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MECHANICAL ENGINEERING
Course Structure R-20

B.Tech VII Semester

B.Tech VII SEMESTER

S.No.	Class	Course Code	Name of the Subject	L	T	P	C
1	PC	C37PC1	Finite Element Methods	3	0	0	3
2	PC	C37PC2	CAD/CAM	3	0	0	3
3	PE	C37PE3A C37PE3B C37PE3C	**Professional Elective-4** Micro Electro Mechanical Systems Mechanical Vibrations Automation in Manufacturing	3	0	0	3
4	PE	C37PE4A C37PE4B C37PE4C	**Professional Elective-5** Tribology Industrial Engineering and Management Additive Manufacturing	3	0	0	3
5	OE	C37OE5	**Open Elective-2**	3	0	0	3
6	PC	C37PC6	CAD/CAM Lab	0	0	2	1
7	PC	C37PC7	Instrumentation and Control Systems Lab and Production Drawing Practice	0	0	2	1
8	PW	C37PW9	Project Work-A	0	0	4	2
9	MC	MC07	Preparation for Competitive World	0	0	0	0
Total							**19**

Mandatory Course:

Preparation for Competitive World: For completion of this course the student can submit the proof of appearing the competitive exams like, GATE, IELTES, GRE, TOEFL, CDAC, CDS, CAT, or any examination organized by NATIONAL TESTING AGENCY (NTA), or college in the level of NTA.

or

The student should request for the provision of conducting Technical seminar by the department. The topic of seminar should be the current technology of computer science. The evaluation will be done by the Departmental Academic Committee (DAC) based on rubrics framed.

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3 /0/ 0/ 3

FINITE ELEMENT METHODS (C37PC1)

Pre-requisite: Thermodynamics

Course Objectives: This course will enable students to:
1. Equip the Finite Element Analysis fundamentals and formulations.
2. Formulate the axial, truss, beam problems.
3. Formulate 2D problems with special cases and use of numerical integration.
4. Formulate heat transfer problems in study sate.
5. Formulate 3D problems and one dimensional dynamic problem.

Course Outcomes: On completion of the course, the students will be able to:
1. Apply FE method for solving field problems using Virtual work and Potential energy formulations.
2. Analyze axial bar, truss and beam problems using FEM.
3. Analyze 2D structural problems using CST element and analyze plane stress, plane strain and axis symmetric problems and Apply the concepts of numerical integration in FE modeling
4. Solve linear 1D and 2D heat conduction and convection heat transfer problems.
5. Formulate 3D elements, apply finite element method to estimate natural frequencies for stepped bar and beam.

UNIT – I:
Introduction:
Finite Element Method for solving field problems. Stress and Equilibrium, Boundary conditions. Strain – Displacement relations. Stress – strain relations. One Dimensional Problem: Finite element modeling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations, Treatment of boundary conditions, Quadratic shape functions.

UNIT – II:
Analysis of Trusses: Stiffness Matrix for Plane Truss and Space Truss Elements, Stress Calculations. Analysis of Beams: Element stiffness matrix for two nodes, two degrees of freedom per node beam element, Load Vector, Deflection, Stresses.

UNIT – III:
Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Estimation of Load Vector, Stresses. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements. Two dimensional four noded Isoparametric elements and numerical integration.

UNIT – IV:

Steady State Heat Transfer Analysis: one dimensional analysis of Slab, fin and two dimensional analysis of thin plate. Analysis of a uniform shaft subjected to torsion.

UNIT – V:

Dynamic Analysis: Formulation of finite element model, element - Mass matrices, evaluation of Eigen values and Eigen vectors for a stepped bar, truss and beam. Finite element – Formulation to 3D problems in stress analysis, convergence requirements, Mesh generation. Techniques such as semiautomatic and fully automatic use of software's such as ANSYS, NISA, NASTRAN, etc.

Text Books:

1. Finite Element Methods: Basic Concepts and applications/Alavala/PHI
2. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu/Pearson.

Reference Books:

1. An Introduction to the Finite Element Method / J.N.Reddy/ Mc GrawHill
2. Finite Element Analysis / SS Bhavikatti / NewAge

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CAD/CAM (C37PC2)

Pre-requisite: Engineering Drawing, Machine Tools and Metrology.

Course Objectives: This course will enable students to:
1. Learn about computer graphics and their application and geometric modeling.
2. Understand the different geometric modeling techniques like solid modeling, surface modeling, and feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication.
3. Learn about the numerical control machining and CNC part programming.
4. Learn importance of group technology; computer aided process planning, computer aided manufacturing resource planning
5. Understand FMS and overall configuration and elements of computer integrated manufacturing systems.

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

1. Explain the basic structure and components of computer hardware used in CAD/CAM. Apply computer graphics techniques in modeling.
2. Design how to use drafting and modeling methods in CAD/CAE fields.
3. Apply the knowledge of CNC machining and part programming to produce objects of intricate shapes with high level of accuracy
4. Apply the principles /methods of GT, CAPP and CAMR planning for product development.
5. Evaluate the various elements and their functions in CIM.

UNIT – I:
Fundamentals of CAD, CAM, Automation, design process, Application of computers for Design, Benefits of CAD, Computer configuration for CAD applications, Computer peripherals for CAD, Design workstation, Graphic terminal, CAD software- definition of system software and application software ,CAD database and structure. Geometric Modeling: 3-D wire frame modeling, wire frame entities and their definitions, Interpolation and approximation of curves, Concept of parametric and non-parametric Representation of curves, Curve fitting techniques, definitions of cubic spline, Bezier and B-spline.

UNIT – II:
Surface modeling: Algebraic and geometric form, Parametric space of surface, Blending functions, parameterization of surface patch, Subdividing, Cylindrical surface, Ruled surface, Surface of revolution Spherical surface, Composite surface, Bezier surface. B-spline surface, Regenerative surface and pathological conditions.

Solid Modeling: Definition of cell composition and spatial occupancy enumeration, Sweep representation, Constructive solid geometry, Boundary representations.

UNIT – III:

NC Control Production Systems: Numerical control, Elements of NC system, NC part Programming: Methods of NC part programming, manual part programming, Computer assisted part programming, Post Processor, Computerized part program, SPPL (A Simple Programming Language). CNC, DNC and Adaptive Control Systems.

UNIT – IV:

Group Technology: Part families, Parts classification and coding. Production flow analysis, Machine cell design.

Computer aided process planning: Difficulties in traditional process planning, Computer aided process planning: retrieval type and generative type, Machinability data systems. Computer aided manufacturing resource planning: Material resource planning, inputs to MRP, MRP output records, Benefits of MRP, Enterprise resource planning, Capacity requirements planning

UNIT – V:

Flexible manufacturing system: FMS S equipment, FMS layouts, Analysis methods for FMS benefits of FMS. Computer aided quality control: Automated inspection- Off-line, On-line, contact, Noncontact; Coordinate measuring machines, Machine vision. Computer Integrated Manufacturing: CIM system, Benefits of CIM

Text Books:

1. CAD/CAM Concepts and Applications / Alavala / PHI
2. CAD/CAM Principles and Applications / P.N.Rao / Mc Graw Hill

Reference Books:

1. CAD/CAM/ Groover M.P/ Pearson
2. CAD/CAM/CIM/ Radhakrishnan and Subramanian / New Age

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MICRO ELECTRO MECHANICAL SYSTEMS (C37PE3A)
(Professional Elective-4)

Pre-requisite: Basic Electrical and Electronics Engineering, Material Science.

Course Objectives: This course will enable students to:
1. Understand concept of MEMS and Microsystems.
2. Recognize the importance of Engineering Science for Microsystems Design and Fabrication.
3. Recognize the importance of Engineering Mechanics for Microsystems Design.
4. Understand concept of thermo Fluid Engineering & Microsystems Design.
5. List the Materials for MEMS & Microsystems and their fabrication.

Course Outcomes: On completion of the course, the students will be able to:
1. Apply the knowledge of MEMS and Microsystems in various engineering fields.
2. Relate Engineering Science for Microsystems Design and Fabrication.
3. Relate Engineering Mechanics for Microsystems Design.
4. Apply the knowledge of Thermo Fluid Engineering & Microsystems Design in various engineering fields.
5. Select Materials for MEMS & Microsystems and their fabrication.

