DEPARTMENT OF MECHANICAL ENGINEERING

Scheme of Instruction

and

Syllabi of

B.E. (Mechanical Engineering)

V & VI SEMESTER

AICTE Model Curriculum

2020-2021

UNIVERSITY COLLEGE OF ENGINEERING

(AUTONOMOUS)

OSMANIA UNIVERSITY

HYDERABAD – 500 007, TELANGANA

UNIVERSITY COLLEGE OF ENGINEERING

Vision

The Vision of the Institute is to generate and disseminate knowledge through a harmonious blend of Science, Engineering and Technology and to serve the society by developing in students heightened intellectual, cultural, ethical and humane sensitivities to foster a scientific temper and to promote professional and technological expertise.

Mission

- To achieve excellence in Teaching and Research.
- To generate, disseminate and preserve knowledge.
- To enable empowerment through knowledge and information.
- Advancement of knowledge in Engineering, Science and Technology.
- Promote learning in free thinking and innovative environment.
- Cultivate skills, attitudes to promote knowledge creation.
- Rendering socially relevant technical services for the community.
- To impart new skills of technology development.
- To inculcate entrepreneurial talents and technology appreciation programmes.
- Technology transfer and incubation.
- To cultivate resolute moral and ethical values.

DEPARTMENT OF MECHANICAL ENGINEERING

Vision

To generate and disseminate knowledge in Mechanical Engineering and nurture professional, technical and scientific temper for serving the needs of the industry, research organizations and society.

Mission

- Create technically competent mechanical engineers to suit the changing needs of global industry and society.
- To cultivate skills, attitudes to promote knowledge creation and technology development.
- Interact with prominent educational institutions and R&D organizations for enhancing teaching, research and consultancy services.

Programme Educational Objectives (PEOs) for BE (Mech.Engg) Programme

PEO 1	To provide the requisite fundamentals of varied subjects related to Mechanical Engineering to conceive, plan, model, design, construct, maintain and improve systems to enhance human comfort.
PEO 2	To provide knowledge of experimental, computational, analytical, simulation tools and techniques require to address the challenges in Mechanical Engineering and other allied fields.
PEO 3	To provide knowledge to apply Mechanical Engineering Fundamentals to design and implement cost effective systems in manufacturing.
PEO 4	To provide effective communication skills, creative methods, ethics and continuous learning techniques to fulfill their professional requirements and societal needs.

Programme Outcomes (POs) of BE (Mech.Engg) Programme

Engineering Graduates will be able to:

PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an mechanical engineering to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems related to mechanical engineering and allied fields reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Mechanical engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the Mechanical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the mechanical engineering practice.

PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the mechanical engineering and management principles and apply these to one‟s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Lifelong learning**: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs) of BE (Mech.Engg) Programme

Engineering Graduates will be able to:

PSO1	Apply the principles of collaborative and multi disciplinary approach for solving problems
PSO2	Able to interact with industry and R&D institutions leading to start-ups/ budding entrepreneurs.

SCHEME OF INSTRUCTION
B.E. (Mechanical Engineering)
V-SEMESTER

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 and Hydraulic Machines	3	0	0	3	30	70	3
2.	PC502ME	Heat Transfer	3	0	0	3	30	70	3
3.	PC503ME	Dynamics of Machines	3	0	0	3	30	70	3
4.	PC504ME	Machine Design	3	0	0	3	30	70	3
5.	PC505ME	Metal Cutting and Machine Tools	3	0	0	3	30	70	3
6.	**Professional Elective-I**		3	0	0	3	30	70	3
	PE511ME	Production Planning and Control							
	PE512ME	Powder Metallurgy							
	PE513ME	Robotic Engineering							
	PE514ME	Theory of Elasticity							
	PE515ME	Automobile Engineering							
Practicals									
7.	PC551ME	Fluid Mechanics and Hydraulic Machines Lab	0	0	3	3	25	50	1.5
8.	PC552ME	Dynamics of Machines Lab	0	0	3	3	25	50	1.5
9.	PW 941ME	Summer Internship-I	0	0	2	2	50	-	1
		Total	**18**	**0**	**8**	**26**	**280**	**520**	**22**

PC 501ME

FLUID MECHANICS AND HYDRAULIC MACHINES

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

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:

1. Define the properties of fluids and classify the fluids.
2. Apply conservation laws to fluid flow problems in engineering applications and examine the stability of a floating bodies.
3. Apply Euler‟s Equation of motion and Bernoulli‟s equation for flow measuring devices and hydraulic machines.
4. Illustrate the working of Hydraulic machines.
5. Analyze the performance of various types of Hydraulic pumps and turbines.

