SYLLABI

BME-01	ENGINEERING MECHANICS	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1.Use scalar and vector analytical techniques for analysing forces in statically determinate structures.
2. Apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems
3. Understand basic kinematics concepts – displacement, velocity and acceleration (and their angular counterparts);
4. Understand basic dynamics concepts – force, momentum, work and energy and Newton's laws of motion.

Topics Covered

UNIT-I	
Introduction to Engineering Mechanics covering, Force Systems Basic concepts, Particle equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static indeterminacy. Friction covering, Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, belt & rope friction, screw jack & differential screw jack.	9
UNIT-II	
Trusses and frames: Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members; Beams & types of beams; Shear force and bending moment diagrams. **Centroid and Centre of Gravity** covering, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere.	9
UNIT-III	
Kinematics of a rigid body: Introduction, Plane motion of a rigid body, Linear motion, Translation of a point with constant acceleration, Equation of motion due to gravity, Angular motion, Relation between angular displacement and angular velocity with constant angular acceleration, Curvilinear motion of a particle, Normal and tangential acceleration, General plane motion, Instantaneous centre of rotation **Introduction to Stress & Strain:** Hooks law, stress strain relations, normal and shear	9

strain. Thermal effects.	
UNIT-IV	
Kinetics of rigid body: Introduction, Laws of motion, Kinetics of rigid bodies, Motion on inclined rough surface, Analysis of lift motion, Motion of two bodies connected by a string, Pure rotation of a rigid body, General motion of a rigid body, Work and energy, Linear and angular momentum, D-Alembert's principle, Work energy principle and its application. **Mechanical Vibrations:** Basic terminology, free and forced vibrations, resonance and its effects; Degree of freedom; Derivation for frequency and amplitude of free vibrations without damping and single degree of freedom system, simple problems.	9
EXPERIMENTS **Note: Minimum Eight experiments are to be performed** 1. Tensile strength test on universal testing machine 2. Compressive strength test on universal testing machine 3. Impact test on Impact testing machine 4. Hardness testing of given specimen on Vicker/Brinell hardness testing machine 5. Torsion test of a rod on torsion testing machine 6. Determination of closed coil and open coil spring stiffness on spring testing machine 7. Experiments on friction between belt and pulley 8. Experiments on flywheel 9. Friction experiments on inclined plane/Screw jack 10. Experiments on bending of simple supported and cantilever beams 11. Statics experiments on equilibrium 12. Experiment on moment of inertia	

Books& References

1. Engineering Mechanics: Statics and dynamics - I.H. Shames(PHI)
2. Vector Mechanics for Engineers, Vol I - Statics, Vol II – Dynamics, F. P. Beer and E. R. Johnston (Tata McGraw Hill).
3. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I – Statics, Vol II –Dynamics,J. L. Meriam and L. G. Kraige (John Wiley).
4. Engineering Mechanics: Principles of Statics and Dynamics R. C. Hibbler, (Pearson Press).
5. Engineering Mechanics -S S Bhavikatti (New Age International)
6. Engineering Mechanics - D S Kumar (Katson)
7. Engineering Mechanics, M. K. Harbola, (Cengage Learning)
8. Engineering Mechanics - H D Ram and A K Chauhan (McGraw Hill)
9. Engineering Mechanics- R. K. Bansal (Laxmi Publications)

BME-02	**FUNDAMENTALS OF MECHANICAL ENGINEERING**	
Course category	:	For Other Department
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this

		course

1. The knowledge of basic laws of thermodynamics; steam generation and its properties; refrigeration cycles, properties and machines; and reciprocating engine such as two/four strokes IC engines.
2. The knowledge of measuring instruments, types of transducers for measurement of different geometrical parameters.
3. The ability to understand different types of stresses, Hooke's law and its applications, different mechanical properties of engineering materials.
4. The knowledge of different types of beams, shear force and bending moment diagrams for statically determinate beams, stresses in simple bending of beams and torsion in circular shafts.

Topics Covered

UNIT-I	9
Thermodynamics First and second law of thermodynamics, statements of Second Law of Thermodynamics and their equivalence, Third law of thermodynamics, Steam properties, Steam processes at constant pressure, volume, enthalpy and entropy, Classification of steam boilers, boiler mounting and accessories, Refrigeration, Basics of Vapour compression and vapour absorption system, Coefficient of performance (COP), Refrigerants properties. **Reciprocating Machines** Introduction to hydraulic machine and compressor, Carnot cycle, Otto and Diesel cycles, Working of two and four strokes petrol and diesel engines.	
UNIT-II	9
Measurement & Metrology Introduction to measurement and measuring instruments, Types of sensors and transducers and their characteristics, measuring error uncertainty analysis, Temperature, pressure, velocity, flow, strain, force and torque introduction of dial gauges, slip gauges and sine bar **Engineering Materials** Classification of materials, Ferrous and nonferrous metals, Composition of cast iron, carbonsteel, alloy steel and their mechanical properties, Non-ferrous metals such as Cu, Al, Zn, Cr, Ni etc. properties and its applications.	
UNIT-III	
Simple Stress and Strain Introduction, Normal and shear stresses, Poisson's ratio, Elastic constants and their relationships, Hooke's law, Deflection of bars of uniform and varying cross-sections, Strain energy in due to static loading, Stress-strain diagrams for ductile and brittle materials **Mechanical Properties and Testing** Introduction to Toughness, Hardness, Fracture, Fatigue, Strength and deformation, Tensile, compression, Hardness, Impact, Fatigue, spring stiffness tests.	9
UNIT-IV	9
Beams Introduction, Beams classification, types of loading, Free body diagram, Shear force and bending moment, Analysis of beams, Shear force and bending moment diagrams for statically determinate beams, Simple bending theory, Stress of beams of different cross sections **Torsion of Circular shafts** Introduction, Torsion of circular shafts, Shear stress due to torsion, Polar modulus, Power transmission	
EXPERIMENTS	

Note: Minimum Eight experiments are to be performed

1. Tensile strength test on universal testing machine.
2. Compressive strength test on universal testing machine.
3. Bend/rebend test on Izod.
4. Impact test on Impact testing machine.
5. Hardness testing on Vicker/Brinell hardness testing machine.
6. Torsion test of a rod on torsion testing machine.
7. Stiffness test on spring testing machine.
8. Study of two stroke and four stroke engine model.
9. Fatigue test on fatigue testing machine.
10. Deflection on bending of simple supported and cantilever beams.
11. Determination of COP of vapour absorption system.
12. Determination of COP of vapour compression refrigeration system.
13. Study of steam boilers model.
14. Study of domestic refrigerator.

Books & References

1. Basic and Applied Thermodynamics-P. K. Nag (Tata McGraw Hill)
2. Basic Thermodynamics- Cengel(Tata McGraw Hill).
3. Applied Thermodynamics-Onkar Singh (New Age International)
4. Elements of Materials science and Engineering-Van Vlash (Jhon Wiley & Sons)
5. Material Science-V. Raghvan (Prentice Hall India Limited)
6. Mechanical Measurement-G. Beckwith Thomas (Narosa Publishing House)
7. Mechanical Measurement – Sirohi (New Age Publications)
8. Strength of Materials-S. Ramamurtham (Dhanpat rai Publishing Co.)
9. Strength of Materials-R. K. Rajput (S. Chand)
10. Strength of Materials–R. K. Bansal (Lakshmi Publications)

BME-03	**MANUFACTURING PROCESSES**	
Course category	:	For Other Department
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The students will be able to understand the basic manufacturing processes and different types of mechanical properties of ferrous, non-ferrous metals and alloys.
2. The basic knowledge ofdifferent forming and casting processes and foundry tools used for the manufacturing of different products.
3. The knowledge of different machine tools and machining processes, welding processes and their applications.
4. The knowledge of sheet metal processes and their applications, powder metallurgy

