code	Course Title						Core / Elective
OE601ME	**Entrepreneurship**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation
- To understand the behavioural aspects of entrepreneurs and time management

Course Outcomes

At the end of the course, the students will be able to

1. Understand Indian Industrial Environment, Entrepreneurship and Economic growth, Small and Large Scale Industries, Types and forms of enterprises.
2. Identify the characteristics of entrepreneurs, Emergence of first generation entrepreneurs, Conception and evaluation of ideas and their sources.
3. Practice the principles of project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis.
4. Apply the concepts of Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques
5. Understand the Behavioural aspects of entrepreneurs, Time Management, Various approaches of time management, their strengths and weakness. The urgency addiction and time management matrix.

UNIT-I

Indian Industrial Environment-competence, Opportunities and Challenges. Entrepreneurship and Economic growth. Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs. Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas and their sources. Choice of Technology - Collaborative interaction for Technology development.

UNIT-III

Project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis, project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management. Assessment of tax burden.

UNIT-V

Behavioural aspects of entrepreneurs: Personality - determinants, attributes and models. Leadership concepts and models. Values and attitudes. Motivation aspects. Change behaviour. Time Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management",* Himalaya Publishing House, 1997
2. Prasanna Chandra, *"Project-Planning, Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd. 1995.
3. Stephen R. Covey and A. Roger Merrill, *"First Things First",* Simon and Schuster Publication, 1994.
4. G.S. Sudha, *"Organizational Behaviour",* 1996.
5. Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005.

Course Code	Course Title						Core / Elective
OE602ME	**INDUSTRIAL ROBOTICS**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**0**	**0**	**0**	**30**	**70**	**3**

Course Objectives

- To familiarize the student with the anatomy of robot and their applications.
- To provide knowledge about various kinds of end effectorsusage.
- To equip the students with information about various sensors used in industrial robots.
- To make the student understand the importance of spatial transformation of robots using forward and inverse kinematics.
- To specify and provide the knowledge of techniques involved in robot vision in industry.
- To equip students with latest robot languages implemented in industrial manipulators.

Course Outcomes

- Able to demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics and have an understanding of the functionality and limitations of robot actuators and sensors.
- Able to demonstrate an ability to apply spatial transformation to obtain forward/Inverse kinematics equation of robot manipulators using analytical/numerical/simulation tools.
- Able to apply knowledge and choose the best & economically suitable sensors/end effectors required for specific applications.
- Able to understand the importance of robot vision and apply the learnt techniques to get the required information from input images.
- Able to design and develop a industrial robot for a given purpose economically.
- Appreciate the current state and potential for robotics in new application areas.

UNIT – I

Introduction to Robotics: Basic structure of Robots. Degree of freedom of Robots, Work envelope, Classification of Robots based on Drive Technology, Work-Envelope and motion control methods. Application of Robots in Industry, Repeatability, Precision and Accuracy as applied to Robots, Specifications of robots used for various applications. End effectors, Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers, Two fingered and three fingered grippers, internal grippers and external grippers, Selection and design considerations.

UNIT – II

Requirements of a Sensor: Principles and Applications of the following types of sensors- Position of sensors (Piezo electric sensor, LVDT, Resolvers, Optical encoders, Pneumatic position sensors), Range sensors (Triangulation principle, Structured, Lighting approach, Time of flight range finders, Laser range meters), Proximity sensors (Inductive, Hall effect, Capacitive, Ultrasonic and Optical proximity sensors), Touch sensors (Binary sensors, Analog sensors), Wrist Sensors, Compliance Sensors, Slip Sensors.

UNIT – III

Kinematic Analysis of Robots: Rotation matrix. Homogeneous transformation matrix, Denavit&Hartenberg representation, Euler and RPY angles representation. Representation of absolute position and orientation in terms of joint parameters, Direct Kinematics of manipulators, Inverse kinematics of Robot arm for position and orientation. Redundancy in Robots, Static force analysis

UNIT-IV

Introduction to Techniques used in Robot Vision: Image acquisition, illumination techniques, imaging geometry, basic relationship pixels, preprocessing, segmentation & description of 3-dimensional structures, their recognition and interpretation. Types of Camera, frame grabbing, sensing and digitizing image data, Signal conversion, Image Storage, Lighting techniques, Image processing and analysis, Data reduction, Segmentation, Feature extraction, Object recognition, and various algorithms, Applications, Inspection, identification, visual serving and navigation.

UNIT – V

Robot Programming Languages: Characteristics of robot level languages, task level languages. Teach pendant programming, Lead through programming, Robot programming languages, VAL programming, Motion commands, Sensor commands. End effecter commands, Simple programs. RGV, AGV, Implementation of robots in industries, various steps, Safety considerations for robot operations. Economic analysis of robots, Pay back method, EUAC method and Rate of return method

Suggested Readings:

1. Groover M P, **"Industrial Robotics"**, McGraw Hill Publications,1999.
2. Fu. K.S., GonZalez R.C., Lee C.S.G. "**Robotics, Control-sensing vision and Intelligence**", McGraw Hill, Int. Ed.,1987.
3. Spong and Vidyasagar, "**Robot Dynamics & Control**", John Wiley and Sons,Ed.,1990.
4. Mittal and Nagrath, "**Industrial Robotics**", Tata McGraw Hill Publications,2004.
5. Saha&Subirkumarsaha, '**Robotics'**, TMH,India.

Course Code	Course Title						Core/Elective
PC691ME	**METROLOGY & MACHINE TOOLS LAB**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To have knowledge of various precision measuring instruments.
- To familiarise machining and metal cutting operations.

Course Outcomes

After completing this course, the student will be able to:

1. Select and apply the knowledge of measuring tools for external, internal and angular measurements for promoting the qualitative production management.
2. Adapt the principles of optical measurements in measurement of screw and gear profiles.
3. Choose and practice the appropriate methods of force measuring devices principles for required situation.
4. Demonstrate the need of machine alignment test for qualitative production.
5. Practice calibration principles for maintaining the required precision of instruments / tools.
6. Select and practice the methods of temperature measurement.
7. Select cutting tool materials and tool geometries along with appropriate cutting conditions for different work materials and grind the cutting tools to the required geometry.
8. Recognize and summarize the features and applications of various machine tools like Lathe, Milling, Drilling, Grinding, Shaping, Slotting etc.

List of Experiments:

A) Metrology & Instrumentation:

1. Measurement with inside, outside and depth micrometers, Vernier calipers and Height gauges.
2. Measurement of roundness errors with Bench Centres, V-block and dial guage.
3. Measurement of Linear and Angular dimensions with Tool Maker's Microscope: Flat specimens.Plain cylindrical specimens with centers and threaded components.
4. Measurement of angles with Sinebar, Bevel protractor and Precision level.
5. Measurement with Dial Indicator / Electrical Comparator / Mechanical Comparator / Dial Bore Gauge / Snap Gauge/Plug gauges.
6. Calibration and Force measurement with Strain gauge type load cell/Proving Ring/spring type sensor

B) Machining Operations:

7. Thread cutting exercise on lathe machine as single start and multi start threads.
8. Typical exercises on lathe machine(Turning,Step turning,Facin,Parting off &Taper turning).
9. Typical exercises on shaper, cylindrical grinding machine.
10. Exercise of simple gear manufacturing on milling machine.
11. Production of threads with taps and threading dies and milling cutters.

C) Metal Cutting:

12. Estimation of shear angle by measuring thickness and length of chips.
13. Measurement of Cutting forces with Lathe tool dynamometer and determination of friction angle and stresses on shear plane and rake plane.
14. Study of geometrical tests on lathe machine.

Note: At least ten experiments should be conducted.