Unit-I
Overview and working principles of MEMS and Microsystems: MEMS & Microsystems, Evolution of Micro fabrication, Microsystems and Microelectronics, Microsystems and miniaturization, Applications of MEMs in Industries, Micro sensors, Micro actuation, MEMS with Micro actuators Micro accelerometers, Micro fluidics.

Unit-II
Engineering Science for Microsystems Design and Fabrication: Atomic structure of Matter, Ions and Ionization, Molecular Theory of Matter and Intermolecular Forces, Doping of Semiconductors, The Diffusion Process, Plasma Physics, Electrochemistry, Quantum Physics.

Unit-III
Engineering Mechanics for Microsystems Design: Static Bending of Thin plates, Mechanical Vibration, Thermo mechanics, Fracture Mechanics, Thin- Film Mechanics, and Overview of Finite Element Stress Analysis.

Unit-IV
Thermo Fluid Engineering & Microsystems Design: Overview of Basics of Fluid Mechanics in Macro and Mesoscales, Basic equations in Continuum Fluid Dynamics, Laminar Fluid Flow

in Circular Conduits, Computational Fluid Dynamics, Incompressible Fluid Flow in Micro conduits, Fluid flow in Sub micrometer and Nano scale, Overview of Heat conduction in Solids, Heat Conduction in Multilayered Thin films and in solids in sub micrometer scale, Design Considerations, Process Design Mechanical Design, Mechanical design using FEM, Design of a Silicon Die for a Micro pressure sensor.

Unit-V

Materials for MEMS & Microsystems and their fabrication: Substrates and Wafers, Active substrate materials, Silicon as a substrate material, Silicon compounds, Silicon Piezo resistors, Gallium Arsenide, Quartz, Piezoelectric Crystals and Polymers, Photolithography, Ion implantation, Diffusion and oxidation, Chemical and Physical vapor deposition, etching, Bulk micro manufacturing, Surface Micromachining, The LIGA Process.

Text Books:

1. Tia-Ran Hsu, "MEMS & Microsystems: Design & Manufacturing", TMH, 2002.
2. Chang Liu, "Foundation of MEMS", Pearson, 2012.

Reference Books:

1. Maluf, M., "An Introduction to Micro electromechanical Systems Engineering", Artech House, 2000.
2. Trimmer, W.S.N., "Micro robots and Micromechanical Systems: Sensors & Actuators", Vol 19, 1989.
3. Trim., D.W, "Applied Partial Differential Equations", PWS-Kent Publishing, 1990

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MECHANICAL VIBRATIONS (C37PE3B)
(Professional Elective-4)

Pre-requisite: Engineering Mechanics, Kinematics of Machines, Dynamics of Machines

Course Objectives: This course will enable students to:
1. Understand and appreciate the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.
2. Obtain linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF).
3. Write the differential equation of motion of vibratory systems.
4. Make free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi-degree of freedom linear systems.
5. Understand Continuous system for torsional vibrations of shafts.

Course Outcomes: On completion of the course, the students will be able to:
1. Appreciate the need and importance of vibration analysis in mechanical design of machine parts that operate in vibratory conditions.
2. Analyze the mathematical model of a linear vibratory system to determine its response.
3. Obtain linear mathematical models of real-life engineering systems.
4. Use Lagrange‟s equations for linear and nonlinear vibratory systems.
5. Develop a Continuous system relation for torsional vibrations of shafts.

Unit-I
Single degree of Freedom systems – I: Undamped and damped free vibrations, forced vibrations, coulomb damping; Response to excitation, rotating unbalance and support excitation, vibration isolation and transmissibility.

Unit-II
Single degree of Freedom systems – II: Response to Non-Periodic Excitations, UNIT impulse – UNIT step and UNIT Ramp functions, response to arbitrary excitations, The Convolution Integral, shock spectrum, System response by the Laplace Transformation method.
Vibration measuring instruments: Vibrometers, velocity meters & accelerometers.

Unit-III
Two-degree freedom systems: Principal modes – undamped and damped free and forced vibrations; undamped vibration absorbers.

Unit-IV

Multi degree freedom systems: Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties, Free and forced vibration by Modal analysis, Method of matrix inversion, Torsional vibrations of multi- rotor systems and geared systems; Discrete- Time systems.

Unit-V

Numerical Methods: Raleigh's stodola's, Matrix iteration, Rayleigh- Ritz Method and Holzer's methods.

Continuous system: Free vibration of strings–longitudinal oscillations of bars- traverse vibrations of beams- Torsional vibrations of shafts.

Critical speeds of shafts: Critical speeds without and with damping, secondary critical speed.

Text Books:

1. Meirovitch, "Elements of Vibration Analysis", Tata McGraw Hill, 2001.
2. G. K. Groover, "Mechanical Vibrations", 2nd Edition, New Chand Publications, 1972

Reference Books:

1. SS Rao, "Mechanical Vibrations", Pearson, 4th Edition, 2009.
2. Rao V.Dukkipati& J Srinivas, "Mechanical Vibration", PHI, 2010.
3. Mechanical Vibrations Practice and Basic Theory: V. Ram Murthy, Narosa Publishing House, New Delhi, 2000.

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AUTOMATION IN MANUFACTURING (C37PE3C)
(Professional Elective-4)

Pre-requisite: Production Planning and Control, Operations Research.

Course Objectives: This course will enable students to:
1. Understand the basic concepts and principle of automation in manufacturing system
2. Understand the technology of how materials should be handled using automated and retrieval system.
3. Learn how to create automated flow lines and analyze how automated flow lines work
4. Gain knowledge on automated assembly systems like GT and FMS.
5. Understand how to check the quality in design and manufacturing, adaptive control systems and automated inspection methods.

Course Outcomes: On completion of the course, the students will be able to:
1. Evaluate the basic concepts of automation in machine tools.
2. Describe the importance of automated material handling and storage systems
3. Design various parts of IC engines under the influence of dynamic and inertia forces.
4. Analyze various automated flow lines, assembly systems and line balancing methods.
5. Interpret the importance of adaptive control systems, automated inspection systems.

Unit-I
Over View of Manufacturing and Automation: Production systems, Automation in production systems, Automation principles and strategies, Manufacturing operations, production facilities. Basic elements of an automated system, levels of automation; Hardware components for automation and process control, programmable logic controllers and personal computers.

Unit-II
Material Handling and Identification Technologies: Material handling, equipment, Analysis. Storage systems, performance and location strategies, Automated storage systems, AS/RS, types. Automatic identification methods, Barcode technology, RFID.

Unit-III
Manufacturing Systems and Automated Production Lines: Manufacturing systems: components of a manufacturing system, Single station manufacturing cells; Manual Assembly lines, line balancing Algorithms, Mixed model Assembly lines, Alternative Assembly systems. Automated production lines, Applications, Analysis of transfer lines.

Unit-IV

Automated Assembly Systems: Fundamentals, Analysis of Assembly systems. Cellular manufacturing, part families, cooling, production flow analysis. Group Technology and flexible Manufacturing systems, Quantitative Analysis.

Unit-V

Quality Control and Support Systems: Quality in Design and manufacturing, inspection principles and strategies, automated inspection, contact Vs non contact, CMM. Manufacturing support systems. Quality function deployment, computer aided process planning, concurrent engineering, shop floor control, just in time and lean production.

Text Books:

1. Automation, production systems and computer integrated manufacturing/ Mikell.P Groover/PHI/3rd edition/2012.
2. Automation, Production Systems and CIM/ Mike J P. Grower/PHI.
3. CAD/CAM/CIM/ P. Radha Krishnan & S. Subrahamanyarn and Raju/New Age International Publishers/ 2003.

Reference Books:

1. System Approach to Computer Integrated Design and Manufacturing/ Singh/John Wiley /96.
2. Computer Aided Manufacturing/Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang/ Pearson/ 2009.
3. Manufacturing and Automation Technology / R Thomas Wright and Michael Berkeihiser / Good Heart/Willcox Publishers

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TRIBOLOGY (C37PE4A)
(Professional Elective-5)

Pre-requisite: Production Planning and Control, Material Handling systems, Operations Research.

Course Objectives: This course will enable students to:
1. Know the importance of lubrication and its specific applications.
2. Understand the principles of hydro dynamic theory of lubrication and various theory of lubrication.
3. Study the hydro dynamic theory applied to journal bearings.
4. Know the advantages, disadvantages and applications of hydro dynamic journal bearings.
5. Understand the concept bearing materials.