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.

PC502ME

HEAT TRANSFER

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

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:

1. Illustrate the basic modes of heat transfer with its associated laws in simple geometries.
2. Solve the problems of steady state and transient heat conduction with simple and multi-layer geometries.
3. Analyze heat transfer coefficients for free and forced convection, considering boundary layers.
4. Develop relationships for radiation exchange between (Opaque, Diffuse, Gray) Surfaces in an enclosure, Blackbody radiation exchange.
5. 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.

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

PC503ME

DYNAMICS OF MACHINES

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

Course Objectives:

- To find static and dynamic forces on planar mechanisms.
- To know the causes and effects of unbalanced forces in machine members.
- 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:

1 Compare and contrast various methods of static and dynamic analysis of planar and spatial mechanisms.
2 Evaluate Gyroscopic effects on Naval ships, Aeroplanes and Automobile.
3 Analyze balancing problems in rotating and reciprocating machinery.
4 Design systems like governors and flywheels for controlling speed and energy fluctuations.
5 Determine natural frequencies and conditions for resonance of single degree and multi degree systems.

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.

PC504ME

MACHINE DESIGN

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

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:

1 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.

2 Illustrate various mechanical components under different loading conditions & constraints.

3 Analyse various mechanical components under simple and combined loads.

4 Determine (material, dimensions, shape, number) mechanical components subjected to various types of loads, constraints & failure criterions.

5 Design mechanical components for specific applications in industry.

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.

PC505ME

METAL CUTTING AND MACHINE TOOLS

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

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:

1 Develop the relations for shear angle, shear strain, forces and temperatures associated with orthogonal cutting.
2 Select the cutting fluids, tool materials and coatings to control the tool wear and temperature.
3 Evaluate the tool life and economics of machining for maximum production and minimum cost.
4 Select the appropriate machine tool and tool & work holding devices for machining of components.
5 Illustrate the various finishing techniques and unconventional machining processes.

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.

PE 511ME

PRODUCTION PLANNING & CONTROL

(Professional Elective-I)

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

Course Objectives:

- To understand the importance of PPC in an organization and the role of forecasting in PPC
- To learn the role of inventory management in PPC and various inventory control techniques
- To understand the concepts of routing and scheduling
- To understand the objectives of line balancing and aggregate planning
- 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:

1 Identify the objectives, functions, applications of PPC and forecasting techniques.

2 Apply different Inventory Control Techniques for determining the optimum inventory.

3 Solve routing and scheduling problems.

4 Illustrate various types of Line Balancing Techniques and Aggregate Planning Strategies.

5 Identify various types of dispatching techniques.

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.

PE 512ME

POWDER METALLURGY

(Professional Elective-I)

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

Course Objectives:

- To know the various powder manufacturing methods
- To understand the powder characterization techniques
- To know the sintering and post sintering practices of powders
- To learn the pressing and compaction tooling for various powders
- 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:

1 Illustrate basic powder production methods of powder metallurgy.
2 Identify and characterize the various powders and their properties.
3 Apply the sintering technology to develop various PM products.
4 Analyze the pressing and sintering tools for powder making.
5 Select the testing methods and applications of industrial products manufactured by PM method.

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.

PE513ME

ROBOTIC ENGINEERING

(Professional Elective-I)

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

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:

1 Identify and classify various robot configurations with their workspaces and their usage in industry.
2 Perform forward and inverse kinematics operations & determine singularity conditions for various robot configurations.
3 Compare and contrast various techniques available to find forward and inverse dynamic solutions for various general robot configurations.
4 Implement various path planning techniques & control algorithms for computing end effector motions for generalized robotic tasks.
5 Interface various hardware and software components to develop robotic systems for industry & Evaluate their performance.

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.

PE514ME

THEORY OF ELASTICITY

(Professional Elective-I)

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

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:

1 Illustrate the basic concepts in continuum mechanics of solids, including of strain, internal force, stress and equilibrium in solids.
2 Implementation of energy principles in solution of strength of materials problems.
3 Derivation of constitutive relations of plane stress and strain.
4 Derivation of stress-strain relations for linearly elastic solids such as beams and plates, and Torsion of shafts.
5 Analyze axisymmetric problems such as cylinders and rotating discs and stability of columns.

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.

PE 515ME

AUTOMOBILE ENGINEERING

(Professional Elective-I)

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

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:

1 Identify principal parts of an automobile and their layout.
2 Illustrate the working principles of Drive train and Transmission Systems.
3 Enumerate the working principles of Steering, Axle, Wheels and Tyres.
4 Examine the functioning of Suspension and braking systems.
5 Analyse of alternative Energy Sources for Automobile applications and latest automobiles.