Course Code	Course Title						Core/Elective
PC692ME	Computer Aided Engineering LAB						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	-	-	-	2	25	50	1

Course Objectives:

- To introduce fundamentals of the analysis software, its features and applications.
- To learn the basic element types in Finite Element analysis.
- To know the concept of discretization of continuum. Loading conditions and analyze the structure using pre-processor and postprocessor conditions.

Course Outcomes:

- Classify the types of Trusses (Plane Truss & Spatial Truss) and Beams (2D & 3D) with various cross sections to determine Stress, Strains and deflections under static, thermal and combined loading
- Generalized Plane stress, plane strain conditions & axi-symmetric loading on inplane members to predicting the failure behavior and finding the SCF
- Analyse connecting rod with tetrahedron and brick elements, performing static analysis on flat & curved shells to determine stresses, strains with different boundary conditions.
- Predict the natural frequencies and modes shapes using Modal, Harmonic analysis. Also finding the critical load using Buckling analysis
- Simulate steady state heat transfer analysis of chimney, Transient heat transfer of castings, Non linear, Buckling analysis of shells CFD analysis
- Evaluate the stiffness matrix, B matrix and loading matrices of beam in plane/solid elements using MATLAB / Python software

1. Analysis of Plane Truss & Spatial Truss with various cross sections and materials to determine member forces, member strains & stresses, joint deflections under static, thermal and combined loading.
2. 2D & 3D beam analysis with different sections, different materials for different loads (forces and moments with different end supports.
3. 1D, 2D and 3D meshing with different element sizes for different CAD geometry (Proposed Experiment)
4. Static analysis of plates with a hole to determine the deformations, the Stresses to study the failure behavior and SCF.
5. Plane stress, plane strain and axi-symmetric loading on the in plane members with in plane landing to study the stresses and strains.
6. Static analysis of connecting rod with tetrahedron and brick elements
7. Static Analysis of flat and curved shell due to internal pressure and moments to estimate the strains, stresses and reactions forces and moments with different boundary conditions .
8. Buckling analysis of plates, shells and beams to estimate BF and modes.
9. Modal analysis of beams, plates and shells for natural frequencies and mode shapes.

10. Harmonic analysis of a Shaft subjected to periodic force and transient analysis of plate subjected to stepped and ramped loading with varying time .
11. Steady state heat transfer Analysis Cross section of chimney and transient heat transfer analysis of solidification of castings.
12. Non linear analysis of cantilever beam with non-linear materials at tip moment and post Buckling analysis of shells for critical loads
13. Coupled field analysis.
14. Flow analysis of pipe with different fluids/gasses/air for velocity and pressure gradients.
15. Implicit and Explicit Analysis of car with 300m/s (Proposed Experiment)
16. CFD analysis of aerofoil design.
17. CFD analysis of ducts/impeller/fan.
18. CFD analysis of racing car (Proposed Experiment)
19. Use of MATLAB / Python for finding B matrix, stiffness matrix and loading matrices of beam/in plane/solid elements and interfacing with CAE software's .

Note : Any 12 experiments to be conducted

FACULTY OF ENGINEERING

Scheme of Instruction & Examination

(AICTE Model Curriculum for the Academic Year 2020-2021)

and

Syllabi

B.E. V and VI Semester

of

Four Year Degree Programme

in

Production Engineering

(With effect from the academic year 2020– 2021)

(As approved in the faculty meeting held on - -2020)

Issued by

Dean, Faculty of Engineering

Osmania University, Hyderabad – 500 007

2020

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Production Engineering) V – SEMESTER

S.No.	Course Code	CourseTitle	SchemeofInstructions				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC501PE	Machine Tool Design	3	-	-	3	30	70	3	3
2	PC502ME	Design of Machine Elements	3	-	-	3	30	70	3	3
3	PC503ME	Dynamics of Machines	3	-	-	3	30	70	3	3
4	PC504ME	Metal Cutting and Machine Tools	3	-	-	3	30	70	3	3
5	PC502PE	Computer Aided Design and Manufacturing	3	-	-	3	30	70	3	3
LaboratoryCourse										
6	PC591PE	Computer Aided Production Drawing	-	-	2	2	25	50	3	1
7	PC592ME	Dynamics of Machines Lab	-	-	2	2	25	50	3	1
8	PC592PE	Modern Manufacturing and Testing Lab	-	-	2	2	25	50	3	1
		Total	15	-	06	21				18

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Production Engineering) VI – SEMESTER

S.No.	Course Code	CourseTitle	SchemeofInstructions				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC601ME	Machine Design	3	-	-	3	30	70	3	3
2	PC602ME	Metrology and Instrumentation	3	-	-	3	30	70	3	3
3	PC603ME	Finite Element Analysis	3	-	-	3	30	70	3	3
4	PEME	Professional Elective – I	3	-	-	3	30	70	3	3
5	OEC - 1	Open Elective – 1	3	-	-	3	30	70	3	3
6	OEC - 2	Open Elective – 2	3	-	-	3	30	70	3	3
LaboratoryCourse										
7	PC691ME	Metrology and Machine Tools Lab	-	-	2	2	25	50	3	1
8	PC692ME	Computer Aided Engineering Lab	-	-	2	2	25	50	3	1
9		Summer Internship*								2
		Total	18	00	04	22				22

Open Elective - 1 (OE601ME) : Entrepreneurship (Not for Mechanical / Prod. / Automobile)
Open Elective - 2 (OE602ME) : Industrial Robotics (Not for Mechanical / Prod. / Automobile)

PROFESSIONAL ELECTIVE - I	
PE611PE	Additive Manufacturing Technology
PE612ME	Automobile Engineering

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

* *At the end of VI semester students should undergo summer Internship - Credits for Summer Internship will be awarded in VII semester*

Course Code	Course Title						Core/Elective
PC 501 PE	MACHINE TOOL DESIGN						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
-	3	--	--	--	30	70	3

Course Objectives:

- To understand the basics and working principles of machine tools.
- To grasp and understand the functional and operational requirements of different types of machine tools.
- To learn the knowledge of design of different types of drives and gears to meet varied functional and operational requirements.
- To understand the hydro dynamics mechanism of machine tools.
- To learn the knowledge of hydraulic controls of machine tools.

Course Outcomes:

After completion of the course, the students will able:

- To differentiate between various machines tools & their specifications, recognize the kinematics and its mechanism of the machines.
- To recognize the drives of the machine tools at varies speeds.
- To understand the drives and analysis of the machine tool componants.
- To recognize the varies spindle speeds of machine tool elements.
- To understand the varies hydraulic controls of machine tools.

Unit-1

Classification of machine tools. Mechanisms used for converting rotary to linear motion and intermittent motion. Kinematic structures of machine tools - general purpose, special purpose, automatic screw cutting machines. Basic features of transfer machines. Numerical Control of machine tools, advantages and limitations. Schematic diagrams of NC systems.

Unit-II

Drives of machine tools; selection of range of speeds and feeds. Speed layout in GP, AP and logarithmic progression. Standardization of speeds and feeds. Productivity loss. Selection of highest and lowest speeds, range ratio. Design of ray diagram and structural diagrams for machine tool gear boxes. Determination of number of teeth and module of gears in gear box design. Rules for layout of gear box having sliding clusters. Sliding cluster and clutched drives, Ruppert drive.

Unit-III

Feed gear boxes: Norton and Meander gear boxes. Stepped and step less regulation of speeds.Strength and Rigidity design analysis. Design of beds, frames, Columns and Guide ways.Materials for structures. Methods to improve the rigidity of structures. Overall compliance of machine tool. Thermal effects - functional accuracy of machine tool.

Unit-IV

Spindle units; Spindles of lathe, Drilling, Milling and Grinding machines materials for spindles. Spindle design. Effect of clearance on the rigidity of spindle. Hydro-dynamic and Hydro-static bearings; Requirements of spindle bearings.

