**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**

**B.Tech. 4-Year COURSE STRUCTURE & SYLLABUS (R22 Regulations)**

**Mechanical Engineering**

**I YEAR I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Matrices and Calculus | 3 | 1 | 0 | 4 |
|  |  | Applied Physics | 3 | 1 | 0 | 4 |
|  |  | C Programming and Data Structures | 3 | 0 | 0 | 3 |
|  |  | Engineering Workshop | 0 | 1 | 3 | 2.5 |
|  |  | English for Skill Enhancement | 2 | 0 | 0 | 2 |
|  |  |  Fuels & Lubricants Laboratory | 0 | 0 | 2 | 1 |
|  |  | Applied Physics Laboratory | 0 | 0 | 3 | 1.5 |
|  |  | English Language and Communication Skills Laboratory | 0 | 0 | 2 | 1 |
|  |  | C Programming and Data Structures Laboratory | 0 | 0 | 2 | 1 |
| 10. |  | Environmental Science | 3 | 0 | 0 | 0 |
| 11. |  | Induction Programme |  |  |  |  |
|  |  | **Total**  | **14** | **3** | **12** | **20** |

**I YEAR II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Ordinary Differential Equations and Vector calculus  | 3 | 1 | 0 | 4 |
|  |  | Engineering Chemistry | 3 | 1 | 0 | 4 |
|  |  | Computer Aided Engineering Graphics | 1 | 0 | 4 | 3 |
|  |  | Classical Engineering Mechanics | 3 | 0 | 0 | 3 |
|  |  | Engineering Materials | 2 | 0 | 0 | 2 |
|  |  | Python Programming Laboratory | 0 | 1 | 2 | 2 |
|  |  | Engineering Chemistry Laboratory | 0 | 0 | 2 | 1 |
|  |  | Elements of Mechanical Engineering | 0 | 0 | 2 | 1 |
|  |  | **Total**  | **12** | **3** | **10** | **20** |

**II YEAR I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Probability, Statistics & Complex Variables | 3 | 1 | 0 | 4 |
|  |  | Mechanics of Solids | 3 | 0 | 0 | 3 |
|  |  | Metallurgy &Material Science  | 3 | 0 | 0 | 3 |
|  |  | Production Technology | 3 | 0 | 0 | 3 |
|  |  | Thermodynamics  | 3 | 1 | 0 | 4 |
|  |  | Production Technology Laboratory | 0 | 0 | 2 | 1 |
|  |  | Material Science & Mechanics of Solids Laboratory | 0 | 0 | 2 | 1 |
|  |  | Computer Aided Machine Drawing | 0 | 0 | 2 | 1 |
|  |  | Constitution of India | 3 | 0 | 0 | 0 |
|  |  | **Total Credits** | **18** | **2** | **6** | **20** |

**II YEAR II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Basic Electrical and Electronics Engineering | 3 | 0 | 0 | 3 |
|  |  | Kinematics of Machinery | 3 | 0 | 0 | 3 |
|  |  | Fluid Mechanics & Hydraulic Machines | 3 | 0 | 0 | 3 |
|  |  | IC Engines & Gas Turbines | 3 | 0 | 0 | 3 |
|  |  | Instrumentation and Control Systems | 3 | 0 | 0 | 3 |
|  |  | Basic Electrical and Electronics Engineering Laboratory | 0 | 0 | 2 | 1 |
|  |  | Fluid Mechanics & Hydraulic Machines Laboratory | 0 | 0 | 2 | 1 |
|  |  | Instrumentation and Control Systems Laboratory | 0 | 0 | 2 | 1 |
|  |  | Real-time Research Project/Field-Based Project | 0 | 0 | 4 | 2 |
|  |  | Gender Sensitization Lab | 0 | 0 | 2 | 0 |
|  |  | **Total Credits** | **15** | **0** | **12** | **20** |

**III YEAR I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Dynamics of Machinery | 3 | 0 | 0 | 3 |
|  |  | Design of Machine Elements | 3 | 0 | 0 | 3 |
|  |  | Metrology & Machine Tools | 3 | 0 | 0 | 3 |
|  |  | Business Economics & Financial Analysis | 3 | 0 | 0 | 3 |
|  |  | Steam Power & Jet Propulsion | 3 | 0 | 0 | 3 |
|  |  | CAD/CAM | 2 | 0 | 0 | 2 |
|  |  | Thermal Engineering Laboratory | 0 | 0 | 2 | 1 |
|  |  | Metrology & Machine Tools Laboratory | 0 | 0 | 2 | 1 |
|  |  | Kinematics & Dynamics Laboratory | 0 | 0 | 2 | 1 |
|  |  | Intellectual Property Rights | 3 | 0 | 0 | 0 |
|  |  | **Total Credits** | **20** | **0** | **6** | **20** |

**III YEAR II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Machine Design  | 3 | 0 | 0 | 3 |
|  |  | Heat Transfer | 3 | 0 | 0 | 3 |
|  |  | Finite Element Methods | 3 | 0 | 0 | 3 |
|  |  | Professional Elective - I | 3 | 0 | 0 | 3 |
|  |  | Open Elective - I | 3 | 0 | 0 | 3 |
|  |  | Heat Transfer Lab | 0 | 0 | 2 | 1 |
|  |  | Computer Aided Engineering Laboratory | 0 | 0 | 2 | 1 |
|  |  | Advanced Communication Skills Laboratory | 0 | 0 | 2 | 1 |
|  |  | Industrial Oriented Mini Project/ Internship |  |  |  | 2\* |
|  |  | Environmental Science | 3 | 0 | 0 | 0 |
|  |  | **Total Credits** | **18** | **0** | **6** | **20** |

**\*MC609 - Environmental Science – Should be Registered by Lateral Entry Students Only.**

**IV YEAR I SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Industrial Management | 2 | 0 | 0 | 2 |
|  |  | Refrigeration & Air Conditioning | 3 | 0 | 0 | 3 |
|  |  | Professional Elective – II | 3 | 0 | 0 | 3 |
|  |  | Professional Elective – III | 3 | 0 | 0 | 3 |
|  |  | Professional Elective - IV | 3 | 0 | 0 | 3 |
|  |  | Open Elective - II | 3 | 0 | 0 | 3 |
|  |  | Project Stage - I | 0 | 0 | 6 | 3 |
|  |  | **Total Credits** | **17** | **0** | **6** | **20** |

**IV YEAR II SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Credits** |
|  |  | Professional Elective – V | 3 | 0 | 0 | 3 |
|  |  | Professional Elective - VI | 3 | 0 | 0 | 3 |
|  |  | Open Elective - III | 3 | 0 | 0 | 3 |
|  |  | Project Stage - II including seminar | 0 | 0 | 22 | 11 |
|  |  | **Total Credits** | **9** | **0** | **22** | **20** |

**\*MC – Satisfactory/Unsatisfactory**

**PROFESSIONAL ELECTIVES OFFERED IN R22**

**Professional Elective - I**

|  |  |
| --- | --- |
|  | Unconventional Machining Processes |
|  | Power Plant Engineering |
|  | Mechanical Vibrations |
|  | Microprocessors in Automation |

**Professional Elective – II**

|  |  |
| --- | --- |
|  | Artificial Intelligence in Mechanical Engineering |
|  | Automobile Engineering |
|  | Industrial Robotics |
|  | Mechatronics |

**Professional Elective – III**

|  |  |
| --- | --- |
|  | Production Planning & Control |
|  | Computational Fluid Dynamics |
|  | Composite Materials |
|  | Solar Energy Technology |

**Professional Elective – IV**

|  |  |
| --- | --- |
|  | Re-Engineering |
|  | Non Conventional Energy Sources |
|  | Operations Research |
|  | Electric and Hybrid Vehicles |

**Professional Elective – V**

|  |  |
| --- | --- |
|  | Automation in Manufacturing |
|  | Turbo Machinery |
|  | Additive Manufacturing |
|  | Energy Conservation and Management |

**Professional Elective – VI**

|  |  |
| --- | --- |
|  | Industry 4.0 |
|  | Fluid Power System |
|  | Fuzzy Logic and ANN |
|  | Total Quality Management |

**List of Open Electives**

**Open Elective (OE – I)**

1. Basic Mechanical Engineering

2. Renewable energy Sources

**Open Elective (OE – II)**

1. Quantitative Analysis for Business Decisions

2. Industrial Engineering &Management

**Open Elective (OE – III)**

1. Entrepreneurship Development

2. Elements of Electric and Hybrid vehicles

I Year I Sem

Matrices and Calculus

Applied Physics

C Programming and Data Structures

**Engineering Workshop**

**Pre-requisites**:Practical skill

**Course Objectives**:

* To Study of different hand operated power tools, uses and their demonstration.
* To gain a good basic working knowledge required for the production of various engineering products.
* To provide hands on experience about use of different engineering materials, tools, equipments and processes those are common in the engineering field.
* To develop a right attitude, team working, precision and safety at work place.
* It explains the construction, function, use and application of different working tools, equipment and machines.
* To study commonly used carpentry joints.
* To have practical exposure to various welding and joining processes.
* Identify and use marking out tools, hand tools, measuring equipment and to work to prescribed tolerances.

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

* Study and practice on machine tools and their operations
* Practice on manufacturing of components using workshop trades including pluming, fitting, carpentry, foundry, house wiring and welding.
* Identify and apply suitable tools for different trades of Engineering processes including drilling, material removing, measuring, chiseling.
* Apply basic electrical engineering knowledge for house wiring practice.

**1. TRADES FOR EXERCISES:**

**At least two exercises from each trade:**

1. Carpentry – (T-Lap Joint, Dovetail Joint, Mortise & Tenon Joint)
2. Fitting – (V-Fit, Dovetail Fit & Semi-circular fit)
3. Tin-Smithy – (Square Tin, Rectangular Tray & Conical Funnel)
4. Foundry – (Preparation of Green Sand Mould using Single Piece and Split Pattern)
5. Welding Practice – (Arc Weldimg & Gas Welding)
6. House-wiring – (Parallel & Series, Two-way Switch and Tube Light)
7. Black Smithy – (Round to Square, Fan Hook and S-Hook)

**2. TRADES FOR DEMONSTRATION & EXPOSURE:**

Plumbing, Machine Shop, Metal Cutting (Water Plasma), Power tools in construction and Wood Working

**Text Books:**

1. Workshop Practice /B. L. Juneja / Cengage
2. Workshop Manual / K.Venugopal / Anuradha.

**Reference Books:**

1. Work shop Manual - P.Kannaiah/ K.L.Narayana/ Scitech
2. Workshop Manual / Venkat Reddy/ BSP

English for Skill Enhancement

Fuels & Lubricants Laboratory

Applied Physics Laboratory

English Language and Communication Skills Laboratory

C Programming and Data Structures Laboratory

**Environment Science**

**Induction Programme**

**Computer Aided Engineering Graphics**

**Pre-requisites: Nil**

**Course objectives:**

* To develop the ability of visualization of different objects through technical drawings
* To acquire computer drafting skill for communication of concepts, ideas in the design of engineering products

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

CO 1 Apply computer aided drafting tools to create 2D and 3D objects

CO2 sketch conics and different types of solids

CO3 Appreciate the need of Sectional views of solids and Development of surfaces of solids

CO4 Read and interpret engineering drawings

CO5 Conversion of orthographic projection into isometric view and vice versa manually and by using computer aided drafting

**UNIT – I:**

INTRODUCTION TO ENGINEERING Graphics:

Principles of Engineering Graphics and their Significance, Scales – Plain & Diagonal, Conic Sections including the Rectangular Hyperbola – General method only. Cycloid, Epicycloid and Hypocycloid

**INTRODUCTION TO Computer aided drafting – views, commands and conics**

**UNIT- II:**

ORTHOGRAPHIC PROJECTIONS:

Principles of Orthographic Projections – Conventions – Projections of Points and Lines, Projections of Plane regular geometric figures.—Auxiliary Planes.

**Computer aided orthographic projections** – points, lines and planes

**UNIT – III:**

Projections of Regular Solids – Auxiliary Views - Sections or Sectional views of Right Regular Solids – Prism, Cylinder, Pyramid, Cone – Auxiliary views

**Computer aided projections of solids** – sectional views

**UNIT – IV:**

Development of Surfaces of Right Regular Solids – Prism, Cylinder, Pyramid and Cone

**Development of surfaces using computer aided drafting**

**UNIT – V:**

ISOMETRIC PROJECTIONS:

Principles of Isometric Projection – Isometric Scale – Isometric Views –Conventions – Isometric Views of Lines, Plane Figures, Simple and Compound Solids – Isometric Projection of objects having non- isometric lines. Isometric Projection of Spherical Parts. Conversion of Isometric Views to Orthographic Views and Vice-versa –Conventions

**Conversion of orthographic projection into isometric view using computer aided drafting.**

TEXT BOOKS:

1. Engineering Drawing N.D. Bhatt / Charotar.
2. Engineering Drawing and graphics Using AutoCAD Third Edition, T. Jeyapoovan, Vikas: S.Chand and company LTD.

REFERENCE BOOKS:

1. Engineering Drawing, Basant Agrawal and C M Agrawal, Third Edition McGraw Hill.
2. Engineering Graphics and Design, WILEY, Edition 2020.
3. Engineering Drawing, M. B. Shah, B.C. Rane / Pearson.
4. Engineering Drawing, N. S. Parthasarathy and Vela Murali, Oxford.
5. Computer Aided Engineering Drawing – K Balaveera Reddy et al. – CBS Publishers

**Note: - External examination is conducted in conventional mode and for internal evaluation to be done by both conventional as well as using computer aided drafting**.

**Classical Engineering Mechanics**

Course Objectives:

* To understand the resolving forces and moments for a given force system.
* To analyze the types of friction for moving bodies and problems related to friction.
* To determine the centroid and second moment of area

 Course Outcomes:

At the end of the course, the student will be able to:

* + Resolve forces and moments for a given system.
	+ Analyze the friction for moving bodies.
	+ Determine centroid and second moment for a given area of a body.

**UNIT-I:**

**Introduction to Mechanics**: Basic Concepts, system of Forces Coplanar Concurrent Forces -Components in Space -Resultant -Moment of Forces and its Application - Couples and Resultant of Force Systems. Equilibrium of system of Forces: Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems.

**UNIT-II:**

**Friction**: Types of friction -Limiting friction -Laws of Friction -static and Dynamic Frictions -Motion of Bodies-Wedge Screw, Screw-jack and differential screw –jack

**UNIT-III:**

**Centroid and Center of Gravity**: Introduction – Centroids of lines – Centroids of area - Centroids of Composite figures - Theorem of Pappus -Centre of Gravity of Bodies – Centroids of Volumes – Center of gravity of composite bodies.

**UNIT-IV:**

**Area moments of Inertia**: Introduction – Definition of Moment of Inertia -Polar Moment of Inertia – Radius of gyration - Transfer Theorem for moment of inertia – Moments of inertia by integration - Moments of Inertia of Composite Figures, Product of Inertia, Transfer Formula for Product of Inertia.

**UNIT-V:**

**Mass Moment of Inertia**: Introduction - Moment of Inertia of Masses – Radius of gyration - Transfer Formula for Mass Moments of Inertia – Mass moments of inertia by integration - Mass moment of inertia of composite bodies.

**TEXT BOOKS:**

1. Singer’s Engineering Mechanics Statics and Dynamics by K. Vijaya Kumar Reddy and J. Suresh Kumar, BS Publications, 3rd Edition (SI Units) Fifth impression 2013.
2. Engg. Mechanics by Irving Shames, G. Krishna Mohan Rao, Prentice Hall

**REFERENCE BOOKS:**

1. Engineering Mechanics by Timoshenko & Young
2. Engineering Mechanics by Umesh Regl, Tayal.
3. A text of Engineering Mechanics by YVD Rao, K. Govinda Rajulu, M. Manzoor Hussain, Academic Publishing Company
4. Text Book in Applied Mechanics by Malhotra, Subramanian, Gahlot and Rathore, New Age.
5. Engineering Mechanics by KL Kumar, Tata McGraw Hill.
6. Engineering. Mechanics by M.V. Seshagiri Rao & D Rama Durgaiah.
7. Engineering Mechanics by S.S. Bhavikati & K.G. Rajasekharappa

**Engineering Materials**

**Elements of Mechanical Engineering**

**Course objectives**

* To provide the essential basic knowledge of mechanical Engineering to the students

**Course Outcomes**

* Understand different types of power generation
* Summarize different types of manufacturing processes and Power transmission systems
* Discuss about conventional and non-conventional sources of energy
* Identify automation of various manufacturing processes in engineering practice.
* Describe the basic concepts and applications of industrial robotics

UNIT- I:

Energy: Power Generation: External and internal combustion engines-Thermal Power Plants-Working Principle, layouts, element/component description, advantages, disadvantages, applications.

2-Stroke, 4-Stroke Engines and their Components.

Refrigeration: Mechanical Refrigeration and types – units of refrigeration – Air Refrigeration system, Vapour Compression Refrigeration System- Principle of operation.

Modes and mechanisms of heat transfer – Basic laws of heat transfer –General discussion about applications of heat transfer.

UNIT-II:

Machine and Mechanisms-Degrees of Freedom, functions of Flywheel and Governors, Types of joints-Riveted, welded and bolted joints. Applications, Merits and Demerits.

Power Transmission Elements: Gears terminology of spur, helical and bevel gears, gear trains. Belt drives (types). Chain drives.

UNIT- III:

Manufacturing Processes: Primary and secondary process. Casting: Types, equipment, applications. Metal forming processes-rolling, extrusion

Welding: Types – Equipment –Techniques employed – advantages / disadvantages – Gas cutting – Brazing and soldering.

UNIT- IV:

Machine Tools: Introduction to lathe, drilling machine, milling machine, grinding machine- Operations performed. CNC Machines- Basic elements, advantages. Limits, fits and tolerances, Surface finish of various manufacturing process.

UNIT -V:

Non-conventional sources of energy-Solar, wind, tidal, biogas and nuclear- Principles. Robotics – Joints, end effectors, applications. Introduction to 3D Printing.

Text Books:

1. Sadhu Singh, Basic Mechanical Engineering, S.Chand & Co.Ltd, New Delhi, 2012.
2. Elements of Mechanical Engineering Fourth Edition S.Trymbaka Murthy 2016.

References:

1. Hajra Choudhary, S.K. and Hajra Choudhary, A. K., Elements of Workshop Technology Vols. I & II, Indian Book Distributing Company Calcutta, 2007.

Applied Physics Lab

C Programming and Data Structures Lab

**Elements of Mechanical Engineering Lab**

* 1. Assembly and disassembly of IC Engines
	2. Determination of flash and fire point of lubricating oils.
	3. Determination of viscosity of given oil.
	4. Metal joining processes – soldering and welding.
	5. Demonstration of lathe milling, drilling, grinding machine operations.
	6. Study of transmission system – gear box
	7. Study of Boilers - Models
	8. Determination of thermal conductivity - composite slab apparatus
	9. Measurement of length, height, diameter by vernier calipers
	10. Measurement of diameters by micrometer
	11. Determination of time period and natural frequency of simple pendulum
	12. Determination of time period and natural frequency of compound pendulum

Environmental Science

I Year II Sem

Ordinary Differential Equations and Vector calculus

Engineering Chemistry

Engineering Materials

Python Programming Lab

Engineering Chemistry Lab

 English Language and Communication Skills Lab

II Year I Sem

 Probability and Statistics & Complex Variables

**Mechanics of Solids**

**Course Objectives:** The objective is to learn the fundamental concepts of stress, strain, and deformation of solids with applications to bars, beams, and columns. Detailed study of engineering properties of materials is also of interest. Fundamentals of applying equilibrium, compatibility, and force-deformation relationships to structural elements are emphasized. The students are introduced to advanced concepts of flexibility and stiffness method of structural analysis. The course builds on the fundamental concepts of engineering mechanics course.

This course will advance the students’ development of the following broad capabilities:

* Students will be able to understand basic concepts of stress, strain and their relations based on linear elasticity. Material behaviors due to different types of loading will be discussed.
* Students will be able to understand and know how to calculate stresses and deformation of a bar due to an axial loading under uniform and non-uniform conditions.
* Students will understand how to develop shear-moment diagrams of a beam and find the maximum moment/shear and their locations
* Students will understand how to calculate normal and shear stresses

**Course Outcomes:**

* Analyze the behavior of the solid bodies subjected to various types of loading;
* Apply knowledge of materials and structural elements to the analysis of simple structures;
* Undertake problem identification, formulation and solution using a range of analytical methods;
* Analyze and interpret laboratory data relating to behavior of structures and the materials they are made of, and undertake associated laboratory work individually and in teams.
* Expectation and capacity to undertake lifelong learning

**UNIT – I:**

**Simple Stresses & Strains:** Elasticity and plasticity – Types of stresses & strains–Hooke’s law– stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson’s ratio & volumetric strain – Elastic moduli & the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain energy – Resilience – Gradual, sudden, impact and shock loadings.