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.

PC26ME

FLUID MECHANICS AND HYDRAULIC MACHINERY LABORATORY

Instruction: (3P) per week *Duration of SEE: 3 hours*
CIE: 25 Marks *SEE: 50 Marks*
Credits: 1.5

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:

1 Illustrate the working of Hydraulic machines.
2 Apply the Bernoulli‟s principle in flow measurement used in hydraulic machines.
3 Analyze working principles of hydraulic pumps and turbines.
4 Evaluate the theoretical concepts and apply them in the functioning of hydraulic machines
5 Estimate the performance of pumps and turbines.

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

PC 552ME

DYNAMICS OF MACHINES LABORATORY

Instruction: (3P) per week *Duration of SEE: 3 hours*
CIE: 25 Marks *SEE: 50 Marks*
Credits: 1.5

Course Objectives:

- Carry out the kinematic and dynamic analysis of planar and spatial mechanisms
- Find out natural frequencies, forced frequencies and other important parameters for different vibrating systems using Universal vibration apparatus.
- Perform modal analysis of vibrating systems
- Study the working of gyroscope and governors
- Effects of rotary unbalancing and methods of reduction

Course Outcomes:

1 Importance of vibrations in mechanical systems & analyse Single and multi-degree freedom vibrating systems.
2 Inspect methods to reduce effects of static and dynamic unbalance due to rotating systems. machines.
3 Investigate the effect of various governors on speed control of mechanisms.
4 Evaluate the reaction torque due to gyroscopic effects in systems.
5 Carry out the kinematic and dynamic analysis of planar and spatial mechanisms.

Experiments to be conducted:
Study experiment on:

1. To determine experimentally, the Mass Moment of Inertia of a Flywheel and Axle and compare with theoretical value.
2. To verify the formula of a Simple Pendulum and to show that the time period is independent of the mass of the bob
3. To determine the radius of gyration "K" of given compound pendulum
4. To find the damping coefficient(c), damping ratio (ξ) and logarithmic decrement (δ) of damped longitudinal vibrations of spring mass system
5. To study the Torsional vibration (undamped) of single Rotor Shaft system.
6. To study the free Torsional vibrations of two rotor system and to determine the frequency of vibration theoretically and experimentally.
7. To study the response of a beam under forced oscillations and compare the experimental response with theoretical for resonance frequency.
8. To determine critical speed or whirling speed of a rotating shaft and to verify the value theoretically
9. To verify the law of gyroscopic couple, $T = I\ \omega\ \omega p$ with the help of motorized Gyroscope calibrate the gyroscope.
10. To determine Centrifugal Forces of the Governor and Plot the Characteristic Curves of the governor.
11. To balance the given unbalanced rotating masses by drawing force polygon and couple polygon.
12. To find the natural and damped frequency of an Aluminium cantilever beam in transverse vibrations

13. Determination of natural frequency of transverse vibration in a given aluminium rod with concentrated weights at two places using Dunkerley method
14. To determine the radius of gyration L and thereby determining the mass moment of inertia of a connecting rod.
15. Modal analysis of a composite beam
16. Simulation experiments on Kinematic and dynamic analysis of mechanisms and systems using **Msc Adams software**

    Analysis of Freely falling body, Body moving up the slope, Simple pendulum, Linear spring, and Non-linear spring

    Simulation of kinematic and dynamic analysis of:

    Four bar Mechanisms, Slider crank Mechanisms, Spur Gear Analysis, Multi-link robots, Cam Mechanisms and Rope and Chain drive systems

Note: At least 10 experiments (08 hardware+02 software) from the set of above experiments needs to be conducted by each student.

Suggested Reading:

1. Msc Adams 2013.2 User Guide
2. Universal Vibration Apparatus User Manual (KC Engineers)
3. Static & Dynamic balancing of rotating masses, user manual (KC Engineers)
4. Gyroscope apparatus User Manual(KC Engineers)
5. Centrifugal Governors User Manual (KC Engineers)

PW 941ME

SUMMER INTERNSHIP

Instruction: 6 weeks *CIE: 50 marks*
Credits: 1

Internship Objectives:

- Will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn, understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Gain experience in writing Technical reports/projects.
- Expose students to the engineer‟s responsibilities and ethics.
- Familiarize with various materials, processes, products and their applications along with relevant aspects of quality control.
- Promote academic, professional and/or personal development.
- Expose the students to future employers.
- Understand the social, economic and administrative considerations that influence the working environment of industrial organizations
- Understand the psychology of the workers and their habits, attitudes and approach to problem solving.