Unit-V

Hydraulic controls: various controls used in machine tools. Hydraulic and Pneumatic systems used in machine tools. Positive displacement pumps. Power pack. Relief valves, check valves, flow control valves, multi position direction control valves, Filters, Accumulators. Speed regulation of surface grinding machine. Hydro- copying systems.

Suggested Reading:

1. G C Sen & Bhattacharya, *Principles of machine tools,* New Central Book Agency, Calcutta.
2. N K Mehta, *Machine Tool Design and Numerical Control,* Tata McGraw-Hill Publishing co. Ltd.
3. S.K.Basu, *Design of machine tools*, Allied Publishers
4. S R Majumdar, *Hydraulic Systems- Principles & Maintenance*, Tata Mc.Graw-Hill Publishing Company *Limited; New* Delhi

Course Code	Course Title						Core/Elective
PC502ME	DESIGN OF MACHINE ELEMENTS						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
	3	--	--	--	30	70	3

Course Objectives:

- Importance of codes, materials, manufacturing processin design of mechanical components
- Importance of theories of failure and effects of fatigue and stress concentration on the life of the component
- Learn the concepts required to design machine components like keys, shafts, couplings
- Will learn to determine size of rivets, welds and cotter joints for specific applications
- Will Understand the concepts used for designing machine components like cotters, bolts, nuts

Course Outcomes:

- Identify & Use codes and standards, selection proper material & perform static design.
- Analyze cyclic loading conditions and provide fatigue design of components
- Analyze machine elements like keys, shafts and couplings,
- Evaluate various joining techniques like welding, riveting and cotter joints.
- Synthesize an d design screw threads for fasteners and power screw applications.

UNIT-I

Steps involved in Design, Design considerations of Machine Elements, Materials used and their specifications. Codes and standards used in design. Practice of using Design data book. Concept of Aesthetics & Ergonomics in design, Preferred numbers. Manufacturing considerations in design. Concept of Value analysis, Principles of concurrent design,

Types of loads and simple stresses. Principal stresses, Stresses due to Biaxial and Triaxial loads. Stress concentration effects, Factor of safety. Theories of failures. Design of components subjected to impact loading.

UNIT-II

Design for Fatigue: Fluctuating stresses, fatigue strength and endurance limit Stress concentration factor and Notch sensitivity. Factors affecting fatigue strength. S-N diagram, Soderberg and Modified Goodman's diagrams for fatigue design, Cumulative fatigue - Miner's rule.

UNIT-III

Design of shafts: solid, hollow and splined shafts under torsion and bending loads. Design of keys. Design of couplings – Industrial Flange coupling, Flexible rubber bush couplings.

UNIT-IV

Design of Joints: Cotter and Knuckle joints. Design of rivetted and welded joints under direct and eccentric loads.

UNIT-V

Design of Screw threads: Design of bolts and nuts, Locking devices for nuts, Bolts of uniform strength. Design of gasket joints, Bolted joints under eccentric loads, Differential and Compound Screws, Design of power Screws and screw jack.

Suggested Reading:

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw-Hill Publ, 3rd Edn. 2010.
2. J.E. Shigley & Charles R. Mischke "Mechanical Engineering Design", Tata McGraw-Hill.,6th ed.2010.
3. P. Kannaiah, Machine Design, Sci-Tech Publ., 2009.
4. P.C. Sharma & D.K. Aggarwal, "Machine Design", S.K. Kataria & Sons, 10th edn, 2003
5. V. B. Bhandari, "Design Data Book " 2nd edition, ", Tata McGraw-Hill Publ, 2019

Note : Solution of Numerical problems using Design data book should be practiced.

Course Code	Course Title						Core/Elective
PC503ME	DYNAMICS OF MACHINES						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
Kinematics of Machines	3	--	--	--	30	70	3

Course Objectives:

- To know effect of inertia of links, and external forces on the input torque, and forces developed at joints in typical mechanisms in motion; understand the gyroscopic couple and its effect on vehicles in motion.
- To know the working principles and characteristics of typical governors, as also the function of flywheels.
- To know the concept of unbalancing rotating and reciprocating masses in single and multi-cylinder in line and radial engines.
- To understand the phenomena of free of free and forced, including the effect of damping for single dof systems, and concepts of isolating vibration.
- To determine natural frequencies of undammed, damped and forced vibrating systems of one, two and multi degree freedom systems.

Course Outcomes:

- Analyse static and dynamic forces in slider crank and other mechanisms; determine the magnitude of gyroscopic couple and its effect on vehicles in motion.
- Evaluate the performance of various types of governors and design flywheels considering speed and energy fluctuation
- Analyse problems of balancing in rotating and reciprocating machinery.
- Evaluate the natural frequencies of single and two degree of freedom systems in free and forced vibration mode, also considering the effect of damping.
- Determine the natural frequencies and mode shapes of multi degree of freedom systems, including by Dunkerley, Raleigh and Holzer methods.

UNIT-I

Static and Dynamic Force Analysis: *Static equilibrium:* Constraint and Applied forces, Static Force analysis of Single slider crank mechanism without Friction, Principle of Superposition.

Dynamic Equilibrium: d'Alambert's Principle, Equivalent offset inertia force, Dynamic force Analysis of Slider Crank Mechanism,

Engine Force Analysis: Piston effort, Force along connecting rod, thrust on sides of cylinder, crank effort. Thrust on bearing. Dynamically Equivalent System for Connecting Rod.

Gyroscope: Gyroscopic Couple, gyroscopic effects on aeroplanes, naval ships.

Stability of two wheel vehicle only.

UNIT-II

Governors: Working principle of governor, Classification & types of governors, analysis of Watt, Porter, and Hartnell governors. Characteristics of governors:

Controlling Force, Stability, Isochronism, Sensitivity, Power and Effort of governors.

Flywheels: Functions, Differences between flywheel and governor, turning moment diagrams, flywheel analysis for I-C Engines and presses.

UNIT - III

Balancing: Static balancing, Dynamic balancing, balancing of several masses rotating in several planes, consideration of bearing forces, balancing of reciprocating masses, primary balancing shaking forces in single cylinder engine, partial balancing and its effects, secondary balancing.

UNIT - IV

Vibrations: Vibrations of Single degree freedom system (axial, transverse and torsional), Equivalent system of combination of springs, Stepped shaft, Whirling speed of shafts.

Damped Vibrations: Types of damping, Vibrations with viscous damping

Forced Damped Vibrations: Magnification factor, Resonance, Vibration isolation and Transmissibility.

UNIT –V

Vibration Analysis of Multi Degree Freedom Systems: Torsional Vibrations of Two rotor, three rotor and Geared systems. Natural frequencies of two degree freedom systems Modes of vibration approximate methods for determining natural frequencies: Dunkerley's method, Rayleigh's method. Holzer's method (only Theory).

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. Thomas Bevan, the Theory of Machines, CBS Publishers & Distributors, 2004.
3. John J.Uicker, Jr. Gordon, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
4. J.S. Rao and Gupta, Theory and Practice of Mechanical Vibrations, Prentice Hall, 1984.
5. R.L.Nortan, "Kinematics and Dynamics of Machinery", Tata McGraw Education Pvt. Ltd , New Delhi, 2009.
6. Ghosh and Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press, 1988.

Course Code	Course Title						Core/Elective
PC504ME	**METAL CUTTING & MACHINE TOOLS**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

- To learn the tool material, geometry and mechanics of metal cutting for turning, drilling and milling.
- To know the heat distribution, tool wear, tool life, and machinability
- To learn the principle and working of various machine tools like lathe, shaper, planer, milling, drilling and grinding machines etc.
- To learn various types of fixtures, conventional and unconventional machining processes.