**UNIT – II:**

**Shear Force and Bending Moment:** Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

**UNIT – III:**

**Flexural Stresses:** Theory of simple bending – Assumptions – Derivation of bending equation: M/I = f/y = E/R Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections – Design of simple beam sections.

**Shear Stresses:** Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T angle sections.

**UNIT – IV:**

**Principal Stresses and Strains:** Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr’s circle of stresses – Principal stresses and strains – Analytical and graphical solutions.

**Theories of Failure**: Introduction – Various theories of failure - Maximum Principal Stress Theory, Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).

**UNIT – V:**

**Torsion of Circular Shafts:** Theory of pure torsion – Derivation of Torsion equations: T/J = q/r = Nθ/L – Assumptions made in the theory of pure torsion – Torsional moment of resistance – Polar section modulus – Power transmitted by shafts – Combined bending and torsion and end thrust – Design of shafts according to theories of failure.

**Thin Cylinders:** Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and volumetric strains – changes in diameter, and volume of thin cylinders– Thin spherical shells.

**TEXT BOOKS:**

1. Strength of materials – R.S. Kurmi and Gupta.
2. Solid Mechanics, by Popov
3. Strength of Materials – Ryder. G.H.; Macmillan Long Man Pub.
4. Strength of Materials – W.A. Nash, TMH

**REFERENCE BOOKS:**

1. Strength of Materials -By Jindal, Umesh Publications.
2. Analysis of structures by Vazirani and Ratwani.
3. Mechanics of Structures Vol –I by H. J. Shah and S. B. Junnarkar, Charotar Publishing House Pvt. Ltd.
4. Strength of Materials by D.S Prakash Rao, Universities Press Pvt. Ltd.
5. Strength of Materials by S. S. Rattan, Tata McGraw Hill Education Pvt. Ltd.
6. Fundamentals of Solid Mechanics by M. L. Gambhir, PHI Learning Pvt. Ltd
7. Strength of Materials by R.K Rajput, S. Chand & Company Ltd.

**Metallurgy & Materials Science**

**UNIT – I**:

Crystal Structure: Unit cells, Metallic and Ceramic crystal structures. Imperfection in solids: Point, line, surface and volume defects; dislocations, strengthening mechanisms, slip systems, critical resolved shear stress.

**UNIT – II:**

Hume –Rothery Rules: Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic,Eutectiodperitectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstrctural aspects of ledeburite, austenite, pearlite, ferrite and cementite.

**UNIT –III:**

Heat treatment of steels: Isothermal transformation diagrams for Fe-C alloys and microstructures development. Martensite, Bainite. Annealing. Normalising, Hardening, Tempering and Spheroidising.

**UNIT – IV:**

Continuous cooling curves and interpretation of final microstructures and properties-Thermo mechanical treatments like austempering, martempering, surface hardening methods like case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening

**UNIT – V:**

Alloy steels, properties and applications of stainless steels and tool steels, maraging steels- Types of cast irons(grey, white, malleable and spheroidal graphite cast irons), copper and its alloys (Brass and bronze)- Aluminium and its alloys (Al-Cu Alloys). Ceramics and Composites: Types, properties and applications.

**TEXT BOOKS:**

1. V. Raghavan, “Material Science and Engineering’, Prentice Hall of India Private Limited, 1999.
2. W. D. Callister, 2006, “Materials Science and Engineering-An Introduction”, 6th Edition, Wiley India.
3. SIDNEY H AVNER, Introduction to Physical Metallurgy.

**REFERENCE BOOKS:**

1. Kenneth G. Budinski and Michael K. Budinski, “Engineering Materials”, Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
2. U. C. Jindal, “Engineering Materials and Metallurgy”, Pearson, 2011.

**Production Technology**

**Pre-requisites:** None

**Course Objectives:**

* To expose the students to understand the concept of basic casting processes & furnaces.
* To provide a technical understanding of various joining processes used in the manufacturing industry.
* To impart the students to the concepts of solid state welding processes.
* To teach the concepts of rolling and various press working operations.
* To provide a technical understanding of different metal forming processes like extrusion, forging and high energy rate forming processes.

**Course Outcomes**: Student will be able to:

CO1: Elaborate the fundamentals of various moulding, casting techniques and furnaces.

CO2: Identifiy the importance of permanent joining and principle behind different welding processes.

CO3: Explain the concepts of solid state welding processes

CO4: Understand the concepts of rolling and sheet metal operations in metal working.

CO5: Elaborates the uniqueness of extrusion, forging and high energy rate forming processes in metal working.

**UNIT – I:**

**Casting:** Steps involved in making a casting – Advantage of casting and its applications; Patterns - Pattern making, Types, Materials used for patterns, pattern allowances; Properties of moulding methods. Methods of Melting - Crucible melting and cupola operation – Defects in castings; Principles of Gating – Requirements – Types of gates, Design of gating systems – Riser – Function, types of Riser and Riser design. Casting processes – Types – Sand moulding, Centrifugal casting, die- casting, Investment casting, shell moulding; Solidification of casting.

**UNIT – II:**

**Welding:** Classification – Types of welds and welded joints and their characteristics, Welding Positions - Gas welding - Types, oxy-fuel gas cutting – standard time and cost calculations. Arc welding, Shielded metal arc welding, submerged arc welding, Resistance welding, Thermit welding.

**UNIT – III:**

Inert Gas Welding \_ TIG Welding, MIG welding, Friction welding, Friction Stir Welding, induction welding, explosive welding, Laser Welding; Soldering and Brazing; Heat affected zone in welding. Welding defects – causes and remedies; destructive and non- destructive testing of welds.

**UNIT – IV:**

Hot working, cold working, strain hardening, recovery, recrystallisation and grain growth. Sheet metal Operations: Stamping, Blanking and piercing, Coining, Strip layout, Hot and cold spinning – Bending and deep drawing. Rolling fundamentals – theory of rolling, types of Rolling mills and products. Forces in rolling and power requirements. Drawing and its types – wire drawing and Tube drawing –. Types of presses and press tools. Forces and power requirement in the above operations.

**UNIT – V:**

**Extrusion of Metals:** Basic extrusion process and its characteristics. Hot extrusion and cold extrusion - Forward extrusion and backward extrusion – Impact extrusion – Extruding equipment – Tube extrusion, Hydrostatic extrusion. Forces in extrusion

**Forging Processes:** Forging operations and principles – Tools – Forging methods – Smith forging, Drop Forging – Roll forging – Forging hammers: Rotary forging – forging defects – cold forging, swaging, Forces in forging operations.

**High Energy Rate Forming Processes:** Principles of Explosive Forming, Electro-hydraulic Forming, Electro-magnetic forming and rubber pad Forming.

**TEXT BOOKS:**

1. Manufacturing Technology / P.N. Rao Vol.1 & 2 / Mc Graw Hill
2. Manufacturing Engineering & Technology / Serope Kalpakjian / Steven R. Schmid / Pearson

**REFERENCE BOOKS:**

1. Metal Casting / T.V Ramana Rao / New Age
2. Production Technology / G. Thirupathi Reddy / Scitech
3. Manufacturing Processes/ J.P. Kaushish / PHI Publications

**Thermodynamics**

**Pre-requisite**: Engineering Chemistry and Physics

**Course Objective**: To understand the treatment of classical Thermodynamics and to apply the First and Second laws of Thermodynamics to engineering applications

**Course Outcomes**: At the end of the course, the student should be able to Understand and differentiate between different thermodynamic systems and processes. Understand and apply the laws of Thermodynamics to different types of systems undergoing various processes and to perform thermodynamic analysis. Understand and analyze the Thermodynamic cycles and evaluate performance parameters.

**Tables/Codes: Steam Tables and Mollier Chart, Refrigeration Tables**

**UNIT – I:**

**Introduction: Basic Concepts:** System, Control Volume, Surrounding, Boundaries, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process, Exact & Inexact Differentials, Cycle – Reversibility – Quasi – static Process, Irreversible Process, Causes of Irreversibility – Energy in State and in Transition, Types, Displacement & Other forms of Work, Heat, Point and Path functions, Zeroth Law of Thermodynamics – Concept of Temperature – Principles of Thermometry – Reference Points – Const. Volume gas Thermometer – Scales of Temperature, Ideal Gas Scale

**UNIT – II:**

PMM I - Joule’s Experiments – First law of Thermodynamics – Corollaries – First law applied to a Process – applied to a flow system – Steady Flow Energy Equation.

Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence / Corollaries, PMM of Second kind, Carnot’s principle, Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Principle of Entropy Increase – Energy Equation, Availability and Irreversibility – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics.

**UNIT – III:**

Pure Substances, p-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point at critical state properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation Property tables. Mollier charts – Various Thermodynamic processes and energy Transfer – Steam Calorimetry.

Perfect Gas Laws – Equation of State, specific and Universal Gas constants – various Non-flow processes, properties, end states, Heat and Work Transfer, changes in Internal Energy – Throttling and Free Expansion Processes – Flow processes

**UNIT – IV:**

Deviations from perfect Gas Model – Vader Waals Equation of State – Compressibility charts – variable specific Heats – Gas Tables

Mixtures of perfect Gases – Mole Fraction, Mass friction Gravimetric and volumetric Analysis – Dalton’s Law of partial pressure, Avogadro’s Laws of additive volumes – Mole fraction, Volume fraction and partial pressure, Equivalent Gas const. And Molecular Internal Energy, Enthalpy, sp. Heats and Entropy of Mixture of perfect Gases and Vapour, Atmospheric air - Psychrometric Properties – Dry bulb Temperature, Wet Bulb Temperature, Dew point Temperature, Thermodynamic Wet Bulb Temperature, Specific Humidity, Relative Humidity, saturated Air, Vapour pressure, Degree of saturation – Adiabatic Saturation, Carrier’s Equation – Psychrometric chart.

**UNIT – V:**

**Power Cycles:** Otto, Diesel, Dual Combustion cycles, Sterling Cycle, Atkinson Cycle, Ericsson Cycle, Lenoir Cycle – Description and representation on P–V and T-S diagram, Thermal Efficiency, Mean Effective Pressures on Air standard basis – comparison of Cycles, Brayton and Rankine cycles – Performance Evaluation.

**Refrigeration Cycles:** Bell-Coleman cycle, Vapour compression cycle-performance Evaluation.

**TEXT BOOKS:**

1. Engineering Thermodynamics / PK Nag / Mc Graw Hill
2. Thermodynamics for Engineers / Kenneth A. Kroos ; Merle C. Potter/ Cengage

**REFERENCE BOOKS:**

1. Engineering Thermodynamics / Chattopadhyay/ Oxford
2. Engineering Thermodynamics / Rogers / Pearson

**Production Technology Laboratory**

**Pre-requisites:** Production Technology

**Course Objectives:**

* Know about the basic Physical, Chemical Properties of materials
* Learn the basic operation of various manufacturing processes
* Design and fabricate a simple product

**Course Outcomes:** After completion of the course, the student will be able to

CO 1: Analyze the given problem and conducts investigation on the experimental setup.

CO 2: Operate different types of welding machines

CO 3: Perform operations on mechanical press.

CO 4: get familiarity with processing of Plastics.

CO 5: Effectively communicate and explain the experimental analysis.

**Minimum of 12 Exercises need to be performed**

 **I. Metal Casting Lab:**

1. Pattern Design and making - for one casting drawing.
2. Sand properties testing - Exercise -for strengths, and permeability – 1
3. Moulding Melting and Casting - 1 Exercise

**II. Welding Lab:**

1. ARC Welding Lap & Butt Joint - 2 Exercises

2. Spot Welding - 1 Exercise

3. TIG Welding - 1 Exercise

4. Plasma welding and Brazing - 2 Exercises

 (Water Plasma Device)

**III. Mechanical Press Working:**

1. Blanking & Piercing operation and study of simple, compound and progressive press tool.

2. Hydraulic Press: Deep drawing and extrusion operation.

3. Bending and other operations

**IV. Processing Of Plastics**

1. Injection Moulding

2. Blow Moulding

**REFERENCE BOOK:**

1. Dictionary of Mechanical Engineering – G.H.F. Nayler, Jaico Publishing House.

**Materials Science & Mechanics of Solids Lab**

**Course Objective:** The Objective is to make the students to learn the concepts of Metallurgy and Material Science in manufacturing processes, which convert raw materials into useful products.

**Course Outcomes:** The Primary focus is to provide undergraduates with a fundamental knowledge in associated materials properties, their selection and applications. Upon graduation, students would acquire and develop the necessary skills for successful careers in the materials-related industries.

**List of Experiments:**

1. Preparation and study of crystal models for simple cubic, body centred cubic, face centred cubic and hexagonal close packed structures.
2. Preparation and study of the Microstructure of pure metals like Iron, Cu and Al.
3. Preparation and study of the Microstructure of Mild steels, low carbon steels, high Carbon steels.
4. Study of the Microstructures of Various Cast Irons.
5. Study of the Microstructures of Non-Ferrous alloys. (Al, Cu, Mg)
6. Hardenability of steels by Jominy End Quench Test.

**MECHANICS OF SOLIDS:**

**Course Objectives:** The objective is to learn the fundamental concepts of stress, strain, and deformation of solids with applications to bars, beams, and columns. Detailed study of engineering properties of materials is also of interest. Fundamentals of applying equilibrium, compatibility, and force-deformation relationships to structural elements are emphasized. The students are introduced to advanced concepts of flexibility and stiffness method of structural analysis. The course builds on the fundamental concepts of engineering mechanics course.

The students will advance the students’ development of the following broad capabilities:

* Students will be able to understand basic concepts of stress, strain and their relations based on linear elasticity. Material behaviors due to different types of loading will be discussed.
* Students will be able to understand and know how to calculate stresses and deformation of a bar due to an axial loading under uniform and non-uniform conditions.
* Students will understand how to develop shear-moment diagrams of a beam and find the maximum moment/shear and their locations
* Students will understand how to calculate normal and shear stresses on any cross-section of a beam. Different cross-sections (including I-beam) will be discussed and applied Continuous Assessment Test 10 marks Mid Semester Test 15 marks End

**Course Outcomes**

* Analyze the behavior of the solid bodies subjected to various types of loading.
* Apply knowledge of materials and structural elements to the analysis of simple structures.
* Undertake problem identification, formulation and solution using a range of analytical methods
* Analyze and interpret laboratory data relating to behavior of structures and the materials they are made of, and undertake associated laboratory work individually and in teams.
* Expectation and capacity to undertake lifelong learning.

**List of Experiments:**

* + - 1. Direct tension test
			2. Bending test on Simple supported beam
			3. Bending test on Cantilever beam
1. Torsion test
2. Brinell hardness test/ Rockwell hardness test
3. Test on springs
4. Izod Impact test/ Charpy Impact test

**Computer Aided Machine Drawing**

**Pre-requisites:** Engineering graphics

**Course objectives:** To familiarize with the standard conventions for different materials and machine parts in working drawings. To make part drawings including sectional views for various machine elements. To prepare assembly drawings given the details of part drawings.

**Course Outcomes**:

* Preparation of engineering and working drawings with dimensions and bill of material during design and development. Developing assembly drawings using part drawings of machine components.
* Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs, ribs.
* Types of sections – selection of section planes and drawing of sections and auxiliary sectional views. Parts not usually sectioned.
* Methods of dimensioning, general rules for sizes and placement of dimensions for holes, centers, curved and tapered features.
* Title boxes, their size, location and details - common abbreviations and their liberal usage
* Types of Drawings – working drawings for machine parts.

**Drawing of Machine Elements and simple parts**

Selection of Views, additional views for the following machine elements and parts with every drawing proportion.

1. Popular forms of Screw threads, bolts, nuts, stud bolts, tap bolts, set screws.
2. Keys, cottered joints and knuckle joint.
3. Rivetted joints
4. Shaft coupling, spigot and socket pipe joint.
5. Journal, pivot and collar and foot step bearings.

**Assembly Drawings:**

Drawings of assembled views for the part drawings of the following using conventions and easy drawing proportions.

1. Steam engine parts – stuffing box, cross head, Eccentric.
2. Machine tool parts: Tail stock, Tool Post, Machine Vices.
3. Other machine parts - Screw jack, Connecting rod, Plumber block, Fuel Injector
4. Valves - Steam stop valve, spring loaded safety valve, feed check valve and air cock.

**NOTE:**

1. First angle projection to be adopted.
2. All the drawing components/Assembly to be drawn using any Computer aided drafting package

**TEXT BOOKS:**

1. Machine Drawing / N.D. Bhatt / Charotar
2. Machine Drawing with Auto CAD / Goutham Pohit, Goutam Ghosh / Pearson

**REFERENCE BOOKS:**

1. Machine Drawing by / Bhattacharyya / Oxford
2. Machine Drawing / Ajeet Singh / Mc Graw Hill.

**Constitution of India**

II Year II Sem

**Basic Electrical and Electronics Engineering**

**Kinematics of Machinery**

**Prerequisites:** Basic principles of Mechanics

**Course Objectives:** The objective is to study the relative motion, velocity, and accelerations of the various elements in a mechanism. In mechanical Engineering we come across number of mechanisms such as four bar/slider crank/double slider crank/straight line motion mechanism etc. Mechanism deals with only relative motions. Once we make a study considering for us also there it is called kinetics. The first course deals with mechanisms, their inversions straight line motion mechanisms steering mechanisms etc. Also study of cams/gears & gear trains & belts are also introduced.

**Course Outcomes:** The main purpose is to give an idea about the relative motions obtained in all the above type of components used in mechanical Engineering.

**UNIT – I:**

**Mechanisms:** Elements or Links – Classification – Rigid Link, flexible and fluid link – Types of kinematics pairs – sliding, turning, rolling, screw and spherical pairs – lower and higher pairs – closed and open pairs – constrained motion – completely, partially or successfully and incompletely constrained.

**Mechanism and Machines** – Mobility of Mechanisms: Grubler’s criterion, classification of machines – kinematics chain – inversions of mechanism – inversions of quadric cycle chain, single and double slider crank chains, Mechanical Advantage.

**UNIT – II:**

**Kinematics:** Velocity and acceleration – Motion of link in machine – Determination of Velocity and acceleration – Graphical method – Application of relative velocity method.

**Plane motion of body:** Instantaneous center of rotation- centrodes and axodes – Three centers in line theorem – Graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method.

Kliens construction - Coriolis acceleration - determination of Coriolis component of acceleration

**Analysis of Mechanisms:** Analysis of slider crank chain for displacement- velocity and acceleration of slider – Acceleration diagram for a given mechanism.

**UNIT – III:**

**Straight-line motion mechanisms:** Exact and approximate copied and generated types – Peaucellier - Hart - Scott Russel – Grasshopper – Watt -Tchebicheff’s and Robert Mechanism - Pantographs

**Steering gears:** Conditions for correct steering – Davis Steering gear, Ackerman’s steering gear.

**Hooke’s Joint:** Single and double Hooke’s joint –velocity ratio – application – problems.

**UNIT – IV:**

**Cams:** Definitions of cam and followers – their uses – Types of followers and cams – Terminology – Types of follower motion - Uniform velocity, Simple harmonic motion and uniform acceleration and retardation. Maximum velocity and maximum acceleration during outward and return strokes in the above 3 cases.

**Analysis of motion of followers:** Tangent cam with Roller follower – circular arc cam with straight, concave and convex flanks.

**UNIT – V:**

**Higher pair:** Friction wheels and toothed gears – types – law of gearing, condition for constant velocity ratio for transmission of motion – velocity of sliding

Forms of teeth, cycloidal and involutes profiles – phenomena of interferences – Methods of interference. Condition for minimum number of teeth to avoid interference – expressions for arc of contact and path of contact of Pinion & Gear and Pinion & Rack Arrangements– Introduction to Helical – Bevel and worm gearing

**Gear Trains:** Introduction – Types – Simple – compound and reverted gear trains – Epicyclic gear train. Methods of finding train value or velocity ratio of Epicyclic gear trains. Selection of gear box - Differential gear for an automobile.