Internship Outcomes:

1 Understand the actual industrial environment and tuned to readily accept the works for execution.

2 Generate detail project reports and understand industry administration and finance. machines.

3 Troubleshoot problems with more confidence.

4 Design systems/products following standard procedures and norms.

5 Interact with fellow workers and manage the activities efficiently.

INTERNSHIP ACTIVITIES

During summer vacation after 4th/ 6th sem.
Internship with Industry/ Govt. / NGO/ PSU/ Any Micro/ Small/ Medium enterprise/ Online Internship.

INTERNSHIP REPORT

(a) Student's diary/ daily log

The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students‟ thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit.
Student‟s Diary and Internship Report should be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training. It will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary.
- Adequacy & quality of information recorded.
- Drawings, sketches and data recorded.

- Thought process and recording techniques used.
- Organization of the information.

(b) Internship report

After completion of Internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period. The student may contact Industrial Supervisor/ Faculty Mentor/TPO for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor and Faculty

Mentor. The Internship report will be evaluated on the basis of following criteria:

i. Originality.
ii. Adequacy and purposeful write-up.
iii. Organization, format, drawings, sketches, style, language etc.
iv. Variety and relevance of learning experience.
v. Practical applications, relationships with basic theory and concepts taught in the course.

EVALUATION THROUGH SEMINAR PRESENTATION/VIVA-VOCE

The student will give a seminar based on his training report, before an expert committee constituted by the Department as per norms of the institute. The evaluation will be based on the following criteria:

- Quality of content presented.
- Proper planning for presentation.
- Effectiveness of presentation.
- Depth of knowledge and skills.
- Attendance record, daily diary, departmental reports shall also be analyzed along with the internship report.

Seminar presentation will enable sharing knowledge & experience amongst students & teachers and build Communication skills and confidence in students.

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

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	0	0	3	30	70	3
2	PC602ME	Finite Element Analysis	3	0	0	3	30	70	3
3	**Professional Elective-II**		3	0	0	3	30	70	3
	PE621ME	Design of Solar Energy systems							
	PE622ME	Refrigeration and Air Conditioning							
	PE623ME	Control system Theory							
	PE624ME	Additive Manufacturing Technologies							
4	**Professional Elective-III**		3	0	0	3	30	70	3
	PE631ME	Mechatronics systems							
	PE632ME	Fatigue Creep and Fracture							
	PE633ME	Computational Fluid Flows							
	PE634ME	Non- Conventional Machining and Forming methods							
5	HS901MC	Managerial Economics & Accountancy	3	0	0	3	30	70	3
6.	**Open Elective-I**		3	0	0	3	30	70	3
Practicals									
7.	PC651ME	Metal Cutting & Metrology Lab	0	0	3	3	25	50	1.5
8.	PC652ME	CAE Lab	0	0	2	2	25	50	1
9.	PC653ME	Mini Project	0	0	4	4	50	0	2
10.	PW 961 ME	Summer Internship	Six weeks duration, evaluation will be done in VII-Semester						
		Total	**18**	**0**	**9**	**27**	**280**	**520**	**22.5**
* At the end of VI semester students should undergo summer Internship - Credits for Summer Internship-II will awarded in VII semester									

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
OE606ME	Finite Element Method

PC601ME

METROLOGY AND INSTRUMENTATION

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

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:

1 Illustrate manufacturing process variables.
2 Explain the measurement of the physical phenomenon.
3 Understand and Apply measurement principles in Industrial requirements.
4 Evaluate the methods of measurements affecting Mechanical Engineering Process.
5 Design, innovate and modify measuring technology.

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 multi jet gauge heads; computation and match gauging.

UNIT-II: Optical projector-measurement by comparison, movement and translation, chart gauge types and micro gauge 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.

PE602ME

FINITE ELEMENT ANALYSIS

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

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:

1 Illustrate the concept of Finite Element Method and realize its limitations.
2 Construct shape functions for 1D, 2D and 3D linear and higher order elements.
3 Applying 1D, 2D and 3D elements to solve different static structural and heat transfer problems.
4 Solve 1D and 2D steady state heat transfer, and 1D eigen value and eigen vector problems.
5 Analyze time dependent heat transfer problems and review of Finite Element analyses softwares.

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.

PE621ME

DESIGN OF SOLAR ENERGY SYSTEMS
(Professional Elective-II)

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

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 develop solar hybrid systems for different applications.

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

1 Illustrate solar radiation and its physical function of the measuring devices.
2 Compare and contract technologies of solar cell fabrication methods.
3 Calculate the required size of solar cell systems for maximum output in peak hours.
4 Illustrate the solar thermal system for different applications.
5 Evaluate the performance of combined solar thermal and solar cell systems.