Course Outcomes:

- Understand the cutting tool geometry, mechanism of chip formation and mechanics of orthogonal cutting.
- Understand the thermal aspects of metal cutting, influence of tool wear on tool life and machinability.
- Identify basic parts and operations of machine tools including lathe, shaper, planer, milling, drilling, and boring machines.
- Design locating and clamping devices to produce a component.
- Understand the principles of various finishing processes and gear manufacturing processes
- Understand the principle and working of various unconventional machining processes.

UNIT-I

Cutting Tool Materials: High carbon steel, HSS, Stellites, Carbides, Coated carbides, Diamonds, Tool material properties; **Tool Geometry:** Nomenclature of single point cutting tool by ASA & ORS systems. Geometry of drills, milling cutters; **Chip Formation:** Types of chips, BUE, Chip breakers; **Machining:** Orthogonal and oblique cutting, Mechanics of metal cutting, Merchant's analysis, Shear angle, Solutions of Merchant and Lee & Shafer.

UNIT-II

Thermal Aspects of Metal Cutting: Sources of heat and heat distribution, various methods of measurement of temperature, Cutting fluids and applications; **Tool Wear, Tool Life and Machinability:** Types of wear, mechanism of tool wear, Tool life & Machinability, Machinability index. Taylor's tool life equation; **Economics of Machining:** Tool life for maximum production, minimum cost.

UNIT-III

Machine Tools: Constructional features and specifications of machine tools, various operations on Lathe, Types of Lathes - capstan and turret Lathes; Drilling, Milling and Boring machines. Indexing methods, differences between shaper, planer and slotter, Tool holding and work holding devices Quick return mechanisms.

UNIT-IV

Grinding Machines: Types of grinding, Abrasives and bonds used for grinding wheels. Specification and selection of grinding wheels; Broaching, Lapping, Honing, Polishing, Buffing, Super Finishing and Burnishing.

Screws and Gear Manufacturing: Tapping, Chasers, Thread rolling, Thread milling, Thread grinding. Gear shaping, Gear hobbing, Gear shaving and grinding.

UNIT-V

Jigs and Fixtures: Design principles for location and clamping. Quick clamping devices Types of Jigs and fixtures. Applications of Jigs and Fixtures.

Unconventional Machining: Principle of working, merits, demerits and applications of USM, AJM, EDM, ECM, LBM and EBM

Suggested Reading:

1. B.L. JuneJa and Shekon, "Fundamentals of Metal Cutting & Machines Tools", Wiley Eastern Ltd. 1987.
2. P.N. Rao, "Manufacturing Technology – Metal Culling & Machine Tools", Vol. 2, Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Amitab Ghosh and Mallick, "Manufacturing Science", Affiliated East West Press 1985.
4. P.K Misha, "Non Traditional Machining Processes", Narosa Publications, 2006.
5. V.K.Jain “Advanced Machining Processes“ Allied Publishers, Hyderabad, 2011.
6. A. Bhattacharyya, “Metal Cutting Theory and Practice” New Central Book Agency (P) Ltd. Calcutta, 1996.
7. Stephan Radavich, “Gear Manufacturing”, CRC Press, ,1 Edn,2011

Course Code	Course Title						Core/Elective
PC502PE	**COMPUTER AIDED DESIGN AND MANUFACTURING**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Computer aided design and its standards
- Geometric modelling and its types and techniques
- NC machine and Part programming of machining
- Advanced NC machines, Basic exposure to industrial robots and Group Technology
- Importance and significance of CAPP, CAQC, Reverse engineering and Rapid Prototyping

Course Outcomes

After completing this course, the student will be able to:

1. Appraise about the product life cycle and CAD standards. Analyse the geometric transformations.
2. Differentiate the types of geometric modelling and apprehend the application of geometric modelling w.r.t real time applications.
3. Execute the part programming for machining.
4. Identify the working of CNC, DNC, Robots and analyse the applications of GT.
5. Differentiate the various CAPP, CAQC techniques and understand the advancement in CAM technologies i.e. reverse engineering and rapid prototyping.

Unit -I

Fundamentals of CAD: Introduction to CAD and its tools, Product life cycle, sequential and concurrent engineering,Computer Aided Design, Coordinate systems,2D transformations.CAD standards- Graphical Kernel System (GKS), Data exchange standards- IGES, STEPetc.Types of CAD database, various types of network.

Unit –II

Geometric Modeling: Types of geometric modeling. Wireframe modeling -representation of analytic and synthetic curves, Hermite curves, Bezier curves, B-splinecurves, NURBS, Entities of surface modelling, Analytic surface entities andbicubicpatches, Bezier and B-spline surfaces, Solid modelling techniques, CSG and B-rep**.**

UNIT-III

Numerical Control Machine Tools: Features and elements of NC, Positional, paraxial and contouring types. Definitions of axes. Definitions of interpolation, post -processor, preparatory and miscellaneous functions, Canned cycles, Tool length and cutter radius compensation. Manual and computer aided part programming (APT) for simple components. Programming with MACROS.

UNIT-IV

Computer Numerical Control: CNC, DNC and Adaptive control systems. Machining centers.
Industrial Robots: Robot Anatomy, Configurations, Programming methods and Applications.
GT: Part families, layout, part classification and coding system. Opitz, MICLASS, CODE system

UNIT-V

CAPP: Variant and Generative process planning. **FMS & CIMS:** Building blocks of Flexible Manufacturing systems and their control, Elements of CIMS.
Computer Aided Inspection and QC: Coordinate Measuring Machine, Non-contact inspection: Machine vision, Scanning Laser Beam Devices Quality control. CAD/CAM Integration.
Introduction to Rapid Prototyping Technique and Reverse Engineering.

Suggested Readings:

1. Arvid R. Eide, Roland D. Jenison, Lane H. Mashaw, Larry L. Northup, "Introduction to EngineeringDesign" McGraw -Hill, 1998.
2. Ibrahim Zeid. CAD/CAM, Theory and Practice, McGraw. Hill Inc. New York, 2011.
3. Grover, MP and Zimmers E.W. CAD/CAM, Prentice Hall of India, 1989.
4. Rao, PN. CAD/CAM: Principles and Applications, 2nd Edition, Tata McGraw Hill, New Delhi, 2004.
5. YoramKoren, Computer Control of Manufacturing Systems, McGraw Hill Int, New York, 1994.
6. Ishrat M Mirzana, "CAD/CAM", Radiant Publishing House, 4th Edition, Hyderabad, 2014
7. Elanchezhian. C. Sunder Selwyn. T. Shanmuga Sunder, G, Computer Aided Manufacturing, Laxmi
Publications (P) Ltd., 2nd Edition, New Delhi, 2007.

Course Code	Course Title						Core/Elective
PC591PE	**COMPUTER AIDED PRODUCTION DRAWING LAB**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

The objectives of this course is to impart knowledge of

- To learn design criteria of machine components, importance of production drawing in selection of materials and manufacturing process.
- To learn application of principles to design various machine components by applying limits, tolerances, surface finish and many more techniques of production drawing.

Course Outcomes

After completing this course, the student will be able to:

- Create various models of the machine components.
- Prepare the production drawings of the parts from the given assembly drawing
- Indicate details pertaining to manufacturing requirements and generate the bill of materials.
- Prepare the process sheet for the components drawn.
- Demonstrate the documentation and presentation skills

List of Experiments

1. Part modeling from given assembly drawings (Stuffing Box, Steam Engine Cross Head, Universal Coupling, Foot Step Bearing, Eccentric and Drill Jig) using any solid modeling package.
2. Geometrical dimensioning and tolerance representation on part drawings of above mentioned drawings.
3. Conventional practices indicating Dimensional, Form & Position tolerances.
4. Calculation of limits, suggestion of suitable fits for mating parts with Interference detection.
5. Surface finish, surface treatments- specification and indication methods on the drawings.
6. Generation of production drawings in 2D from part models representing Limits, fits, tolerances, Surface finish, geometrical and form tolerance etc.
7. Preparation of Process sheet incorporating Tool work orientation diagrams.