Course Outcomes: On completion of the course, the students will be able to:
1. Understand the fundamentals of tribology and associated parameters.
2. Apply concepts of tribology for the performance analysis and design of components of relative motion.
3. Analyze the requirements and design of hydrodynamic journal for a given application.
4. Analyze the hydro dynamic journal bearings, hydro dynamic thrust bearings, hydro static thrust and hydro static bearings.
5. Select proper bearing materials and lubricants for a given tribological application

Unit-I
Introduction to tribology : Historical background, practical importance and subsequent use in the field, Lubricants types and their physical properties, and specific field of applications, types of additives, extreme pressure lubricants, standard grades of lubricants, selection of lubricants. Hydrostatic lubrication: introduction to hydrostatic lubrication, hydrostatic step bearing, load carrying capacity and oil flow through hydrostatic step bearing, numerical examples.

Unit-II
Hydrodynamic theory of lubrication: principle of hydrodynamic theory of lubrication Various theories of lubrication, petroff's equation, mechanism of pressure development in oil film ,Reynolds's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing.

Unit-III

Hydro dynamic journal bearings: hydro-dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl anti- friction bearing. Friction and power losses in lightly loaded journal bearings: friction in concentric bearings, bearing modulus, Somerfield's number and its significance, end leakages in journal bearings, heat balance, numerical examples of full journal bearings only.

Unit-IV

Air lubricated bearing: Advantages and disadvantages, application to Hydrodynamic journal bearings, hydrodynamic thrust bearings. Hydro static thrust bearings. Hydrostatic bearing Analysis including compressibility effect. Study of current concepts of boundary friction and dry friction.

Unit-V

Types of bearing oil pads: Hydrostatic bearing wick oiled bearings, oil rings, pressure feed bearing, and partial bearings- externally pressurized bearings.
Bearing materials: Commonly used bearing materials, properties of typical bearing materials, advantages and disadvantages

Text Books:

1. Fundamentals of Tribology, Basu, Sen GuptaandAhuja/PHI
2. TribologyinIndustry: Sushil KumarSrivatsava, S.Chand &Co.

Reference Books:

1. Introduction totribology of Bearings– B.C.Majumdar/S.Chand
2. Engineering Tribology ,Prasanta Saahoo, PHI Learning Private Limited, New Delhi 2011
3. Engineering Tribology, G.W.Stachowiak and A.W. Batchelor, Butterworth-Heinemann,1992

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INDUSTRIAL ENGINEERING AND MANAGEMENT (C37PE4B)
(Professional Elective-5)

Pre-requisite: Knowledge of Manufacturing, General Management, Mathematics & Statistics.

Course Objectives: This course will enable students to:
1. Perform as industry leaders in the global marketplace, capable of successfully planning, controlling, and implementing large-scale projects.
2. Flourish and work effectively in diverse, multicultural environments emphasizing the application of teamwork and communication skills.
3. Understand and apply the principles of Management, science, technology, engineering, and mathematics involving industry-relevant problems.
4. Maintain high standards of professional and ethical responsibility.
5. Contribute to the profitable growth of industrial economic sectors by using IE analytical tools, effective computational approaches, and systems thinking methodologies.

Course Outcomes: On completion of the course, the students will be able to:
1. Apply knowledge of Management, mathematics, science, and engineering.
2. Design a system to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
3. Analyze the concepts of work study and work sampling and to follow ergonomics principles effectively.
4. Evaluate functions of marketing and manufacturing planning activities.
5. Acquire knowledge on contemporary and emerging issues important to professional practice.

Unit-I

Introduction to Industrial Engineering And Management: Concept of Industrial Engineering (I.E),History and Development of I.E, Role of I.E, Applications of I.E, Production Management vs I.E, Principles of Management, Functions of Management, Taylor's Scientific Management, Maslow's Theory of Human Needs, Leadership Styles, Principles of Organization, Types of Organization Structures their Merits and Demerits, Entrepreneurship.

Unit-II

Production and Operations Management: Plant Location, Principles of Plant Layout, Different Types of Plant Layouts, different Types of Production Systems, Travel Chart Technique, Simple Problems on Assembly Line Balancing.
Production Planning and Control: Production Cycle, Product Design and Development, Production Planning and Control Techniques, Simple problems.

Plant Maintenance: Objectives and Types, Equipment Selection, Maintenance Planning. Materials Handling- Principles, Concept of Unit Load, Containerization, Selection of Material Handling Equipment, Applications of Belt Conveyors, Cranes, Forklift Trucks in Industry
Production Planning and Control: Production Cycle, Product Design and Development, Production Planning and Control Techniques, Simple problems.

Unit-III

Work Study: Concept of Productivity, Method Study- Basic steps in Method Study, Process Charts, Diagrams, Models and Templates, Principles of Motion Economy, Micro Motion Study, Therbligs, SIMO Chart, PMTS, MOST, Work Measurement - Stop Watch Procedure of Time Study, Performance Rating, Allowances, Work Sampling, Simple Problems, Ergonomics.
Materials Management: Introduction, Purchasing, Objectives of Purchasing Department, Buying Techniques, Purchase Procedure, Stores and Material Control, Inventory Control, EOQ Model(Simple Problems), Supply Chain Management. Quality Control - Statistical Quality Control, Control Charts for Variables and Attribute, Simple Problems, Acceptance Sampling, Deming's Contribution to Quality. Total Quality Management, Taguchi's Quality Engineering, Value Analysis and Value Engineering

Unit-IV

Marketing: Functions of Marketing, Marketing Mix, Product Life Cycle. Channels of Distribution and Sales Management. Manufacturing planning: MRP, MRP-II, JIT, CIM.

Unit-V

Human Resources Management (HRM): Concepts of HRM, Basic Functions of HR Manager: Manpower Planning, Recruitment, Selection, Training and Development, Placement, Wage and Salary Administration, Promotion, Transfer, Separation, Performance Appraisal.
Industrial Relations: Trade Unions, Industrial Disputes, Strikes, Lock-Out, Picketing, Gherao, Settlement of Industrial Disputes, Collective Bargaining, Industrial Dispute Act 1947 and Factories Act 1948

Text Books:

1. Industrial Engineering & Management by N.V.S Raju, Cengage Learning Publications
2. Principles of Management by Koontz and ODonnel

Reference Books:

1. Production and Operations Management by Everette Adam and Ronald Ebert.
2. Operations Management by John McClain and Joseph Thames.
3. Industrial Engineering and Production Management by Tulsa, S. Chand and C

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ADDITIVE MANUFACTURING (C37PE4C)
(Professional Elective-5)

Pre-requisite: Engineering Physics, CAD/CAM, Composite Materials.

Course Objectives: This course will enable students to:
1. Understand the need for Additive Manufacturing / Rapid Prototype / 3D Printing Technologies in product development and the required Tooling and Applications.
2. Learn the Basic Concepts of CAD and Reverse Engineering, CAD model preparation, Tool path Generation, etc., Acquire knowledge of Software for Additive Manufacturing Technology.
3. Study the principles of Liquid based Additive Manufacturing Systems such as Stereo-lithography Apparatus (SLA).
4. Study the principles of Solid based Additive Manufacturing Systems such as Fused Deposition Modeling and Laminated Object Manufacturing, their advantages and applications.
5. Study the principles of Powder based Additive Manufacturing Systems such as Selective Laser Sintering, Three-Dimensional Printing, Laser Engineered Net Shaping (LENS), and Electron Beam Melting, their advantages and applications.

Course Outcomes: On completion of the course, the students will be able to:
1. Evaluate real-life scenarios and recommend the appropriate use of 3D printing technology
2. Describe different RP techniques.
3. Discuss fundamentals of Reverse Engineering.
4. Apply the principles of CAD and Reverse Engineering in product design and development.
5. Analyze the effects of surface finish and microstructural properties on behavior for components produced using additive manufacturing

Unit-I
Introduction: Overview – History - Need-Classification – Additive Manufacturing / Rapid Prototype / 3D Printing Technologies in product development – Materials for Additive Manufacturing Technology – Tooling – Applications.

Unit-II
CAD and Reverse Engineering: Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing – Tool path Generation – softwares for Additive Manufacturing Technology, MIMICS, MAGICS.

Unit-III

Liquid based additive manufacturing systems: Classification – Liquid based system – Stereo-lithography Apparatus (SLA) – Principle, process, advantages and applications.

Unit-IV

Solid based additive manufacturing systems: Solid based system – Fused Deposition Modeling – Principle, process, advantages and applications – Laminated Object Manufacturing.