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. Mertens Konrad, “Photovoltaics : Fundamentals, Technology and Practice”, John Wiley & Sons Inc., 2014.

PC622ME

REFRIGERATION AND AIR CONDITIONING

(Professional Elective-II)

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

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:

1 Distinguish different types of refrigerants and their properties used in the refrigeration cycle.

2 Analyze the performance of vapour compression and vapour absorption system.
3 Distinguish between conventional and non-conventional refrigeration system.
4 Apply the principles of Psychrometrics to estimate the air conditioning loads for the industrial applications.
5 Illustrate various methods to obtain cryogenic temperatures.

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.

PE623ME

CONTROL SYSTEMS THEORY

(Professional Elective-II)

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

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:

1. Distinguish between open loop and closed systems with examples.
2. Develop mathematical models of mechanical, electrical, electro-mechanical systems.
3. Evaluate the effects of transient and steady state responses and apply these models to real time systems.
4. Apply the time response and frequency response methods to determine the stability of the system.
5. Apply the concepts of discrete time control systems. Analyse and design multi input, multi output systems by state space analysis.

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.

PE624ME

ADDITIVE MANUFACTURING TECHNOLOGIES

(Professional Elective-II)

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

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:

1 Interpret the features of Additive Manufacturing (AM) and compare it with conventional CNC Technology.
2 Illustrate the working principle, advantages, limitations and applications of various Additive Manufacturing Technologies .
3 Interpret various types of errors in STL file and other data formats used in AM and identify the role of Topology optimization in AM.
4 Analyze different types of software‟s used in 3D Printing Technology.
5 Apply the knowledge of various AM technologies for developing innovative applications.

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:

Vat Photopolymerization 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 softwares 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/

PE631ME

MECHATRONICS SYSTEMS

(Professional Elective-III)

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

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:

1 Illustrate the architecture of mechatronic systems.
2 Design some simple measurement systems using different sensors.
3 Demonstrated ability to design basic control systems using different actuators.
4 Execute PLC programs for industrial Applications.
5 Demonstrate an understanding of analogue and digital interfacing.

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.

PE632ME

FATIGUE CREEP AND FRACTURE

(Professional Elective-III)

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

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:

1 Enumerate the design philosophy and recognize formulate fatigue design.
2 Illustrate the factors affecting fatigue and methods to improve fatigue strength.
3 Evaluate ductile and brittle fracture.
4 Predict the stress field at the crack tip.
5 Calculate and measure creep deformation.

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

PE 633ME

COMPUTATIONAL FLUID FLOWS

(Professional Elective-III)

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

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:

1 Establish the governing equations for different types of fluid flow systems.
2 Illustrate method of averaging of turbulent flow properties and classify second order partial differential equations.
3 Devise finite difference equations based on accuracy, type of differencing and analyse their stability.
4 Solve equations using FDM and numerical methods on discretised domain.
5 Apply Finite volume method for basic equations of heat transfer and fluid flow problems.

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.

PE634ME

NON-CONVENTIONAL MACHINING & FORMING METHODS

(Professional Elective-III)

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

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:

1 Illustrate the basic principles of non-conventional machining techniques.
2 Select non-conventional machining techniques for various materials.
3 Illustrate principles of non-conventional forming techniques.
4 Select modern forming processes to various metals.
5 Analyze the process parameters of non-conventional machining and forming techniques.

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.

OE601BM

ENGINEERING APPLICATIONS IN MEDICINE
(Open Elective-I)

Instruction: 3 Periods per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*
Credits: 3

Course Objectives:

- To make the students gain basic knowledge of Human Physiology.
- To make the students learn the applications of various branches of engineering in Medicine.

Course Outcomes: Upon the completion of the course, the students will be able to:

1. Describe the major organ systems of the human body
2. Understand the concepts of bioelectricity and medical instruments
3. Apply solid and fluid mechanics principles to joints and blood flow respectively
4. Learn the need and applications of BCI
5. Analyze and choose proper biomaterial for various applications

UNIT-I

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

UNIT-II

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-III

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 Hagen-Poiseuille flow to blood flow.

UNIT-IV

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-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. Ozkaya, Nordin. M, *Fundamentals of Biomechanics*, Springer International Publishing, 4th Edition, 2017.
3. Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
4. John G.Webster, *Medical Instrumentation: Application and Design*, John Wiley and Sons Inc., 3rd Ed., 2003.