***Suggested Reading**:*

1. K. L. Narayana, P. Kannaiah and K. Venkat Reddy, "*Production Drawing"*, New Age International (P) Ltd. Revised edition 1997.
2. P. Narasimha Reddy, T. A. Janardhan Reddy and C. Srinivas Rao, "*Production Drawing Practice"*, Hi-Tech Publishers, 2001.

Course Code	Course Title						Core/Elective
PC592ME	**DYNAMICS OF MACHINES LAB**						**Core**
Prerequisite	**Contact Hours per week**				**CIE**	**SEE**	**Credits**
	L	**T**	**D**	**P**			
Theory of Machines	**--**	**--**	**--**	**2**	**25**	**50**	**1**

Course Objectives:

- To understand the effects and importance of kinematic and dynamic analysis of mechanisms
- To understand effects and analysis of Single degree freedom vibration systems
- To study the gyroscope, governors and cams
- To carry out the static and dynamic analysis of four bar mechanisms and drives

Course Outcomes:

- To experimentally quantify the effect of inertia forces in systems like flywheel, gyroscope and governors.
- To evaluate vibrational characteristics of various systems experimentally.
- To Synthesize balancing method of multi plane rotating masses.

List of Experiments

1. Centrifugal Governors: Experiment on Performance Characteristic Curves.
2. Estimation of Gyroscopic Couple & Understanding of Gyroscopic Effects on a rotating disc.
3. Static and Dynamic Balancing of Rotating Masses.
4. Determination of Moment of Inertia of Connecting Rod by compound pendulum method.
5. Damped and Undamped Torsional Vibrations of Single and Double Rotor System.
6. Single DOF (Degrees of Freedom) of Spring Mass Damper System. (Damped and Undamped Systems).
7. Free and Forced Vibration of Simply Supported Cantilever Beam.
8. Dunkerley Method to Find Fundamental Frequencies.
9. Critical Speed of Shaft.
10. Modal Analysis of Beam.
11. Cam Analysis of Cams.
12. Any Experiment explaining dynamic aspects of mechanical systems.

Additional Experiments Suggested

1. Determination of Moment of Inertia of Flywheel.
2. Experiment with Bifilar System.

Demonstration Experiments (Can't be allocated in final exams)

1. Velocity Ratios of Simple, Compound, Epicyclic and Differential Gear Trains.
2. Virtual Lab Experiment I – Governors.
3. Virtual Lab Experiment II – Natural Frequency of Cantilever beam.

Note: Minimum ten experiments should be conducted in the semester.

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. John J.Uicker, J r. G o r d o n, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
3. Lab manual supplied by department.

Course Code	Course Title						Core/Elective
PC592PE	**Modern Manufacturing and Testing Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To study the features of CNC machine tool.
- To know application of various CNC machine.
- To understand various production processes.
- To understand the working principles of various Modern manufacturing methods.
- To have knowledge of various NDT method***s.***

Course Outcomes

After completing this course, the student will be able to:

1. Decide on the process parameters to be adopted and applicability of various materials that are suitable for mechanical energy based machining processes
2. Decide on the process parameters to be adopted and applicability of various materials that are suitable for electrical and thermal based machining processes
3. Will be able to understand the CNC control in modern manufacturing system.
4. Will be able to distinguish between various manufacturing processes.
5. Will be able to select appropriate manufacturing process to manufacture any component.

List of Experiments:

A: Computer Aided Manufacturing Practice.

1. Step turning and taper turning on CNC.
2. External multiple turning cycles.
3. Grooving and threading operation.
4. Contour milling on CNC.
5. Circular pocketing on CNC

B: Modern Manufacturing Practice.

6. Experiments on Electro Discharge Machine.
7. Develop simple objects using 3D printing technology.
8. Exercise on spinning / flow forming operations.
9. Manufacturing of simple components with composite materials.
10. Study of simple dies and performing blanking and piercing operations by using mechanical presses.

C: Non Destructive Testing.

11. Detection of surface flaws of materials with visible dye.
12. Detection of surface flaws of materials with fluorescent dye.
13. Detection of sub surface flaws using Magnetic Particle Testing using Dry Powder.
14. Detection of sub surface flaws using Magnetic Particle Testing using Wet Powder.

Note: At least ten experiments should be conducted.

Course Code	Course Title						Core/Elective
PC601ME	MACHINE DESIGN						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
DMM	3	--	--	--	30	70	3

Course Objectives:

- Importance of helical coil springs and leaf springs in mechanical systems
- Understand the design of gears such as spur, Helical and bevelgears
- How to apply design concepts in bearing design
- Importance of design procedure in designing IC engine components
- Utilization of curved beams on mechanical components

Course Outcomes:

- Analyze helical coil springs and leaf springs for mechanical systems
- Evaluate kinematic transmission systems using gears
- Select bearing system for specific applications
- Design various IC engine components
- Determine load carrying capacity of curved beams

Note: Standard Design data book is allowed in University exam.

UNIT-I

Mechanical Springs: function of springs, Types of springs and materials used. Design of helical coil springs based on strength deflection and energy considerations. End preparation of coil springs, Design for fluctuating loads. Principles of limit design, Concentric springs

Leaf Springs: Stresses and Deflection.Nipping of Leaf springs

UNIT-II

Gears: Types of gears and materials used. Standards for gear specifications. design of spur gears, Helical and Bevel Gears basedstrength criterion -Lewis equation, Wear considerations, dynamic tooth load, Types of gear tooth failure and preventive measures.

UNIT-III

Bearings: Materials used for Bearings. Classification of Bearings. Viscosity of Lubricants Theory of Hydrostatic and Hydrodynamic lubrication. Design of sliding contact bearings - for axial and thrust loads

Rolling Contact Bearings: Different types of rolling element bearings and their constructional details.Static and Dynamic load carrying capacity, Load-life relationship, Design of deep groove ball bearing and roller bearing only, Design for cyclic loads,

UNIT-IV

I.C. Engine Parts: Design of piston, connecting rod and crank shafts. Design of Flywheels for I.C. Engines and Presses

UNIT-V

Curved beams: Theory of bending of members with initial curvature - rectangular, circular and Trapezoidal sections. Design of crane Hooks, Machine frames and C-clamps.

Design of chain drives: types of chain drives, polygonal effect, power rating of roller chains, design of roller and bush type chain, silent chain.

Suggested Reading:

1. V. B. Bhandari, “Design of Machine Elements”, Tata McGraw-Hill Publ, 3rd Edn. 2010.
2. J.E. Shigley & Charles R. Mischke “Mechanical Engineering Design”, Tata McGraw-Hill.,6th ed.2010.
3. P. Kannaiah, Machine Design, Sci-Tech Publ., 2009.
4. P.C. Sharma & D.K. Aggarwal, "Machine Design", S.K. Kataria & Sons, 10th edn, 2003
5. V. B. Bhandari, “Design Data Book ” 2nd edition, ”, Tata McGraw-Hill Publ, 2019

Note : Solution of Numerical problems using Design data book should be practiced.

Course Code	Course Title	Core/Elective

PC602ME	METROLOGY & INSTRUMENTATION						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- To familiarize with Limits & fits, I.S.O. system and the instruments used to measure these limits.
- To have knowledge of various precision linear and angular measuring instruments.
- To learn the importance of form and how to measure form errors.
- To understand the working principles of various instruments used for the measurement of strain, forces, pressure, temperature and vibrations.