**TEXT BOOKS:**

1. Theory of Machines and Mechanisms/JOSEPH E. SHIGLEY/ Oxford
2. Theory of Machines / S. S. Rattan / Mc Graw Hill Publishers.

**REFERENCE BOOKS:**

1. Theory of Machines / Sadhu Singh / Pearson.
2. Theory of Machines / Thomas Bevan/CBS.

**Fluid Mechanics & Hydraulic Machines**

**Course Objectives:** The objectives of the course are to enable the student;

* To understand the basic principles of fluid mechanics
* To identify various types of flows
* To understand boundary layer concepts and flow through pipes
* To evaluate the performance of hydraulic turbines
* To understand the functioning and characteristic curves of pumps

**Course Outcomes:**

* Able to explain the effect of fluid properties on a flow system.
* Able to identify type of fluid flow patterns and describe continuity equation.
* To analyze a variety of practical fluid flow and measuring devices and utilize Fluid Mechanics principles in design.
* To select and analyze an appropriate turbine with reference to given situation in power plants.
* To estimate performance parameters of a given Centrifugal and Reciprocating pump.
* Able to demonstrate boundary layer concepts.

**UNIT – I:**

**Fluid statics**: Dimensions and units: physical properties of fluids- specific gravity, viscosity, and surface tension - vapour pressure and their influence on fluid motion- atmospheric, gauge and vacuum pressures – measurement of pressure- Piezometer, U-tube and differential manometers.

**UNIT – II:**

**Fluid kinematics**: Stream line, path line and streak lines and stream tube, classification of flows-steady & unsteady, uniform & non-uniform, laminar & turbulent, rotational & irrotational flows-equation of continuity for one dimensional flow and three-dimensional flows.

**Fluid dynamics**: Surface and body forces –Euler’s and Bernoulli’s equations for flow along a stream line, momentum equation and its application on force on pipe bend.

**UNIT – III:**

**Boundary Layer Concepts:** Definition, thicknesses, characteristics along thin plate, laminar and turbulent boundary layers (No derivation) boundary layer in transition, separation of boundary layer, submerged objects – drag and lift.

**Closed conduit flow:** Reynold’s experiment- Darcy Weisbach equation- Minor losses in pipes- pipes in series and pipes in parallel- total energy line-hydraulic gradient line. Measurement of flow: Pitot tube, venturi meter, and orifice meter, Flow nozzle

**UNIT – IV:**

**Basics of turbo machinery:** Hydrodynamic force of jets on stationary and moving flat, inclined, and curved vanes, jet striking centrally and at tip, velocity diagrams, work done and efficiency, flow over radial vanes.

**Hydraulic Turbines:** Classification of turbines, Heads and efficiencies, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine-working proportions, work done, efficiencies, hydraulic design –draft tube theory- functions and efficiency.

**Performance of hydraulic turbines**: Geometric similarity, Unit and specific quantities, characteristic curves, governing of turbines, selection of type of turbine, cavitation, surge tank, water hammer.

**UNIT – V:**

**Centrifugal pumps**: Classification, working, work done – barometric head- losses and efficiencies specific speed- performance characteristic curves, NPSH.

**Reciprocating pumps:** Working, Discharge, slip, indicator diagrams.

**TEXT BOOKS:**

1. Hydraulics, Fluid mechanics and Hydraulic Machinery - MODI and SETH.
2. Fluid Mechanics and Hydraulic Machines by Rajput.

**REFERENCES:**

1. Fluid Mechanics and Fluid Power Engineering by D.S. Kumar, Kotaria & Sons.
2. Fluid Mechanics and Machinery by D. Rama Durgaiah, New Age International.
3. Hydraulic Machines by Banga & Sharma, Khanna Publishers.

**IC Engines & Gas Turbines**

**Pre-requisite**: Thermodynamics

**Course Objective**:

1. Explain the Components of IC Engines and systems
2. Analyze the stages of combustion to improve the performance of IC engines with respect to fuel economy and control of emissions in global, environmental and social context
3. Understand and evaluate the performance analysis of the major components and systems of IC engines and their applications
4. Explore to the components and working principles of rotary, reciprocating, dynamic and axial compressors
5. Understand the significance of gas turbines in real context in power generation

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

1. Elaborate the working principles of IC Engine systems and its classification
2. Explore the combustion stages of SI and CI engines, and factors influence for better combustion
3. Evaluate the testing and performance parameters of IC engines
4. Explain the function and working principles of rotary, reciprocating, dynamic axial compressors
5. Understand the working principle of gas turbine and its classification with thermodynamic analysis

**UNIT – I:**

**I.C. Engines:** Classification - Working principles of Four & Two stroke engine, SI & CI engines, Valve and Port Timing Diagrams, Air – Standard, air-fuel and actual cycles - Engine systems – Carburetor and Fuel Injection Systems for SI engines, Fuel injection systems for CI engines, Ignition, Cooling and Lubrication system, Fuel properties and Combustion Stoichiometry.

**UNIT – II:**

Normal Combustion and abnormal combustion in SI engines – Importance of flame speed and effect of engine variables – Abnormal combustion, pre-ignition and knocking in SI Engines – Fuel requirements and fuel rating, anti-knock additives – combustion chamber – requirements, types of SI engines.

Four stages of combustion in CI engines – Delay period and its importance – Effect of engine variables – Diesel Knock– Need for air movement, suction, compression and combustion induced turbulence in Diesel engine – open and divided combustion chambers and fuel injection– Diesel fuel requirements and fuel rating

**UNIT – III:**

**Testing and Performance:** Parameters of performance - measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, Brake power – Determination of frictional losses and indicated power – Performance test – Heat balance sheet and chart

Classification of compressors – Fans, blowers and compressors – positive displacement and dynamic types – reciprocating and rotary types.

**Reciprocating Compressors:** Principle of operation, work required, Isothermal efficiency volumetric efficiency and effect of clearance volume, staged compression, under cooling, saving of work, minimum work condition for staged compression

**UNIT – IV:**

**Rotary Compressor (Positive displacement type):** Roots Blower, vane sealed compressor, mechanical details and principle of working – efficiency considerations.

**Dynamic Compressors:** Centrifugal compressors: Mechanical details and principle of operation – velocity and pressure variation. Energy transfer-impeller blade shape-losses, slip factor, power input factor, pressure coefficient and adiabatic coefficient – velocity diagrams – power.

**Axial Flow Compressors:** Mechanical details and principle of operation – velocity triangles and energy transfer per stage degree of reaction, work done factor - isentropic efficiency- pressure rise calculations – Polytropic efficiency.

**UNIT – V:**

**Gas Turbines:** Simple Gas Turbine Plant – Ideal Cycle – Closed Cycle and Open Cycle for Gast Turbines, Constant Pressure Cycle, Constant Volume Cycle, Efficiency – Work Ratio and Optimum Pressure Ration for Simple Gas Turbine Cycle. Parameters of Performance, Actual Cycle.

**TEXT BOOKS:**

1. I.C. Engines / V. Ganesan / Mc Graw Hill
2. Thermal Engineering / Mahesh M Rathore / Mc Graw Hill

**REFERENCE BOOKS:**

1. Applied Thermodynamics for Engineering Technologists / Eastop / Pearson
2. Fundamentals of Classical Thermodynamics / Vanwylen G.J., Sonntag R.E. / Wiley Eastern
3. Internal Combustion Engines Fundamentals – John B. Heywood – McGraw Hill Ed.

**Instrumentation and Control Systems**

**Prerequisite:** Mathematics-I, Thermodynamics, Basic of Electrical and Electronics Engineering.

**Course Objectives:**

1. To impart the basic knowledge of the functional blocks of measurement systems.
2. To provide technical understanding of various Temperature and pressure measuring instruments.
3. To expose the students to know the working of various physical variable Level, Flow, Speed and Acceleration measuring instruments.
4. To understand the working of various physical and Electrical variables Stress, Humidity, Force, Torque and Power measuring instruments.
5. To understand the concept of control system and calculate transfer functions of mechanical and translational systems with different techniques.

**Course Outcome:** After completion of the course, the student will be able to

CO1: Know the basic knowledge of the functional blocks of measurement systems.

CO2: Describe the working of various physical variable Temperature and pressure measuring instruments.

CO3: Explain the working of various physical variable Level, flow, Speed and Acceleration measuring instruments.

CO4: Understand the working of various physical and Electrical variables Stress, Humidity, Force, Torque and Power measuring instruments.

CO5: Understand the concept of control system and calculate transfer functions of mechanical and translational systems with different techniques.

**UNIT – I:**

Definition – Basic principles of measurement – Measurement systems, generalized configuration and functional description of measuring instruments – examples. Static and Dynamic performance characteristics– sources of errors, Classification and elimination of errors. Measurement of Displacement: Theory and construction of various transducers to measure displacement – Using Piezo electric, Inductive, capacitance, resistance, ionization and Photo electric transducers; Calibration procedures.

**UNIT – II:**

Measurement of Temperature: Various Principles of measurement-Classification: Expansion Type: Bimetallic Strip- Liquid in glass Thermometer; Electrical Resistance Type: Thermistor, Thermocouple,

RTD; Radiation Pyrometry: Optical Pyrometer; Changes in Chemical Phase: Fusible Indicators and Liquid crystals. Measurement of Pressure: Different principles used- Classification: Manometers, Dead weight pressure gauge Tester (Piston gauge), Bourdon pressure gauges, Bulk modulus pressure gauges, Bellows, Diaphragm gauges. Low pressure measurement – Thermal conductivity gauges, ionization pressure gauges, McLeod pressure gauge.

**UNIT – III:**

Measurement of Level: Direct methods – Indirect methods – Capacitive, Radioactive, Ultrasonic, Magnetic, Cryogenic Fuel level indicators –Bubbler level indicators.

Flow measurement: Rotameter, magnetic, Ultrasonic, Turbine flowmeter, Hot – wire anemometer, Laser Doppler Anemometer (LDA).

Measurement of Speed: Mechanical Tachometers, Electrical tachometers, Non- contact type Stroboscope; Measurement of Acceleration and Vibration: Different simple instruments – Principles of Seismic instruments – Vibrometer and accelerometer using this principle- Piezo electric accelerometer.

**UNIT – IV:**

Stress-Strain measurements: Various types of stress and strain measurements –Selection and installation of metallic strain gauges; electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending, compressive and tensile strains – Temperature compensation techniques, Use of strain gauges for measuring torque, Strain gauge Rosettes.

Measurement of Humidity: Moisture content of gases, Sling Psychrometer, Absorption Psychrometer, Dew point meter. Measurement of Force, Torque and Power- Elastic force meters, load cells, Torsion meters, Dynamometers.

**UNIT – V:**

Elements of Control Systems: Introduction, Importance – Classification – Open and closed systems-

Servomechanisms – Examples with block diagrams – Temperature, speed and position control systems- Transfer functions- First and Second order mechanical systems

**TEXT BOOKS:**

1. Principles of Industrial Instrumentation & Control Systems, - Alavala, - Cengage Learning
2. Optimization Methods for Engineers, NVS Raju, PHI Publications
3. Basic Principles – Measurements (Instrumentation) & Control Systems – S. Bhaskar – Anuradha Publications.

**REFERENCE BOOKS:**

1. Measurement Systems: Applications & design, E. O. Doebelin, TMH
2. Instrumentation, Measurement & Analysis, B.C. Nakra & K.K. Choudhary, TMH
3. Experimental Methods for Engineers / Holman
4. Mechanical and Industrial Measurements / R. K. Jain/ Khanna Publishers.
5. Mechanical Measurements / Sirohi and Radhakrishna / New Age International.

**Basic Electrical and Electronics Engineering Lab**

**Fluid Mechanics & Hydraulic Machines Lab**

**Course Objectives:**

* To understand the basic principles of fluid mechanics.
* To identify various types of flows.
* To understand boundary layer concepts and flow through pipes.
* To evaluate the performance of hydraulic turbines.
* To understand the functioning and characteristic curves of pumps.

**Course Outcomes:**

* Able to explain the effect of fluid properties on a flow system.
* Able to identify type of fluid flow patterns and describe continuity equation.
* To analyze a variety of practical fluid flow and measuring devices and utilize fluid mechanics principles in design.
* To select and analyze an appropriate turbine with reference to given situation in power plants.
* To estimate performance parameters of a given Centrifugal and Reciprocating pump.
* Able to demonstrate boundary layer concepts

**List of Experiments:**

1. Impact of jets on Vanes.
2. Performance Test on Pelton Wheel.
3. Performance Test on Francis Turbine.
4. Performance Test on Kaplan Turbine.
5. Performance Test on Single Stage Centrifugal Pump.
6. Performance Test on Multi Stage Centrifugal Pump.
7. Performance Test on Reciprocating Pump.
8. Calibration of Venturimeter.
9. Calibration of Orifice meter.
10. Determination of friction factor for a given pipe line.
11. Determination of loss of head due to sudden contraction in a pipeline.
12. Verification of Bernoulli’s Theorems.

**Instrumentation and Control Systems Lab**

**Pre-requisites**: Basic principles of Instrumentation and control systems

**Course Outcomes:** At the end of the course, the student will be able to Characterize and calibrate measuring devices. Identify and analyze errors in measurement. Analyze measured data using regression analysis. Calibration of Pressure Gauges, temperature, LVDT, capacitive transducer, rotameter.

**LIST OF EXPERIMENTS:**

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 amplitude of an engine bed at various loads.
11. Study and calibration of McLeod gauge for low pressure.
12. Measurement and control of Pressure of a process using SCADA system.
13. Measurement and control of level in a tank using capacitive transducer with SCADA.
14. Measurement and control of temperature of a process using resistance temperature detector with SCADA.

**Real-time Research Project**

**Gender Sensitization Lab**

III Year I Sem

**Dynamics of Machinery**

**Pre-requisite:** Kinematics of Machinery

**Course Objectives:** The objective is to introduce some of the components mainly used in IC Engines and make analysis of various forces involved. Subjects deals with topics like inertia forces in slider crank mechanism; IC Engine components & the analysis like governors is introduced. It also deals with balancing of rotating & reciprocating parts. Studies are made about balancing of multi cylinder engines, Radial engines etc. study of primary & secondary forces are considered while balancing. Finally they are introduced to the topic of vibrations. The study deals with linear, longitudinal, & torsional vibrations. The idea is to introduce the concept of natural frequency and the importance of resonance and critical speeds.

**Course Outcome:** the study of KOM & DOM are necessary to have an idea while designing the various machine members like shafts, bearings, gears, belts & chains and various I.C. Engine Components & Machine tool parts.

**UNIT – I:**

**Precession:** Gyroscopes – effect of precession – motion on the stability of moving vehicles such as motorcycle – motorcar – aeroplanes and ships.

**Static and Dynamic Force Analysis:** Static force analysis of planar mechanisms – Analytical Method – Dynamic Force Analysis – D’Alembert’s principle, Dynamic Analysis of 4-link mechanism, Slider Crank Mechanism.

**UNIT – II:**

**Turning Moment Diagram and Flywheels:** Engine Force Analysis – Piston Effort, Crank Effort, etc., Inertia Force in Reciprocating Engine – Graphical Method - Turning moment diagram –fluctuation of energy – flywheels and their design - Inertia of connecting rod- inertia force in reciprocating engines – crank effort and torque diagrams.-.

**UNIT – III:**

**Friction:** pivots and collars – uniform pressure, uniform wear – friction circle and friction axis: lubricated surfaces – boundary friction – film lubrication. Clutches – Types – Single plate, multi-plate and cone clutches. **Brakes and Dynamometers:** Types of brakes: Simple block brake, band and block brake-internal expanding shoe brake-effect of braking of a vehicle. Dynamometers – absorption and transmission types. General description and methods of operation.

**UNIT – IV:**

**Governors:** Types of governors - Watt, Porter and Proell governors. Spring loaded governors – Hartnell and Hartung with auxiliary springs. Sensitiveness, isochronisms and hunting **–** stability – effort and power of the governors.

**Balancing:** Balancing of rotating masses- Primary, Secondary, and higher balancing of reciprocating masses. Analytical and graphical methods. Unbalanced forces and couples. Examination of “V” and multi cylinder in-line and radial engines for primary and secondary balancing- locomotive balancing – Hammer blow – Swaying couple – variation of tractive effort.

**UNIT – V:**

**Vibrations:** Free Vibration of mass attached to vertical spring- Damped free vibrations– Transverse loads – vibrations of beams with concentrated and distributed loads. Dunkerly’s method – Raleigh’s method. Whirling of shafts – critical speed – torsional vibrations – one, two and three rotor systems.

**TEXT BOOKS:**

1. Theory of Machines /S.S.Rattan / Mc Graw Hill.
2. Theory of Machines /Sadhu Singh/ Pearson

**REFERENCE BOOKS:**

1. Theory of Machines and Mechanisms/Joseph E. Shigley / Oxford
2. Theory of Machines / Rao,J.S & R.V. Duggipati/ New Age

**Design of Machine Elements**

**Note:** Design Data books are not permitted in the Examinations. The design must not only satisfy strength criteria but also rigidity criteria.

**Pre-requisites:** Engineering mechanics, mechanics of solids, manufacturing processes, metallurgy and material science.

**Course Objectives:**

* To understand the general design procedures and principles in the design of machine elements.
* To study different materials of construction and their properties and factors determining the selection of material for various applications.
* To determine stresses under different loading conditions.
* To learn the design procedure of different fasteners, joints, shafts and couplings.

**Course Outcomes:**

* The student acquires the knowledge about the principles of design, material selection, component behavior subjected to loads, and criteria of failure.
* Understands the concepts of principal stresses, stress concentration in machine members and fatigue loading.
* Design on the basis of strength and rigidity and analyze the stresses and strains induced in a machine element.

**UNIT – I:**

**Introduction:** General considerations in the design of Engineering Materials and their properties – selection –Manufacturing consideration in design. Tolerances and fits –BIS codes of steels.

**Design for Static Strength:** Simple stresses – Combined stresses – Torsional and Bending stresses – Impact stresses – Stress strain relation – Various theories of failure – Factor of safety – Design for strength and rigidity – preferred numbers. The concept of stiffness in tension, bending, torsion and combined situations.

**UNIT – II:**

**Design for Fatigue Strength:** Stress concentration–Theoretical stress Concentration factor–Fatigue stress concentration factor- Notch Sensitivity – Design for fluctuating stresses – Endurance limit – Estimation of Endurance strength – Gerber’s curve– Goodman’s line– Soderberg’s line.

**UNIT – III:**

**Riveted, Welded and Bolted Joints:** Riveted joints- methods of failure of riveted joints-strength equations-efficiency of riveted joints-eccentrically loaded riveted joints.

Welded joints-Design of fillet welds-axial loads-circular fillet welds under bending, torsion. Welded joints under eccentric loading.

Bolted joints – Design of bolts with pre-stresses – Design of joints under eccentric loading – locking devices – bolts of uniform strength.

**UNIT – IV:**

**Keys, Cotters and Knuckle Joints:** Design of keys-stresses in keys-cottered joints-spigot and socket, sleeve and cotter, Gib and cotter joints-Knuckle joints.

**UNIT – V:**

**Shafts:** Design of solid and hollow shafts for strength and rigidity – Design of shafts for combined bending and axial loads – Shaft sizes – BIS code. - Gaskets and seals (stationary & rotary)

**Shaft Couplings:** Rigid couplings – Muff, Split muff and Flange couplings. Flexible couplings – Flange coupling (Modified).

**TEXT BOOKS:**

1. Design of Machine Elements / V. Bhandari / Mc Graw Hill
2. Machine Design / Jindal / Pearson

**REFERENCE BOOKS:**

1. Design of Machine Elements / V. M. Faires / Macmillan
2. Design of Machine Elements-I / Kannaiah, M.H / New Age

**Metrology & Machine Tools**

**Pre-requisites: None**

**Course Objectives:**

* To impart the fundamental aspects of the metal cutting principles and their application in studying the behavior of various machining processes.
* To train in knowing the fundamental parts of various machine tools and their kinematic schemes.
* To improve problem solving skills by determining the machining time of various machining processes.
* To provide technical understanding of basic concepts of engineering metrology and its practice in the industry.
* To make the student to improve applications aspect in the measurements and control of a process in manufacturing.

**Course Outcome:** At the end of the course, the student will be able to

CO1: Explain the principles of metal cutting and working of lathe machine tools.

CO2: Understand working of drilling, boring, shaping, slotting, planning machine tools and estimation of machining time.