process, basic heat treatment processes, nonmetallic materials and features of manufacturing establishment.	
Topics Covered	
UNIT-I	
Introduction Introduction and importance of Manufacturingprocesses, classification and overview of Manufacturing processes. **Mechanical Properties of Materials** Strength, elasticity, plasticity, stiffness, malleability,ductility, brittleness, malleability, toughness hardness, resilience, hardness, machine ability, formability, weldability, Elementary ideas of fracture fatigue & creep. **Steels and Cast Irons** Carbon steels, their classification based on percentage of carbon as low, mild,medium & high carbon steel, their properties & applications. Wrought iron, Cast iron. Alloy steels:stainless steel, tool steel. **Alloys of Non Ferrous Metals** Common uses of various non-ferrous metals (Copper, Zink, Tin,Magnesium, Lead, Aluminum etc.) & alloys and its composition such as Cu-alloys: Brass, Bronze, Al-alloys	9
UNIT-II	
Forming Processes Hot-working &cold-working, Basic metal forming operations & uses of such as: Forging, Rolling, Wire & Tube drawing and Extrusion, and their uses. Press-work: Die & Punch assembly, cutting and forming, its applications. **Casting** Pattern making, Materials, pattern making tools, pattern typesand allowances. Type and composition of Molding sands and theirdesirable properties. Foundry tools, Mould making with the use of a core. Gating system. Casting defects & remedies.Cupola Furnace. Brief description of various types of casting processes.	9
UNIT-III	
Machining Lathe-machine: principle, types, main parts, specifications and operations performed on it., Basic description of machines and operations of Shaper-Planer, Drilling, Milling & Grinding. **Welding** Introduction, classification of welding processes. Gas-welding, types of flames and theirapplications. Electric-Arc welding. Resistance welding. Soldering & Brazing processes and their uses.	9
UNIT-IV	
Sheet Metal Work Tools and equipments used in sheet metal work, metals used for sheets, standard specification for sheets, Typesof sheet metal operations: shearing, drawing, bending **Powder Metallurgy** Introduction of powder metallurgy process: powder production, blending, compaction,Sintering **Heat Treatment Processes** Introduction to Heat- treatment of carbon steels: annealing, normalizing,quenching, tempering and case-hardening, Introduction to Galvanizing and Electroplating. **Non-Metallic Materials** Common types & uses of Wood, Cement-concrete, Ceramics, Rubber, Plasticsand Composite-materials **Manufacturing Establishment** Plant location. Plant layout–its types. Types of Production. Productionversus Productivity.	9

Books&References

1. Workshop Technology Vol-I-B. S. Raghubanshi (DhanpatRai and Sons)
2. Workshop Technology Vol-II-B. S. Raghubanshi (DhanpatRai and Sons)
3. Production Technology - R.K. Jain (Khanna publication
4. Manufacturing Processes- H. N. Gupta, R. C. Gupta, ArunMital (New Age publisher)
5. Manufacturing Science -Ghosh and Mallik(EWP)
6. Manufacturing processes – SantoshBhatnagar (B S publication)
7. Production Technology – P. C. Sharma (S. Chand)
8. Manufacturing technology – Machine Tools- P. N. Rao(TMH)
9. Manufacturing technology – Foundry, Forming and Welding- P. N. Rao(TMH).
10. Manufacturing Engineering & Technology- Kalpakjian (Pearson)

BME-10	**WORKSHOP TECHNOLOGY**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 0, Tutorial: 0 , Practical: 4
Number of Credits	:	2
Course Assessment Methods	:	Continuous assessment through one Viva voce, Practical work/record, attendance and Major Practical Examination
Course Outcomes	:	After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes

1. Understand the importance,materials, applications and safetyin different shops for the development of a product/component.
2. The knowledge of tools and processesused in carpentry and foundry shops for the development of products through casting process.
3. The knowledge of forming process will develop skills for producing products using different tools and processes in black smithy and sheet metal shops.
4. The knowledge of tools and processes in machine shop and welding shop will develop ability of producing different products.

Topics Covered

Note: Make at least one job in each shop

1. Introduction
- Need and importance of workshop
- Mechanical properties of metals
- Ferrous Metals and alloys- composition and applications
- Non-Ferrous Metals and alloys- composition and applications
- Safety in each shop

2. Carpentry Shop:
- Draw layout of carpentry shop
- Study of tools & operations and carpentry joints.
- Preparation of half-lap corner joint, mortise & tennon joint
- Simple exercise on woodworking lathe

3. Fitting Shop:
- Layout of fitting shop
- Study of tools & operations

- Simple exercises involving fitting work.
- Simple exercises involving drilling/tapping/die

4. Black Smithy Shop:

- Layout of Smithy Shop
- Study of tools & operations
- Hot and cold working
- Simple exercises base on black smithy operations such as upsetting, drawing down, punching, bending, fullering & swaging.

5. Welding Shop:

- Layout of welding shop
- Study of equipment of gas welding & arc welding
- Preparation of simple butt and lap welded joints.
- Oxy-acetylene flame cutting

6. Sheet-metal Shop:

- Layout of Sheet metal shop
- Metals used in sheet metal work such as Galvanized iron, Copper sheet, Aluminum sheet
- Study of tools & operations
- Fabrication of Funnel, tool-box, tray, electric panel box etc.

7. Machine Shop:

- Layout of Machine shop
- Study of Lathe, Drilling, Shaper, Planer and Milling Machines and commonly done operations on these machines
- Single point and Multi-point Cutting tools
- Making a job on lathe involving plane turning step turning, taper turning, and threading operations

8. Foundry Shop:

- Layout of foundry shop
- Study of tools & operations
- Study on pattern allowances
- To prepare a mould with the use of a core and cast it
- Study of casting defects

BME-11	**MATERIAL SCIENCE AND ENGINEERING**	
Course category	:	Basic Science & Maths (BSM)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the importance of numerous materials with their basic concepts including crystallography and imperfections.
2. The understanding about the advanced materials testing by different testing methodsfor

measuring various mechanical properties. 3. The knowledge of different surface behavior studies aboutmaterials including heat treatment processes, TTT diagram and other related processes. 4. The knowledge of various materials and their non-mechanical properties; electrical, magnetic, electronic, etc.	
Topics Covered	
UNIT-I	9
Introduction Historical perspective, importance of materials, Engineering materials for future **Crystallography and imperfections:** Concept of unit cell, space lattice, Bravais lattices, common crystal structures, Atomic packing factor and density. Miller indices, X-ray crystallography techniques, imperfections, Defects & Dislocations.	
UNIT-II	9
Phase Diagram Uniary and Binary diagrams, Phase rules, Types of equilibrium diagrams: solid solution type, eutectic type and combination type, Iron-carbon equilibrium diagram. **Mechanical Properties and Testing** Stress strain diagram, Ductile and brittle materials, stress Vs strength, toughness, hardness, fracture, fatigue and creep. Testing Methods for measuring Strength, Hardness, Impact strength, Fatigue Strength, Creep etc, **Micro Structural Examination** Microscope principle and methods, comparative study of microstructure of various metals and alloys, such as Mild steel, CI, Brass. Scanning Electron Microscope (SEM).	
UNIT-III	9
Ferrous & Non-ferrous materials Furnaces, various types of carbon steels, alloy steels and cast irons, its properties and uses.Cu, Al, Zn, Cr, Ni etc. and its applications **Heat Treatment:** Annealing, Normalizing, Quenching, Tempering and Case hardening. Time Temperature Transformation (TTT) diagrams.	
UNIT-IV	9
Magnetic properties Concept of magnetism- Dia, para, ferro magnetic materials, Hysteresis, Soft and hard magnetic materials, Magnetic Storages. **Electrical Properties** Energy band, concept of conductor, insulator and semiconductor. Intrinsic and extrinsic semi-conductors, P-n junction and transistors,Super conductivity and its applications, Messier effect. Type I& Type II superconductors. High Temperature superconductors Brief description of optical and thermal materials, Composite Materials and its uses. Smart materials & Nano-materials and their potential applications.	

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following:

1. Tensile test on universal testing machine.
2. Compressive on universal testing machine.
3. Impact test on impact testing machine.
4. Hardness testing of given specimen on Vicker/Brinell/Rockwell hardness testing machine
5. Bending test of given mild steel specimen on UTM.
6. Study of corrosion and its effects.
7. Experiment on NDT (non-destructive testing)
8. Spring index test on spring testing machine.
9. Comparative study of microstructures of materials (mild steel, gray C.I., brass, copper etc.)
10. Experiment on heat treatment process (such as annealing, normalizing, quenching, case hardening).

Books & References

1. Material Science and Engineering – Smith, Hashemi and Prakash (Tata McGraw Hill)
2. Material Science- Narula (Tata McGraw Hill)
3. Material Science & Engineering - Van Vlash (John Wiley & Sons)
4. Elements of Material Science & Engineering -W.D. Callister (Wiley India Pvt. Ltd.)
5. Technology of Engineering Materials- Philip and Bolton (Butterworth-Heinamann)
6. Material Science -V. Raghvan (Prentice Hall of India)

BME-12 ENGINEERING THERMODYNAMICS

Course category	:	Engineering Fundamentals (EF)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The basic understanding of Thermodynamic processes for pure substances and ideal gases and ability to demonstrate the Zeroth law and First Law of Thermodynamics.
2. Ability to apply the First Law of Thermodynamics for control surface and control volume systems and demonstrate the Second Law of Thermodynamics and its application to various systems.
3. Students will demonstrate the use of Second Law of Thermodynamics of systems for entropy and analysis of different Thermodynamics processes.
4. Ability to demonstrate the various properties of steam and introduction to power cycles.