Course Outcomes

After completing this course, the student will be able to:

6. To understand limits, fits and tolerances and their applications. Linear and angular measurements and measuring instruments.
7. To understand the design of limit gauges, evaluate roughness and its measurement.
8. To understand basic measuring system, static and dynamic characteristics of instruments
9. To understand various principles to measure pressure, temperature, displacement, force, torque and vibrations.

UNIT – I

Introduction to Limits, Fits,Tolerances as per ISO, types of interchangeability and limit gauges.Taylor's Principle of guage design, Uses of Plug, Ring and Snap gauges. Introduction to Linear and Angular measurements – Slip gauges and End bars – Gauge materials, Different types of Micrometers, Height gauges Tomlinson gauges. Precision polygon, Sine bar, Auto collimator**.**

UNIT – II

Comparators: Dial indicators, Mechanism of Dial indicators, Mechanical comparators, Pneumatic comparators, Optical comparators, Electrical comparators, Tool maker's Microscope and its applications. Measurement of Straightness and Flatness Roundness measurement with bench centers and talyround.

UNIT-III

Introduction to Surface Roughness Measurements, Profilometer, Taylor Hobson Talysurf. Application of Thread metrology - 2 wire and 3 wire methods, Gear measurement - Gear tooth thickness, Parkinson gear tester, General geometric tests for testing machine tools – Lathe, drill and Mill.

UNIT –IV

Introduction to Elements of instrumentation - Static and Dynamic characteristics, Types of errors, Transducers, LVDT, Strain measurement -Wire and foil type resistance strain gauges. Rosette Gauges,Bonding procedure Lead resistance compensation. Proving ring, Strain gauge load cells, measurement of axial load and torsion by strain gauges, Piezo-electric load cell.

UNIT – V

Introduction to Seismic Transducers -displacement and acceleration measurement, Pressure measurement -Bourdon pressure gauge, pirani gauge. Temperature measurement by thermo couples and its law.Types of materials used in thermocouples Protection tubes. Extension wire- Series and parallel circuit's compensation.

Suggested Readings:

1. I.C. Gupta – "Engineering metrology", Dhanpat Rai Publications, New Delhi.
2. Rega Rajendra, "Principles of Engineering Metrology", Jaico Publishing House, Mumbai.
3. RK Jain, "Engineering Metrology", Khanna Publications, 1996.
4. Doeblin,"Measurement Systems Application and Design", Tata Mc¬Graw Hill,5th ed., 2004.
5. Beckwith, Buck, Lienhard, Mechanical Measurements, Paerson education india.
6. P. Donald Echman, "Industrial Instrumentation", John Wiley and Sons, 1996.
7. Hume, "Engineering Metrology", Kalyani Publications, 1985.

Course Code	Course Title						Core/Elective
PC603ME	FINITE ELEMENT ANALYSIS						Core
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
EM, MOM, HT	3	-	-	-	30	70	3

Course Objectives:

1. Equip the students with the Finite Element Analysis fundamentals and formulations
2. Enable the students to formulate the axial, truss, beam and 2d problems
3. Enable the students to formulate the heat conduction and dynamics problems
4. Able to understand use of numerical integration and Gaussian quadrature
5. Enable the students to perform engineering simulations using FE software (ANSYS)

Course Outcomes:

1. Summarize basic equations of elasticity and formulate finite element modeling of one dimensional element using Potential energy approach.
2. Formulate finite element modeling of truss and frame elements along with the concepts of transformation from local to global matrices.
3. Interpolate Hermitian shape function of beam element in natural coordinate system.
4. Develop stiffness matrix for a plane stress & plane strain conditions on a CST, Axisymmetric elements by interpolating shape functions in natural coordinate system.
5. Formulate finite element model to steady state heat transfer analysis using one & two dimensional elements.
6. Formulate mass and stiffness matrices of 1D & beam elements to establish Eigen values &Eigen vectors using Lagarangian and Hamilton principles.

UNIT-I

Introduction to Finite Element Method for solving field problems, Stress and Equilibrium, Boundary conditions, Strain, Displacement, Stress-Strain relations.

One dimensional problems: Finite element modeling coordinates and shapes functions, Potential Energy approach: Assembly of Global stiffness matrix and load vector, Finite element equations, Treatment of boundary conditions, Galerkin's approach, Quadratic shape functions.

UNIT-II

Analysis of trusses and frames: Element stiffness matrix for a truss member, Analysis of plane truss with two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node, Analysis of Beams: Element stiffness matrix for two nodes (two degrees of freedom per node).

UNIT-III

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Finite element modeling of axi-symmetric solids subjected to axi-symmetric loading with triangular elements.

UNIT-IV

Two dimensional four noded iso-parametric elements and numerical integration. Steady state heat transfer analysis: One dimensional analysis of a fin and two dimensional analysis of thin plate, Analysis of circular shaft subjected to torsion.

UNIT-V

Dynamic Analysis: Formulation of finite element model, element matrices, Evaluation of Eigen values and Eigen vectors for a stepped bar and a beam, Time dependent field problems: Application to one dimensional heat flow in a rod **Convergence requirements.** Introduction to Finite Element Analysis Software.

Suggested Reading:

1. G.Ramamurthy, Applied Finite Element Analysis, I.K. International Publishing House Pvt.Ltd., New Delhi, 2009.
2. Tirupathi R, Chandraputla and Ashok D Belagundu, Introduction to Finite Elements in Engineering, Prcatice Hall of India,1997.
3. Rao S S, The Finite Element Method in Engineering, Pergamon Press, 1989.

4. Segerlind L J, Applied Finite Element Analysis, Wiley Eastern, 1984.
5. Reddy JN, An Introduction to Finite Element Method, McGraw-Hill, 1984.

Course Code	Course Title						Core/Elective
PC611PE	**ADDITIVE MANUFACTURING TECHNOLOGIES**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

- To introduce the basics and importance of additive manufacturing/rapid prototyping technologies.
- To familiarize various types of A.M. processes.
- To acquire knowledge, techniques and skills to select relevant additive manufacturing process.
- To learn different rapid tooling techniques.
- To Recognize various STL formats and slicing methods and tessellation
- To explore the potential of additive manufacturing in different industrial sectors.

Course Outcomes:

Students will be able to

- Describe fundamentals of additive manufacturing, classify and explain advantages and disadvantages AM processes.
- Describe the operating principles, capabilities, and limitations of liquid and solid based additive manufacturing systems
- Explain the operating principles, capabilities and limitations of powder based additive manufacturing systems
- Classify rapid tooling techniques and select suitable tooling for a given application.
- Select and use right CAD data formats and AM software in additive manufacturing of a part
- Explore the potential applications of additive manufacturing in different industrial sectors

UNIT-I

Introduction: Prototyping fundamentals: Need for time compression in product development, Need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies.

UNIT-II

Liquid-based AM Systems: Stereolithography Apparatus (SLA): Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages; Solid ground curing (SGC): Process, working principle, Applications, Advantages and Disadvantages; Polyjet: Process, Working Principle, Applications, Advantages and Disadvantages.

Solid-based AM Systems: Laminated Object Manufacturing (LOM): Process, working principle, Applications, Advantages and Disadvantages, Fused Deposition Modelling (FDM): Process, working principle, Applications, Advantages and Disadvantages; Multi-Jet Modelling (MJM): Process, working principle, Applications, Advantages and Disadvantages

UNIT-III

Powder Based AM Systems: Selective laser sintering (SLS): Process, working principle, Applications, Advantages and Disadvantages; Three dimensional Printing (3DP): Process, working principle, Applications, Advantages and Disadvantages; Laser Engineered Net Shaping (LENS): Process, working principle, Applications, Advantages and Disadvantages; Electron Beam Melting (EBM): Process, working principle, Applications, Advantages and Disadvantages.