CO3: Describe the Principles of working and operations performed on milling and grinding machines.

CO4: Explain the use of various measuring instruments, gauges and system of limits, fits and tolerances.

CO5: Describe the process of measuring the surface roughness, screw thread parameters & principles of coordinate measuring machines.

**UNIT – I:**

Metal cutting: Introduction, elements of cutting process – Geometry of single point tool, Chip formation and types of chips, tool materials, tool life, tool wear, cutting fluids, Analysis of orthogonal cutting- Merchant’s force diagram, Machinability.

Engine lathe – Principle of working, types of lathe, specifications, operations on lathe, Lathe attachments. – Single spindle and multi-spindle automatic lathes.

**UNIT – II:**

Drilling and Boring Machines – Geometry of twist drill, Principles of working, specifications, types, operations performed, machining time calculations, Types of Boring machines and applications.

Shaping, slotting and planing machines –Principles of working, specifications, types of operations performed, applications, quick return mechanisms, machining time calculations.

**UNIT – III:**

Milling machines – Principles of working – Types of milling machines – Geometry of milling cutters methods of indexing. Grinding – theory of grinding – classification of grinding machines. Types of abrasives, bonds. Selection of a grinding wheel. Lapping, honing and broaching machines, comparison and Constructional features, machining time calculations

**UNIT – IV:**

**Introduction to Metrology:** Terminology, Methods of measurements, Selection of measuring Instruments Linear Measurement: Line and end standard, slip gauges, micrometers, spirit level.

**Limits, fits and tolerances**- Types of Fits - Unilateral and bilateral tolerance system, hole and shaft basis system. Interchangeability and selective assembly.

**Limit Gauges:** Taylor’s principle, Design of GO and NO-GO gauges.

Measurement of angles using Bevel protractor and Sine bar. Measurement of flatness using straight edges, surface plates, optical flat and auto collimator.

**UNIT – V:**

Surface Roughness Measurement: Factors affecting the surface roughness, reasons for controlling the surface texture, elements of surface texture-Roughness, Waviness, evaluation of surface roughness-CLA, RMS, Rz Values. Methods of measurement of surface finish, Talysurf. Screw thread measurement, Gear measurement; Machine Tool Alignment Tests on lathe, milling and drilling machines. Coordinate Measuring Machines: Types and Applications of CMM.

**TEXT BOOKS:**

1. Machine Tool Practices/ Kibbe, Johne. Neely, T. White, Rolando O. Meyer/ Pearson
2. Engineering Metrology/ R.K. Jain/ Khanna Publishers.

**REFERENCE BOOKS:**

1. Principles of Machine Tools, Bhattacharyya A and Sen.G.C / New Central Book Agency.
2. Fundamentals of Dimensional Metrology / Connie Dotson / Thomson
3. Fundamentals of Metal Machining and Machine Tools / Geoffrey Boothroyd / McGraw Hill
4. Principles of Engineering Metrology/ Rega Rajendra/ Jaico Publishers.
5. Metrology and Measurement/ Bewoor & Kulkarni/ Tata Mc Graw Hill

**Business Economics & Financial Analysis**

**Course Objective:** To learn the basic Business types, impact of the Economy on Business and Firms specifically. To analyze the Business from the Financial Perspective.

**Course Outcome:** The students will understand the various Forms of Business and the impact of economic variables on the Business. The Demand, Supply, Production, Cost, Market Structure, Pricing aspects are learnt. The Students can study the firm’s financial position by analysing the Financial Statements of a Company.

**UNIT – I: Introduction to Business and Economics**

**Business**: Structure of Business Firm, Theory of Firm, Types of Business Entities, Limited Liability Companies, Sources of Capital for a Company, Non-Conventional Sources of Finance.

**Economics:** Significance of Economics, Micro and Macro Economic Concepts, Concepts and Importance of National Income, Inflation, Money Supply in Inflation, Business Cycle, Features and Phases of Business Cycle. Nature and Scope of Business Economics, Role of Business Economist, Multidisciplinary nature of Business Economics.

**UNIT – II: Demand and Supply Analysis**

**Elasticity of Demand:** Elasticity, Types of Elasticity, Law of Demand, Measurement and Significance of Elasticity of Demand, Factors affecting Elasticity of Demand, Elasticity of Demand in decision making, Demand Forecasting: Characteristics of Good Demand Forecasting, Steps in Demand Forecasting, Methods of Demand Forecasting.

**Supply Analysis:** Determinants of Supply, Supply Function & Law of Supply.

**UNIT – III: Production, Cost, Market Structures & Pricing**

**Production Analysis:** Factors of Production, Production Function, Production Function with one variable input, two variable inputs, Returns to Scale, Different Types of Production Functions.

**Cost analysis**: Types of Costs, Short run and Long run Cost Functions.

**Market Structures**: Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, Monopolistic Competition.

**Pricing:** Types of Pricing, Product Life Cycle based Pricing, Break Even Analysis, Cost Volume Profit Analysis.

**UNIT – IV: Financial Accounting:** Accounting concepts and Conventions, Accounting Equation, Double-Entry system of Accounting, Rules for maintaining Books of Accounts, Journal, Posting to Ledger, Preparation of Trial Balance, Elements of Financial Statements, Preparation of Final Accounts.

**UNIT – V: Financial Analysis through Ratios:** Concept of Ratio Analysis, Liquidity Ratios, Turnover Ratios, Profitability Ratios, Proprietary Ratios, Solvency, Leverage Ratios (simple problems).

Introduction to Fund Flow and Cash Flow Analysis (simple problems).

**TEXT BOOKS:**

1. D. D. Chaturvedi, S. L. Gupta, Business Economics - Theory and Applications, International Book House Pvt. Ltd. 2013.
2. Dhanesh K Khatri, Financial Accounting, Tata McGraw Hill, 2011.
3. Geethika Ghosh, Piyali Gosh, Purba Roy Choudhury, Managerial Economics, 2e, Tata McGraw Hill Education Pvt. Ltd. 2012.

**REFERENCE BOOKS:**

1. Paresh Shah, Financial Accounting for Management 2e, Oxford Press, 2015.
2. S. N. Maheshwari, Sunil K Maheshwari, Sharad K Maheshwari, Financial Accounting, 5e, Vikas Publications, 2013.

**Steam Power & Jet Propulsion**

**Note:** Steam Table book Permitted.

**Pre-requisite**: Thermodynamics

**Course Objective**: To apply the laws of Thermodynamics to analyze steam and gas turbine cycles and to perform analysis of the major components of steam and gas turbine plants and their applications.

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

* Develop state – space diagrams based on the schematic diagrams of process flow of steam and gas turbine plants
* Apply the laws of Thermodynamics to analyze thermodynamic cycles
* Differentiate between vapour power cycles and gas power cycles
* Infer from property charts and tables and to apply the data for the evaluation of performance parameters of the steam and gas turbine plants
* Understand the functionality of major components of steam and gas turbine plants and to do the analysis of these components

**UNIT – I:**

**Steam Power Plant:** Rankine cycle - Schematic layout, Thermodynamic Analysis, Concept of Mean Temperature of Heat addition, Methods to improve cycle performance – Regeneration & reheating.

**Boilers** – Classification – Working principles with sketches including H.P.Boilers – Mountings and Accessories – Working principles- Boiler horse power, Equivalent Evaporation, Efficiency and Heat balance – Draught- Classification – Height of chimney for given draught and discharge- Condition for maximum discharge- Efficiency of chimney.

**UNIT – II:**

**Steam Nozzles:** Stagnation Properties- Function of nozzle – Applications and Types- Flow through nozzles- Thermodynamic analysis – Assumptions -Velocity of nozzle at exit-Ideal and actual expansion in nozzle- Velocity coefficient- Condition for maximum discharge- Critical pressure ratio- Criteria to decide nozzle shape- Super saturated flow, its effects, Degree of super saturation and Degree of under cooling - Wilson line.

**UNIT – III:**

**Steam Turbines:** Classification – Impulse turbine; Mechanical details – Velocity diagram – Effect of friction – Power developed, Axial thrust, Blade or diagram efficiency – Condition for maximum efficiency. De-Laval Turbine - its features- Methods to reduce rotor speed-Velocity compounding and Pressure compounding- Velocity and Pressure variation along the flow – Combined velocity diagram for a velocity compounded impulse turbine.

**Reaction Turbine:** Mechanical details – Principle of operation, Thermodynamic analysis of a stage, Degree of reaction –Velocity diagram – Parson’s reaction turbine – Condition for maximum efficiency.

**UNIT – IV:**

**Steam Condensers**: Requirements of steam condensing plant – Classification of condensers – Working principle of different types – Vacuum efficiency and Condenser efficiency – Air leakage, sources and its affects, Air pump- Cooling water requirement.

**Gas Turbines:** Simple gas turbine plant – Ideal cycle, essential components – Parameters of performance – Regeneration, Inter cooling and Reheating –Closed and Semi-closed cycles – Merits and Demerits- Combustion chambers and turbines of Gas Turbine Plant- Brief Concepts, combined cycle.

**UNIT – V:**

**Jet Propulsion:** Principle of Operation –Classification of jet propulsive engines – Working Principles with schematic diagrams and representation on T-S diagram - Thrust, Thrust Power and Propulsion Efficiency – Turbo jet engines – Needs and Demands met by Turbo jet – Schematic Diagram, Thermodynamic Cycle, Performance Evaluation Thrust Augmentation – Methods.

**Rockets:** Application – Working Principle – Classification – Propellant Type – Thrust, Propulsive Efficiency – Specific Impulse – Solid and Liquid propellant Rocket Engines.

**TEXT BOOKS:**

1. Thermal Engineering / Mahesh M Rathore/ Mc Graw Hill
2. Gas Turbines – V. Ganesan /Mc Graw Hill

**REFERENCE BOOKS:**

1. Gas Turbine Theory/ Saravanamuttoo, Cohen, Rogers/ Pearson
2. Fundamentals of Engineering Thermodynamics / Rathakrishnan/ PHI
3. Thermal Engineering/ Rajput/ Lakshmi Publications

**CAD/CAM**

**Pre-requisites:** To learn the importance and use of computer in design and manufacture

**Course objectives:** To provide an overview of how computers are being used in design, development of manufacturing plans and manufacture. To understand the need for integration of CAD and CAM

**Course Outcomes:** Understand geometric transformation techniques in CAD. Develop mathematical models to represent curves and surfaces. Model engineering components using solid modeling techniques. Develop programs for CNC to manufacture industrial components. To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.

**UNIT – I:**

Fundamentals of CAD/ CAM, Application of computers for Design and Manufacturing, Benefits of CAD/ CAM - Computer peripherals for CAD/ CAM, Design workstation, Graphic terminal, CAD/ CAM software- definition of system software and application software, CAD/ CAM database and structure.

**Geometric Modeling:** Wire frame modeling, wire frame entities, 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, parametrization 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 Modelling:** 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**: F.M.S equipment, FMS layouts, Analysis methods for FMS benefits of FMS.

**Computer aided quality control**: Automated inspection- Off-line, On-line, contact, Non-contact; 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
3. CAD/CAM/ Groover M.P/ Pearson

**REFERENCE BOOKS:**

1. CAD/CAM/CIM/ Radhakrishnan and Subramanian / New Age

**Thermal Engineering Lab**

**Pre-Requisite:** Thermodynamics & Thermal Engineering - I

**Objective:** To understand the working principles of IC Engines, Compressors.

**List of Experiments**

1. I.C. Engines Valve / Port Timing Diagrams
2. I.C. Engines Performance Test for 4 Stroke SI engines
3. I.C. Engines Performance Test for 2 Stroke SI engines
4. I.C. Engines Morse, Retardation, Motoring Tests
5. I.C. Engine Heat Balance – CI/SI Engines
6. I.C. Engines Economical speed Test on a SI engine
7. I.C. Engines effect of A/F Ratio in a SI engine
8. Performance Test on Variable Compression Ratio Engine
9. IC engine Performance Test on a 4S CI Engine at constant speed
10. Volumetric efficiency of Air – Compressor Unit
11. Dis-assembly / Assembly of Engines
12. Study of Boilers

**Note:** Perform any 10 out of the 12 Exercises.

**Metrology & Machine Tools Lab**

**Course Objectives:**

1. To import practical exposure to the metrology equipment & Machine Tools

2. To conduct experiments and understand the working of the same.

**Prerequisites:** Theoretical exposure to Metrology and machine tools.

**Course Outcomes:** After completion of the course, the student will be able to

CO 1: identify parts of Lathe and perform different operations on Lathe

CO 2: identify parts of drilling machine and perform operations on drilling machine

CO 3: identify parts of Milling Shaping and Planning machine and perform operations on Milling, Shaping and Planning machine

CO 4: identify various measuring instruments and use them appropriately.

CO 5: Measure surface finish of machined components.

**List of Experiments:**

1. Step turning on lathe machine
2. Taper turning on lathe machine
3. Thread cutting and knurling on lathe machine (2 exercises)
4. Measurement of cutting forces on lathe
5. Machining of holes using Drilling and boring machines.
6. Gear cutting on the Milling machine
7. Grinding of Tool angles using Cylindrical / Surface Grinding
8. Measurement of lengths, heights, diameters by vernier calipers, micrometers.
9. Measurement of Diameter of bores by internal micrometers and dial bore indicators.
10. Use of gear teeth vernier calipers for checking the chordal addendum and chordal height of the spur gear.
11. Angle and taper measurements by bevel protractor and sine bars.
12. Thread measurement by 2-wire and 3-wire methods.
13. Surface roughness measurement by Tally Surf.
14. Use of mechanical comparator

**Kinematics & Dynamics Lab**

**Pre-requisites:**

Prerequisites for the graduate-level course are Kinematics, Dynamics, differential equations, motion simulation, displacement, velocity, acceleration, force, torque, power, Newton’s motion laws, vibration, Gyroscopic Effect, Cams, Bearings.

**Course Objectives:** The objective of the lab is to understand the kinematics and dynamics of mechanical elements such as linkages, gears, cams and learn to design such elements to accomplish desired motions or tasks.

**Course Outcomes:** Upon successful completion of this lab, students should be able to:

* Understand types of motion
* Analyze forces and torques of components in linkages
* Understand static and dynamic balance
* Understand forward and inverse kinematics of open-loop mechanisms

**Experiments:** (A Minimum of 10 experiments are to be conducted)

1. To determine the state of balance of machines for primary and secondary forces
2. To determine the frequency of torsional vibration of a given rod
3. Determine the effect of varying mass on the centre of sleeve in porter and proell governor
4. Find the motion of the follower if the given profile of the cam
5. The balance masses statically and dynamically for single rotating mass systems
6. Determine the critical speed of a given shaft for different n-conditions
7. For a simple pendulum determine time period and its natural frequency
8. For a compound pendulum determine time period and its natural frequency
9. Determine the effect of gyroscope for different motions
10. Determine time period, amplitude and frequency of undamped free longitudinal vibration of single degree spring mass systems.
11. Determine the pressure distribution of lubricating oil at various load and speed of a Journal bearing.
12. Determine time period, amplitude and frequency of damped free longitudinal vibration of single degree spring mass systems

**Intellectual Property Rights**

**UNIT – I:**

Introduction to Intellectual property: Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

**UNIT – II:**

Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

**UNIT – III:**

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer

**UNIT – IV:**

Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation.

Unfair competition: Misappropriation right of publicity, false advertising.

**UNIT – V:**

New development of intellectual property: new developments in trade mark law; copy right law, patent law, intellectual property audits.

International overview on intellectual property, international – trade mark law, copy right law, international patent law, and international development in trade secrets law.

**TEXT BOOKS & REFERENCE BOOKS:**

1. Intellectual property right, Deborah. E. Bouchoux, Cengage learning.
2. Intellectual property right – Unleashing the knowledge economy, prabuddha ganguli, Tata McGraw Hill Publishing company ltd.

III Year II Sem

**Machine Design**

**Note:** Design Data Book is permitted. Design of all components should include design for strength and rigidity apart from engineering performance requirements.

**Pre-requisites**: Study of engineering mechanics, design of machine members-I and theory of machines.

**Course objectives**:

* To gain knowledge about designing the commonly used important machine members such as bearings, engine parts, springs, belts, gears etc.
* To design the components using the data available in design data books.

**Course Outcomes:**

* Knowledge about journal bearing design using different empirical relations.
* Estimation of life of rolling element bearings and their selection for given service conditions.
* Acquaintance with design of the components as per the standard, recommended procedures which is essential in design and development of machinery in industry.

**UNIT – I:**

**Sliding contact bearings:** Types of Journal bearings – Lubrication – Bearing Modulus – Full and partial bearings – Clearance ratio – Heat dissipation of bearings, bearing materials – journal bearing design.

**UNIT – II:**

**Rolling contact bearings:** Ball and roller bearings – Static load – dynamic load – equivalent radial load – design and selection of ball & roller bearings.

**UNIT – III:**

**Engine Parts:** Connecting Rod: Thrust in connecting rod – stress due to whipping action on connecting rod ends –Pistons, Forces acting on piston – Construction, Design and proportions of piston.

**UNIT – IV:**

**Mechanical Springs:** Stresses and deflections of helical springs – Extension and compression springs – Design of springs for fatigue loading – natural frequency of helical springs – Energy storage capacity – helical torsion springs – Design of co-axial springs, Design of leaf springs.

**Belts & Pulleys**: Transmission of power by Belt and Rope Drives, Transmission efficiencies, Belts – Flat and V types – Ropes - pulleys for belt and rope drives.

**UNIT – V:**

**Gears:** Spur gears& Helical gears- Brief introduction involving important concepts – Design of gears using AGMA procedure involving Lewis and Buckingham equations. Check for wear.

**TEXT BOOKS:**

1. Design of Machine Elements / Spotts/ Pearson
2. Machine Design / Pandya & Shah / Charothar

**REFERENCE BOOKS:**

1. Design of Machine Elements-II / Kannaiah / New Age
2. Design of Machine Elements / Sharma and Purohit/PHI
3. Design Data Book/ P.V. Ramana Murti & M. Vidyasagar/ B.S. Publications
4. Design Data Handbook/ S. Md. Jalaludeen/ Anuradha Publishers

**Heat Transfer**

**Note:** Heat Transfer Data Book is permitted.

**Pre-requisite**: Thermodynamics

**Course Objectives**: To provide knowledge about application of conduction, convection and radiation heat transfer concepts to different practical applications

**Course Outcome**: At the end of this course, student will be able to

* Understand the basic modes of heat transfer
* Compute one dimensional steady state heat transfer with and without heat generation
* Understand and analyze heat transfer through extended surfaces
* Understand one dimensional transient conduction heat transfer
* Understand concepts of continuity, momentum and energy equations
* Interpret and analyze forced and free convective heat transfer
* Understand the principles of boiling, condensation and radiation heat transfer
* Design of heat exchangers using LMTD and NTU methods

**UNIT – I:**

**Introduction:** Modes and mechanisms of heat transfer – Basic laws of heat transfer –General discussion about applications of heat transfer.

**Conduction Heat Transfer:** Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady, and periodic heat transfer – Initial and boundary conditions

**One Dimensional Steady State Conduction Heat Transfer:** Homogeneous slabs, hollow cylinders, and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation

**UNIT – II:**

**One Dimensional Steady State Conduction Heat Transfer:** Variable Thermal conductivity – systems with heat sources or Heat Generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature

**One Dimensional Transient Conduction Heat Transfer:** Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi-infinite body.

**UNIT – III:**

**Convective Heat Transfer:** Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham  Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations – Integral Method as approximate method -Application of Von Karman Integral Momentum Equation for flat plate with different velocity profiles.

**Forced convection: External Flows:** Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

**UNIT – IV:**

**Internal Flows:** Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus flow.

**Free Convection:** Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

**Heat Exchangers:** Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

**UNIT – V:**

**Heat Transfer with Phase Change:**

**Boiling**: Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling. **Condensation:** Film wise and drop wise condensation –Nusselt’s Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations.