Topics Covered

UNIT-I	9
Fundamental Concepts and Definitions Introduction and definition of thermodynamics, Microscopic and Macroscopic approaches, Systems, surroundings, Concept of continuum, Control system, control volume and control surface, Properties intensive & extensive and state of Thermodynamic properties, point and path properties,	

process, Thermodynamic equilibrium, Reversibility and irreversibility, Quasi static process, reversible and irreversible Energy and its forms, Work and heat, Ideal & Real gas, Dalton's law, Amagat's law, Property of mixture of gases. **Zeroth law of thermodynamics** Zeroth law of thermodynamics, Temperature and its' measurement. **First law of thermodynamics for closed system** Introduction of first law of thermodynamics, Calculation of work in various processes and sign convention, work, Joules' experiment, Internal energy andenthalpy	
UNIT-II	9
First law of thermodynamics for open system First law of thermodynamics applied to open systems, Steady flow systems and their analysis, Steady flow energy equation, and applied to Boilers, Condensers, Turbine, Throttling process, Pumps etc. Analysis of unsteady processes such as filling and evacuation of vessels with and without heat transfer, Limitations of first law of thermodynamics, PMM-I **Second law of Thermodynamics** **Introduction to II**nd law of thermodynamics, Kelvin Plank statement of second law of thermodynamics, Clausius statement of second law of thermodynamics,Devices converting heat to work, Thermal reservoir, Heat engines, Efficiency, Devices converting work to heat, Heat pump, refrigerator, Reversed heat engine and their COP, thermodynamic temperature scale, PMM-II	
UNIT-III	9
Entropy Clausius inequality, Concept of Entropy, Entropy change in different thermodynamic processes, Tds equation, Principle of entropy increase, T-S diagram, Statement of the third law of thermodynamics. **Availability and Irreversibility** Available and unavailable energy, Availability and Irreversibility, Helmholtz & Gibb's function, Second law efficiency.	
UNIT-IV	9
Properties of steam and cycle Property of steam, Triple point, Critical point, Sub-cooled liquid, Saturation states, Superheated states, Phase transformation process of water, Graphical representation of pressure, volume and temperature, P-T & P-V diagrams, T-S and H-S diagrams, use of property diagram, Steam-Tables & Mollier charts, Dryness factor and it's measurement, processes involving steam in closed and open systems, Simple Rankine cycle.	

Books & References

1. Engineering Thermodynamics - P.K. Nag (Tata McGraw Hill)
2. Fundamentals of Thermodynamics – Sonntag (Wiley India Pvt. Ltd)
3. Fundamentals of Classical Thermodynamics - Van Wylen (John Wiley & sons)
4. Thermodynamics - J.P. Holman (McGraw Hill)
5. Engineering Thermodynamics - Jones and Dugans (PHI Learning Pvt. Ltd)

BME-13 MEASUREMENT & METROLOGY

Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture:2, Tutorial: 1 , Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination

Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding of measurement and measuring instruments, sensors and transducers, signal transmission and processing.
2. The knowledge of time related measurements, measurements of pressure, strain, temperature, force, torque, acceleration and vibration.
3. The knowledge of standards of linear measurement, line and end standards, limit fits and tolerances, interchangeability and standardization, linear and angular measuring devices and systems, comparators, limit gauges and gauge design.
4. The knowledge of measurement of geometric forms like straightness, flatness, roundness, tool maker's microscope, profile project autocollimator, Interferometry, Measurement of screw threads, gears and surface texture.

Topics Covered

UNIT-I	6
Mechanical Measurements Introduction to measurement and measuring instruments, Generalized measuring system and functional elements, units of measurement, static and dynamic performance characteristics of measurement devices, calibration, concept of error, sources of error, statistical analysis of errors. **Sensors and Transducers** Types of sensors, sensors for common engineering measurements, types of transducers and their characteristics	
UNIT-II	6
Time related measurements Counters, stroboscope, frequency measurement by direct comparison, Measurement of displacement **Measurement of pressure** Gravitational, directing acting, elastic and indirect type pressure transducers, Measurement of very low pressure (vacuum) **Strain measurement** Types of strain gauges and their working, strain gauge circuits, temperature compensation, strain rosettes, calibration **Measurements of force and torque** Different types of load cells, elastic transducers, pneumatic& hydraulic systems, seismic measurement **Temperature measurement** Thermometers, bimetallic thermocouples, thermistors and pyrometers	
UNIT-III	6
Flow Measurements: Hot wire anemometry, laser Doppler velocimetry, rotameter **Measurement of Acceleration and Vibration**: Accelerometers vibration pickups and decibel meters, vibrometers. **Metrology and Inspection:** Standards of linear measurement, line and end standards, Interchangeability and standardisation, Linear and angular measurements devices and systems **Comparators:** Sigma, Johansson's Microkrator, Limit gauges classification, Taylor's Principle of Gauge Design.	

UNIT-IV	6
Limits, Fits & Tolerance and surface roughness Introduction to Limits, Fits, Tolerances and IS standard, Limit Gauges, Measurement of geometric forms like straightness, flatness, roundness, Tool makers microscope, profile project autocollimator, Principle and use of interferometry, optical flat, Measurement of screw threads and gears, Surface texture: quantitative evaluation of surface roughness and its measurement.	

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following:

1. To measurement of strain (gauge) through MS flat iron with help of Digital Strain indicator.
2. Measurement of displacement using linear variable differential transducer (LVDT)
3. To determine the temperature of bulb filament with the help of partial radiation pyrometer
4. To demonstrate the application of the law of intermediate Temperature
5. To measure the diameter of 'GO' and 'NOT GO Ends of a plug gauge with the help of micrometer and to determine the tolerance provide.
6. To measure the amount of clearance provided in the given fit with the help of dial caliper
7. To measuring the included angle of given hexagonal/ octagonal piece with the help of venire bevel protractor and to verify the same using the formula.
8. To measure the taper angle of given with the help of slip gauges and sine bar.
9. To measure the effective diameter of a screw thread using three wire method of a 1" BSW tap and find the flomle angle.
10. To study and sketch of tool mater microscope for measurement of dimensional parameters of the given work piece

Books & References

1. Measurement Systems, Application Design - Doeblein E.O (McGraw Hill)
2. Mechanical Measurements - Beckwith Thomas G. (Narosa Publishing House, N. Delhi)
3. Engineering Metrology - Hume K.J. (MacDonald and Co.)
4. Instrumentation, Measurement and Analysis- BC Nakra and K.K.Choudhary ,McGraw Hill.
5. Mechanical Measurement – Sirohi (New Age Publishers)
6. Engineering Metrology- Gupta, I.C. (Dhanpat Rai & Sons, New Delhi)
7. Mechanical Measurement - Jain, R.K (Khanna Publishers)
8. Mechanical Measurements and Control - Kumar D.S. (Metropolitan, N. Delhi)

BME-14	**MECHANICS OF SOLIDS**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to determine stresses in solid members under different conditions.
2. The ability to calculate deflections in beams under different support conditions, deflection in helical and leaf springs under different loading conditions.
3. The ability to determine stresses in thin and thick cylindrical and thin spherical shells

and buckling loads in columns under different support conditions.

4. Able to understand advanced topics of Mechanics of solids for further Research and Industry Applications.

Topics Covered

UNIT-I	9
Stress and strain, elastic constants, Poisson's ratio, Principal planes and principal stresses, Mohr's circle for plane stress and plane strain; Bending and torsion and its combination, Strain energy due to principal stresses, Energy of distortion and dilatation. thermal stresses; strain gauges and rosettes.	
UNIT-II	9
Beams: Review of SFD BMD, Pure bending, combined direct and bending stresses, shear stresses in beams, combined bending and torsion of solid and hollow circular shafts, Deflection of beams, Equation of elastic curve, Mecaulay's method, Area moment method, Fixed beam carrying point load and uniformly distributed load, continuous beams, Castgliano's theorem Introduction to Springs, Helical springs under axial loads and axial twist, Deflection of spring by energy method, Open and closed coil helical springs under axial and twist loadings.	
UNIT-III	9
Thin cylindrical and spherical shells: Hoop and Longitudinal stresses and strain, Cylindrical shell with hemispherical ends, Volumetric strain, Wire wound cylinders, spherical shell. **Thick cylindrical shell:**Stresses in thick cylinders subjected to internal or external pressures, Compound cylinders, Stresses due to interference fits. **Columns and Struts:**Classification, Euler's theory for long column for different end conditions, Limitations, Rankine formulae for struts/columns. Introduction to other theories.	
UNIT-IV	9
Generalised Hooks Law. Introduction to 3D stresses and Mohr's circle. Elastic stabilities and Theories of Failure. Determination of shear centre for I-section and channel section.	