Unit-V

Powder Based Additive Manufacturing Systems: Selective Laser Sintering – Principles of SLS process – Process – advantages and applications – Three-Dimensional Printing – Principle – process – advantages and applications – Laser Engineered Net Shaping (LENS) – Electron Beam Melting.

Text Books:

1. Chua C.K., Leong K.F, "Rapid prototyping: Principles and applications", World Scientific Publishers, 3rd Edition, 2010.
2. Gebhardt A., "Rapid Prototyping", Hanser Gardener Publications, 2003.

Reference Books:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering Applications: A tool box for prototype development", CRC Press, 2007.
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
3. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press, 2000.

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CAD/CAM LAB (C37PC6)

Pre-Requisite: Engineering Drawing, Machine Drawing, CAD/CAM

Course Objectives: This course will enable students to:

1. Learn the softwares and equipments associated with CAD/CAM.
2. Understand the basic concepts about CAD/CAM.
3. Understand the concepts of Surface modeling and sheet Metal Working.
4. Learn basic concepts of deflection and stresses in 2D and 3D trusses and beams.
5. Understand the concept of stresses in 3D and shell structures.

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

1. Design a part or assembly of parts using Computer-Aided Design software.
2. Develop 2D and 3D models using modeling softwares.
3. Apply the knowledge of surface and sheet metal working operations in Practice.
4. Modeling of simple machine parts and assemblies from the part drawings using standard CAD packages.
5. Create CNC part programming and perform its manufacturing.

List of Experiments:

1. Drafting: Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances.
2. Part Modeling: Generation of various 3D Models through Protrusion, revolve, sweep. Creation of various features. Study of parent child relation. Feature based and Boolean based modeling and Assembly Modeling. Study of various standard Translators. Design of simple components.
3. Determination of deflection and stresses in 2D and 3D trusses and beams.
4. Determination of deflections, principal and Von-mises stresses in plane stress, plane strain and Axi-symmetric components.
5. Determination of stresses in 3D and shell structures (at least one example in each case).
6. Estimation of natural frequencies and mode shapes, harmonic response of 2D beam.
7. Study state heat transfer analysis of plane and axi-symmetric components.
8. Development of process sheets for various components based on Tooling and Machines.
9. Development of manufacturing defects and tool management systems.
10. Study of various post processors used in CNC Machines.
11. Development of CNC programming for free form and sculptured surfaces using CAM software.
12. Machining of simple components on CNC turning machine.

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MECHANICAL ENGINEERING-R20

B.Tech VII Semester **L/T/P/C**
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INSTRUMENTATION AND CONTROL SYSTEM LAB AND PRODUCTION DRAWING PRACTICE (C37PC7)

Pre – Requisites: Engineering Drawing, Machine Drawing, Metrology.

Course Objectives:
1. Understanding of conventional representations of various materials and machine components.
2. Understanding the various limits, fits and tolerances adopted in the production drawings.
3. Understanding the various surface treatment symbols used and assembly production drawings of simple components.
4. Understanding the process of calibration of various instruments.(one more ICS lab)

Course Outcomes: After completion of this course, the student is expected to be able to:
1. Understand the conventions used in a production drawing.
2. Determine limits and fits and allocate tolerances for machine components.
3. Convert machine drawings into production drawings.
4. Apply concepts and methods in the preparation of production drawings.
(ICS)
1. Calibrate the pressure, Strain and displacement measuring instruments.
2. Use the magnetic & speed pickups for the speed measurement.
3. Calibrate of flow measurement by rotameter.
4. Calibrate different instruments used for temperature measurement.

(A) INSTRUMENTATION AND CONTROL SYSTEM LAB

1. Calibration of Pressure Gauges.
2. Calibration of transducer for temperature measurement.
3. Study and calibration of LVDT transducer for displacement measurement.
4. Calibration of strain gauge for temperature measurement.
5. Calibration of thermocouple for temperature measurement.
6. Calibration of capacitive transducer for angular displacement.
7. Study and calibration of photo and magnetic speed pickups for the measurement of speed.
8. Calibration of resistance temperature detector for temperature measurement.
9. Study and Calibration of a rotameter for flow measurement.
10. Study and use of a seismic pickup for the measurement of vibration and amplitude of an engine bed at various loads.

(B) PRODUCTION DRAWING PRACTICE

Unit-I

Conventional Representation of Materials: conventional representation of parts – screw joints, welded joints, springs, gears, electrical, hydraulic and pneumatic circuits – methods of indicating notes on drawings. Limits, Fits and Tolerances: Types of fits, exercises involving selection /interpretation of fits and estimation of limits from tables.

Unit-II

Form And Positional Tolerances: Introduction and indication of form and position tolerances on drawings, types of run out, total run out and their indication.

Unit-III

Surface Roughness and Its Indication: Definition, types of surface roughness indication – Surface roughness obtainable from various manufacturing processes, recommended surface roughness on mechanical components. Heat treatment and surface treatment symbols used on drawings.

Unit-IV

Detailed and Part Drawings: Drawing of parts from assembly drawings with indications of size, tolerances, roughness, form and position errors etc.

Unit-V

Production Drawing Practice: Part drawings using computer aided drafting by CAD software.

Text Books:

1. Production and Drawing /K.L. Narayana & P. Kannaiah/ New Age.
2. Machine Drawing with Auto CAD/ Pohit and Ghosh, PE.

Reference Books:

1. Geometric dimensioning and tolerancing/James D. Meadows/ B.S.Publications.
2. Engineering Metrology/ R.K. Jain/Khanna Publications.

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MECHANICAL ENGINEERING
Course Structure R-20

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B.Tech VIII SEMESTER

S.No.	Class	Course Code	Name of the Subject	L	T	P	C
1	OE	C38OE1	**Open Elective-3**	3	0	0	3
2	PE	C38PE2A C38PE2B C38PE2C	**Professional Elective-6** Computational Fluid Dynamics Manufacturing of Composites Flexible Manufacturing System	3	0	0	3
3	PW	C38PW3	Project Work-B	0	0	18	9
4	PW	C38PW4	Seminar	0	0	3	2
5	PW	C38PW5	Industrial Oriented Mini Project	0	0	0	2
Total							**19**

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COMPUTATIONAL FLUID DYNAMICS (C38PE2A)
(Professional Elective-6)

Pre-requisite: Fluid Mechanics, Linear Algebra, Partial differential Equations

Course Objectives: This course will enable students to:
1. Understand the numbering system and errors in numerical techniques and representation of integers, fractions etc.
2. Impart the knowledge of governing equations for fluid flow and finite difference applications in heat conduction and convection.
3. Learn the numerical method used to solve the partial differential equation.
4. Review of equations governing fluid flow and heat transfer
5. Learn the concept of Finite volume method and Interpolation method.

Course Outcomes: On completion of the course, the students will be able to:
1. Solve the errors involved in numerical techniques
2. Analyze the internal fluid flow phenomena of thermal fluid flow.
3. Acquire the knowledge of various types of fluid flow governing equations.
4. Analyze fluid flow governing equations and special forms of Navier-stokes equation.
5. Explain finite volume method, interpolation concepts and compute problems.

Unit-I
Elementary details in numerical techniques: Number system and errors – representation of integers, fractions, floating point arithmetic, loss of significance and error propagation – condition for instability – computational methods for error estimation – convergence of sequences.

Unit-II
Applied Numerical Methods: Solution of a system of simultaneous Linear Algebraic Equations – Iterative schemes of Matrix Inversion – Direct Methods for Matrix inversion, Direct Methods for banded matrices. Finite Difference applications in heat conduction and convection – Heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction – finite difference application in convective heat transfer – closure.

Unit-III
Finite Differences – discretization, consistency, stability. Fundamentals of fluid flow modeling – Introduction, elementary finite difference quotients, implementation aspects of finite-difference equations, consistency, explicit and implicit methods

Unit-IV

Introduction to first order wave equation – stability of hyperbolic and elliptic equations, fundamentals of fluid flow modeling, conservative property, the upwind scheme. Review of Equations governing Fluid Flow and Heat Transfer – Introduction, conservation of mass, Newton‟s second law of motion – expanded forms of Navier- stokes equations – conservation of energy principle – special forms of the Navier-stokes equations.

Unit-V

Steady flow – dimensionless form of Momentum and Energy equations – Stokes equation, conservative body force fields – stream function – Vorticity formulation.