OE 602CE

DISASTER MANAGEMENT
(Open Elective-I)

Instruction: 3 Periods per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*
Credits: 3

Course Objectives:

- To introduce basic conceptual understanding of natural & man-made hazards and different contextual aspects.
- To develop the knowledge and understanding of the International and nationalstrategy for disaster reduction (UN-ISDR)
- To ensure skills and abilities to analyze potential effects of disasters and of the strategies and methods to deliver public health response to avert these effects.
- To promote the use of science and technology for implementing the disaster risk reduction (DRR) plans and policies.

Course Outcomes:

1. Aptitude to link hazards, risk, vulnerability, differential impacts and capacity building to the life and property loss during disasters and its impacts on the society and sustainability.
2. Ability to understand various aspects of natural and man-made hazards and emerging trends
3. Acquaintance with different steps involved in disaster risk reduction (DRR) and international initiatives for prevention, mitigation and preparedness.
4. Knack to appreciate the national policy and role of individuals, communities, and government organizations in disaster management.
5. Capacity to identifying current technological constraints and hazard specific solutions, particularly construction codes etc.

UNITI: INTRODUCTION TO DISASTER

- Understanding the Concepts, Definitions and Terminologies used in the field of Disaster Management (i.e. Hazard, Risk, Vulnerability, Resilience, and Capacity Building).
- Differential impacts of Disasters in terms of Gender, Age, Social Status, Location, Prosperity, Disabilities.
- Disaster- Development Nexus.

UNIT II: TYPES of HAZARDS AND EMRGING TRENDS

- Classification, Causes, Consequences and Controls of
  I) Geophysical hazards-Earthquakes, Landslides, Tsunami
  II) Weather related hazards- Meteorological (Cyclones, Storm-surge and Lighting)
  Hydrological (Floods, Droughts, Avalanches)
  Climatological (Wildfire, Cold & Heat Waves)
  III) Biological hazards-Epidemic & Pandemics,
  IV) Technological hazards-Chemical, Industrial, Nuclear
  V) Man-made hazards-Structural Failure, Fire, Transportation accidents, Terrorism and Wars
- Emerging Disasters- Urban Areas, Climate Change.
- Reginal and Global Trends-loss of life & Property in various hazards

UNIT III: DISASTER MANAGEMENT CYCLE AND INTERNATIONAL FRAMEWORK

- Disaster Management Cycle
  Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness
  During Disaster – Evacuation – Disaster Communication – Search and Rescue– Emergency Operation Centre – Incident Command System – Relief and Rehabilitation –

Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment

- Paradigm Shift in Disaster Management: International Decade for Natural Disaster Reduction; Yokohama Strategy; Hyogo Framework of Action

UNIT IV: DISASTER RISK MANAGEMENT IN INDIA

- Disaster Profile of India – Mega Disasters of India and Lessons Learnt
- Disaster Management Act 2005 – Institutional and Financial Mechanism
- National Policy on Disaster Management,
- National Guidelines and Plans on Disaster Management;
- Role of Government (local, state and national),Non-Government and Inter-governmental Agencies

UNIT V: TECHNOLOGICAL APPROACHES TO DISASTER RISK REDUCTION

- Geo-informatics in Disaster Management (RS, GIS, GPS and RS)
- Disaster Communication System (Early Warning and Its Dissemination)
- Land Use Planning and Development Regulations
- Disaster Safe Designs and Constructions
- Structural and Non Structural Mitigation of Disasters
- Science &Technology Institutions for Disaster Management in India

Suggested Books/ Material/ References

1. Coppola D P, 2007. Introduction to International Disaster Management, Elsevier Science (B/H), London.
2. Manual on natural disaster management in India, M C Gupta, NIDM, New Delhi
3. An overview on natural & man-made disasters and their reduction, R K Bhandani, CSIR, New Delhi
4. World Disasters Report, 2009. International Federation of Red Cross and Red Crescent,Switzerland
5. Disasters in India Studies of grim reality, AnuKapur& others, 2005, 283 pages, Rawat Publishers, Jaipur
6. 10 Disaster Management Act 2005, Publisher by Govt. of India
7. Publications of National Disaster Management Authority (NDMA) on Various Templatesand Guidelines for Disaster Management
8. National Disaster Management Policy, 2009, GoI

OE 54EC

ELECTRONIC INSTRUMENTATION
(Open Elective-I)

Instruction: 3 Periods per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*
Credits: 3

Course Objectives:

- To familiarize with various measurement parameters and Standards of measurement.
- To learn the working principles of various types of Microphones and Hygrometers.
- To understand the operation and applications of CRO.
- To understand about the operation of various transducers.
- 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 – Operationand 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, Prentice-Hall of India Private Limited, New Delhi, 1994.
4. R .S. Khandpur, *"Handbook of biomedical Instrumentation",* Tata McGraw- Hill publishing company Limited, New Delhi, 2000.