Books & References

1. Introduction of Mechanics of Materials – I.H. Shames
2. Strength of Materials-S. Ramamurtham (Dhanpat Rai Publishing Co.)
3. Strength of Materials-R. K. Rajput (S. Chand)
4. Strength of Materials-Ryder (Mcmillan Publishers India Limited)
5. Strength of Materials-Timoshenko and Young (Tata McGraw Hill)
6. Advanced Mechanics of Solids-L S Srinath (Tata McGraw Hill)
7. Mechanics of Solids – Egor P. Popov (Pearson)
8. Mechanics of materials-Pytel (CL Engineering)

BME-15	**ENGINEERING MATERIALS**

Course category	:	Department Core (DC)

Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The importance of materials including understanding of crystallography and imperfections.
2. The understanding about the advanced materials testing by different testing methods for measuring various mechanical properties.
3. The knowledge of different surface behavior studies about materials including heat treatment processes, TTT diagram and other related processes.
4. The knowledge of various materials and their non-mechanical properties; electrical, magnetic, electronic, etc.

Topics Covered

UNIT-I	9
Introduction Importance of materials, Historical perspective, engineering materials for future requirements**Crystalline nature of solids** Crystal system, unit cell, space lattice, Bravais lattices, common crystal structures, Atomic packing factor and density. Miller indices, Imperfections, Defects & Dislocations.	
UNIT-II	9
Mechanical properties and Testing Stress strain diagram for Ductile & brittle material, Toughness, Hardness, Fracture, Fatigue and Creep. Measurement of Strength, Hardness, Impact Strength, Fatigue Strength, Creep etc. **Phase Diagram and Equilibrium Diagram** Uniary and Binary diagrams, Phase rules. Types of equilibrium diagrams: Solid solution type, eutectic type and combination type, Iron-carbon equilibrium diagram.	
UNIT-III	9
Ferrous & Non-ferrous material Various types of carbon steels, alloy steels and cast irons, its properties, uses and applications,Cu, Al, Zn, Cr, Ni etc. and its applications **Heat Treatment:** Various types of heat treatment processes such as Annealing, Normalizing, Quenching, Tempering, and various case hardening processes. Time Temperature Transformation (TTT) diagrams. Diffusion: Diffusion of Solids, Fick's I and II law.	
UNIT-IV	9
Dielectric & Magnetic properties Dielectric Materials and their applications, Concept of magnetism- Dia, para, ferro magnetic materials, Hysteresis, Soft and hard magnetic materials, Magnetic Storages **Electronic Properties** Energy band, concept of conductor, insulator and semiconductor. Intrinsic and extrinsic semi-conductors, P-n junction and transistors, Messier effect. Type I& Type II superconductors. High	

Temperature superconductors.Brief description of other material such as optical and thermal materials, Composite Materials and its uses, Smart materials & Nano-materials and their potential applications	

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following:

1. Tensile test on universal testing machine
2. Compressive on universal testing machine
3. Toughness measurement of materials by Impact testing Machine
4. Hardness testing of given specimen on Vicker/Brinell/Rockwell hardness testing machine
5. Bending test
6. Study of corrosion and its effects.
7. Experiment on NDT (non destructive testing)
8. Spring index test on spring testing machine.
9. Comparative study of microstructures of materials
10. Experiment on heat treatment processes.

Books & References

1. Material Science and Engineering – Smith, Hashemi and Prakash (Tata McGraw Hill)
2. Material Science- Narula (Tata McGraw Hill)
3. Material Science for Engineering Students- Fischer (Academic Press)
4. Material Science & Engineering - Van Vlash (John Wiley & Sons)
5. Elements of Material Science & Engineering -W.D. Callister (Wiley India Pvt. Ltd.)
6. Technology of Engineering Materials- Philip and Bolton (Butterworth-Heinamann)
7. Material Science -V. Raghvan (Prentice Hall of India)
8. Elements of Material Science & Engineering- Van Vlack (Pearson)

BME-16 FLUID MECHANICS

Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The fundamental concepts of fluid mechanics and knowledge of fluid and its properties, types of fluid flows, 3D fluid flow, etc.
2. The knowledge of parameters of fluid statics, Pressures on plane and curved surfaces, stability of immersed and floating bodies.
3. Understand the various aspects of Laminar and Turbulent Flow.
4. The ability to carry out dimensional analysis in fluid mechanics.

Topics Covered

UNIT-I	9

Introduction Fluid and continuum, Physical properties of fluids, Rheology of fluids **Fluid Statics** Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, centre of pressure, buoyancy, stability of immersed and floating bodies.	
UNIT-II	9
Kinematics of Fluid flow Types of fluid flows: Steady and unsteady, uniform and non-uniform, laminar and turbulent flows, rotational and irrotational flows, compressible and incompressible flows, subsonic, sonic and supersonic flows, sub-critical, critical and supercritical flows, one, two and three dimensional flows, streamlines, continuity equation for 3D and 1D flows, circulation, stream function and velocity potential, source, sink, doublet and half-body **Dynamics of Fluid Flow** Euler's Equation of motion along a streamline and its integration, Bernoulli's equation and its applications-Pitot tube, orifice meter, venturi meter and bend meter, notches and weirs, momentum equation and its application to pipe bends. Naviers strokes equation.	
UNIT-III	9
Laminar and Turbulent Flow Equation of motion for laminar flow and turbulent flow, measurement of turbulence, eddy viscosity, mixing length concept and velocity distribution in turbulent flow over smooth and rough surfaces, minor& major losses,in pipe.	
UNIT-IV	9
Dimensional Analysis and Hydraulic Similitude Dimensional analysis, Buckingham's Pi theorem, important dimensionless numbers and their significance, geometric, kinematics and dynamic similarity, model studies **Boundary Layer Analysis** Boundary layer thickness, boundary layer over a flat plate, laminar boundary layer, application of momentum equation, turbulent boundary layer, laminar sublayer, separation and its control, Drag and lift, an aerofoil Sectionand Magnus effect.	

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following:

1. To verify the momentum equation using the experimental set-up on impact of jet.
2. To determine the coefficient of discharge of an orifice of a given shape. Also, to determine the coefficient of velocity and the coefficient of contraction of the orifice mouth piece.
3. To calibrate an orifice meter and study the variation of the co-efficient of discharge with the Reynolds number.
4. To calibrate a Venturimeter and study the variation of the co-efficient of discharge with the Reynolds number.
5. To calibrate a bend meter and study the variation of the co-efficient of discharge with the Reynolds number.
6. To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.
7. To study the velocity distribution in a pipe and also to compute the discharge by integrating the velocity profile.
8. To determine the major losses in commercial pipes.
9. To study the boundary layer velocity profile over a flat plate and to determine the boundary layer thickness.
10. To determine Meta-centric height of a given ship model.
11. To determine the head loss for a sudden enlargement
12. To determine the head loss for a sudden Contraction
13. To measure the surface tension in a given liquid.
14. Varification of Bernoulli's equation.

Books & References

1. Introduction of fluid mechanics & Fluid Machines - S.K. Som, &G Biswas (TMH, 2000, 2e)
2. Fluid Mechanics & Turbomachines -M M Das (Oxford University Press)
3. Fluid Mechanics & Machinery - S.K. Agarwal (TMH)
4. Fluid Mechanics through Problems - Garde, R.J. (New Age International Pvt. Ltd, 2e)
5. Mechanics of Fluids -I.H.Shames (McGraw Hill, Int. Student, Education, 1988)
6. Fluid Mechanics - Jagdish Lal(Metropolitan Book Company)
7. Elementary Mechanics of Fluids -Hunter Rouse (John Wiley & Sons Omc. 1946)
8. Fluid mechanics – F M White (McGraw-Hill Education)
9. Fluid mechanics by Cengel and Cimbala (McGraw-Hill Education)

BME-17	**KINEMATICS OF MACHINES**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. To understand the kinematics of links, its classification and applications in different planar mechanisms and machines, and ability to determine kinematic quantities of linksin

different planar mechanisms.