Finite volume method: Approximation of surface integrals – volume integrals – Interpolation and differentiation practices – upwind interpolation – linear interpolation and quadratic interpolation.

Text Books:

1. Suhas V. Patankar, “Numerical heat transfers and fluid flow”, Hemashava Publishers Corporation, Tata McGraw Hill.
2. Muralidaran, “Computational Fluid Flow and Heat Transfer”, Narosa Publications, 2nd Edition, 2014.

Reference Books:

1. John D. Anderson, “Computational Fluid Dynamics – Basics with applications” Tata McGraw Hill.
2. Tapan K. Sengupta, “Fundamentals of Computational Fluid Dynamics”, Universities Press

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MANUFACTURING OF COMPOSITES (C38PE2B)
(Professional Elective-6)

Pre-requisite: Engineering Physics, Engineering Materials, Manufacturing Technology.

Course Objectives: This course will enable students to:
1. Understand the concepts of composites, their properties, applications, and testing methods.
2. Learn about the manufacturing processes for Thermo setting matrix composites and Thermoplastic matrix composites
3. Gain knowledge of various methods of processing the Metal Matrix Composites.
4. Learn about the Ceramic Matrix Composites, Nano-composites, and Carbon-Carbon Composites, their properties, Fabrication methods, and Applications
5. Learn various methods of Repair and Non-destructive testing for composite materials

Course Outcomes: On completion of the course, the students will be able to:
1. Describe the important properties of composites, their applications, and testing methods.
2. Identify the manufacturing methods of Polymer Matrix Composites
3. Apply the knowledge acquired in the manufacturing of Metal Matrix Composites, Ceramic Matrix Composites, and Nano-composites to practical situations
4. Identify and assess the damage in Composites by Non-destructive testing methods, and repair the same
5. Apply the knowledge of various methods for Repair and Non-destructive testing for composite materials

Unit-I
Introduction to Composites: Concept of composites – Classification of composites – Applications of composites – Metals vs Composites – Composites lay-up nomenclature – Laminating stacking – Standard orientation and sequence of ply.
Properties and testing of composites: Composite properties – Volume fraction calculations – Elastic behavior. Composites testing – types of testing – Physical testing, Mechanical testing, chemical testing, Thermal testing, Rheological testing.

Unit-II
Manufacturing of Polymer Matrix Composites: Processes for Thermosetting matrix composites – Hand layup and spray up techniques, Filament winding, Pultrusion, Resin transfer moulding, Autoclave moulding. Processes for Thermoplastic matrix composites – Injection moulding, Film stacking, Diaphragm forming. Thermoplastic tape laying. Stacking of reinforcements – Manufacturing Process Selection – Criteria, Product Fabrication Techniques – Mould and Tool Making method.

Unit-III

Manufacturing of Metal Matrix Composites (MMC): Introduction – Classification, Advantages and disadvantages – Reinforcements and Matrices. Processing of MMC – Processing methods – Liquid state processing, Stir Casting, Infiltration, Squeeze casting – Gas pressure – Pressure die – Solid state fabrication – Diffusion bonding – Sintering – In situ fabrication of MMC – Co-deposition methods – Electrolytic co-deposition – Spray co-deposition – Vapour co-deposition.

Unit-IV

Manufacturing of Ceramic Matrix Composites (CMCs): Introduction – Types – Properties – Interfaces – Fabrication methods of CMCs – Polymer Infiltration and Pyrolysis – Chemical Vapour Infiltration – Liquid Silicon Infiltration – Direct Oxidation Process – Slurry Infiltration – Selective Laser Sintering – Applications of CMCs. Carbon – Carbon Composites – Introduction, Processing of CCC, Advantages – limitations and Applications of CCC.

Nano Composites: Nano-composites and fillers – Synthesis of nano-composites – Solution casting – Melt blending – In-situ polymerization – Electro deposition – Advantages – limitations and Applications of nano-composites.

Unit-IV

Repair and NDT of Composites: Repair of Composites – Damage in Composites – Damage Assessment – Contaminations – Types of repair – Scarfing and Stepping.

Non-destructive testing methods for composite materials- Ultrasonic Testing (UT) – Acoustography – Radiographic Testing (RT) – Shearography Testing – Thermography.

Text Books:

1. Mazumdar S, “Composites manufacturing: materials, product, and process engineering”, CRC press, 2001.
2. Balasubramanian, M., “Composite materials and processing”, CRC press, 2013.
3. Campbell Jr, F.C. ed, “Manufacturing processes for advanced composites”, Elsevier, 2003.

Reference Books:

1. B. D. Agarwal and L. J. Broutman, Wiley, “Analysis and performance of fiber Composites”, Inter science, New York, 1980.
2. R. M. Jones, “Mechanics of Composite Materials”, McGraw Hill Company, New York, 1975.
3. Isaac and M Daniel, “Engineering Mechanics of Composite Materials”, Oxford University Press, 1994.

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FLEXIBLE MANUFACTURING SYSTEM (C38PE2C)
(Professional Elective-6)

Pre-requisite: CAD/CAM.

Course Objectives: This course will enable students to:
1. Understand the concepts of development of manufacturing systems.
2. Learn about FMS supervisory computer control and types of software and their specifications.
3. Gain knowledge of FMS simulation and database techniques.
4. Learn about the group technology techniques to improve productivity.
5. Understand the applications of flexible manufacturing systems and factory of the future.

Course Outcomes: On completion of the course, the students will be able to:
1. Perform planning, scheduling and control of flexible manufacturing systems.
2. Apply the knowledge acquired in computer control and software for flexible manufacturing systems.
3. Apply simulation and database techniques in planning for FMS database
4. Design flexible manufacturing cell after carrying out group technology study and to finally create the FMS.
5. Analyze FMS applications in machining and sheet metal fabrication and design factory for the future.

Unit-I
Planning, scheduling and control of flexible manufacturing systems: Introduction to FMS– development of manufacturing systems – benefits – major elements – types of flexibility – FMS application and flexibility –single product, single batch, and – batch scheduling problem – knowledge based scheduling system.

Unit-II
Computer control and software for flexible manufacturing systems: Introduction – composition of FMS– hierarchy of computer control –computer control of work centre and assembly lines – FMS supervisory computer control – types of software specification and selection – trends.

Unit-III
FMS simulation and data base: Application of simulation – model of FMS– simulation software – limitation – manufacturing data systems – data flow – FMS database systems – planning for FMS database.

Unit-IV

Group Technology and justification of FMS:

Introduction – matrix formulation – mathematical programming formulation –graph formulation – knowledge based system for group technology – economic justification of FMS- application of possibility distributions in FMS systems justification.

Unit-V

Applications of FMS and factory of the future: FMS application in machining, sheet metal fabrication, prismatic component production – aerospace application – FMS development towards factories of the future – artificial intelligence and expert systems in FMS – design philosophy and characteristics for future.

Text Books:

1. Jha, N.K. "Handbook of flexible manufacturing systems", Academic Press Inc., 1991.
2. Groover M.P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt., New Delhi, 1996.

Reference Books:

1. Kalpakjian, "Manufacturing Engineering and Technology", Addison-Wesley Publishsing Co., 1995.
2. Radhakrishnan P. and Subramanyan S., "CAD/CAM/CIM", Wiley Eastern Ltd., New Age International Ltd., 1994.
3. Raouf, A. and Ben-Daya, M., Editors, "Flexible manufacturing systems: recent development", Elsevier Science, 1995.
4. TaiichiOhno, "Toyota Production System: Beyond large-scale Production", Productivity Press (India) Pvt. Ltd. 1992.

List of Open Electives offered by Department of Mechanical Engineering

Open Elective-1 (VI SEMESTER)

S.No.	Course Code	Name of the Subject
1	C36OE6A	Optimization Techniques
2	C36OE6B	Solar Energy Appliances
3	C36OE6C	Fundamentals of Engineering Materials

Open Elective-2 (VII SEMESTER)

S.No.	Course Code	Name of the Subject
1	C37OE5A	Power Plant Engineering
2	C37OE5B	Design and Analysis of Experiments
3	C37OE5C	Production Planning and Control

Open Elective-3 (VIII SEMESTER)

S.No.	Course Code	Name of the Subject
1	C38OE1A	Renewable Energy Systems
2	C38OE1B	Digital Manufacturing
3	C38OE1C	Industrial Management

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OPTIMIZATION TECHNIQUES (C36OE6A)
(Open Elective-1)

Pre-requisite: Mathematics, Numerical Methods.