OE604EC

PRINCIPLES OF ELECTRONIC COMMUNICATION SYSTEMS

(Open Elective-I)

Instruction: 3 Periods per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*
Credits: 3

Course Objectives:

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

Course Outcomes: Student will be able to

1. Understand the working of analog and digital communication systems
2. Understand the OSI network model and the working of data transmission
3. Understand the concepts of modulation and demodulations
4. Understand the evolution of communication technologies from traditional telephony systems to modern wireless communication systems.
5. 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 Zig Bee, 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.

OE605ME

3D PRINTING TECHNOLOGY
(Open Elective-I)

Instruction: 3 Periods per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*
Credits: 3

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 softwares.
- To know diversified applications of 3D Printing Technologies.

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

1 Interpret the features of 3D Printing and compare it with conventional methods.
2 Illustrate the working principle of liquid, solid and powder based 3D Printing Technologies.
3 Identify various types of errors in STL file and other data formats used in 3D Printing Technology.
4 Select suitable software used in 3D Printing Technology.
5 Apply the knowledge of various 3D Printing technologies for developing innovative applications.

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. Rafiq Noorani, 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/

OE606ME

FINITE ELEMENT METHOD
(Open Elective-I)

Instruction: 3 Periods per week *Duration of SEE: 3 hours*
CIE: 30 Marks *SEE: 70 Marks*
Credits: 3

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:

1. Demonstrate a basic understanding of the concepts, mathematical formulation and numerical implementation.
2. Demonstrate the ability to invoke appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems.
3. Underlying the FEA as applied to solid mechanics.
4. Solve 2D vector variable problems and analyze higher order elements and its applications.
5. Create his/her own FEA computer programs using Matlab to solve simple engineering problems.

UNIT I: Introduction

Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

UNIT II: One-Dimensional Problems

One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices – Solution of problems from solid mechanics and heat transfer. Longitudinal vibration frequencies and mode shapes.

UNIT III: Two Dimensional Scalar Variable Problems

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements – Shape functions and element matrices and vectors. Application to Field Problems – Thermal problems – Torsion of Non circular shafts –Quadrilateral elements – Higher Order Elements.

UNIT IV: Two Dimensional Vector Variable Problems

Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects – Stress calculations – Plate and shell elements.

UNIT V: Isoparametric Formulation

Natural co-ordinate systems – Isoparametric elements – Shape functions for iso parametric elements – One and two dimensions – Serendipity elements – Numerical integration and application to plane stress problems – Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software.

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.

PC651ME

METAL CUTTING AND METROLOGY

Instruction: (3P) per week *Duration of SEE: 3 hours*
CIE: 25 Marks *SEE: 50 Marks*
Credits: 1.5

Course Objectives:

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

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

1. Perform different operations on lathe, Shaper and Milling Machine Tools
2. Perform Finishing operations on flat and curved surfaces
3. Estimate shear angle, stresses involved, power required and tool life in metal cutting
4. Evaluate tolerances, taper angles, roundness, and roughness for a component
5. Calibrate the precision measuring instruments

List of Experiments:

(a) Metrology

1. Linear measurements with inside, outside and depth micrometers, Vernier calipers and Height gauges.
2. Measurement of roundness errors with Bench Centre method and V-block method.
3. Measurement of thread elements with Tool Maker‟s Microscope
4. Measurement of angles with Sinebar, Bevel protractor and Precision level.
5. Tolerance measurement with Electrical Comparator, Mechanical Comparator and GO -No GO Gauge.
6. Calibration of Outside micrometer and Dial gauge.
7. Profile measurement with profile projector
8. Surface roughness measurement using surface roughness tester

(b) Metal Cutting & Machine Tools

1. External & Internal thread cutting on Lathe: single start and multi start threads.
2. V Block machining on Shaper
3. Machining of Square and Hexagonal bolt heads on Milling Machine Tool.
4. Spur Gear cutting on milling machine tool.
5. Study of cylindrical grinding, reaming and burnishing operations
6. Estimation of shear angle by measuring thickness and length of chips.
7. Measurement of Cutting forces with Lathe tool dynamometer and determination of friction angle and stresses on shear plane and rake plane.
8. a) Test for tool life. b) Measurement of Chip-tool interface temperature by thermocouple.