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT. Rapid Tooling Classification: Indirect Rapid Tooling Methods: Arc Spray Metal Deposition, Investment Casting, Sand Casting, 3D Keltool process; Direct Rapid Tooling: Direct AIM, LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.

UNIT-IV

AM Data Formats: Reengineering for Digital Representation, STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs, Generic Solution, Other Translators, Newly Proposed Formats, Mesh Refining by Sub Division Techniques.

AM Software: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3D View, Velocity 2, Rhino, STL View 3 Data Expert and 3D doctor, SurgiGuide, 3-matic, Simplant, MeshLab.

UNIT-V

AM Applications: Application: Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture; RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customised Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Bio-molecules, Web Based Rapid Prototyping Systems.

Suggested Reading:

1. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific Publications, Third Edition, 2010.
2. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer, 2001
3. Wohlers Report 2000 – Terry Wohlers, Wohlers Associates, 2000
4. Rapid Prototyping & Engineering Applications – Frank W. Liou, CRC Press, Taylor & Francis Group, 2011

Course Code	Course Title						Core/Elective
PE612ME	**AUTOMOBILE ENGINEERING**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Understand the Working of Fuel, Ignition, and cooling Systems.
- Understand the Working of Lubrication and Electrical Systems
- Understand the Working of Suspension, Steering and Braking Systems.
- Understand the Working of Power Transmission.
- Understand the Necessity of Pollution Control and Maintenance.

Course Outcomes

After completing this course, the student will be able to:

1. Generalize the different types of automobiles, list the engine components, describe the functioning of IC engines and classify the fuel supply system for S.I and C.I engines
2. Differentiate the types of lubrication system; identify different lubrication and cooling systems used in vehicles. Classify ignition system and describe the functioning of battery and automobile air conditioning system.
3. List the salient features of different steering mechanisms, describe the importance of wheel alignment and wheel balancing, describe the importance of different suspension systems and shock absorbers used in an automobile
4. Identify different components in power transmission system design a system, components, or process to meet desired needs with in realistic constrains such as economic, environmental, health and safety, describe about braking system
5. Adapt techniques, skills and modern engineering tools necessary to control the pollution, record the automobile parts maintenance, design and build components and system to reduce pollution of automobile vehicles

UNIT – I

Types of automobiles: Normal, Hybrid and Hydrogen fuel vehicles. Engine location and its components, chassis layout, crank shaft proportion, firing order, piston and piston rings, cylinder liners, valves and operation mechanism, inlet and exhaust manifolds, carburetion and fuel injection system, mechanical fuel injection system & electronic fuel injection system.

UNIT – II

Lubricating systems: Wet sump, dry sump and petrol systems, and Cooling systems: Water pumps, radiators, thermostat control anti freezing compounds. Types of Ignition systems, modern ignition systems, types of batteries and charging systems, starting motors, lighting and electrical accessories, automobile air-conditioning.

UNIT-III

Steering systems: Linkage arrangements and its components modified Ackerman linkage, wheel alignment, caster and camber. Rack and pinion assembly – recent trends Wheel and tyres: Tyre construction, specification. Tyre wear and causes, wheel balancing, types of suspension system, independent suspension coil and leaf springs, torsion bar, shock absorbers.

UNIT –IV

Power Train: Clutches, gear and gearbox manual, semi-automatic and automatic gearboxes. Torque converter, propeller shaft, universal coupling differential, four-wheel drive system.Brake systems: Description and operation of hydraulic brake, leading and trailing shoe layout, disc brakes, master cylinder, hand brake linkage, recent trends.

UNIT – V

Maintenance: Pollution control, trouble shooting and servicing procedure overhauling, engine tune up, tools and equipment for repair and overhaul, testing equipment, pollution control technologies used for petrol and diesel engines, types and study of catalytic converters, Euro norms 2 & 3 and Bharat Norms – recent trends.

Suggested Readings:

1. Crouse & Anglin, 'Automotive Mechanics' Tata McGraw Hill, Publishing Co., Ltd., New Delhi, Tenth edition - 2004..
2. Kirpal Singh, "Automobile Engineering", Vol I & II Standard Publishers, Delhi.
3. Joseph Heitner, 'Automotive Mechanics', Affiliated East West Pvt., Ltd.,
4. C.P. Nakra, "Basic Automobile Engineering", Dhanpat Rai Publishing Co.(P) Ltd., New Delhi, 2003

Course Code	Course Title						Core / Elective
OE601ME	**Entrepreneurship**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation
- To understand the behavioural aspects of entrepreneurs and time management

Course Outcomes

At the end of the course, the students will be able to

1. Understand Indian Industrial Environment, Entrepreneurship and Economic growth, Small and Large Scale Industries, Types and forms of enterprises.
2. Identify the characteristics of entrepreneurs, Emergence of first generation entrepreneurs, Conception and evaluation of ideas and their sources.
3. Practice the principles of project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis.
4. Apply the concepts of Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques
5. Understand the Behavioural aspects of entrepreneurs, Time Management, Various approaches of time management, their strengths and weakness. The urgency addiction and time management matrix.

UNIT-I

Indian Industrial Environment-competence, Opportunities and Challenges. Entrepreneurship and Economic growth. Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs. Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas and their sources. Choice of Technology - Collaborative interaction for Technology development.

UNIT-III

Project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis, project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management. Assessment of tax burden.

UNIT-V

Behavioural aspects of entrepreneurs: Personality - determinants, attributes and models. Leadership concepts and models. Values and attitudes. Motivation aspects. Change behaviour. Time

Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management",* Himalaya Publishing House, 1997
2. Prasanna Chandra, *"Project-Planning, Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd. 1995.
3. Stephen R. Covey and A. Roger Merrill, *"First Things First",* Simon and Schuster Publication, 1994.
4. G.S. Sudha, *"Organizational Behaviour",* 1996.
5. Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005.

Course Code	Course Title						Core / Elective
OE602ME	**INDUSTRIAL ROBOTICS**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**0**	**0**	**0**	**30**	**70**	**3**

Course Objectives

- To familiarize the student with the anatomy of robot and their applications.
- To provide knowledge about various kinds of end effectorsusage.
- To equip the students with information about various sensors used in industrial robots.
- To make the student understand the importance of spatial transformation of robots using forward and inverse kinematics.
- To specify and provide the knowledge of techniques involved in robot vision in industry.
- To equip students with latest robot languages implemented in industrial manipulators.

Course Outcomes

- Able to demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics and have an understanding of the functionality and limitations of robot actuators and sensors.
- Able to demonstrate an ability to apply spatial transformation to obtain forward/Inverse kinematics equation of robot manipulators using analytical/numerical/simulation tools.
- Able to apply knowledge and choose the best & economically suitable sensors/end effectors required for specific applications.
- Able to understand the importance of robot vision and apply the learnt techniques to get the required information from input images.
- Able to design and develop a industrial robot for a given purpose economically.
- Appreciate the current state and potential for robotics in new application areas.

UNIT – I

Introduction to Robotics: Basic structure of Robots. Degree of freedom of Robots, Work envelope, Classification of Robots based on Drive Technology, Work-Envelope and motion control methods. Application of Robots in Industry, Repeatability, Precision and Accuracy as applied to Robots, Specifications of robots used for various applications. End effectors, Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers, Two fingered and three fingered grippers, internal grippers and external grippers, Selection and design considerations.