Course Objectives: This course will enable students to:
1. Illustrate various techniques for optimization
2. Apply optimization methods to various engineering problems
3. Analyze Numerical methods for nonlinear programming problems
4. Ability to adapt the characteristics of dynamic programming applications
5. Interpret the simulation models

Course Outcomes: On completion of the course, the students will be able to:
1. Apply detailed theoretical and practical aspects of optimization and control of non-linear systems.
2. Analyze and interpret and the solution obtained by optimization algorithms.
3. Apply optimum solutions with system approach to both industry and service sector.
4. Evaluate results of various optimality techniques to select most suitable one among these techniques.
5. Apply the concepts of simulation for various applications.

UNIT- I
Introduction to Optimization: Optimization Origin and development– Mathematical models - Optimization methods in engineering – characteristics of optimization models- methods of optimization – applications- formulation of Optimization problem-graphical methods for optimization

UNIT- II
Non-linear programming: Analytical One dimensional minimization methods - Unconstrained optimization techniques- Analytical Multi-Dimensional Unconstrained optimization techniques--multi dimensional with equality constraints- inequality constraints.

UNIT- III
Numerical Methods for One-dimensional nonlinear programming- classification – general methods of solution-Distinction between Analytical and Numerical methods- unimodal functions- Fibonacci search- golden section search method- interpolation methods.

UNIT- IV

Dynamic Programming – Definition- Bellman's principle of Optimality- characteristics of Dynamic programming-applications of Dynamic programming approach- load distribution problem- assignment techniques in logistics and material handling

UNIT -V

Simulation - Concept of Simulation- merits and demerits- Applications- methodology- types of simulation model-languages-General purpose simulation system- SIMSCRIPT- GPPS-SIMULA.

Text Books:

1. Optimization Methods for Engineers/ N.V.S. Raju/PHI publications
2. S.S. Rao, Engineering optimization: Theory and Practice, New age international, 3rd edition, 2013.
3. K. Deb., Optimization for Engineering Design: Algorithms and Examples, PHI, 2nd Edition, 2012.
4. J. S. Arora, Introduction to Optimum Design, Academic press, 4th Edition, 2017.

Reference Books:

1. Optimization theory & Applications / S.S.Rao / New Age International.
2. Introductory to operation Research / Kasan& Kumar / Springar.

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SOLAR ENERGY APPLIANCES (C36OE6B)
(Open Elective-1)

Pre-requisite: Nil

Course Objectives: This course will enable students to:
1. Learn the fundamental concepts of about solar energy systems and devices.
2. Understand the knowledge on solar cookers, performance of solar cookers, testing of solar cookers and its applications.
3. Learn about the different types of solar dryers and applications of solar dryers.
4. Know the importance of solar desalination system and study of various desalination techniques.
5. Understand types of solar furnaces and its components and typical solar furnace designs.

Course Outcomes: On completion of the course, the students will be able to:
1. Analyze the basic working principle of solar cell, solar home and street lighting systems and applications.
2. Apply the knowledge of solar drying systems in different applications.
3. Analyze the principles of desalination system in acquiring the best system.
4. Design solar furnaces along with practical case studies.
5. Apply the modern contexts for solar energy growth/recession to stakeholder preference, fuel constraints, and solar rights/access.

UNIT -I
Solar Lighting- Solar cell – Working principle of a solar cell – Solar home lighting systems – Solar street lighting systems - Solar lanterns – Applications - Rural electrification process – Case studies.

UNIT- II
Solar Cooking- Introduction – Types of solar cookers – Advantages and Dis advantages - Box type – Parabolic dish cooker - Performance evaluation of solar cookers – Testing of a solar cooker Applications of solar cooking - Case studies.

UNIT -III
Solar Drying- Introduction – Need for solar drying - Basics of solar drying – Types of solar dryers – Direct type solar dryer – Mixed mode type solar dryer – Forced circulation type dryers – Hybrid dryer – Bin type dryer –Solar timber drying – Applications - Case studies.

UNIT -IV

Solar Desalination-Introduction – Necessity for desalination – Study on various desalination techniques – Comparison between conventional and solar desalination – Basics of solar still - Simple solar still – Material problems in solar still – Solar disinfection and its methods – Case studies on various desalination techniques.

UNIT V

Solar Furnaces-Introduction – Types of solar furnaces – Components of solar furnaces – Concentrator – Heliostat –Sun tracking – Typical solar furnace designs – Single concentrator furnace – Single heliostat solar furnace - Multiple heliostats solar furnace – Case studies on solar furnaces.

Text Books:

1. Solar Photo voltaics: Fundamentals, Technologies And Applications by Chetan Singh Solanki Fundamentals, Technologies And Applications.
2. Fundamentals and Applications of Renewable Energy by Mehmet Kanoglu (Author), Yunus A. Cengel (Author)

Reference Books:

1. Suhatme and Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata
2. McGrawHill, 2008.
3. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw
4. Hill, 2010.
5. Rai, G.D., Solar Energy Utilization, Khanna Publishers,Delhi, 2010.
6. Michael Grupp, Time to Shine: Applications of Solar Energy Technology, John Wiley
7. & Sons,2012.
8. SM Sze, Kwok K Ng: Physics of semiconductor devices, third edition, John Wiley &
9. Sons, 2007.
10. Daniel J. O'Connor, 101 patented solar energy uses,VanNostrand Reinhold Co., 2007.
11. Martin A. Green, Solar Cells Operating Principles, Technology, and System
12. Applications Prentice- Hall, 2008.

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FUNDAMENTALS OF ENGINEERING MATERIALS (C36OE6C)
(Open Elective-1)

Pre-requisite: Engineering Drawing, Metal Cutting and Machine Tools.

Course Objectives: This course will enable students to:
1. Learn about basic structure of materials.
2. Understand the construction and interpretation of phase diagrams.
3. Understand the concept of iron-carbon phase diagram, TTT diagram and heat treatment processes.
4. Analyze the different forms of iron obtained during heating of steel.
5. Learn about the ceramics, polymers and composites and their applications.

Course Outcomes: On completion of the course, the students will be able to:
1. Identify the crystalline structure of steel and determination of grain size by different methods.
2. Understand the construction of phase diagrams, lever rule and phase rule.
3. Analyze the theory of time temperature and transformation and iron iron-carbon phase diagrams.
4. Distinguish between the various forms of steel.
5. Describe the various uses of ceramics, polymers and composite materials.

Unit-I
Structure of Metals: Crystallography, Miller's indices, Packing Efficiency, Density calculations. Grains and Grain Boundaries. Effect of grain size on the properties. Determination of grain size by different methods.
Constitution of Alloys: Necessity of alloying, Types of solid solutions, Hume – Rothery rules, Intermediate alloy phases.

Unit-II
Phase Diagrams: Construction and interpretation of phase diagrams, Phase rule, Lever rule, Binary phase Diagrams, Isomorphous, Eutectic and Eutectoid transformations with examples.

Unit-III
Steels: Iron-Carbon Phase Diagram and Heat Treatment, Study of Fe-Fe3C phase diagram. Construction of TTT diagrams. Annealing, Normalizing, Hardening and Tempering of steels, Hardenability. Alloy steels.

Unit-IV

Cast Irons: Structure and properties of White Cast iron, Malleable Cast iron, Grey cast iron.
Engineering Materials: Non-ferrous Metals and Alloys: Structure and properties of copper and its alloys, Aluminium and its alloys, Al-Cu phase diagram, Titanium and its alloys.

Unit-V

Ceramics, Polymers and Composites: Crystalline ceramics, glasses, cermets: structure, properties and applications. Classification, properties and applications of composites. Classification, Properties and applications of Polymers.
Smart Materials: Properties, Advantages and Applications of Smart Mterials.

Text Books:

1. Material Science and Metallurgy/ Kodgire
2. Essentials of Materials Science and engineering / Donald R. Askeland / Thomson.