**Radiation Heat Transfer:** Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks.

**TEXT BOOKS:**

1. Heat and Mass Transfer – Dixit /Mc Graw Hill
2. Heat and Mass Transfer / Altamush Siddiqui/ Cengage

**REFERENCE BOOKS:**

1. Essential Heat Transfer - Christopher A Long / Pearson
2. Heat Transfer –Ghoshdastidar / Oxford

**Finite Element Methods**

**Pre-requisites**: Mechanics of Solids

**Course Objective**: The aim of the course is to provide the participants an overview on Finite Element Method, Material models, and Applications in Civil Engineering. At the end of the course, the participants are expected to have fair understanding of:

* Basics of Finite Element Analysis.
* Available material models for structural materials, soils and interfaces/joints.
* Modeling of engineering systems and Soil–Structure Interaction (SSI).
* Importance of interfaces and joints on the behavior of engineering systems.
* Implementation of material model in finite element method and applications

**Course Outcomes**: At the end of the course, the student will be able to, Apply finite element method to solve problems in solid mechanics, fluid mechanics and heat transfer. Formulate and solve problems in one dimensional structures including trusses, beams and frames. Formulate FE characteristic equations for two dimensional elements and analyze plain stress, plain strain, axi-symmetric and plate bending problems. ANSYS, ABAQUS, NASTRAN, etc.

**UNIT – I:**

Introduction to Finite Element Methods: General Procedure – Engineering Applications – Stress and Equilibrium, Strain – Displacement relations. Stress – strain relations: Finite Elements: 1- Dimensional, 2 – Dimensional, 3-Dimensional & Interpolation Elements

**One Dimensional Problems:** 1-D Linear and 1-D Quadratic Elements - 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:** Derivation of Stiffness Matrix for Plane Truss, Displacement of Stress Calculations.

**Analysis of Beams:** Element stiffness matrix for two noded, two degrees of freedom per node beam element, Load Vector, Deflection.

**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.

**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 3 D problems in stress analysis, convergence requirements, Mesh generation. techniques such as semi-automatic and fully Automatic use of softwares such as ANSYS, ABAQUS, NASTRAN using Hexahedral and Tetrahedral Elements.

**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 Graw Hill
2. Finite Element Analysis / SS Bhavikatti / New Age
3. Finite Element Method/ Dixit/Cengage

**Professional Elective – I**

**Unconventional Machining Processes**

**Course Overview:** The objective of this course is to introduce the student to more advanced topics in the machining processes. To bring out the need for Unconventional Machining Processes which will overcome the difficulties associated with Traditional Machining.

**Course Objectives:**

* To differentiate conventional and Unconventional Machining Processes and Ultrasonic Machining.
* To understand the process capabilities of abrasive, water jet and electro-chemical machining processes.
* To understand the working principle & important features of electrical discharge machining process.
* To understand the process parameters, accuracy and surface finish of electron beam & laser beam machining Processes.
* To understand the working principle & metal removal rate of plasma arc machining and abrasive finishing process.

**Course Outcomes:** After completion of the course, the student will be able to

CO 1: Study the need for unconventional machining processes and explain ultrasonic machining process.

CO 2: Describe Abrasive jet, Water jet, and Abrasive water jet machining and electrochemical machining process.

CO 3: Describe working principle and process variables of EDM process.

CO 4: Explain the process capabilities and process parameters of Electron Beam machining and Laser Beam machining.

CO 5: Describe the working of Plasma Arc machining, chemical machining and Abrasive Finishing processes.

**UNIT – I:**

**Introduction** – Need for non-traditional machining methods-Classification of modern machining processes – considerations in process selection. Materials. Applications.

Ultrasonic machining – Elements of the process, mechanics of metal removal process, parameters, economic considerations, applications and limitations, recent development.

**UNIT – II:**

**Abrasive Jet Machining, Water Jet Machining And Abrasive Water Jet Machining**: Basic principles, equipment, process variable, and mechanics of metal removal, MRR, application and limitations.

**Electro – Chemical Processes**: Fundamentals of electro chemical machining, electrochemical grinding, electro chemical honing and deburring processes, metal removal rate in ECM, Tool design, Surface finish and accuracy, economic aspects of ECM – Simple problems for estimation of metal removal rate.

**UNIT – III:**

**Thermal Metal Removal Processes**: General Principle and applications of Electric Discharge Machining, Electric Discharge Grinding and electric discharge wire cutting processes – Power circuits for EDM, Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, methods surface finish and machining accuracy, characteristics of spark eroded surface and machine tool selection. Wire EDM, principle, applications.

**UNIT – IV:**

Generation and control of electron beam for machining, theory of electron beam machining, comparison of thermal and non-thermal processes –General Principle and application of laser beam machining – thermal features, cutting speed and accuracy of cut.

**UNIT – V:**

Application of plasma for machining, metal removing mechanism, process parameters, accuracy and surface finish and other applications of plasma in manufacturing industries. Chemical machining – principle - maskants - applications.

Magnetic abrasive finishing, Abrasive flow finishing, Electro stream drilling, shaped tube electrolyte machining.

**TEXT BOOKS:**

1. Advanced Machining Processes / VK Jain / Allied publishers
2. Modern Machining Processes - P. C. Pandey, H. S. Shan/ Mc Graw Hill

**REFERENCE BOOKS:**

1. Unconventional Manufacturing Processes/ Singh M.K/ New Age Publishers
2. Advanced Methods of Machining/ J.A. McGeough/ Springer International
3. Non-Traditional Manufacturing Processes/ Benedict G.F./ CRC Press

**Professional Elective – I**

**Power Plant Engineering**

**Pre-Requisites:** None

**Course Objective:** The goal of this course is to become prepared for professional engineering design of conventional and alternative power-generation plants. The learning objectives include

* Analysis and preliminary design of the major systems of conventional fossil-fuel steam-cycle power plants.
* A working knowledge of the basic design principles of nuclear, gas turbine, combined cycle, hydro, wind, geothermal, solar, and alternate power plants.
* Awareness of the economic, environmental, and regulatory issues related to power generation.

**Course Outcomes:** At the end of the course students are able to:

* Understand the concept of Rankine cycle.
* Understand working of boilers including water tube, fire tube and high pressure boilers and determine efficiencies.
* Analyze the flow of steam through nozzles
* Evaluate the performance of condensers and steam turbines
* Evaluate the performance of gas turbines

**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 equipments, types of coals, coal handling, choice of handling equipment, coal storage, Ash handling systems.

**Combustion Process:** Properties of coal – overfeed and underfeed 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 starting equipment, 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.

**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.

**Hydro Projects and Plant:** Classification – Typical layouts – plant auxiliaries – plant operation pumped storage plants.

**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, 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. Power Plant Engineering/ P. K. Nag / Mc Graw Hill
2. Power Plant Engineering / Hegde / Pearson.

**REFERENCES BOOKS:**

1. Power Plant Engineering / Gupta / PHI
2. Power Plant Engineering / A K Raja / New age

**Professional Elective – I**

**Mechanical Vibrations**

**Pre-requisites:** Engineering Mechanics

**Course objectives:** Understand various levels of vibrations and remedies for each of them.

**Course Outcomes:** At the end of the course, the student will be able to, Understand the causes and effects of vibration in mechanical systems. Develop schematic models for physical systems and formulate governing equations of motion. Understand the role of damping, stiffness and inertia in mechanical systems Analyze rotating and reciprocating systems and compute critical speeds. Analyze and design machine supporting structures, vibration isolators and absorbers.

**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.

**UNIT – III:**

**Two-degree freedom systems:** Principal modes- undamped and damped free and forced vibrations; undamped vibration absorbers;

**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 – IV:**

**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.

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

Vibration measuring instruments: Vibrometers, velocity meters & accelerometers

**UNIT – V:**

**Sound level and subjective response to sound:** Subjective response to sound, frequency dependent human response to sound, sound-pressure dependent human response, the decibel scale, relationship among sound power, sound intensity and sound pressure level, relationship between sound power level and sound intensity, relationship between sound intensity level and sound pressure level, sound measuring instruments.

**TEXT BOOKS:**

1. Elements of Vibration Analysis / Meirovitch/ Mc Graw Hill
2. Principles of Vibration / Benson H. Tongue/Oxford

**REFERENCE BOOKS:**

1. Mechanical Vibrations / SS Rao / Pearson
2. Mechanical Vibration /Rao V. Dukkipati, J Srinivas/ PHI
3. Mechanical Vibrations/ G.K. Grover/ Nemchand & Brothers

**Professional Elective – I**

**Microprocessors in Automation**

**Unit 1: Basic Concepts of Digital Circuits**

Number Systems, Logic Gates, Combinational Circuits, Flip-flops, Sequential Logic Circuits: Counters, Shift Registers.

Basic components and computer architecture- CPU, Memory and Peripherals

**Unit 2: Architecture of Microprocessor**

Introduction, Origin, Historical Developments, Introduction to 8085 Functional Block Diagram, Registers, ALU, Bus Systems, Timing and Control Signals, PIN diagram, Machine Cycles, Instruction Cycle and Timing States, Instruction Timing Diagrams, Addressing Modes. Concept of Interrupt, Need for Interrupts, Interrupt structure, Multiple Interrupt requests and their handling, Programmable interrupt controller

**Unit 3: Assembly Language Programming**

Instruction Set, Simple programs in 8085 mainly on Addition, Subtraction, Multiplication, Rotation, Ascending and Descending of the given data

**Unit 4: Memory and I/O Device Interfacing**

Memory Interfacing - Memory structure and its requirements, Basic Concept in Memory Interfacing, Address Decoding, Interfacing Circuits, Address Decoding and Memory Addresses, Typical Examples on Memory interfacing : Interface (2k x 8) ROM, (8k x 8) EPROM, and (1k x 8) RAM with 8085.

IO Interfacing – Basic Interfacing Concepts-Peripheral I/O instructions, I/O Execution, Device Selection and data transfer, absolute vs. Partial Decoding, Input Interfacing, Interfacing I/Os using Decoders

**Unit 5: Architecture of Microcontroller**

Introduction to Microcontrollers and how they differ from microprocessors, Block diagram of Microcontrollers, Architecture of 8051 microcontroller, Pin Diagram, Instruction set, simple 8051 programming, introduction to ARM microcontroller and its applications.

**Text Books**

1. Microprocessor Architecture, Programming, and Applications with the 8085, Ramesh Gaonkar, PENRAM International Publishers.
2. The 8051 Microcontroller and Embedded Systems: Using Assembly and C, Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D, Mckinlay, 2nd Edition, Pearson publication, 2007.

**Reference Books**

1. Microprocessors and Interfacing: Programming and Hardware, Douglas V. Hall
2. Microcomputer Experimentation with the Intel SDK-85, Lance A. Leventhal, Prentice Hall
3. Introduction to Microprocessors, Aditya P Mathur, Tata McGraw-Hill, Europe; 3rd Edition, 1990.
4. Digital Electronics: An Introduction to Theory and Practice, William H. Gothmann, PHI Learning Private Limited.
5. Digital and microprocessor technology, Patrick J O'Connor, Prentice-Hall, 1983.
6. Digital and Microprocessor Engineering, S.J.Cahill, Wllis Horwood Limited (John Wiley & Sons).
7. Digital Control Systems, Benjamin C. Kuo, Oxford University Press (2/e, Indian Edition, 2007).
8. Digital Computer Electronics: An Introduction to Microcomputers, Albert Pual Malvino, Tata McGraw-Hill Publishing Company Ltd.

**Open Elective – I**

**Basic Mechanical Engineering**

**UNIT-I**:

Energy: Power Generation: External and internal combustion engines-Thermal Power Plants-Working Principle, layouts, element/component description, advantages, disadvantages, applications.

2-Stroke, 4-Stroke Engines and their Components.

Refrigeration: Mechanical Refrigeration and types – units of refrigeration – Air Refrigeration system, Vapour Compression Refrigeration System- Principle of operation.

Modes and mechanisms of heat transfer – Basic laws of heat transfer –General discussion about applications of heat transfer.

**UNIT-II**:

Machine and Mechanisms-Degrees of Freedom, functions of Flywheel and Governors,

Types of joints-Riveted, welded and bolted joints. Applications, Merits and Demerits.

Power Transmission Elements: Gears terminology of spur, helical and bevel gears, gear trains. Belt drives (types). Chain drives.

**UNIT-III**:

Manufacturing Processes: Primary and secondary process. Casting: Types, equipment, applications. Metal forming processes-rolling,extrusion

Welding: Types – Equipment –Techniques employed – advantages / disadvantages – Gas cutting – Brazing and soldering.

**UNIT-IV:**

Machine Tools: Introduction to lathe, drilling machine, milling machine, grinding machine-Operations performed. CNC Machines- Basic elements, advantages. Limits, fits and tolerances, Surface finish of various manufacturing process.

**UNIT-V:** Non-conventional sources of energy-Solar, wind, tidel, biogas and nuclear- Principles.

Robotics – Joints, end effectors, applications. Introduction to 3D Printing.

**Text Books:**

1. Kumar, T., LeenusJesu Martin and Murali, G., Basic Mechanical Engineering, Suma Publications, Chennai, 2007.
2. Sadhu Singh, Basic Mechanical Engineering, S.Chand & Co.Ltd, New Delhi, 2012

**References:**

1. Prabhu, T. J., Jai Ganesh, V. and Jebaraj, S., Basic Mechanical Engineering, Scitech Publications, Chennai, 2000.
2. Hajra Choudhary, S.K. and Hajra Choudhary, A. K., Elements of Workshop Technology Vols.I& II, Indian Book Distributing Company Calcutta, 2007.
3. Nag, P.K., Power Plant Engineering, Tata McGraw-Hill, New Delhi, 2008.
4. Rattan, S.S., Theory of Machines, Tata McGraw-Hill, New Delhi, 2010.

**Open Elective – I**

**Renewable energy Sources**

**COURSE OBJECTIVES:**

1. To provide an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternate energy sources and their technology and application.
2. To explore society’s present needs and future energy demands, examine conventional energy sources and systems, including fossil fuels and nuclear energy.
3. To focus on alternate, renewable energy sources such as solar, biomass (conversions), wind power, geothermal, and hydro, Energy conservation methods.

**COURSE OUTCOMES:**

1. At the successful completion of course, the student is expected to have/be able to:
2. Explain the main sources of energy including Solar energy and their primary applications in Global Context.
3. Describe the challenges and problems associated with the use of solar energy sources and its Economic Evaluation
4. Discuss significance of Wind energy systems and its components with basic working principles
5. Elaborate the sources of energy from wate by various means such as OTEC, Tidal energy etc.
6. Narrate the importance and potential of geo thermal energy and MHD power generation

**Unit-I:**

SOLAR RADIATION AND COLLECTING DEVICES: Solar Incident Flux, Extra-terrestrial Radiation, Clear Sky Irradiation, Solar Radiation Measurement, Monthly Average Radiation on Tilted Surfaces. Cover plates, Collector Plate Surfaces, Collector Performance, Collector Improvement, Effect of Incident Angle, Heat Transfer to Fluids, Heat Transfer Factors, Concentrating Collectors, Reflectors.

**Unit-II:**

SOLAR SYSTEM DESIGN AND ECONOMIC EVALUATION Hot water heating, heating and hot water systems , pumps and fans, sizing pipe and duct work, fundamentals of economic analysis, systems optimization

**Unit-III:**

WIND ENERGY SYSTEMS: Orientation systems and Regulating devices, Types of Wind Turbines, Operating Characteristics, Basics of Airfoil Theory, Wind energy for water pumping and generation of electricity, Installation operation and maintenance of small wind energy conversion systems.

**Unit-IV:**

ENERGY FROM WATER: OTEC–Principle of operation, Open and Closed OTEC cycles, Wave energy: Wave energy conversion machines and recent advances Tidal Energy: Single basin and double basin tidal systems Small-Mini-Micro hydro system: Concepts, Types of turbines, Hydrological analysis.

**Unit-V:**

GEOTHERMAL ENERGY: Introduction, Classification of Geo-thermal areas, Applications of Geo-thermal energy for power generation, Economics of Geo-thermal energy. MHD POWER GENERATION: Principles of MHD Power Generation, Ideal MHD–Generator Performance, Practical MHD Generator: Faraday and Hall Configurations, MHD Technology.

TEXT BOOK:

1. Peter J.Lunde Solar Thermal Engineering, John Wiley & Sons.
2. G.N Tewari , Solar Thermal Engineering , TMH

REFERENCE BOOKS:

1. H.P Garg, Solar Energy Fundamentals and Applications, TMH.
2. S.P Sukhatme, Solar Energy Principles of thermal storage, TMH

**Heat Transfer Lab**

**Pre-requisite**: Thermodynamics

**Course Objectives**: To enable the student to apply conduction, convection and radiation heat transfer concepts to practical applications

**Course Outcome**: At the end of the lab sessions, the student will be able to

* Perform steady state conduction experiments to estimate thermal conductivity of different materials
* Perform transient heat conduction experiment
* Estimate heat transfer coefficients in forced convection, free convection, condensation and correlate with theoretical values
* Obtain variation of temperature along the length of the pin fin under forced and free convection
* Perform radiation experiments: Determine surface emissivity of a test plate and Stefan- Boltzmann’s constant and compare with theoretical value

**Minimum twelve experiments from the following:**

* + - 1. Composite Slab Apparatus – Overall heat transfer co-efficient.
1. Heat transfer through lagged pipe.
2. Heat Transfer through a Concentric Sphere
3. Thermal Conductivity of given metal rod.
4. Heat transfer in pin-fin
5. Experiment on Transient Heat Conduction
6. Heat transfer in forced convection apparatus.
7. Heat transfer in natural convection
8. Parallel and counter flow heat exchanger.
9. Emissivity apparatus.
10. Stefan Boltzman Apparatus.
11. Critical Heat flux apparatus.
12. Study of heat pipe and its demonstration.
13. Film and Drop wise condensation apparatus

**Computer Aided Engineering Lab**

**Pre-requisites:** To give the exposure to usage of software tools for design and manufacturing. To acquire the skills needed to analyze and simulate engineering systems.

**Course Objectives:** To be able to understand and handle design problems in a systematic manner. To be able to apply CAD in real life applications. To be understand the basic principles of different types of analysis.

**Course Outcomes:** To understand the analysis of various aspects in of manufacturing design

**Note: conduct any TEN excercises from the list gien below:**

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 NC Machines.
11. Development of NC code for free form and sculptured surfaces using CAM software.
12. Machining of simple components on NC lathe and Mill by transferring NC Code / from CAM software.

 Advanced Communication Skills lab

**Environmental Science**

**Course Objectives:**

* Understanding the importance of ecological balance for sustainable development.
* Understanding the impacts of developmental activities and mitigation measures
* Understanding the environmental policies and regulations

**Course Outcomes:**

Based on this course, the Engineering graduate will understand /evaluate / develop technologies on the basis of ecological principles and environmental regulations which in turn helps in sustainable development

**UNIT – I:**

**Ecosystems:** Definition, Scope and Importance of ecosystem. Classification, structure, and function of an ecosystem, Food chains, food webs, and ecological pyramids. Flow of energy, Biogeochemical cycles, Bioaccumulation, Biomagnification, ecosystem value, services and carrying capacity, Field visits.

**UNIT – II:**

**Natural Resources: Classification of Resources:** Living and Non-Living resources, **water resources:** use and over utilization of surface and ground water, floods and droughts, Dams: benefits and problems. **Mineral resources:** use and exploitation, environmental effects of extracting and using mineral resources, **Land resources:** Forest resources, **Energy resources:** growing energy needs, renewable and non-renewable energy sources, use of alternate energy source, case studies.

**UNIT – III:**

**Biodiversity and Biotic Resources:** Introduction, Definition, genetic, species and ecosystem diversity. Value of biodiversity; consumptive use, productive use, social, ethical, aesthetic and optional values. India as a mega diversity nation, Hot spots of biodiversity. Field visit. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts; conservation of biodiversity: In-Situ and Ex-situ conservation. National Biodiversity act.

**UNIT – IV:**

**Environmental Pollution and Control Technologies: Environmental Pollution:** Classification of pollution, **Air Pollution:** Primary and secondary pollutants, Automobile and Industrial pollution, Ambient air quality standards. **Water pollution:**  Sources and types of pollution, drinking water quality standards. **Soil Pollution:** Sources and types, Impacts of modern agriculture, degradation of soil. **Noise Pollution:** Sources and Health hazards, standards, **Solid waste:** Municipal Solid Waste management, composition and characteristics of e-Waste and its management. **Pollution control technologies:** Wastewater Treatment methods: Primary, secondary and Tertiary.

Overview of air pollution control technologies, Concepts of bioremediation. **Global Environmental Problems and Global Efforts: C**limate change and impacts on human environment. Ozone depletion and Ozone depleting substances (ODS). Deforestation and desertification. International conventions / Protocols: Earth summit, Kyoto protocol, and Montréal Protocol.