2. To study the mechanisms consisting of lower pairs, and to be able to synthesize ~~of~~ slider crank mechanism and four bar mechanisms.
3. To understand the gear tooth profiles, law of gearing and different types of gear trains for power transmission
4. To understand different types of cams and followers motions, cam profile generation techniques

Topics Covered

UNIT-I	9
Introduction Links-types, Kinematics pairs-classification, Constraints-types, Degrees of freedom of planar mechanisms, Mobility-Grashof's law, Grubler's equation, linkage mechanisms, kinematic inversions of four bar chain, slider crank chain and double slider crank chain, limit position, mechanical advantage, transmission angle **Velocity in Planar Mechanisms** Relative velocity method, Velocities in four bar mechanism, slider crank mechanism and quick return motion mechanism, Instantaneous center method, Types & location of instantaneous centers, Kennedy's theorem, Velocities in four bar mechanism & slider crank mechanism **Acceleration in Planar Mechanisms** Acceleration of a point on a link, Acceleration diagram for four bar mechanism & slider crank mechanism, Coriolis component of acceleration.	
UNIT-II	9
Mechanisms with Lower Pairs Pantograph, Exact straight-line motion mechanisms-Peaucellier's, Hart and Scott Russell mechanisms, Approximate straight line motion mechanisms–Grass-Hopper, Watt and Tchebicheff mechanisms, Universal joint **Kinematic Synthesis of Planar Linkages** Graphical method-Two and Three position synthesis of four bars and slider crank mechanisms using relative pole method, Three position graphical synthesis for path and motion generation Analytical method-Freudenstein's equation, Classification of synthesis problem, Precision points for function generation	
UNIT-III	9
Gears Classification & terminology, helical, bevel, rack and pinion gears, Law of gearing, Involute and cyclodidal gear profiles, Tooth forms & comparisons, Systems of gear teeth, conjugate action, spur gear contact ratio, Interference & under cutting in involute gear teeth, Minimum number of teeth on spur gear and pinion to avoid interference **Gear Trains** Simple, Compound, Reverted and epicyclic gear trains, Sun and planet gear	
UNIT-IV	9

Cams

Cams and Followers-Classification & terminology, Follower Motion-Uniform velocity, Simple harmonic motion, Uniform acceleration and retardation, parabolic motion, cycloidal motion, Cam Profile generation, radial cam, Knife edge, roller and flat face followers, Pressure angle and undercutting, Cam size

Analytical methods of cam design – tangent cam with reciprocating roller follower and circular arc cams with flat faced follower

Books & References

1. Theory of Machines-S.S. Rattan (Tata McGraw Hill)
2. Theory of Machines and Mechanisms-Ghosh & Mallik (East West Press)
3. Theory of Machines and Mechanisms- Shigley (McGraw Hill)
4. Theory of Machines and Mechanisms- Rao & Dukkipati (New Age International)
5. Theory of Machines - Thomas Bevan (CBS Publishers)
6. Theory of Machines – Malhotra & Gupta (Satya Prakasan, Tech. India)
7. Kinematics and Dynamics of Machinery – Robert L. Norton (Tata McGraw Hill)
8. Mechanisms of Machines – Cleghorn W. L. (Oxford University Press)

BME-18 ENERGY CONVERSION SYSTEMS

Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor testand One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the general principles of mass and energy conservation, thermodynamic relations; ability to analyze combustion of fuels, heat reaction and calculation, study different types of condensers and its performance parameters.
2. The knowledge of different types of boilers, heat balance and different types of vapor power cycles
3. Turbine, different types of steam turbines and related parameter calculations.
4. Working of gas turbines cycles, jet propulsion and introduction to rocket engine.

Topics Covered

UNIT-I 9

Thermodynamic relations

Conditions for exact differentials, Maxwell relations, Clapeyron equation, Joule-Thompson coefficient and Inversion curve. Coefficient of volume expansion, Adiabatic and Isothermal compressibility

Fuels and Combustion

Combustion analysis, heating values, air requirement, Air/Fuel ratio, standard heat of reaction and effect of temperature on standard heat of reaction, heat of formation, Adiabatic flame temperature.	
UNIT-II	9
Boilers Classifications and working of boilers, boiler mountings and accessories, Draught and its calculations, air pre-heater, feed water heater, super heater. Boiler efficiency, Equivalent evaporation, Boiler trial and heat balance Condenser: Classification of condenser, sources, air leakage, condenser performance parameters. **Vapour Power cycles** Rankine cycle, effect of pressure and temperature on Rankine cycle, reheat cycle, Regenerative cycle, Feed water heaters, Binary vapour cycle, Cogeneration.	
UNIT-III	9
Steam and Gas Nozzles Flow through Convergent and convergent-divergent nozzles, variation of velocity, area and specific volume, Choked flow, throat area, Nozzle efficiency, Off design operation of nozzle, Effect of friction on nozzle, Super saturated flow. **Steam Turbines** Classification of steam turbine, Impulse and Reaction turbines, Staging, Stage and Overall efficiency, Reheat factor, Bleeding, Velocity diagram of simple and compound multistage impulse and reaction turbines and related calculations, work done, efficiencies of reaction, Impulse reaction turbines, state point locus, Losses in steam turbines, Governing of turbines, Comparison with steam engine.	
UNIT-IV	9
Gas Turbines Gas turbine classification, Brayton cycle, Principles of gas turbine, Brayton cycle with intercooling, reheat and regeneration and their combinations, Stage efficiency, Polytropic efficiency. Deviation of actual cycles from ideal cycles. **Jet Propulsion** Introduction to the principles of jet propulsion, Turbojet and turboprop, Ramjet engines, Principle of rocket propulsion, Introduction to Rocket Engine.	

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following

1. Study of Fire Tube boiler
2. Study of Water Tube boiler
3. Study and working of Two stroke petrol Engine
4. Study and working of Four stroke petrol Engine
5. Study and working of two stroke Diesel Engine
6. Study and working of four stroke Diesel Engine.
7. Study of Velocity compounded steam turbine
8. Study of Pressure compounded steam turbine
9. Study of Impulse & Reaction turbine
10. Study of steam Engine model.
11. Study of Gas Turbine Model

Books & References

1. Basic and Applied Thermodynamics - P.K. Nag (TMH)
2. Applied Thermodynamics for Engineering Technologists- Eastop (Pearson Education)
3. Applied thermodynamics - Onkar Singh (New Age International)
4. Applied Thermodynamics - Venkanna & Swati (PHI)
5. Thermodynamics and Energy Systems Analysis - Borel and Favrat (CRC Press)
6. Mechanics and Thermodynamics of Propulsion - Hill and Peterson (Pearson Education)

7. Gas turbine Theory & Practice - Cohen & Rogers (Addison Wesley Long man)

BME-20	**MECHANICAL ENGINEERING DRAWING**	
Course category	:	Engineering Fundamentals (EF)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 0, Tutorial : 0 , Practical: 4
Number of Credits	:	2
Course Assessment methods	:	Continuous assessment through one Viva, Practical work/record, attendance and Major Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand layout of drawing sheet, IS codes, scales, different types of lines, section lines, dimensioning, etc.
2. The orthographic projections of simple solids; drawings of parts of temporary fastener, i.e., nuts and bolts and permanent fasteners, i.e., riveted joints and its applications to boiler joint.
3. The knowledge of assembly drawing of cotter joint, knuckle joint, stuffing box, etc. and production drawing of simple machine components
4. The knowledge of basic commands and development of drawings of simple solids in AutoCAD software and free hand sketching of machine components.

Topics Covered

UNIT-I	
Introduction (1 drawing sheet) Graphics Language, Classification of machine drawings, Layout of drawing sheet, IS codes, Scales, Lines, Section lines, Dimensioning	8
Orthographic Projections (2 drawing sheets) Introduction, Principles of first angle and third angle projection, Orthographic views, Drawing of machine elements in first angle projection, Selection of views, Sectional views, Missing views	8
Fasteners Drawing (2 drawing sheets) Temporary fasteners-Screw threads nomenclature, Bolts and nuts Permanent fasteners-Rivets and riveting, Types of rivet heads, Types of riveted joints, Boiler joint	8
Assembly Drawing (2 drawing sheets) Assembly drawing of cotter joint, knuckle joint, stuffing box, cross head, pedestal bearing, eccentric, lathe tail stock, screw jack, safety valve etc.	8
Production Drawing (1drawing sheet) Types, Use of different symbols such as machining, surface roughness symbols etc, Examples of simple machine elements gear, crank, jig, connecting rod, pulley, piston etc	4
Computer Aided Drafting (2 drawings) Introduction to drafting software like AutoCAD, Basic commands and development of 2D and 3D drawings of simple parts	8
Free hand sketching* Introduction, Need for free hand sketching, **Draw free hand sketching of the following machine components on sketch book** 1. Conventional representations of engineering materials	4

2. Locking arrangements of nuts
3. Types of foundation bolts
4. Types of studs
5. Types of pulleys
6. Types of keys
7. Rigid coupling or Flexible coupling
8. Types of Welded symbols
9. Surface Roughness nomenclature, machining symbols, indication of surface roughness

Note: **Students are required to submit the free hand sketching assignment at the end of the semester*

Books & References

1. Machine Drawing - KL Narayana, P Kannaiah, KV Reddy (New Age)
2. Machine Drawing - PS Gill (SK Kataria &Sons)
3. Machine Drawing -N. Siddeshswar, P Kannaiah, VVS Shastry (Tata McGraw Hill)
4. Engineering Drawing - RK Dhawan (S. Chand)
5. AutoCAD-S. Vshal (Dhanpat Rai)
6. Engineering Graphics - BK Goel & PK Goel (SK Kataria)
7. Computer Aided Engineering Graphics - Rajashekhar Patil (New Age)
8. Engineering Drawing - Dhananjay A Jolhe (Tata McGraw Hill)
9. Engineering Drawing - CM Agrawal (Tata McGraw Hill)

BME-26 MACHINE DESIGN-I

Course category	:	Department Core (DC)
Pre-requisite Subject	:	Mechanics of Solids (BME-14)
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The understanding of design of mechanical components/systems, associated design parameters and standards, and knowledge of engineering materials and their properties.
2. The ability to design mechanical components under the static loads and dynamic loads based on different criteria.
3. The ability to design temporary and permanent joints such as riveted, bolted and welded joints as well as design of cotter and knuckle joints and its engineering applications.
4. The knowledge of design of circular shafts under the combined loadings, selection of keys, and design of rigid & flexible couplings.