Reference Books:

1. Introduction to Physical Metallurgy / Sidney H. Avner.
2. Materials Science and engineering / William and callister.
3. Elements of Material science / V. Rahghavan

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POWER PLANT ENGINEERING (C37OE5A)
(Open Elective-2)

Pre-requisite: Thermodynamics, Fluid Mechanics and Hydraulic Machines, Thermal Engineering – I, Thermal Engineering – II

Course Objectives: This course will enable students to:
1. Gain basic knowledge of Different types of Power Plants, site selection criteria and combustion process.
2. Understand the concepts of diesel plant, gas turbine plant and methods of direct energy conversion.
3. Get knowledge on working principle of Hydro electric power plant and methods of Non-conventional energy sources.
4. Gain basic knowledge on different types of Nuclear power plants and nuclear fuel.
5. Understand the Power Plant Economics, discussing environmental and safety aspects of power plant operation

Course Outcomes: On completion of the course, the students will be able to:
1. Select the suitability of site for a power plant and combustion processes.
2. Propose suitable power plant as per the requirement of industry.
3. Explain working of hydro-electric power plant and power generation from non-conventional sources.
4. Explain working principle of different types of nuclear power plant and radioactive waste disposable methods.
5. Analyze the cost of power plant by calculating load factor, capacity factor, average load and peak load, etc on a power plant and Indicate safety aspects of power plants.

Unit-I
Introduction to the Sources of Energy – Resources and Development of Power in India
Steam Power Plant: Plant Layout – Working of different Circuits – Fuel and handling equipment's – types of coals – coal handling – choice of handling equipment – coal storage and ash handling systems.
Combustion Process: Properties of coal – overfeed and under feed fuel beds – traveling grate stokers, spreader stokers, retort stokers – pulverized fuel burning system and its components – combustion needs and draught system – cyclone furnace – design and construction – Dust collectors – cooling towers and heat rejection. Corrosion and feed water treatment.

Unit-II

Internal Combustion Engine Plant: Diesel power plant: Introduction – IC Engines, types, construction – Plant layout with auxiliaries – fuel supply system – air intake system – lubrication and cooling system – super charging.

Gas Turbine Plant: Introduction – Classification – construction – Layout with auxiliaries – Principles of working of closed and open cycle gas turbines. Combined Cycle Power Plants and comparison

Direct Energy Conversion: Solar energy – Fuel cells – Thermo electric and Thermo Ionic – MHD generation.

Unit-III

Hydro Electric Power Plant: Water power – Hydrological cycle – flow measurement –drainage area characteristics – Hydrographs – storage and Pondage – classification of dams and spill ways – Classification of plants – Typical layouts – plant auxiliaries – plant operation – pumped storage plants.

Power from Non-Conventional Sources: Utilization of Solar Collectors – Principle of Working – Wind Energy, types, HAWT, VAWT – Tidal Energy.

Unit-IV

Nuclear Power Station: Nuclear fuel –breeding and fertile materials – Nuclear reactor –reactor operation.

Types of Reactors: Pressurized water reactor, Boiling water reactor, sodium-graphite reactor, fast Breeder Reactor, Homogeneous Reactor, Gas cooled Reactor. Radiation hazards and shielding – radioactive waste disposal

Unit-V

Power Plant Economics and Environmental Considerations: Capital cost – Investment of fixed charges – operating costs. General arrangement of power distribution – Load curves and load duration curve. Definitions of connected load, Maximum demand, demand factor, average load, load factor, diversity factor – related exercises. Effluents from power plants and Impact on environment – pollutants and pollution standards – Methods of Pollution control

Text Books:

1. P. C. Sharma, “Power Plant Engineering” S.K. Kataria Publishers.
2. Arora and S. Domkundwar, “A Course in Power Plant Engineering”.

Reference Books:

1. Rajput, “A Text Book of Power Plant Engineerin”, Laxmi Publications.
2. Ramalingam, “Power plant Engineering”, SciTech Publishers.
3. P. K. Nag, “Power Plant Engineering”, Tata McGraw Hill, 2nd Edition.
4. G.D. Rai, “An Introduction to Power Plant Technology”.
5. Elanchezhian, “Power plant Engineering”, I.K. International Pub. 2019

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DESIGN AND ANALYSIS OF EXPERIMENTS (C37OE5B)
(Open Elective-2)

Pre-requisite:

Course Objectives: This course will enable students to:
1. Understand the fundamentals of experimentation and principles of experimentation.
2. Know the basic concepts of probability and statistics including ANOVA.
3. Study basic concepts of factorial design, fractional factorial design and orthogonal arrays.
4. Understand basic concepts of response surface methodology.
5. Learn how to plan, design and conduct experiments efficiently and effectively and analyze the resulting data to obtain the required conclusions.

Course Outcomes: On completion of the course, the students will be able to:
1. Understand renewable energy sources identify key factors in designing experiments for a given problem.
2. Develop appropriate experimental design to conduct experiments for a given problem
3. Analyze experimental data to derive valid conclusions.
4. Optimize process conditions by developing empirical models using experimental data.
5. Design robust products and processes using parameter design approach.

Unit-I
Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.

Unit-II
Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.

Unit-III
Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard
Orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Unit-IV
Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression.

Unit-V

Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.

Text Books:

1. Design and Analysis of Experiments, International student version by Douglas C. Montagomery, Eighth Edition 2013.
2. 2. Design and Analysis of Experiments by Paneer Selvam R, 2012

Reference Books:

1. Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008.
2. Ross PJ, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008

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MECHANICAL ENGINEERING-R20

B.Tech VII Semester **L/T/P/C**
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PRODUCTION PLANNING AND CONTROL (C37OE5C)
(Open Elective-2)

Pre-requisite: Nil

Course Objectives: This course will enable students to:
1. Understand the importance of Production planning and control.
2. Know about forecasting principles, inventory management.
3. Understand the line balancing methods.
4. Study scheduling policies and line of balance.
5. Understand the various forms used in dispatching.

Course Outcomes: On completion of the course, the students will be able to:
1. Analyze the objectives and functions of production planning and control.
2. Evaluate MRP and JIT systems against traditional inventory control systems.
3. Examine the basics of variability and its role in the performance of a production system.
4. Apply forecasting and scheduling techniques to production systems.
5. Interpret dispatching procedures and various forms used in dispatching.

Unit-I
Introduction: Definition – Objectives of Production Planning and Control – Functions of production planning and control - Types of production systems - Organization of production planning and control department.
Forecasting – Definition- uses of forecast- factors affecting the forecast- types of forecasting- their uses - general principle of forecasting. Forecasting techniques- quantitative and qualitative techniques.Measures of forecasting errors.

Unit-II
Inventory management – Functions of inventories – relevant inventory costs – ABC analysis – VED analysis – Basic EOQ model- Inventory control systems –continuous review systems and periodic review systems, MRP I, MRP II, ERP, JIT Systems - Basic Treatment only.
Aggregate planning – Definition – aggregate-planning strategies – aggregate planning methods – transportation model.

Unit-III
Line Balancing: Terminology, Methods of Line Balancing, RPW method, Largest Candidate method and Heuristic method. Routing – Definition – Routing procedure – Factors affecting routing procedure, Route Sheet.

Unit-IV

Scheduling –Definition – Scheduling Policies – types of scheduling methods – differences with loading – flow shop scheduling **–** job shop scheduling, line of balance (LOB) – objectives - steps involved.

Unit-V

Dispatching: Definition – activities of dispatcher – dispatching procedures – various forms used in dispatching.

Follow up: definition – types of follow up – expediting – definition – expediting procedures Applications of computers in planning and control.

Text Books:

1. Operations management – Heizer- Pearson.
2. Production and Operations Management / Ajay K Garg / Mc Graw Hill.

Reference Books:

1. Production Planning and Control- Text & cases/ SK Mukhopadhyaya /PHI.
2. Production Planning and Control- Jain & Jain – Khanna publications

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MECHANICAL ENGINEERING-R20

B.Tech VIII Semester **L/T/P/C**
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RENEWABLE ENERGY SYSTEMS (C38OE1A)
(Open Elective-3)

Pre-requisite: Engineering Chemistry, Environmental Sciences.

Course Objectives: This course will enable students to:
1. Apply the concepts of non-renewable and renewable energy systems
2. Analyze the concept of fuel cells. Calculate efficiency, fuel consumption and electric parameters of a simple fuel cell.
3. Evaluate economic efficiency and compare small scale renewable energy projects using major economic measures of pay-back period, simple rate of return, net present value and internal rate of return.
4. Properly utilize used waste domestic and agricultural products for small scale self-sustainable energy production.
5. Understand the ocean energy in an economic manner.

Course Outcomes: On completion of the course, the students will be able to:
1. Analyze renewable energy sources.
2. Apply solar based technologies in place of non-renewable energy sources.
3. Create a better scope on wind energy utilization and research.
4. Apply the basics of reusing bio degradable waste in relevant industries.
5. Evaluate ocean energy and geo-thermal energy relevant to practical situations.