UNIT – II

Requirements of a Sensor: Principles and Applications of the following types of sensors- Position of sensors (Piezo electric sensor, LVDT, Resolvers, Optical encoders, Pneumatic position sensors), Range sensors (Triangulation principle, Structured, Lighting approach, Time of flight range finders, Laser range meters), Proximity sensors (Inductive, Hall effect, Capacitive, Ultrasonic and Optical proximity sensors), Touch sensors (Binary sensors, Analog sensors), Wrist Sensors, Compliance Sensors, Slip Sensors.

UNIT – III

Kinematic Analysis of Robots: Rotation matrix. Homogeneous transformation matrix, Denavit&Hartenberg representation, Euler and RPY angles representation. Representation of absolute position and orientation in terms of joint parameters, Direct Kinematics of manipulators, Inverse kinematics of Robot arm for position and orientation. Redundancy in Robots, Static force analysis

UNIT-IV

Introduction to Techniques used in Robot Vision: Image acquisition, illumination techniques, imaging geometry, basic relationship pixels, preprocessing, segmentation & description of 3-dimensional structures, their recognition and interpretation. Types of Camera, frame grabbing, sensing and digitizing image data, Signal conversion, Image Storage, Lighting techniques, Image processing and analysis, Data reduction, Segmentation, Feature extraction, Object recognition, and various algorithms, Applications, Inspection, identification, visual serving and navigation.

UNIT – V

Robot Programming Languages: Characteristics of robot level languages, task level languages. Teach pendant programming, Lead through programming, Robot programming languages, VAL programming, Motion commands, Sensor commands. End effecter commands, Simple programs. RGV, AGV, Implementation of robots in industries, various steps, Safety considerations for robot operations. Economic analysis of robots, Pay back method, EUAC method and Rate of return method

Suggested Readings:

1. Groover M P, **"Industrial Robotics"**, McGraw Hill Publications,1999.
2. Fu. K.S., GonZalez R.C., Lee C.S.G. "**Robotics, Control-sensing vision and Intelligence**", McGraw Hill, Int. Ed.,1987.
3. Spong and Vidyasagar, "**Robot Dynamics & Control**", John Wiley and Sons,Ed.,1990.
4. Mittal and Nagrath, "**Industrial Robotics**", Tata McGraw Hill Publications,2004.
5. Saha&Subirkumarsaha, '**Robotics'**, TMH,India.

Course Code	Course Title						Core/Elective
PC691ME	**METROLOGY & MACHINE TOOLS LAB**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To have knowledge of various precision measuring instruments.
- To familiarise machining and metal cutting operations.

Course Outcomes

After completing this course, the student will be able to:

6. Select and apply the knowledge of measuring tools for external, internal and angular measurements for promoting the qualitative production management.
7. Adapt the principles of optical measurements in measurement of screw and gear profiles.
8. Choose and practice the appropriate methods of force measuring devices principles for required situation.
9. Demonstrate the need of machine alignment test for qualitative production.
10. Practice calibration principles for maintaining the required precision of instruments / tools.
11. Select and practice the methods of temperature measurement.
12. Select cutting tool materials and tool geometries along with appropriate cutting conditions for different work materials and grind the cutting tools to the required geometry.
13. Recognize and summarize the features and applications of various machine tools like Lathe, Milling, Drilling, Grinding, Shaping, Slotting etc.

List of Experiments:

A) Metrology & Instrumentation:

1. Measurement with inside, outside and depth micrometers, Vernier calipers and Height gauges.
2. Measurement of roundness errors with Bench Centres, V-block and dial guage.
3. Measurement of Linear and Angular dimensions with Tool Maker's Microscope: Flat specimens.Plain cylindrical specimens with centers and threaded components.
4. Measurement of angles with Sinebar, Bevel protractor and Precision level.
5. Measurement with Dial Indicator / Electrical Comparator / Mechanical Comparator / Dial Bore Gauge / Snap Gauge/Plug gauges.
6. Calibration and Force measurement with Strain gauge type load cell/Proving Ring/spring type sensor

B) Machining Operations:

7. Thread cutting exercise on lathe machine as single start and multi start threads.
8. Typical exercises on lathe machine(Turning,Step turning,Facin,Parting off &Taper turning).
9. Typical exercises on shaper, cylindrical grinding machine.
10. Exercise of simple gear manufacturing on milling machine.
11. Production of threads with taps and threading dies and milling cutters.

C) Metal Cutting:

12. Estimation of shear angle by measuring thickness and length of chips.
13. Measurement of Cutting forces with Lathe tool dynamometer and determination of friction angle and stresses on shear plane and rake plane.
14. Study of geometrical tests on lathe machine.

Note: At least ten experiments should be conducted.

Course Code	Course Title						Core/Elective
PC692ME	**Computer Aided Engineering LAB**						Core
Prerequisite	**Contact Hours per Week**				**CIE**	**SEE**	**Credits**
	L	**T**	**D**	**P**			
-	-	-	-	2	25	50	1

Course Objectives:

- To introduce fundamentals of the analysis software, its features and applications.
- To learn the basic element types in Finite Element analysis.
- To know the concept of discretization of continuum. Loading conditions and analyze the structure using pre-processor and postprocessor conditions.

Course Outcomes:

- Classify the types of Trusses (Plane Truss & Spatial Truss) and Beams (2D & 3D) with various cross sections to determine Stress, Strains and deflections under static, thermal and combined loading
- Generalized Plane stress, plane strain conditions & axi-symmetric loading on inplane members to predicting the failure behavior and finding the SCF
- Analyse connecting rod with tetrahedron and brick elements, performing static analysis on flat & curved shells to determine stresses, strains with different boundary conditions.
- Predict the natural frequencies and modes shapes using Modal, Harmonic analysis. Also finding the critical load using Buckling analysis
- Simulate steady state heat transfer analysis of chimney, Transient heat transfer of castings, Non linear, Buckling analysis of shells CFD analysis
- Evaluate the stiffness matrix, B matrix and loading matrices of beam in plane/solid elements using MATLAB / Python software

1. Analysis of Plane Truss & Spatial Truss with various cross sections and materials to determine member forces, member strains & stresses, joint deflections under static, thermal and combined loading.
2. 2D & 3D beam analysis with different sections, different materials for different loads (forces and moments with different end supports.
3. 1D, 2D and 3D meshing with different element sizes for different CAD geometry (Proposed Experiment)
4. Static analysis of plates with a hole to determine the deformations, the Stresses to study the failure behavior and SCF.
5. Plane stress, plane strain and axi-symmetric loading on the in plane members with in plane landing to study the stresses and strains.
6. Static analysis of connecting rod with tetrahedron and brick elements
7. Static Analysis of flat and curved shell due to internal pressure and moments to estimate the strains, stresses and reactions forces and moments with different boundary conditions .
8. Buckling analysis of plates, shells and beams to estimate BF and modes.

9. Modal analysis of beams, plates and shells for natural frequencies and mode shapes.
10. Harmonic analysis of a Shaft subjected to periodic force and transient analysis of plate subjected to stepped and ramped loading with varying time .
11. Steady state heat transfer Analysis Cross section of chimney and transient heat transfer analysis of solidification of castings.
12. Non linear analysis of cantilever beam with non-linear materials at tip moment and post Buckling analysis of shells for critical loads
13. Coupled field analysis.
14. Flow analysis of pipe with different fluids/gasses/air for velocity and pressure gradients.
15. Implicit and Explicit Analysis of car with 300m/s (Proposed Experiment)
16. CFD analysis of aerofoil design.
17. CFD analysis of ducts/impeller/fan.
18. CFD analysis of racing car (Proposed Experiment)
19. Use of MATLAB / Python for finding B matrix, stiffness matrix and loading matrices of beam/in plane/solid elements and interfacing with CAE software's .

Note : Any 12 experiments to be conducted