**UNIT – V:**

**Environmental Policy, Legislation & EIA:** Environmental Protection act, Legal aspects Air Act- 1981, Water Act, Forest Act, Wild life Act, Municipal solid waste management and handling rules, biomedical waste management and handling rules, hazardous waste management and handling rules. EIA: EIA structure, methods of baseline data acquisition. Overview on Impacts of air, water, biological and Socio-economical aspects. Strategies for risk assessment, Concepts of Environmental Management Plan (EMP). **Towards Sustainable Future:** Concept of Sustainable Development, Population and its explosion, Crazy Consumerism, Environmental Education, Urban Sprawl, Human health, Environmental Ethics, Concept of Green Building, Ecological Foot Print, Life Cycle assessment (LCA), Low carbon life style.

**TEXT BOOKS:**

1. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha for University Grants Commission.
2. Environmental Studies by R. Rajagopalan, Oxford University Press.

**REFERENCE BOOKS:**

1. Environmental Science: towards a sustainable future by Richard T. Wright. 2008 PHL Learning Private Ltd. New Delhi.
2. Environmental Engineering and science by Gilbert M. Masters and Wendell P. Ela. 2008 PHI Learning Pvt. Ltd.
3. Environmental Science by Daniel B. Botkin & Edward A. Keller, Wiley INDIA edition.
4. Environmental Studies by Anubha Kaushik, 4th Edition, New age international publishers.
5. Text book of Environmental Science and Technology - Dr. M. Anji Reddy 2007, BS Publications.

IV Year I Sem

**Industrial Management**

**Prerequisites**: None

**Course objectives**:

* Understand the philosophies of management gurus
* Understand the various types of organization structures and their features, and Their advantages and disadvantages.
* Learning various Industrial Engineering Practices like Operations Management techniques, work study, statistical quality control techniques, Job evaluation techniques and network analysis techniques.

**Course outcomes:**

* Able to apply principles of management
* Able to design the organization structure
* Able to apply techniques for plant location, design plant layout and value analysis
* Able to carry out work study to find the best method for doing the work and establish standard time for a given method
* Able to apply various quality control techniques and sampling plans
* Able to do job evaluation and network analysis.

**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 and Management/O.P. Khanna/Khanna Publishers.
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 Management/NVS Raju/Cengage Learning.
5. Industrial Engineering Hand Book/Maynard.
6. Industrial Engineering Management I Ravi Shankar/Galgotia.

**Refrigeration & Air Conditioning**

**Prerequisites:** Thermodynamics

**Course Objectives:**

1. Apply the principles of thermodynamics to analyze different types of refrigeration and HAV
2. To understand the functionality of the major components of the refrigeration and HAV
3. To apply the knowledge in effective refrigeration and HAV systems for better performances in real context
4. Discuss the heating procedure by Air conditioning process
5. Explain the requirement of ventilation devices/processes

## Course Outcomes:

1. Differentiate between different types of refrigeration systems with respect to application as well as conventional & unconventional refrigeration systems.
2. Analyse thermodynamically low temperature refrigeration and Vapour absorption refrigeration for evaluation of performance parameters.
3. Apply the air refrigeration principles for different types of Air craft refrigeration systems
4. Elaborate the principles of psychometrics to design the air conditioning heating /cooling loads for industrial applications.
5. explain the requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load

**UNIT– I:**

**Vapour Compression Refrigeration:** Performance of Complete vapor compression system. Actual Vs Ideal cycle - Effect of operating parameters on COP, **Components of Vapor Compression System:** The condensing unit – Evaporators – Expansion valve – Refrigerants – Properties – ODP & GWP - Load balancing of vapor compression Unit.

**Compound Compression**: Flash inter-cooling – flash chamber – Multi-evaporator & Multistage systems.

**UNIT– II:**

 **Production of Low Temperature:** Liquefaction system, Liquefaction of gases, Hydrogen and Helium, Cascade System – Applications– Dry ice system.

**Vapor absorption system** – Simple and modified aqua – ammonia system – Representation on Enthalpy –Concentration diagram.

 Lithium – Bromide system Three fluid system – HCOP.

**UNIT– III:**

**Air Refrigeration:** Applications – Air Craft Refrigeration -Simple, Bootstrap, Regenerative and Reduced ambient systems – Problems based on different systems.

**Steam Jet refrigeration system**: Representation on T-s and h-s diagrams – limitations and applications.

**Unconventional Refrigeration system** – Thermo-electric – Vortex tube & Pulse tube – working principles.

**UNIT– IV:**

**Air Conditioning:** Psychometric properties and processes – Construction of Psychometric chart.Requirements of Comfort Air –conditioning – Thermodynamics of human body – Effective temperature and Comfort chart – Parameters influencing the Effective Temperature.

**Heating Load Calculations:** Summer/ Winter heating load calculation-heat losses through structure-heat losses due to infiltration. Effects of solar radiation and internal heat sources on heating loads. Air Heating System: Classification - gravity warm heating system, forced warm air heating system balancing a warm air heating system, warm air furnaces, air cleaners, humidifiers & De-humidifiers

**UNIT– V:**

**Air Conditioning Systems:** All Fresh air, Re-circulated air with and without bypass, with reheat systems – Calculation of Bypass Factor, ADP, RSHF, ESHF and GSHF for different systems.

**Ventilation:** Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure. Equipments and Controls: Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, dehumidifiers

**TEXT BOOKS:**

1. Refrigeration & Air Conditioning by C.P. Arora, TMH.
2. Refrigeration & Air Conditioning by Arora & Domkundwar, Dhanpat Rai.
3. Refrigeration and Air Conditioning by Manohar Prasad

**REFERENCE BOOKS:**

1. Basic Refrigeration & Air Conditioning by P.N. Ananthanarayanan, McGraw Hill.
2. Refrigeration and Air Conditioning by Stoecker, Mc Graw Hill.
3. Refrigeration and Air Conditioning by Dr. S.S. Thipse, Jaico.
4. Refrigeration and Air Conditioning by Jordan& Preister, Prentice Hall.
5. Refrigeration and Air Conditioning by Dossat, Mc Graw Hill

**Professional Elective – II**

**Artificial Intelligence in Mechanical Engineering**

**Unit 1**: **Introduction to Artificial Intelligence**

Definition, History, Present state of Artificial Intelligence (AI), Phases of AI, Approaches to AI - Hard or Strong AI, Soft or Weak AI, Applied AI, Cognitive AI, and Applications domains focused on mechanical engineering,

**Unit 2: Problem Solving Methods**

Problem solving methods-1. Uninformed search includes Depth First Search (DFS), Breadth First Search (BFS), Uniform Cost Search (UCS), Depth Limited Search, Iterative Deepening Depth First Search (IDDFS) and bidirectional search. 2. Informed Search (heuristic search) includes greedy best first search, A\* search, memory bounded heuristic search, learning to search better, Simple problems

**Unit 3: Neural Networks**

Introduction to Perceptron and Neural Networks, Activation and Loss functions, Single Neuron of Human and Human Brain Modelling, ANN architecture-Input layer, Hidden layer and output layer, Types of Neural Networks- Single layer feed-forward network, Multilayer feed-forward network, Multi-Layer Perceptron (MLP), Recurrent networks or feedback ANN, Characteristics of Neural Networks, Simple problems on Back Propagation Algorithms to minimize the error

**Unit 4: Machine Learning**

Unsupervised learning- Definition, basic concepts, applications, K-means Clustering, hierarchical Clustering, Dimension Reduction-PCA, Simple Examples

Supervised Learning - Definition, basic concepts, applications, Linear Regression, Multiple Variable Linear Regression, Logistic Regression, Naive Bayes Classifiers, k-NN Classification, Support Vector Machine, Simple Examples.

Reinforcement Learning (RL) - Framework, Component of RL Framework, Types of RL Systems. Q-learning, Examples of RL Systems, Simple Examples

**Unit 5: Ensemble Learning Techniques**

Introduction on ensemble methods, Decision Trees, Bagging, Random Forests, Boostin, Simple Examples

**Text Books**

1. Artificial Intelligence: A Modern Approach, Stuart Russell & Peter Norvig, Prentice-Hall, Third Edition (2009).

**References**

1. Artificial Intelligence, Ela Kumar, Wiley , 2021
2. Artificial Intelligence: Concepts and Applications, Lavika Goel, Kindle Edition, ‎ Wiley , 2021.
3. Nature-Inspired Optimization in Advanced Manufacturing Processes and Systems, Edited by Ganesh M. Kakandikar and Dinesh G. Thakur, CRC press, First edition, 2021.

**Professional Elective – II**

**Automobile Engineering**

**Course Objectives**:

The Objective of this course is to provide the student to

1. Elaborate the Systems of Automobile, Components of Engine, fuel & Lubrication system and its requirements
2. Explain the significance and features of Cooling, Ignition and Electrical Systems
3. Illustrate the working of transmission system and Suspension systems and its components
4. Elaborate the function of each accessory of steering and braking system and their role for effective performance of automobile
5. Discuss the particulates of combustion in CI and SI engines, reasons for formation of particulates and methods adopted to control the pollution

**Course Outcomes:**

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

1. Illustrate the function of each and every system of an automobiles including fuel system and injection approaches
2. Explain the Cooling, ignition and electrical system of the Automobile
3. Describe each component of transmission system of an automobile viz clutch, gear box, propeller shaft and differential and suspension system and the effect of the same on tyre performance and other components of an automobile
4. Analyze the geometry of the steering mechanism and braking system
5. Demonstrate about emission standards, emission control techniques and electrical systems. Student can identify thrust areas for carrying their dissertation in future.

**UNIT – I:**

**Introduction:** Layout ofautomobile – introduction chassis and body components. Types of Automobile engines. – Power unit – Introduction to engine lubrication – engine servicing

**Fuel System:** S.I. Engine: Fuel supply systems, Mechanical and electrical fuel pump – filters – carburetor – types – air filters – petrol injection. Introduction to MPFI and GDI Systems.

**C.I. Engines:** Requirements of diesel injection systems, types of injection systems, DI Systems IDI systems. Fuel pump, nozzle, spray formation, injection timing, testing of fuel pumps. Introduction to CRDI and TDI Systems.

**UNIT – II:**

**Cooling System:** Cooling Requirements, Air Cooling, Liquid Cooling, Thermo, water and Forced Circulation System – Radiators – Types – Cooling Fan - water pump, thermostat, evaporative cooling – pressure sealed cooling – antifreeze solutions.

**Ignition System:** Function of an ignition system, battery ignition system, constructional features of storage, battery, auto transformer, contact breaker points, condenser, and spark plug – Magneto coil ignition system, electronic ignition system using contact breaker, electronic ignition using contact triggers – spark advance and retard mechanism.

**Electrical System:** Charging circuit, generator, current – voltage regulator – starting system, bendix drive mechanism solenoid switch, lighting systems, Horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator etc.

**UNIT – III:**

**Transmission System:** Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid fly wheel – gear boxes, types, sliding mesh, constant mesh, synchro mesh gear boxes, epicyclic gear box, over drive torque converter. Propeller shaft – Hotch – Kiss drive, Torque tube drive, universal joint, differential rear axles – types – wheels and tyres.

**Suspension System:** Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, independent suspension system.

**UNIT – IV:**

**Braking System:** Mechanical brake system, Hydraulic brake system, Master cylinder, wheel cylinder tandem master cylinder Requirement of brake fluid, Pneumatic and vacuum brakes.

**Steering System:** Steering geometry – camber, castor, king pin rake, combined angle toein, center point steering. Types of steering mechanism – Ackerman steering mechanism, Davis steering mechanism, steering gears – types, steering linkages.

**UNIT – V:**

Emissions from Automobiles – Pollution standards National and international – Pollution Control – Techniques – Multipoint fuel injection for SI Engines. Common rail diesel injection Energy alternatives – Solar, Photo-voltaic, hydrogen, Biomass, alcohols, LPG, CNG, liquid Fuels, and gaseous fuels, Hydrogen as a fuel for IC Engines. - Their merits and demerits. Standard Vehicle maintenance practice.

**TEXT BOOKS:**

1. Automobile Engineering / William H Crouse
2. A Text Book Automobile Engineering–Manzoor, Nawazish Mehdi & Yosuf Ali, Frontline Publications.

**REFERENCE BOOKS:**

1. A Text Book of Automobile Engineering by R K Rajput. Laxmi Publications.
2. Automotive Mechanics / Heitner
3. Automotive Engineering / Newton Steeds & Garrett
4. Automotive Engines / Srinivasan
5. A Text Book of Automobile Engineering By Khalil U Siddiqui New Age International

**Professional Elective – II**

**Industrial Robotics**

**Pre-requisites:** Basic principles of Kinematics and mechanics

**Course Objectives:** The goal of the course is to familiarize the students with the concepts and techniques in robotic engineering, manipulator kinematics, dynamics and control, chose, and incorporate robotic technology in engineering systems.

* Make the students acquainted with the theoretical aspects of Robotics
* Enable the students to acquire practical experience in the field of Robotics through design projects and case studies.
* Make the students to understand the importance of robots in various fields of engineering.
* Expose the students to various robots and their operational details.

**Course Outcomes:** At the end of the course, the student will be able to understand the basic components of robots. Differentiate types of robots and robot grippers. Model forward and inverse kinematics of robot manipulators. Analyze forces in links and joints of a robot. Programme a robot to perform tasks in industrial applications. Design intelligent robots using sensors.

**UNIT – I:**

**Introduction:** Automation and Robotics – An over view of Robotics – present and future applications.

**Components of the Industrial Robotics:** common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity.

**UNIT – II:**

**Motion Analysis:** Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems.

**Manipulator Kinematics**-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulators.

**UNIT – III:**

Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.

Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion – straight line motion.

**UNIT – IV:**

**Robot actuators and Feedback components:** Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors – End Effectors and Tools

**UNIT V:**

**Robot Application in Manufacturing:** Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection. Robotic Programming Methods – Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

**TEXT BOOKS:**

1. Industrial Robotics / Groover M P /Mc Graw Hill
2. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson

**REFERENCE BOOKS:**

1. Robot Dynamics and Controls / Spony and Vidyasagar / John Wiley
2. Robot Analysis and control / Asada, Slotine / Wiley Inter-Science
3. Robotics – Fu et al / TMH Publications.

**Professional Elective – II**

**Mechatronics**

**Prerequisites:** Engineering mechanics and mechanics of materials, Electronic circuits - analysis and design, Mathematics - Calculus, differential equations, numerical methods

**Course Objective:**

* To develop an ability to identify, formulate, and solve engineering problems
* To develop an ability to design a system, component, or process to meet desired needs within realistic constraint
* To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
* To work efficiently in multidisciplinary teams

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

* Model, analyze and control engineering systems.
* Control the behavior of a process using appropriate sensors, transducers and actuators.
* Develop PLC programs for a given task.
* Evaluate the performance of mechatronic systems.

**UNIT-I:**

**Introduction**: Definition of Mechatronics products, Design Considerations and Tradeoffs. Overview of Mechatronics products. Intelligent Machine vs Automatic. Machine, Economic and Social justification.

**Actuators and Motion Control**: Characteristics of Mechanical, electrical, Hydraulic and pneumatic actuators and their limitations. Control parameters and system objectives. Mechanical configurations. Popular control system configurations. Popular control system configurations. S-curve, Motor/load inertia maching, design with linear studies.

**UNIT-II:**

**Motion control Algorithms**: Significance of feed control loops, shortfalls, fundamental concepts adaptive and fuzzy control, fuzzy logic compensatory control of transformation and deformation non-linearities.

**UNIT-III:**

**Architecture of intelligent machines**: Introduction to microprocessor and programmable logic controllers and identification of system, system design classification. Motion control aspects in design

**UNIT-IV:**

**Manufacturing Data bases**: data base management systems, CAD/CAM data bases, Graphic data base, Introduction to object oriented concepts, Object oriented model languages, interface, Procedure and Methods in creation, edition and manipulation of data

**UNIT–V:**

**Sensor Interfacing**: Analog and Digital sensors for Motion Measurement, Digital Transducers, Human machine and Machine-Machine interfacing, devices and Strategy.

Machine Vision: Future and Pattern Reorganization Methods, Concepts of Precision and cognition in decision making

**Text Books:**

1. Introduction to Mechatronics and Measurement Systems, Tata McGraw Hill

**Reference Books:**

1. Designing Intelligent Machines by Michel B. Histand and David G. Alciatore, Open University London
2. Control Sensors and Actuators by ICW. Desiha, Prentice Hall.

**Professional Elective – III**

**Production Planning & Control**

**Pre-requisites:** Management Science & Productivity.

**Course Objectives**: Understand the importance of Production planning & control. Learning way of carrying out various functions so as to produce right product, right quantity at right time with minimum cost.

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

1. Understand production systems and their characteristics.

2. Evaluate MRP and JIT systems against traditional inventory control systems.

3. Describe and apply methods of line balancing and routing techniques..

4. Apply various types of scheduling techniques to production systems.

5. Apply dispatching and follow up techniques to the production control and management system.

**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/13th Edition,2019
2. Production and Operations Management / Ajay K Garg / Mc Graw Hill, 1st Edition,2017

**REFERENCE BOOKS:**

1. Production Planning and Control- Text& cases/ SK Mukhopadhyaya /PHI, 2nd Edition, 2007.
2. Production Planning and Control- Jain & Jain – Khanna publications, 8th Edition, 1999.

**Professional Elective – III**

**Computational Fluid Dynamics**

**Pre-requisite:** Heat Transfer and Fluid Mechanics

**Course Objective:** To apply the principles of Heat Transfer and Fluid Mechanics to formulate governing equations for physical problems and to solve those using different numerical techniques

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

* Differentiate between different types of Partial Differential Equations and to know and understand appropriate numerical techniques.
* Solve the simple heat transfer and fluid flow problems using different numerical techniques, viz., FDM.
* Understand and to appreciate the need for validation of numerical solution.

**UNIT - I:**

Basic Aspects of the Governing Equations – Physical Boundary Conditions – Methods of solutions of Physical Problems – Need for Computational Fluid Dynamics – Different numerical/CFD techniques – FDM, FEM, FVM etc., - Main working principle - CFD as a research and design tool – Applications in various branches of Engineering

Mathematical behavior of Partial Differential Equations (Governing Equations): Classification of linear/ quasi linear PDE – Examples - Physical Processes: Wave Equations and Equations of Heat Transfer and Fluid Flow – Mathematical Behavior - General characteristics – Its significance in understanding the physical and numerical aspects of the PDE – One way and Two Way variables – Well posed problems – Initial and Boundary Conditions

Solution of Simultaneous Algebraic Equations: Direct Method – Gauss Elimination – LU Decomposition – Pivoting – Treatment of Banded Matrices – Thomas Algorithm

Iterative Method: Gauss Seidel and Jordan Methods - Stability Criterion

**UNIT - II:**

Finite Difference Method: Basic aspects of Discretization – Finite Difference formulae for first order and second order terms – Solution of physical problems with Elliptic type of Governing Equations for different boundary conditions - Numerical treatment of 1D and 2D problems in heat conduction, beams etc., - Solutions –Treatment of Curvelinear coordinates – Singularities – Finite Difference Discretization – Solution of 1D heat conduction problems in Heat conduction in curve linear coordinates

**UNIT - III**:

FDM: Solution of physical problems with Parabolic type of Governing Equations – Initial Condition –Explicit, implicit and semi implicit methods – Types of errors – Stability and Consistency – Von Neumann Stability criterion– Solution of simple physical problems in 1D and 2D – Transient Heat conduction problems- ADI scheme - Simple Hyperbolic type PDE - First order and Second order wave equations – Discretization using Explicit method - Stability criterion – Courant Number – CFL Condition - Its significance - Treatment of simple problems

**UNIT - IV:**

Finite Difference Solution of Unsteady Inviscid Flows: Lax – Wendroff Technique – Disadvantages – Maccormack’s Technique

Fluid Flow Equations – Finite Difference Solutions of 2D Viscous Incompressible flow problems – Vorticity and Stream Function Formulation – Finite Difference treatment of Lid Driven Cavity Problem - Application to Cylindrical Coordinates with example of flow over infinitely long cylinder and sphere – Obtaining Elliptic Equations

**UNIT - V:**

Finite Difference Applications in Fluid flow problems: Fundamentals of fluid Flow modeling using Burger’s Equation – Discretization using FTCS method with respect to Upwind Scheme and Transport Property – Upwind Scheme and Artificial Viscosity

Solutions of Navier Stokes Equations for Incompressible Fluid Flows: Staggered Grid – Marker and Cell (MAC) Formulation – Numerical Stability Considerations – Pressure correction method - SIMPLE Algorithm

**TEXT BOOKS:**

1. Computational Fluid Dynamics: The basics with applications/ John D Anderson/McGraw Hill Publications
2. Numerical Heat Transfer and Fluid Flow/ S.V. Patankar/ Mc Graw Hill

**REFERENCE BOOKS:**

1. Computational Fluid Flow and Heat Transfer / K Muralidharan and T Sudarajan/ Narosa Publishers.
2. Computational Methods for Fluid Dynamics / Firziger & Peric/ Springer

**Professional Elective – III**

**Composite Materials**

**Course objectives:**

* Develop understanding of the structure of ceramic materials on multiple length scales.
* Develop knowledge of point defect generation in ceramic materials, and their impact on transport properties.
* To describe key processing techniques for producing metal, ceramic-, and polymer-matrix composites.
* To demonstrate the relationship among synthesis, processing, and properties in composite materials.