Topics Covered

UNIT-I	
Introduction to Design, Definition, Design requirements of machine elements, General design procedure, Introduction to Design for Manufacturing, Interchangeability, Limits, Fits and	9

Tolerances, Standards in design, Selection of preferred sizes, Standards designation of carbon & alloy steels, Selection criteria of materials. Design against Static Loading, Modes of failure, Factor of safety and basis of determination, Principal stresses, Torsional and bending stresses, Principal stresses in design of machine element, Theory of failure, Eccentric loading	
UNIT-II	
Cotter and Knuckle Joint, Types of cotter joints, Design of socket and spigot cotter joint, Design of knuckle joint **Design against fluctuating Loads:** Cyclic stresses, Fatigue and endurance limit, Factors affecting endurance limit, Stress concentration factor, Stress concentration factor for machine components, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman & Gerber criteria	9
UNIT-III	
Design of Joints: Design of threaded joints, Preload on the bolt, stiffness of bolt and members, efficiency of joints; Design of weld joints, Specification of welds, weld design under different loading conditions, Design of riveted joints.	9
UNIT-IV	
Design of Shafts Keys and Couplings: Cause of failure in shafts, Materials for shaft, Stresses in shafts, Design of shafts subjected to twisting moment, bending moment and combined twisting and bending moments, Shafts subjected to fatigue loads, Design for rigidity Keys and Couplings, Types of keys, splines, Selection of square & flat keys, Strength of sunk key, Couplings-Design of rigid and flexible couplings **Design of Mechanical Springs:** Types, Material for helical springs, End connections for compression and tension helical springs, Stresses and deflection of helical springs of circular wire, Design of helical springs subjected to static and fatigue loading. **Note: Design data book is allowed in Minor/Major Examinations**	9

EXPERIMENTS

Note: Minimum **Eight** experiments are to be performed from the following. Students are advised to use design data book for the design. Drawing shall be made wherever necessary on small drawing sheets

1. Design of machine components subjected to steady loads
2. Design of machine components subjected combined steady and variable loads
3. Design of boiler riveted joint
4. Design of eccentrically loaded riveted joint
5. Design & drawing of Cotter joint
6. Design & drawing of Knuckle joint
7. Design of shaft for combined constant twisting and bending loads
8. Design of shaft subjected to fluctuating loads
9. Design and drawing of flanged type rigid coupling
10. Design and drawing of flexible coupling

Books & References

1. Mechanical Engineering Design – Joseph E. Shigely (McGraw Hill)
2. Mechanical Design of Machine Components – Norton (Prentice Hall)
3. Fundamentals of Machine Components Design – Juvinall (Wiley)
4. Design of Machine Members - Alex Valance and VI Doughtie (McGraw Hill)
5. Machine design-M.F. Spott (Prentice Hall India)
6. Machine Design-Maleev and Hartman (CBS)
7. Machine design -Black & Adams (McGraw Hill)
8. Design of Machine Elements-V.B. Bhandari (Tata McGraw Hill)

9. Materials Selection in Mechanical Design by Michael F Ashby, BH Publication

BME-27	**HEAT AND MASS TRANSFER**

Course category	:	Department Core (DC)
Pre-requisite Subject	:	Engineering Thermodynamics (BME-12)
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the basic laws of heat transfer and steady state one-dimensional heat conduction for different co-ordinate systems.
2. The knowledge of application of fins for enhancingthe heat transfer rate and natural heat convection over the surfaces of different shapes.
3. The understanding of concepts and estimation of heat transfer under the forced convection, condensation and boiling phenomenon on surfaces and pipes and able to design the different types of heat exchangers, Heat pipes.
4. The understanding of concepts and analysis of thermal radiation and its numerical solutions and introduction to mass transfer.

Topics Covered

UNIT-I	
Introduction to Heat Transfer Concepts of the mechanisms of heat flows; Conduction, convection andradiation; Effect of temperature on thermal conductivity of materials; Introduction tocombined mode of heat transfer mechanism **Conduction** One-dimensional general differential heat conduction equation in the rectangular,cylindrical and spherical coordinate systems. **Steady State One-dimensional Heat conduction** Composite Systems in rectangular, cylindrical and spherical coordinates with & without energy generation; Thermal resistance concept; Analogy between heat andelectricity flow; Thermal contact resistance; Critical thickness of insulation.Concept ofoverall heat transfer coefficients.	9
UNIT-II	
Fins Heat transfer from extended surfaces, Fins of uniform cross-sectional area;Errors of measurement of temperature in thermometer wells. Introduction to transient heat conduction Biot number and lumped system. **Natural Convection** Physical mechanism of natural convection; Buoyant force; Empirical heat transferrelations for natural convection over vertical planes and cylinders, horizontal plates andcylinders, and sphere; Combined free and forced convection.	9
UNIT-III	

Forced Convection Basic concepts; Hydrodynamic boundary layer; Thermal boundary layer;Approximate integral boundary layer analysis; Analogy between momentum and heattransfer in turbulent flow over a flat surface; Mixed boundary layer; Flow over a flatplate; Empirical heat transfer relations; Flow inside ducts; Relation between fluid friction and heat transfer. **Condensation and Boiling** Introduction to condensation phenomena; Heat transfer relations for laminar film, condensation on vertical surfaces and on outside & inside of a horizontal tube, Heat pipes and its application; Boiling, pool boiling& various regims. **Heat Exchanger** Types of heat exchangers; Fouling factors; Overall heat transfer coefficient;Logarithmic mean temperature difference (LMTD) method; Effectiveness-NTU method; Compact heat exchangers.	9
UNIT-IV	
Thermal Radiation Radiation concepts; Radiation properties of surfaces; Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law; Graybody; Shape factor; Black-body radiation; Radiation exchange between diffuse nonblackbodies in an enclosure; Radiation shields; Radiation combined with conduction andconvection; Absorption and emission in gaseous medium; Solar radiation **Introduction to Mass Transfer** Introduction; Fick's law of diffusion; Steady state equimolar counter diffusion;Steady state diffusion though a stagnant gas film	9

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following

1. Conduction - Composite wall experiment
2. Conduction - Composite cylinder experiment
3. Convection - Pool Boiling experiment
4. Convection - Experiment on heat transfer from tube-natural convection.
5. Convection - Heat Pipe experiment.
6. Convection - Heat transfer through fin-natural convection.
7. Convection - Heat transfer through tube/fin-forced convection.
8. Any experiment on Stefan's Law, on radiation determination of emissivity, etc.
9. Experiment on solar collector.
10. Heat exchanger - Parallel flow experiment
11. Heat exchanger - Counter flow experiment
12. Experiment on critical insulation thickness.
13. Conduction - Determination of thermal conductivity of fluids.
14. Conduction - Thermal Contact Resistance Effect between surface.

Books & References

1. Elements of Heat Transfer - Bayazitouglu & Ozisik (McGraw-Hill)
2. Heat Transfer - J.P. Holman (McGraw-Hill International)
3. Schaum's outline of Heat Transfer - Pitts & Sisson (McGraw-Hill International)
4. Principles of Heat Transfer - Frank Kreith (McGraw-Hill Book)
5. Heat Transfer - Vijay Gupta (New Age International (P) Ltd.)
6. Heat Transfer -Y.V.C. Rao (University Press)
7. Heat Transfer - R. Yadav (Central Publishing House)
8. Fundamentals of heat transfer – Incropera,Dewitt (Wiley)
9. Heat Transfer - D S Kumar (S Chand)
10. Heat Transfer by Cengel(TMH)

BME-28	DYNAMICS OF MACHINES	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to carry out static and dynamic force analysis of four bars mechanism and slider crank mechanism, and design of flywheels.
2. To understand types of centrifugal governors, the effects of characteristic parameters and controlling force diagrams and principles of gyroscopic effect and its engineering applications.
3. To Understand the balancing of rotating and reciprocating masses and ability to analyze single degree freedom systems subjected to free, damped and forced vibrations as well as calculation of critical speeds of shaft.
4. To Understand the applications of friction in pivot and collar bearings, belt drives, clutches, brakes and dynamometers.