PC652ME

COMPUTER AIDED ENGINEERING (CAE)

Instruction: (3P) per week *Duration of SEE: 3 hours*
CIE: 25 Marks *SEE: 50 Marks*
Credits: 1

Course Objectives:

- To understand the various features of geometric modelling using standard softwares like Creo(Pro-E) /CATIA/Solid Works like 2d-Sketching, Part Modeling and Assembly.
- To understand the application of Finite Element Analysis using standard packages like ANSYS/ NASTRAN/ADINA in solving structural and thermal problems.

Course Outcomes:

The students will be able to

1. Develop models of engineering components and assemblies using Computer Aided Modelling methods and procedures.
2. Simulate/solve structural and thermal problems using standard software
3. Analyze non-linear engineering problems.
4. Prepare technical document /report.

Computer Aided Modelling

1. Introduction to various features of geometric modeling packages like: Creo (Pro-E) /CATIA/Solid Works.
2. Practicing problems on 2D-Sketching.
3. Creation of various Part Models using extrude, revolve, blend and sweep
4. Creation of Assembly Modelling

Computer Aided Analysis

1. Simple Truss problem
2. Plane Stress and Plane Strain analysis
3. Beam Analysis
4. Modal Analysis
5. Buckling Analysis
6. Thermal analysis
7. Contact analysis

PC653ME

MINI PROJECT

Instruction: (4P) per week *Duration of SEE: 3 hours*
CIE: 25 Marks *SEE: 50 Marks*
Credits: 2

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Write comprehensive report on mini project work.

Guidelines:

1. The mini-project is a team activity having 3-4 students in a team. This is mechanical product design work/ manufacturing process with a focus on mechanical system design/manufacturing process.
2. The mini project may be a complete hardware or a combination of hardware and software. The software part in mini project should be less than 50% of the total work.
3. Mini Project should cater to a small system required in laboratory or real life.
4. It should encompass components, devices, with which functional familiarity is introduced.
5. After interactions with course coordinator and based on comprehensive literature survey/ need analysis, the student shall identify the title and define the aim and objectives of mini-project.
6. Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within first week of the semester.
7. The student is expected to exert on design, development and testing of the proposed work as per the schedule.
8. Art work and Layout should be made using CAD based software.
9. Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

PW 961 ME

SUMMER INTERNSHIP

Instruction: 6 weeks *CIE: 50 marks*
Credits: 2

Internship Objectives:

- Will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn, understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Gain experience in writing Technical reports/projects.
- Expose students to the engineer‟s responsibilities and ethics.
- Familiarize with various materials, processes, products and their applications along with relevant aspects of quality control.
- Promote academic, professional and/or personal development.
- Expose the students to future employers.
- Understand the social, economic and administrative considerations that influence the working environment of industrial organizations
- Understand the psychology of the workers and their habits, attitudes and approach to problem solving.

Internship Outcomes:

1 Understand the actual industrial environment and tuned to readily accept the works for execution.

2 Generate detail project reports and understand industry administration and finance. machines.

3 Troubleshoot problems with more confidence.

4 Design systems/products following standard procedures and norms.

5 Interact with fellow workers and manage the activities efficiently.

Articulation Matrix

INTERNSHIP ACTIVITIES

During summer vacation after 4th/ 6th sem.
Internship with Industry/ Govt. / NGO/ PSU/ Any Micro/ Small/ Medium enterprise/ Online Internship.

INTERNSHIP REPORT

(a) Student's diary/ daily log

The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students‟ thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit.
Student‟s Diary and Internship Report should be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training. It will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary.
- Adequacy & quality of information recorded.
- Drawings, sketches and data recorded.
- Thought process and recording techniques used.
- Organization of the information.

(b) Internship report

After completion of Internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period. The student may contact Industrial Supervisor/ Faculty Mentor/TPO for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor and Faculty

Mentor. The Internship report will be evaluated on the basis of following criteria:

i. Originality.
ii. Adequacy and purposeful write-up.
iii. Organization, format, drawings, sketches, style, language etc.
iv. Variety and relevance of learning experience.
v. Practical applications, relationships with basic theory and concepts taught in the course.

EVALUATION THROUGH SEMINAR PRESENTATION/VIVA-VOCE

The student will give a seminar based on his training report, before an expert committee constituted by the Department as per norms of the institute. The evaluation will be based on the following criteria:

- Quality of content presented.
- Proper planning for presentation.
- Effectiveness of presentation.
- Depth of knowledge and skills.
- Attendance record, daily diary, departmental reports shall also be analyzed along with the internship report.

Seminar presentation will enable sharing knowledge & experience amongst students & teachers and build Communication skills and confidence in students.

***Students have to undergo summer internship of 6 Weeks duration at the end of semester VI and the credits will be awarded after evaluation in VII semester.**