Unit-I
Global and National Energy Scenario: Over view of conventional & renewable energy sources, need & development of renewable energy sources, types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario, Renewable and Non-renewable Energy sources, Energy for sustainable development, Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO_2 reduction potential of renewable energy- concept of Hybrid systems.

Unit-II
Solar Energy: Solar energy system, Solar Radiation, Availability, Measurement and Estimation, Solar Thermal Conversion Devices and Storage, Applications Solar Photovoltaic Conversion solar photovoltaic, solar thermal, applications of solar energy systems.

Unit-III

Wind Energy: Wind Energy Conversion, Potential, Wind energy potential measurement, Site selection, Types of wind turbines, Wind farms, wind Generation and Control. Nature of the wind, power in the wind, factors influencing wind, wind data and energy estimation, wind speed monitoring, classification of wind, characteristics, applications of wind turbines, offshore wind energy – Hybrid systems, wind resource assessment, Betz limit, site selection, wind energy conversion devices. Wind mill component design, economics and demand side management, energy wheeling, and energy banking concepts. Safety and environmental aspects, wind energy potential and installation in India.

Unit-IV

Biogas: Properties of biogas (Calorific value and composition), biogas plant technology and status, Bio energy system, design and constructional features. Biomass resources and their classification, Biomass conversion processes, Thermo chemical conversion, direct combustion, biomass gasification, pyrolysis and liquefaction, biochemical conversion, anaerobic digestion, types of biogas Plants, applications, alcohol production from biomass, bio diesel production, Urban waste to energy conversion, Biomass energy programme in India

Unit-IV

Ocean Energy: Ocean wave energy conversion, principle of Ocean Thermal Energy Conversion (OTEC), ocean thermal power plants, tidal energy conversion, Tidal and wave energy its scope and development, Scheme of development of tidal energy.

Small hydro Power Plant: Importance of small hydro power plants and their Elements, types of turbines for small hydro, estimation of primary and secondary power.

Geothermal Energy: Geothermal power plants, various types, hot springs and steam ejection

Text Books:

1. J Wakhil, “Power plant technology”.
2. G.D Rai, “Non-Conventional Energy Sources”.

Reference Books:

1. Solar Energy - Principles of thermal collection and storage by S. P. Sukhatme
2. Solar Engineering of Thermal Processes by J. A. Duffie and W. A. Beckman
3. Biomass Regenerable Energy by D. D. Hall and R. P. Grover.
4. Renewable Energy Sources by Twidell, J.W. and Weir, A., EFN Spon Ltd., 1986.

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MECHANICAL ENGINEERING-R20

B.Tech VIII Semester **L/T/P/C**
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DIGITAL MANUFACTURING (C38OE1B)
(Open Elective-3)

Pre-requisite: Engineering Drawing, Basics of CAD modeling.

Course Objectives: This course will enable students to:
1. Understand the need of digital fabrication
2. Analyze the Two dimensional layer by layer techniques.
3. Study fused base deposition modeling, advantages and limitations of FDM.
4. Know about extrusion based systems, post processing and the software issues involved in digital fabrication
5. Know the applications of digital fabrication.

Course Outcomes: On completion of the course, the students will be able to:
1. Analyze the importance of digital fabrication.
2. Design different techniques involved in two dimensional layering.
3. Apply the basic principle of extrusion based system.
4. Analyze the software issues involved in digital fabrication and know about extrusion based systems and post processing.
5. Develop knowledge of digital transformation.

Unit-I
Introduction to additive manufacturing: Introduction to AM, AM evolution, Classification of Additive Manufacturing, Distinction between AM & CNC Machining, Advantages of AM

Unit-II
Two- dimensional layer- by layer techniques: Stereo-lithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM)

Unit-III
Extrusion based systems: Introduction, basic principles, Fused Deposition Modeling, Materials, and Limitations of FDM
Post processing: Introduction, Support Material Removal, Surface Texture Improvements, Accuracy Improvements, Aesthetic Improvements

Unit-IV

Software issues for additive manufacturing: Introduction, Preparation of CAD Models: The STL file, Problems with STL files, STL file manipulation, Beyond the STL file, Additional software to assist AM

Unit-V

AM applications: Applications in design, Applications in Engineering Analysis and Planning Medical Applications: Customized Implants and Prosthesis, Aerospace applications and Automotive Applications

Other Applications: Jewelry Industry, Coin Industry, Tableware Industry.

Text Books:

1. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer 2010.
2. Chuaa Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2010.

Reference Books:

1. Ali K.Karmani, EmandAbouel Nasr, "Rapid Prototyping: Theory and Practice", Springer 2006.
2. Andreas Gebhardt, Understanding Additive Manufacture: Rapid Prototyping, Rapid Tooling and Rapid Manufacture, Hanser Publishers, 2013.
3. Hopkinson, N.Haque, and Dickens Rapid Manufacturing: Advanced Research in Virtual and Rapid Prototyping, Taylor and Francis, 2007.

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MECHANICAL ENGINEERING-R20

B.Tech VIII Semester **L/T/P/C**
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INDUSTRIAL MANAGEMENT (C38OE1C)
(Open Elective-3)

Pre-requisite: Fluid Mechanics, Linear Algebra, Partial differential Equations

Course Objectives: This course will enable students to:
1. Understand the basic principles of management, entrepreneurship and organization.
2. Know the various types of organization structures, their features and their advantages and disadvantages.
3. Learn the various industrial engineering practices like operations management.
4. Study the techniques of work study, statistical quality control techniques and job evaluation
5. Learn the concept of network analysis techniques.

Course Outcomes: On completion of the course, the students will be able to:
1. Analyze the Fayol's principles of management, Maslow's theory of human needs and motivation system approach to management.
2. Evaluate the effective application of PPM knowledge to diagnose and solve organizational problems and develop optimal managerial decisions.
3. Differentiate job, batch and mass production and to design different layouts.
4. Demonstrate the roles, skills and functions of management.
5. Apply the theoretical marketing concepts to the practical situations.

Unit-I
Introduction to Management: Entrepreneurship and organization – Nature and Importance of Management, Functions of Management, Taylor's Scientific Management Theory, Fayol's Principles of Management, Maslow's Theory of Human Needs, Douglas McGregor's Theory X and Theory Y, Herzberg's Two-Factor Theory of Motivation, Systems Approach to Management, Leadership Styles, Social responsibilities of Management

Unit-II
Designing Organizational Structures: Departmentalization and Decentralization, Types of Organization structures – Line organization, Line and staff organization, functional organization, Committee organization, matrix organization, Virtual Organization, Cellular Organization, team structure, boundary less organization, inverted pyramid structure, lean and flat organization structure and their merits, demerits and suitability.

Unit-III

Operations Management: Objectives- product design process- Process selection-Types of production system (Job, batch and Mass Production), Plant location-factors- Urban-Rural sites comparison- Types of Plant Layouts- Design of product layout- Line balancing (RPW method) Value analysis-Definition-types of values- Objectives- Phases of value analysis- Fast diagram

Unit-IV

Work Study: Introduction - definition - objectives - steps in work study- Method study - definition, objectives - steps of method study. Work Measurement – purpose - types of study - stop watch methods- steps - key rating – allowances - standard time calculations - work sampling.

Statistical Quality Control: variables-attributes, Shewart control charts for variables- chart, R chart, – Attributes- Defective-Defect- Charts for attributes-p-chart -c chart (simple Problems), Acceptance Sampling- Single sampling- Double sampling plans-OC curves.

Unit-V

Job Evaluation: Methods of job evaluation — simple routing objective systems — classification method factor comparison method, point method, benefits of job evaluation and limitations. Project Management (PERT/CPM): Network Analysis, Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Identifying critical path, Probability of Completing the project within given time, Project Cost Analysis, Project Crashing. (simple problems)

Text Books:

1. Industrial Engineering Management/NVS Raju/Cengage Learning.
2. Industrial Engineering and Management Science/T.R. Banga and S.C. Sarma/Khanna Publishers.

Reference Books:

1. Motion and Time Study by Ralph M Barnes, John Willey & Sons Work Study by lLO.
2. Human factors in Engineering & Design/Ernest J McCormick /TMH.
3. Production & Operation Management /Paneer Selvam/PHI.
4. Industrial Engineering Hand Book/Maynard.
5. Industrial Engineering Management I Ravi Shankar/Galgotia