Topics Covered	
UNIT-I	
STATIC & DYNAMIC FORCE ANALYSIS Static equilibrium of two/three force members, Static equilibrium of member with two forces and torque, Static force analysis of linkages, D'Alembert's principle, Equivalent offset inertia force, Dynamic force analysis of four link mechanism and slider crank mechanism, Dynamically equivalent system **TURNING MOMENT & FLYWHEEL** Engine force analysis-Piston and crank effort, Turning moment on crankshaft, Turning moment diagrams-single cylinder double acting steam engine, four stroke IC engine and multi-cylinder steam engine, Fluctuation of energy, Flywheel and its design	9
UNIT-II	
Governors Terminology, Centrifugal governors-Watt governor, Dead weight governors-Porter & Proell governor, Spring controlled governor-Hartnell governor, Sensitivity, Stability, Hunting, Isochronism, Effort and Power of governor **Gyroscopic Motion** Principles, Gyroscopic torque, Effect of gyroscopic couple on the stability of aero planes, ships& automobiles	9
UNIT-III	

BALANCING OF MACHINES Static and dynamic balancing, Balancing of several masses rotating in the same plane and different planes, Balancing of primary and secondary forces in reciprocating engine, Partial balancing of two cylinder locomotives, Variation of tractive force, swaying couple, hammer blow, Balancing of two cylinder in-line engines **MECHANICAL VIBRATIONS** Introduction, Single degree free & damped vibrations of spring-mass system, Logarithmic decrement, Torsional vibration, Forced vibration of single degree system under harmonic excitation, Critical speeds of shaft	9
UNIT-IV	
Friction **Introduction** Friction in journal bearing-friction circle, Pivots and collar friction-Flat and conical pivot bearing Flat collar bearing, Belt drives-types, material,power transmitted,ratio of drivingtensions for flat belt, centrifugal tension, initial tension, ropedrive-types Laws of friction, Efficiency on inclined plane, Screw friction, Screw jack, Efficiency, Friction in journal bearing-friction circle, Pivots and collar friction-Flat and conical pivot bearing, Flat collar bearing **Clutches, Bakes & Dynamometers** Single and multiple disc friction clutches, Cone clutch, Brakes-types, Single and double shoe brake, Simple and differential Band brake, Band and Block brake, Absorption and transmission dynamometers, Prony brake and rope brake dynamometers	9

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following

1. Experiments on simple and dead weight governor
2. Experiment on spring controlled governor
3. Experiment on gyroscope
4. Experiment on critical speed of shaft
5. Experiment on longitudinal vibration
6. Experiment on transverse vibration
7. Experiment on static/dynamic balancing
8. Experiment on Gear trains
9. Experiment on Gears tooth profile, interference etc.
10. Study of simple linkage models/mechanisms
11. Study of inversions of four bar linkage
12. Study of inversions of single/double slider crank mechanisms
13. Experiment on Brake
14. Experiment on clutches/dynamometers
15. Experiments on friction

Books & References

1. Theory of Machines - Thomas Bevan (CBS Publication)
2. Theory of Machines and Mechanisms- Shigley (Oxford University Press-New Delhi)
3. Theory of Machines and Mechanisms-Ghosh & Mallik (East West Press)
4. Theory of Machines and Mechanisms- Rao & Dukkipati (Wiley)
5. Theory of Machines - S.S. Rattan (Tata McGraw Hill)
6. Theory of Machines – R.K. Bansal (Laxmi)
7. Theory of Machines – Khurmi & Gupta (S Chand)
8. Theory of Machines – P.L. Ballaney (Khanna)
9. Kinematics and Dynamics of Machinery – Robert L. Norton (Tata McGraw Hill)
10. Mechanisms of Machines – Cleghorn W. L. (Oxford University Press)

BME-29	MANUFACTURING SCIENCE	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Able to understand the fundamentals and analysis of Forging and Rolling processes.
2. Knowledge of wire drawing, extrusion, sheet metal working, and unconventional metal forming process such as explosive forming and electromagnetic forming.
3. Knowledge of principles, working and applications of various types of welding processes.
4. Able to understand pattern allowances, moulding sand properties, elements of mould and casting processes.

Topics Covered

UNIT-I	
Introduction Importance of manufacturing, economic & technological considerations in manufacturing, classification of manufacturing processes, materials & manufacturing processes for common items **Basics of Metal Forming** Elastic & plastic deformation. Tresca's & Von Mises' Yield's criteria. Hot & cold working processes. **Forging & Rolling Process** Analysis of forging process for load estimation with sliding friction, sticking friction and mixed condition for slab and disc. Hand, power & drop Forging. Analysis of Rolling Process. Condition for rolling force and power in rolling. Rolling mills & rolled-sections	9
UNIT-II	
Other conventional forming processes Analysis of Wire/strip drawing and maximum-reduction, Tube drawing, Extrusion and its application. Analysis of forming process like cup/deep drawing. Bending & spring-back. **Sheet metal working**: Presses and their classification, Die & punch assembly and press work methods and processes. Cutting/Punching mechanism, Blanking & piercing. Compound & progressive dies. Flat-face & Inclined-face punches and load calculation. **Unconventional metal forming processes** Unconventional metal forming or High Energy Rate Forming (HERF) processes — explosive forming, electromagnetic, electro-hydraulic forming.	9
UNIT-III	
Welding: Survey of welding and allied processes. Gas welding and cutting, process and equipment. Arc welding: Power sources and consumables. TIG & MIG processes and their parameters. Resistance welding - spot, seam projection etc. Atomic hydrogen, submerged arc,	9

electroslag, friction, thermit welding. Soldering & Brazing.Shrinkage/residual stress in welds. Defects in welds and their remedies. Weld decay in Heat affected zone (HAZ). **Other joining processes** Soldering and Brazing	
UNIT-IV	
Casting Basic principle & survey of casting processes. Types of patterns and allowances. Types and properties of moulding sand, sand testing. Design considerations for elements of mould—Gate, Riser, Runner & Core. Solidification of casting. Sand casting— defects, remedies. Cupola furnace. Die Casting, Centrifugal casting, Investment casting, Continuous casting and CO_2 casting etc.	9

Textbooks&Reference books

1. Manufacturing Science -Ghosh and Mallik (EWP)
2. Manufacturing Engineering & Technology- Kalpakjian (Pearson)
3. Materials and Manufacturing by Paul Degarmo. (TMH)
4. Manufacturing technology – Foundry, Forming and Welding- P. N. Rao(TMH).
5. Manufacturing Processes Vol I – H. S. Shan (Pearson)
6. Production Engineering Science - P.C. Pandey (Standard publisher)
7. Production Technology - R.K. Jain (Khanna publication)
8. Production Engineering – P. C. Sharma (S. Chand)
9. Workshop Technology Vol1-B. S. Raghubanshi (Dhanpat Rai and Sons)

BME-30	**SEMINAR**	
Course category	:	Audit Course (AC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture:0, Tutorial : 0 , Practical: 6
Number of Credits	:	3
Course Assessment methods	:	Continuous assessment through quality of material, presentation, quality & extent of external response of question asked and participation in other seminars (attendance)
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to develop effective writing on recent technological development.
2. Ability to make effective presentation on power point.
3. Ability to comprehend question/answers during presentation.
4. Enhance oral communication skills.

BME-31	**MACHINE DESIGN - II**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	Mechanics of Solids (BME-14)
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one

		Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The ability to design different types of mechanical spring under static and fatigue loading, and knowledge of different types of screw threads and design of screw jack.
2. The knowledge of tooth forms, gear tooth materials, manufacturing methods and design of spur gear, helical gear and worm gear.
3. The knowledge of different parameters and selection criteria for the sliding contact bearing, rolling contact ball and roller bearing, its lubrication and mountings.
4. The knowledge of design considerations of IC engines parts and design of cylinder head, piston assembly, connecting rod and crankshaft.