**Course Outcomes:**

* Knowledge of the crystal structures of a wide range of ceramic materials and glasses.
* Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure.
* Able to select matrices for composite materials in different applications.
* Able to describe key processing methods for fabricating composites.

**UNIT – I:**

Introduction: Definition, Classification of Composite materials based on structure, based on matrix, Advantages of composites, Applications of composites, Functional requirements of reinforcement and matrix.

**UNIT – II:**

Types of reinforcements and their properties: Fibers: Carbon, Boron, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres, Comparison of fibres. Role of interfaces: Wettability and Bonding, The interface in Composites, Interactions and Types of bonding at the Interface, Tests for measuring Interfacial strength.

**UNIT – III:**

Fabrication of Polymeric Matrix Composites, Structure and properties of Polymeric Matrix Composites, Interface in Polymeric Matrix Composites, Applications; Fabrication of Ceramic Matrix Composites, Properties of Ceramic Matrix Composites, Interface in Ceramic Matrix Composites, Toughness of Ceramic Matrix Composites Applications of Ceramic Matrix Composites.

**UNIT – IV:**

Fabrication of Metal Matrix Composites: Solid state fabrication, Liquid state fabrication and In-situ fabrication techniques; Interface in Metal Matrix Composites: Mechanical bonding, Chemical bonding and Interfaces in In-situ Composites; Discontinuously reinforced Metal Matrix Composites, Properties and Applications. Fabrication of Carbon fiber composites, properties, interface and applications.

**UNIT – V:**

Micromechanics of Composites: Density, Mechanical Properties: Prediction of Elastic constants, Micro mechanical approach, Halpin-Tsai equations, Transverse stresses; Thermal properties: Hydrothermal stresses and Mechanics of Load transfer from matrix to fiber.

**TEXTS BOOKS:**

1. Composite Materials – Science & Engineering, K.K. Chawla, Springer-Verlag, New York, 1987.
2. An Introduction to Composite Materials*,* Hull, Cambridge, 2nd Edt. 1997.

**REFERENCE BOOKS:**

1. Composites, Engineered Materials Handbook, Vol. 1, ASM International, Ohio, 1988.
2. Structure and Properties of Composites, Materials Science and Technology, Vol. 13, VCH, Weinheim, Germany, 1993.
3. Composite Materials: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman & Hall, London, 1994.

**Professional Elective – III**

**Solar Energy Technology**

**Course Objectives**

1. Focus on solar energy utilization
2. Explain the concepts of solar water heating and its layout
3. Concepts of thermal energy storage
4. Discuss the energy conversion technologies
5. Concentrate the economic aspects of Solar Energy

**Course Outcomes**

1. Explain the solar energy potential and construction details of collector with performance analysis
2. Analyse the concepts of solar water heating technologies and its parameters
3. Narrate the methods of solar energy storage and its working
4. Infer the direct energy conversion and conversion efficiencies calculations
5. Discuss the Principles of Economic Analysis and optimization with respect solar energy

**UNIT-I:**

INTRODUCTION – Solar energy option, specialty and potential – Sun – Earth – Solar radiation, beam and diffuse – measurement – estimation of average solar radiation on horizontal and tilted surfaces – problems – applications. Capturing solar radiation – physical principles of collection – types – liquid flat plate collectors – construction details – performance analysis – concentrating collection – flat plate collectors with plane reflectors – cylindrical parabolic collectors – Orientation and tracking – Performance Analysis.

**UNIT-II:**

DESIGN OF SOLAR WATER HEATING SYSTEM AND LAYOUT: Power generation – solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system – Power cycles, working fluids and prime movers, concentration ratio.

**UNIT-III:**

THERMAL ENERGY STORAGE: Introduction – Need for – Methods of sensible heat storage using solids and liquids – Packed bed storage – Latent heat storage – working principle – construction – application and limitations. Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

**UNIT-IV:**

DIRECT ENERGY CONVERSION: solid-state principles – semiconductors – solar cells – performance – modular construction – applications. conversion efficiencies calculations.

**UNIT-V:**

ECONOMICS: Principles of Economic Analysis – Discounted cash flow – Solar system – life cycle costs – cost benefit analysis and optimization – cost based analysis of water heating and photo voltaic applications.

 **Text books:**

1. Principles of solar engineering/ Kreith and Kerider/Taylor and Franscis/2nd Edition.
2. Solar energy thermal processes/ Duffie and Beckman/John Wiley & Sons

**Reference Books**

1. Solar energy: Principles of Thermal Collection and Storage/ Sukhatme/TMH/2nd edition

2. Solar energy/ Garg/TMH 5. Solar energy/ Magal/Mc Graw Hill

3. Solar Thermal Engineering Systems / Tiwari and Suneja/Narosa 7. Power plant Technology/ El Wakil/TMH

**Professional Elective – IV**

**Re-Engineering**

**Professional Elective – IV**

**Non Conventional Energy Sources**

**Course Objectives:** The Objective of this course is to provide the student to

1. Introduce the need of the non-convectional energy sources.
2. Differentiate various solar collectors
3. Identify the energy resources utilization systems
4. Recognize the source and potential of wind energy and understand the classifications of wind mills.
5. Summarize the principles of bio-conversion, ocean energy and geo thermal energy.

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

1. Choose the appropriate renewable energy as an alternate for conventional power in any application.
2. Understand principles of various solar collectors and use them in different applications
3. Inculcate the knowledge on usage of alternate energy sources in I.C Engines
4. Know various energy conversion techniques
5. Analyze large scale demand of heat energy for meeting day to day domestic, institutional and industrial requirements can be met by utilizing solar thermal systems, biogas, PV cells, wind energy, Geothermal, MHD etc.

**UNIT-I:**

Principles of Solar Radiation, Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power - Physics of the sun, the solar constant, extra-terrestrial and terrestrial solar radiation, Solar radiation on titled surface, Instruments for measuring solar radiation and sun shine, solar radiation data.

**UNIT-II:**

Solar Energy Collection Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors. Solar Energy Storage and Applications: Different methods, sensible, latent heat and stratified storage, solar ponds. Solar applications - solar heating/ cooling techniques, solar distillation and drying, Photovoltaic energy conversion.

**UNIT-III:**

Wind Energy Sources and potentials, horizontal and vertical axis windmills, performance characteristics. Bio-Mass: Principles of Bio-Conversion, Anaerobic /aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, I.C. Engine operation, and economic aspects.

**UNIT-IV:**

Geothermal Energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC: Principles, utilization, setting of OTEC plants, thermodynamic cycles. Tidal and Wave Energy: Potential and conversion techniques, mini-hydel power plants, their economics.

**UNIT-V:**

Direct Energy Conversion Need for DEC, Carnot cycle, limitations, Principles of DEC. Thermo-electric generators, Seebeck, Peltier and Joule Thompson effects, figure of merit, materials, applications, MHD generators, principles, dissociation and ionization, hall effect, magnetic flux, MHD accelerator, MHD engine, power generation systems, electron gas dynamic conversion, economic aspects. Fuel cells, principle, faraday’s laws, thermodynamic aspects, selection of fuels and operating conditions.

**TEXT BOOKS:**

1. Renewable Energy Sources/Twidell & Weir /Taylor and Francis / 2nd Special Indian Edition.
2. Non- conventional Energy Sources / G.D. Rai / Dhanpat Rai and Sons.

**REFERENCES:**

1. Energy Resources Utilization and Technologies/Anjaneyulu & Francis/BS Publications/2012.
2. Principles of Solar Energy / Frank Krieth & John F Kreider / Hemisphere Publications.
3. Non-Conventional Energy / Ashok V Desai / Wiley Eastern.
4. Non-Conventional Energy Systems / K Mittal / Wheeler.
5. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
6. Renewable Energy Resources /Tiwari and Ghosal /Narosa.

**Professional Elective – IV**

**Operations Research**

**Prerequisites**: None

**Course Objectives:** Understanding the mathematical importance of development of model in a particular optimization model for the issue and solving it.

**Course Outcome:** Understanding the problem, identifying variables & constants, Formulation of optimization model and applying appropriate optimization technique

**UNIT – I:**

Development-definition-characteristics and phases-Types of models-Operations Research models- applications.

**Allocation:** Linear Programming Problem Formulation-Graphical solution- Simplex method-Artificial variable techniques: Two-phase method, Big-M method.

**UNIT – II:**

**Transportation problem** - Formulation-Optimal solution, unbalanced transportation problem-Degeneracy.

**Assignment problem**- Formulation-Optimal solution, - Variants of Assignment problem- Travelling salesman problem.

**UNIT – III:**

**Sequencing-** Introduction-Flow-Shop sequencing- n jobs through two machines – n jobs through three machines- Job shop sequencing-two jobs through ‘m’ machines

**Replacement**: Introduction- Replacement of items that deteriorate with time- when money value is not counted and counted- Replacement of items that fail completely- Group Replacement.

**UNIT – IV:**

**Theory of Games**: Introduction- Terminology- Solution of games with saddle points and without saddle points. 2 x 2 games- dominance principle- m x 2 & 2 x n games- Graphical method.

**Inventory**: Introduction- Single item, Deterministic models- purchase inventory models with one price break and multiple price breaks- Stochastic models \_ Demand may be discrete variable or continuous variable- single period model and no setup cost.

**UNIT – V:**

**Waiting lines**: Introduction- Terminology- Single channel- Poisson arrivals and Exponential service times with infinite population.

**Dynamic Programming:** Introduction- Terminology, Bellman’s principle of optimality- Applications of Dynamic programming- shortest path problem- linear programming problem.

**TEXT BOOK:**

1. Operations Research/ J. K. Sharma4e./ MacMilan
2. Introduction to OR/ Hillier & Libemann/TMH

**REFERENCE BOOKS:**

1. Introduction to OR/Taha/PHI
2. Operations Research/NVS Raju/SMS Education/3rd Revised Edition
3. Operations Research /A. M. Natarajan, P.Balasubramaniam, A. Tamilarasi/Pearson Education.
4. Operations Research/ Wagner/ PHI Publications.
5. Operations Research/M.V. Durga Prasad, K.Vijaya Kumar Reddy, J. Suresh Kumar/Cengage Learning.

**Professional Elective – IV**

**Electric and Hybrid Vehicles**

**Course Objectives**

1. Explain the history of Electric vehicles and development
2. Discuss the Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies
3. Explore to basic concept of electric traction, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives etc.
4. Analyse the Fuel Cell based energy storage and Super Capacitor based energy storage etc.
5. Explore to types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others) etc.

**Course Outcomes**

1. Choose the appropriate source of energy for the hybrid electric vehicle based on driving cycle.
2. Analyze the power and energy need of the various hybrid electric vehicle and Measure and Estimate the energy consumption of the Hybrid Vehicles
3. Evaluate energy efficiency of the vehicle for its drive trains
4. Elaborate the types of storage systems such as battery based, fuel cell based etc.
5. Explain the types of Driving Cycles, Fuel Cell EV, Solar Powered Vehicles

**UNIT-I:**

INTRODUCTION TO ELECTRIC VEHICLE: History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.

**UNIT-II:**

INDUCTION TO HYBRID ELECTRIC VEHICLE: Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

**UNIT-III:**

ELECTRIC DRIVE TRAINS: Basic concept of electric traction, introduction to various electric drivetrain topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency

**UNIT-IV:**

TYPES OF STORAGE SYSTEMS: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Calculation for the rating.

**UNIT-V:**

MODELLING OF HYBRID ELECTRIC VEHICLE RANGE: Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2 wheeler, 3 wheeler and 4 wheeler vehicles.

TEXT BOOKS

1. James Larminie, J. Lowry, “Electric Vehicle Technology Explaned”, John Wiley & Sons Ltd. 2003.
2. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.

REFERENCE BOOKS

1. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
2. Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2003.

**Open Elective – II**

**Quantitative Analysis for Business Decisions**

**Course Objective:**

To prepare engineering students to analyze cost/ revenue/ financial data and to make economic and financial analysis in decision making process and to examine the performance of companies engaged in engineering.

**Course Outcome:**

To perform and evaluate present and future worth of the alternate projects and to appraise projects by using traditional and DCF Methods. To carry out cost benefit analysis of projects and to calculate BEP of different alternative projects.

**UNIT- I:**

**Introduction to Engineering Economics-** Basic Principles and Methodology of Engineering Economics– Fundamental Concepts - Demand – Demand Determinants - Law of Demand- Demand Forecasting and Methods - Elasticity of Demand - Theory of Firm – Supply- Elasticity of Supply.

**UNIT- II:**

**Macro Economic Concepts:** National Income Accounting - Methods of Estimation- Various Concepts of National Income - Inflation – Definition – Causes of Inflation and Measures to Control Inflation - New Economic Policy 1991 (Industrial policy, Trade policy, and Fiscal policy) Impact on Industry.

**UNIT- III:**

**Production, Cost, Market Structures & Pricing:**

Production Analysis: Factors of Production, Production Function, Production Function with one variable input, two variable inputs, Returns to Scale, Different Types of Production Functions. Cost analysis: Types of Costs, Short run and Long run Cost Functions. Market Structures: Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, and Monopolistic Competition. Pricing: Types of Pricing, Product Life Cycle based Pricing, Break Even Analysis, Cost Volume Profit Analysis.

**UNIT- IV:**

**Capital Budgeting Techniques:** Significance of Capital Budgeting - cash flows-Time Value of Money- Choosing between alternative investment proposals- Methods of Appraisal Techniques- Pay Back Period - Average Rate of Return – Net Present Value- Internal Rate of Return – Profitability Index.

**UNIT- V:**

**Introduction to Accounting:** Accounting Principles (GAPP), concepts, conventions- - Double entry system of Book keeping – Accounting rules- Journal- ledger- Trial balance- Trading and Profit and Loss account- Balance Sheet. (Simple Problems)

**Reference Books:**

1. Engineering Economics by Henry Malcom Steinar, Principles, Mc Graw Hill Pub.
2. Business Economics - Theory and Applications by D.D.Chaturvedi, S.L.Gupta, International Book House Pvt. Ltd. 2013.
3. Accounting by Jain and Narang, Kalyani Publishers.
4. Cost Accounting by Arora, M.N., Vikas Publication.
5. Financial Management by S.N.Maheshwari, Vikas Publishing House.

**Open Elective – II**

**Industrial Engineering & Management**

**Prerequisites:** None

**Pre-requisites: Nil**

**Course objectives:** The main objectives of this course are the following:

Learn

* Philosophies of various management gurus & characteristics of various organization structures
* Various Industrial Engineering practices
* Human resource management practices
* Network analysis through PERT and CPM techniques

**Course outcomes:** At the end of course, students should be able to

* Practice the management theories proposed by Taylor, Fayol etc
* Consider various factors and identify plant location for given industry.
* Determine EOQ, classify items and implement P-system and Q-system
* Conduct work study (method study+ Work measurement: a) Time study &

Work sampling))

* Practice HRM principles
* Analyze the networks by using PERT & CPM

**UNIT - I:**

**Management and Organisation** – Functions of Management - Contributions of Taylor, Fayol, Douglas Mc-Gregor, Mayo Hertzberg and Maslow. – Systems Approach to Management - *Organisational Structures:*Basic concepts related to Organisation - Departmentation and Decentralisation, Types of mechanistic and organic structures of organisation and their merits, demerits and suitability.

**UNIT- II:**

**Operations Management-I:** Plant location, definition, factors affecting the plant location, comparison of rural and urban sites-methods for selection of plant- Matrix approach. Types of plant layout – various data analyzing forms-travel chart - Work study: Method study and Work measurement. Inventory – functions, types, Determination of Economic Order Quantity (EOQ), ABC and VED analysis. Inventory Control Systems-Continuous review system-periodical review system. Stores Management and Stores Records. Purchase management, duties of purchase of manager, JIT System.

**UNIT –III:**

**Operations Management-II:** Inspection and quality control, types of inspections - Statistical Quality Control-techniques- Charts for variables and attributes. Acceptance sampling plan- single sampling and double sampling plans-OC curves. Introduction to TQM-Quality Circles, ISO 9000 series procedures. Functions of Marketing, Marketing vs Selling, Marketing mix, Product Life Cycle.

**Unit -IV:**

**Human Resources Management (HRM):** Concepts of HRM, HRD and Personnel Management and Industrial Relations (PMIR), HRM vs PMIR, Basic functions of HR Manager: Manpower planning, Recruitment, Selection, Training and Development, Placement, Wage and Salary Administration, Promotion, Transfer, Separation, Performance Appraisal, Grievance Handling and Welfare Administration, Job Evaluation and Merit Rating – Capability Maturity Model (CMM) Levels – Performance Management System.

**UNIT- V:**

**PERT / CPM:** Project management, network modelling-probabilistic model, various types of activity time’s estimation-programme evaluation review techniques- Critical Path-probability of completing the project, Critical Path Method (CPM) - Project crashing. Simple problems.

**TEXT BOOKS**

1. Aryasri, Management Science, McGraw hill, 2012
2. Kumar, Rao and Chhalill: Introduction to Management Science, Cengage 2012.

**REFERENCES:**

1. Stoner, Freeman, Gilbert, Management, Pearson Education, New Delhi, 2012.
2. Amrine, Manufacturing Organization and Management, Pearson, 2012.
3. Chase, Jacobs, Aquilano, Operations Management, McGraw Hill, 2012.
4. Panner Selvam, Production and Operations Management, PHI, 2012.
5. Nadha Muni Reddy & Vijaya Kumar Reddy, Reliability Engineering & Quality Engineering, Galgotia, 2012.
6. Ralph M Barnes, Motion and Time Studies, John Wiley and Sons, 2012.
7. L.S.Srinath, PERT / CPM, Affiliate East-West Press, New Delhi, 2012.
8. Gary Dessler, Human Resource Management, Pearson Education Asia,
9. 2012.
10. Phillip Kotler, Marketing Management, Pearson, 2012.
11. S.K.Basu, K.C.Sahu,B.Rajiv: Industrial Organization and Management, PHI, 2012.
12. Dipak Kumar Bhattacharyya: Industrial Management, Vikas publishing house 2013.

IV Year II Sem

**Professional Elective – V**

**Automation in Manufacturing**

**Course Objectives:**

1. To understand types of Automation and production system technologies in modern manufacturing.
2. To understand importance of automated flow lines in manufacturing a product.
3. To understand the Assembly system and Line Balancing in Manufacturing System.
4. To understand Automated Material handling equipments and Automated Storage Systems.
5. To understand industrial control and automatic inspection techniques.

**Course Outcomes:** After the completion of the course, the student will be able to

CO 1: Describe the importance of Automation implementation in Manufacturing.

CO 2: Analyze the various Automated flow lines.

CO 3: Perform Line balancing of assembly system.

CO 4: Describe automated Material Handling and automated storage

CO 5: Explain Industrial Process controls and automatic inspection.

**UNIT – I:**

**Introduction:** Types and strategies of automation, pneumatic and hydraulic components circuits, Automation in machine tools. Mechanical feeding and too changing and machine tool control transfer the automaton.

**UNIT – II:**

**Automated flow lines**: Methods or work part transport transfer Mechanical buffer storage control function, design and fabrication consideration.

**Analysis of Automated flow lines**: General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

**UNIT – III:**

**Assembly system and line balancing**: Assembly process and systems assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

**UNIT –IV:**

**Automated material handling:** Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems.

Automated storage systems, Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

**UNIT –V:**

**Fundamentals of Industrial controls:** Review of control theory, logic controls, sensors and actuators, Data communication and LAN in Manufacturing.

Business process Re-engineering: Introduction to BPE logistics, ERP, Software configuration of BPE.

**TEXT BOOK:**

1. Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover./Pearson Education/4th Edition, 2016.
2. Computer Control of Manufacturing Systems/ Yoram koren/ Mc Graw Hill/ 1st Edition, 1983.

**REFERENCE BOOKS:**

1. Computer Aided Manufacturing/Tien-Chien Chang, Richard A. Wyskand Hsu-Pin Wang/Pearson/ 3rd Edition, 2005.
2. Automation /W. Buekinsham/PHI Publications/ 1st Edition,2011

**Professional Elective – V**

**Turbo Machinery**

**Pre-requisites:** Thermal Engineering, Heat Transfer

**Course Objectives:**

* Provide students with opportunities to apply basic flow equations
* Train the students to acquire the knowledge and skill of analyzing different turbo machines.
* How to compare and chose machines for various operations

**Course Outcomes:**

* Ability to design and calculate different parameters for turbo machines
* Prerequisite to CFD and Industrial fluid power courses
* Ability to formulate design criteria
* Ability to understand thermodynamics and kinematics behind turbo machines

**UNIT – I:**

**Introduction to Turbomachinery:** Classification of turbo-machines, second law of thermodynamics applied to turbine and compressors work, nozzle, diffuser work, fluid equation, continuity, Euler‘s, Bernoulli‘s, equation and its applications, expansion and compression process, reheat factor, preheat factor

**UNIT – II:**

**Fundamental Concepts of Axial and Radial Machines:** Euler‘s equation of energy transfer, vane congruent flow, influence of relative circulation, thickness of vanes, number of vanes on velocity triangles, slip factor, Stodola, Stanitz and Balje‘s slip factor, suction pressure and net positive suction head, phenomena of cavitation in pumps, concept of specific speed, shape number, axial, radial and mixed flow machines, similarity laws.

**UNIT – III:**

**Gas Dynamics**: Fundamental thermodynamic concepts, isentropic conditions, mach numbers, and area, Velocity relations, Dynamic Pressure, Normal shock relation for perfect gas. Supersonic flow, oblique shock waves. Normal shock recoveries, detached shocks, Aerofoil theory.

**Centrifugal compressor**: Types, Velocity triangles and efficiencies, Blade passage design, Diffuser and pressure recovery. Slip factor, Stanitz and Stodolas formula's, Effect of inlet mach numbers, Pre whirl, Performance

**UNIT – IV:**

**Axial Flow Compressors**: Flow Analysis, Work, and velocity triangles, Efficiencies, Thermodynamic analysis. Stage pressure rise, Degree of reaction, Stage Loading, General design, Effect of velocity, Incidence, Performance

**Cascade Analysis**: Geometrical and terminology. Blade force, Efficiencies, Losses, Free end force, Vortex Blades.

**UNIT – V:**

**Axial Flow Gas Turbines**: Work done. Velocity triangle and efficiencies, Thermodynamic flow analysis, Degree of reaction, Zweifels relation, Design cascade analysis, Soderberg, Hawthrone, Ainley, Correlations, Secondary flow, Free vortex blade, Blade angles for variable degree of reaction. Actuator disc, Theory, Stress in blades, Blade assembling, Material and cooling of blades, Performances, Matching of compressors and turbines, off design performance.

**TEXT BOOKS:**

1. Principles of Turbo Machines/DG Shepherd / Macmillan
2. Turbines, Pumps, Compressors/Yahya/ Mc Graw Hill

**REFERENCE BOOKS:**

1. A Treatise on Turbo machines / G. Gopal Krishnan *and* D. Prithviraj/ SciTech
2. Gas Turbine Theory/ Saravanamuttoo/ Pearson
3. Turbo Machines/ A Valan Arasu/ Vikas Publishing House Pvt. Ltd.

**Professional Elective – V**

**Additive Manufacturing**

**Pre-requisites:** Manufacturing Processes, Engineering Materials

**Course Objectives:**

* To understand the fundamental concepts of Additive Manufacturing (i.e. Rapid Prototyping) and 3-D printing, its advantages and limitations.
* To classify various types of Additive Manufacturing Processes and know their working principle, advantages, limitations etc.
* To have a holistic view of various applications of these technologies in relevant fields such as mechanical, Bio-medical, Aerospace, electronics etc.

**Course Outcomes:** After the completion of the course, the student will be able to

* Explain and summarize the principles and key characteristics of additive manufacturing technologies and commonly used 3D printing and additive manufacturing systems.
* Describe various liquid based Rapid Prototyping systems.
* Understand and apply different powder based Rapid Prototype systems.
* Describe various CAD issues for 3D printing and rapid prototyping and related operations for STL model manipulation.
* Understand and apply Rapid prototyping in various applications like forensic science, anthropology and medicine etc.

**UNIT – I:**

**Introduction:** Prototyping fundamentals, Historical development, Fundamentals of Rapid Prototyping, Advantages and Limitations of Rapid Prototyping, Commonly used Terms, Classification of RP process, Rapid Prototyping Process Chain: Fundamental Automated Processes.

**UNIT – II:**

**Liquid-based Rapid Prototyping 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. Solid ground curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies Solid-based Rapid Prototyping Systems: 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 Rapid Prototyping Systems: Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Three dimensional Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT. Rapid Tooling Classification; Indirect Rapid Tooling Methods: Spray Metal Deposition, RTV Epoxy Tools, Ceramic tools, Investment Casting, Spin Casting, Die casting, Sand Casting, 3D Keltool process. Direct Rapid Tooling: Direct AIM, LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP

**UNIT – IV:**

Rapid Prototyping Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Rapid Prototyping Software’s: Features of various RP software’s like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor.

**UNIT – V:**

RP Applications: Application - Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture. RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Biomolecules.

**TEXT BOOKS:**

1. Rapid prototyping; Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/World Scientific Publications/3rd Edition,2010
2. Rapid Manufacturing /D.T. Pham and S.S. Dimov/Springer/1st Edition,2012

**REFERENCE BOOKS:**

1. Terry Wohlers, Wholers Report 2000, Wohlers Associates.
2. Rapid Prototyping and Manufacturing /PaulF.Jacobs/ASME/ 1st Edition, 1993.

**Professional Elective – V**

**Energy Conservation and Management**

**Course Objectives:**

1. To understand the principles of energy conservation
2. To understand thermal insulation & refractors.
3. To know waste heat recovery systems.
4. To gain knowledge about engineering economics.
5. To impart knowledge Energy management programs.

**Course Outcomes:**

1. Explain the basic concept of energy conservation and its role in energy management.
2. Focus on thermal Insulation & refractors, classification and applications.
3. Discuss the energy conservation opportunities in the energy intensive industries by waste heat recovery system.
4. Analyze the quantum of electrical energy that can be saved by the use of energy efficient lighting systems and energy audit parameters.
5. Understand concept of Project management and energy management Programs

**UNIT-I:**

 ENERGY CONSERVATION: Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management, alternate energy sources, and energy storage.

**UNIT-II:**

THERMAL INSULATION & REFRACTORS: Heat loss through un-insulated surfaces, effects of insulation on current carrying wires – economic thickness of insulation – critical radius of insulation – properties of thermal insulators – classification of insulation materials – classification of refractors – properties of refractors – criteria for good refractory material – applications of insulating & refractory materials.

**UNIT-III:**

WASTE HEAT RECOVERY SYSTEMS: Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchanger – thermal wheel – heat pipe heat exchanger – heat pump – waste heat boilers – incinerators.

HEAT RECOVERY SYSTEMS & HEAT EXCHANGER NETWORKS: Liquid to liquid heat exchangers – gas to liquid heat recovery systems, regenerators, recuperators, rotating regenerators – miscellaneous heat recovery methods – selection of materials for heat exchangers – combined radiation and convective heat exchanger, U tube heat exchanger, tube heat exchanger, fluidized bed heat exchanger – economizer.

**UNIT-IV:**

ENGINEERING ECONOMICS: Managerial objectives, steps in planning – efficiency of organization- capital budgeting – classification of costs – interest – types – nominal and effective interest rates – discrete and continuous compounding – discounting - time value of money – cash flow diagrams – present worth factor, capital recovery factor, equal annual payments – equivalent between cash flows. ENERGY AUDITING: A definition – objectives – level of responsibility – control of energy – uses of energy – check lists – energy conservation schemes – energy index – cost index – pie charts – sankey diagrams – load profiles – types of energy audits – questionnaire – energy audit of industries – general energy audit – detailed energy audit – energy saving potential.

**UNIT-V:**

PROJECT MANAGEMENT: Method of investment appraisal – rate of return method, pay back method, net present value method (NPV) – adoption of the methods in energy conservation campaign – types of projects –– propose of project management – classification – role and qualities of project manager – types of budgets - budget committee – budgeting.

ENERGY MANAGEMENT PROGRAMS: Necessary steps of energy management programme – concepts of energy management – general principles of energy management – energy management in manufacturing and process industries – qualities and functions of energy managers – duties of energy manager - language of energy manager – checklist for top management.

**TEXT BOOKS:**

1. Waste heat recovery systems -D.A. Reay/Pergmon Press.
2. Energy Management -W.R. Murphy & G.Mickay, Butterworths

**REFERENCE BOOKS:**

1. Energy Conservation -P.W.O’ Callaghan, Pargamon Press 1981.
2. Engineering Heat Audits -C.P. Gupta & Rajendra Prakash, Nechand & Bros.
3. Hand book of energy audits -Albert Thumann, The F.Airmont Press Inc., Atlanta Georgia, 1979.
4. Energy Management Principles -Craig B. Smithm, Pergarmon Press

Professional Elective – VI

**Industry 4.0**

**Professional Elective – VI**

**Fluid Power System**

**Pre-requisites**: Fluid Mechanics and Hydraulics Machinery

**Course outcomes:** After doing this, student should be able to

* Understand the Properties of fluids, Fluids for hydraulic systems,
* Governing laws distribution of fluid power, Design and analysis of typical hydraulic circuits.
* Know accessories used in fluid power system, Filtration systems and maintenance of system.

**UNIT- I:**

Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. ISO symbols, energy losses in hydraulic systems. Applications, Basic types and constructions of Hydraulic pumps and motors. Pump and motor analysis. Performan curves and parameters.

**UNIT- II:**

Hydraulic actuators, types and constructional details, lever systems, control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves. Series and parallel pressure compensation flow control valves. Flapper valve Analysis and Design.

**UNIT- III:**

Proportional control valves and servo valves. Nonlinearities in control systems (backlash, hysteresis, dead band and friction nonlinearities). Design and analysis of typical hydraulic circuits. Regenerative circuits, high low circuits, Synchronization circuits, and accumulator sizing.

**UNIT- IV:**

Intensifier circuits Meter-in, Meter-out and Bleed-off circuits; Fail Safe and Counter balancing circuits, accessories used in fluid power system, Filtration systems and maintenance of system. Components of pneumatic systems; Direction, flow and pressure control valves in pneumatic systems. Development of single and multiple actuator circuits. Valves for logic functions; Time delay valve; Exhaust and supply air throttling;

**UNIT- V:**

Examples of typical circuits using Displacement – Time and Travel-Step diagrams. Will-dependent control, Travel-dependent control and Time dependent control, combined control, Program Control, Electropneumatic control and air-hydraulic control, Ladder diagrams. Applications in Assembly, Feeding, Metal working, materials handling and plastics working.

**TEXT BOOKS:**

1. Fluid Power Control systems/ Pippenger, J.J., and R. M. Koff/ New York: McGraw Hill.
2. Fluid Power Systems: modeling, simulation and microcomputer control”/ John Watton/ Prentice Hall International.

**REFERENCE BOOKS:**

1. Fundamentals of Fluid Power Control. / John Watton/ 1st Ed. Cambridge University Press, 2009.
2. Fluid Power with applications”/ Anthony Esposito / Pearson Education.

**Professional Elective – VI**

**Fuzzy Logic and ANN**

**Prerequisite:** Operations research, Optimisation Techniques**,** Control Systems

**Course Objectives:**  The goal of this course is to give a good basic understanding of Neural Networks and Fuzzy Logic. This course is mainly intended for engineers who desire to learn more about these techniques

**Course outcomes:** After completion of this course, the student should be able to

* Learn concepts of neural networks and fuzzy logics
* Understand the topology of multi-layer perceptron, recurrent neural networks and
* Fuzzification & Defuzzification.
* understand the basic structure and operation of Fuzzy logic control systems

**UNIT-I:**

**Evolution of neural networks; Artificial Neural Network**: Basic model, Classification, Feed forward and Recurrent topologies, Activation functions; Learning algorithms: Supervised, Un-supervised and Reinforcement; Fundamentals of connectionist modeling: McCulloach – Pits model, Perceptron, Adaline, Madaline.

**UNIT–II**:

Topology of Multi-layer perceptron, Back propagation learning algorithm, limitations of Multi-layer perceptron. Radial Basis Function networks: Topology, learning algorithm; Kohenen’s self-organising network: Topology, learning algorithm; Bidirectional associative memory Topology, learning algorithm, Applications.

**UNIT–III**:

Recurrent neural networks: Basic concepts, Dynamics, Architecture and training algorithms, Applications; Hopfield network: Topology, learning algorithm, Applications; Industrial and commercial applications of Neural networks: Semiconductor manufacturing processes, Communication, Process monitoring and optimal control, Robotics, Decision fusion and pattern recognition.

**UNIT–IV**:

Classical and fuzzy sets: Introduction, Operations and Properties, Fuzzy Relations: Cardinality, Operations and Properties, Equivalence and tolerance relation, Value assignment: cosine amplitude and max-min method; Fuzzification: Membership value assignment- Inference, rank ordering, angular fuzzy sets. Defuzzification methods, Fuzzy measures, Fuzzy integrals, Fuzziness and fuzzy resolution; possibility theory and Fuzzy

arithmetic; composition and inference; Considerations of fuzzy decision-making.

**UNIT-V:**

 Basic structure and operation of Fuzzy logic control systems; Design methodology and stability analysis of fuzzy control systems; Applications of Fuzzy controllers. Applications of fuzzy theory.

**Text Books:**

1. Neural Networks in Computer Intelligence by Limin Fu, McGraw Hill, 2003.
2. Soft Computing and Intelligent Systems Design, Theory, Tools and Applications by Fakhreddine O. Karray and Clarence De Silva., Pearson Education, India, 2009.

**Reference Books:**

1. Fuzzy Logic with Engineering Applications by Timothy J. Ross, McGraw Hill, 1995.
2. Artificial Neural Networks by B.Yegnanarayana, PHI, India, 2006.

**Professional Elective – VI**

**Total Quality Management**

**Course Objectives:**

1. Develop an understanding of the necessary information and skills needed to manage, control and improve quality practices in the organizations through TQM philosophy.
2. To understands customer and supplier relationship and Bench marketing.
3. Apply TQM in traditional organizations.
4. Analysis of quality in cost and management.
5. To understand various ISO around the world.

**Course Outcomes:** After completion of the course the student will be able to

CO 1: Understand the concept of TQM and various control charts.

CO 2: To analyze the relationship between customer and supplier.

CO 3: Implement TQM in an organization.

CO 4: To evaluate the cost of quality.

CO 5: Understand the third party audit and documentation of various ISO.

**UNIT – I:**

Introduction: The concept of TQM, Quality and Business performance, attitude and involvement of top management, communication, culture and management systems. Management of Process Quality: Definition of quality, Quality Control, a brief history, Product Inspection vs, Process Control, Statistical Quality Control, Control Charts and Acceptance Sampling.

**UNIT – II:**

Customer Focus and Satisfaction: Process Vs. Customer, internal customer conflict, quality focus, Customer Satisfaction, role of Marketing and Sales, Buyer – Supplier relationships. Bench Marketing: Evolution of Bench Marketing, meaning of Bench marketing, benefits of bench marketing, the bench marketing process, pitfalls of bench marketing.

**UNIT – III:**

Organizing for TQM: The systems approach, Organizing for quality implementation, making the transition from a traditional to a TQM organizing, Quality Circles. Productivity, Quality and Reengineering: The leverage of Productivity and Quality, Management systems Vs. Technology, Measuring Productivity, Improving Productivity Re-engineering.

**UNIT – IV:**

The Cost of Quality: Definition of the Cost of Quality, Quality Costs, Measuring Quality Costs, use of Quality Cost Information, Accounting Systems and Quality Management.

**UNIT – V:**

ISO9000: Universal Standards of Quality: ISO around the world, The ISO9000 ANSI/ASQCQ-90. Series Standards, benefits of ISO9000 certification, the third party audit, Documentation ISO9000 and services, the cost of certification implementing the system.

**REFERENCE BOOKS:**

1. Total Quality Management - Joel E. Ross.
2. Beyond TQM - Robert L. Flood.
3. Statistical Quality Control - E. L. Grant.

**Open Elective – III**

**Entrepreneurship ~~Development~~**

OBJECTIVES:

* Study of this subject provides an understanding of the scope of an entrepreneur, key areas of development, financial assistance by the institutions, methods of taxation and tax benefits, etc.

COURSE OUTCOMES:

* Upon completion of the course, students will be able to gain knowledge and skills needed to run a business successfully.

UNIT-I: **ENTREPRENEURSHIP**

Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth.

UNIT-II: **MOTIVATION**

Major Motives Influencing an Entrepreneur – Achievement Motivation Training, Self Rating, Business Game, Thematic Apperception Test – Stress Management, Entrepreneurship Development Programs – Need, Objectives.

UNIT-III: **BUSINESS**

Small Enterprises – Definition, Classification – Characteristics, Ownership Structures – Project Formulation – Steps involved in setting up a Business – Identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment – Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information – Classification of Needs and Agencies.

UNIT-IV: **FINANCING AND ACCOUNTING**

Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, Management of working Capital, Costing, Break Even Analysis, Network Analysis Techniques of PERT / CPM – Taxation – Income Tax, Excise Duty – Sales Tax.

UNIT-V: **SUPPORT TO ENTREPRENEURS**

Sickness in small Business – Concept, Magnitude, Causes and Consequences, Corrective Measures – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger and Sub Contracting

TEXT BOOKS:

1. S.S.Khanka, “Entrepreneurial Development” S.Chand & Co. Ltd. Ram Nagar New Delhi, 1999.
2. Kurahko & Hodgetts, “Enterprenuership – Theory, process and practices”, Thomson learning 6th edition.

REFERENCES:

1. Hisrich R D and Peters M P, “Entrepreneurship” 5th Edition Tata McGraw-Hill, 2002.
2. Mathew J Manimala”, Enterprenuership theory at cross roads: paradigms and praxis” Dream tech, 2nd Edition 2006.
3. Rabindra N. Kanungo, “Entrepreneurship and innovation”, Sage Publications, New Delhi, 1998.
4. EDII “Faulty and External Experts – A Hand Book for New Entrepreneurs Publishers: Entrepreneurship Development”, Institute of India, Ahmadabad, 1986.

**Open Elective – III**

**Elements of Electric and Hybrid vehicles**

**Course Objectives**

1. Explain the history of Electric vehicles and development
2. Discuss the Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies
3. Explore to basic concept of electric traction, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives etc.
4. Analyse the Fuel Cell based energy storage and Super Capacitor based energy storage etc.
5. Explore to types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others) etc.

**Course Outcomes**

1. Choose the appropriate source of energy for the hybrid electric vehicle based on driving cycle.
2. Analyze the power and energy need of the various hybrid electric vehicle and Measure and Estimate the energy consumption of the Hybrid Vehicles
3. Evaluate energy efficiency of the vehicle for its drive trains
4. Elaborate the types of storage systems such as battery based, fuel cell based etc.
5. Explain the types of Driving Cycles, Fuel Cell EV, Solar Powered Vehicles

**UNIT-I:**

INTRODUCTION TO ELECTRIC VEHICLE: History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.

**UNIT-II:**

INDUCTION TO HYBRID ELECTRIC VEHICLE: Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

**UNIT-III:**

ELECTRIC DRIVE TRAINS: Basic concept of electric traction, introduction to various electric drivetrain topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency

**UNIT-IV:**

TYPES OF STORAGE SYSTEMS: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Calculation for the rating.

**UNIT-V:**

MODELLING OF HYBRID ELECTRIC VEHICLE RANGE: Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2 wheeler, 3 wheeler and 4 wheeler vehicles.

**TEXT BOOKS**

1. James Larminie, J. Lowry, “Electric Vehicle Technology Explaned”, John Wiley & Sons Ltd. 2003.
2. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.

REFERENCE BOOKS

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