Topics Covered

UNIT-I	
Power Screws: Forms of threads, multiple threads, Efficiency of square threads, Trapezoidal threads, Stresses in screws, Design of screw jack **Spur Gears** Tooth forms, System of gear teeth, contact ratio, Standard proportions of gear systems, Interference in involute gears, Backlash, Selection of gear materials, Gear manufacturing methods, Design considerations as per AGMA, Beam strength of gear tooth, Dynamic tooth load, Wear strength of gear tooth, Failure of gear tooth, Design of spur gears, AGMA and Indian standards.	9
UNIT-II	
Helical, Bevel and Worm Gears Terminology, Proportions for helical gears, Beam strength and wear strength of helical gears, herringbone gears, crossed helical gears, Design of helical gears. Design of Bevel Gear as per AGMA methodology. Types of worms, Terminology, Gear tooth proportions, Efficiency of worm gears, Heat dissipation in worm gearing, Strength and wear tooth load for worm gears, Design of worm gearing	9
UNIT-III	
Sliding Contact Bearing Types, Plain journal bearing, Hydrodynamic lubrication, Properties and materials, Lubricants and lubrication, Hydrodynamic journal bearing terminology, Bearing characteristic number, Heat generation, Design of journal bearing, Thrust bearing-pivot and collar bearing, Hydrodynamic thrust bearing, **Rolling Contact Bearing** Advantages and disadvantages, Types of ball bearing, Thrust ball bearing, Types of roller bearing, Selection of radial ball bearing, Bearing life, Selection of roller bearings, Dynamic equivalent load for roller contact bearing under constant and variable loading, Reliability of Bearing, Selection of rolling contact bearing, Lubrication of ball and roller bearing, Mounting of bearing	9
UNIT-IV	
Design of Flywheel, pressure vessels, belt, Introduction to design of IC Engine Parts.	9

Note: Design data book is allowed in the Minor/Major Examination.

EXPERIMENTS

(i) Minimum Six experiments out of the following are to be performed. Students are advised to use design data book for the design. Drawing shall be made wherever necessary on small drawing sheets

(ii) Mini Project: Students are required to write computer program and validate it for the design of at least two machine components studied in Machine Design-I and Machine Design-II theory subjects as home assignment which is be submitted at the end of the semester.

1. Design and drawing of helical spring subjected to static and fatigue loading
2. Design and drawing of screw jack
3. Generation of gear tooth profile
4. Design of spur gear drive
5. Design of helical gear drive
6. Design of worm and worm wheel
7. Design of journal bearing
8. Design of thrust bearing
9. Selection of ball and roller bearing
10. Design of cylinder and cylinder head
11. Design of piston assembly
12. Design of connecting rod
13. Design of crankshaft

Books & References

1. Mechanical Engineering Design – Joseph E. Shigely (McGraw Hill)
2. Mechanical Design of Machine Components – Norton (Prentice Hall)
3. Fundamentals of Machine Components Design – Juvinall (Wiley)
4. Design of Machine Members-Alex Valance and VI Doughtie (McGraw Hill)
5. Machine design-M.F. Spott (Prentice Hall India)
6. Machine Design-Maleev and Hartman (CBS)
7. Machine design -Black & Adams (McGraw Hill)
8. Design of Machine Elements-V.B. Bhandari (Tata McGraw Hill)

BME-32 REFRIGERATION & AIR CONDITIONING

Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the refrigeration principles, air refrigeration cycles and introduction to the different refrigerants.
2. Understand the knowledge of vapour compression refrigeration system and performance calculations.

3. Understand the knowledge of vapour absorption refrigeration systems. 4. Understand the psycometry in air conditioning systems and introduction to various refrigerating equipment and its application.	
Topics Covered	
UNIT-I	
Refrigeration Introduction to refrigeration system, Methods of refrigeration, Carnot refrigerationcycle, Unit of refrigeration, C.O.P. **Air Refrigeration cycle** Open and closed air refrigeration cycles, Bell Colemanair refrigeration cycle, Aircraft refrigeration system, Classification ofaircraft refrigeration system. **Refrigerants** Classification of refrigerants, Nomenclature, Desirable properties of refrigerants,Common refrigerants, secondary refrigerants and CFC free refrigerants.	9
UNIT-II	
Vapour Compression System Single stage system, Analysis of vapour compression cycle, Use of T-S and P-Hcharts, Effect of change in suction and discharge pressures on C.O.P, Effect of sub cooling& superheating of refrigerant on C.O.P of the cycle,Actual vapour compression refrigeration cycle, Multistage vapour compression systemrequirement, Removal of flash gas, Intercooling, Cascade system. **Vapour Absorption system** Working Principal of vapour absorption refrigeration system, Comparisonbetween absorption & compression systems, Ammonia – Water vapour absorption system, Lithium-Bromide water vapour absorption system.	9
UNIT-III	
Air Conditioning Introduction to air conditioning, Psychometric properties and their definitions,Psychometric chart, Different Psychometric processes, Adiabatic mixing of two streams, Thermal analysis of human body,Effective temperature and comfort chart. Cooling and heating load calculations. Selection of inside & outside design conditions, Heat transfer through walls & roofs, Infiltration & ventilation, Internal heat gain, Sensible heat factor (SHF), By pass factor, Grand Sensible heat factor (GSHF), Apparatus dew point (ADP). Introduction to desiccant cooling.	9
UNIT-IV	
Refrigeration Equipment & Applications Elementary knowledge of refrigeration & air conditioning equipment's, e.g., compressors, condensers, evaporators & expansion devices, Air washers, Cooling,towers & humidifying efficiency, Food preservation, Cold storage, Refrigerates Freezers,Ice plant, Water coolers, Elementary knowledge of transmission and distribution of airthrough ducts and fans.	9

EXPERIMENTS

Minimum Eight experiments are to be conducted from the following

1. Refrigeration test rig and calculation of various performance parameters.
2. Analysis of different types of expansion devices used in refrigeration system.
3. Basic components of air-conditioning system.
4. Experiment on air-conditioning test rig & calculation of various performance parameters.
5. Experiment on air washers.
6. Study air washer.
7. Study of window air conditioner.
8. Central air conditioning plant and its detailed study.
9. Cold-storage and its detailed study.
10. Experiment on Ice-plant.
11. Study of Hermetically sealed compressor.
12. Analysis of vortex tube refrigerator
13. Determine the COP of vapour absorption

Books & References

1. Refrigeration and Air conditioning - Manohar Prasad (New Age International (P) Ltd)
2. Refrigeration and Air conditioning - C.P Arora (Tata McGraw Hill).
3. Refrigeration and Air conditioning - Arora &Domkundwar (Dhanpat Rai & Co.(p) Ltd-delhi).
4. Refrigeration and Air conditioning -Stoecker &Jones (McGraw-Hill Education India Pvt.Ltd - New Delhi).
5. Principle of Refrigeration - Roy J. Dossat (Pearson).
6. Refrigeration and Air conditioning - P.L. Baloney (Khanna).
7. Thermal Environment Engineering - Kuhen, Ramsey & Threlkeld (Prentice Hall)
8. Performance studies of desiccant cooling systems - P.Rai, S.K. Shukla (Lambert publication Germany)

BME-33	**IC ENGINES**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The importance & Classification of engine and air standard cycles.
2. The knowledge of SI Engines, of carburetor and performance parameters.
3. The knowledge of CI Engines, performance parameters and its control.
4. The knowledge of cooling systems and lubrication systems Supercharging&Turbocharging.

Topics Covered

UNIT-I	
Introduction to IC Engines Engine classification, Air standard cycles, Otto cycle,Diesel cycle, Dual cycle sterlin & ericssion, Comparison, Actual cycle analysis, Two and four stroke engines, SI and CI engines,Valve timing diagram, Rotary engines, homogeneous and stratified charge engine. **Fuels** Fuels for SI and CI engine, Important qualities of SI and CI engine fuels, Ratingof SI engine and CI engine fuels, Dopes, Additives, Gaseous fuels, Alternative fuels for IC engines ,like, LPG, CNG, Biogas,Producer gas Hydrogen & biodiesel.	9
UNIT-II	
Testing and Performance of IC engines Performance parameters, Basic measurements, Blow by measurement, Testing of SI and CI engines. Morse test, heat balance sheet, constant speed / variable speed test, Eeffect of altitude fuel on power output. **SI Engines** Combustion in SI engine, Flame propagation and speed, Ignition delay, Abnormal combustion and itscontrol, combustion chamber design for SI engines. Carburetion, Mixture requirements, Carburetor types, scavenging, Theory of carburetor, MPFI. Ignition system requirements, Magneto and battery ignition systems, ignition timing andspark plug, Electronic ignition, GDI and HCCI engine, CRDI.	9
UNIT-III	
CI Engines Combustion in CI engines, Ignition delay, Knock and it's control, Combustion chamber design of CI engines, Fuel injection in CI engines, Requirements, Types of injection systems, Fuel pumps,Fuel injectors, Injection timings, CRDI, pollution and it's control.	9
UNIT-IV	
Engine Cooling: Different cooling systems, Radiators and cooling fans. **Lubrication:** Engine friction, Lubrication principle, Type of lubrication, Lubrication oils, And its properties. **Supercharging:**supercharger, Types of supercharging & turbocharger	9

EXPERIMENTS

Minimum eight experiments are to be conducted from the following:

1. Study and experiments on ignition system of I.C. engine.
2. Study and experiments on fuel supply of S.I. engine-carburettor, fuel injection pump and MPFI.
3. Experiments on fuel supply system of C.I. engine- Injector and fuel pump.
4 Determination of indicated H.P. of I.C. engine by Morse test.
5 Performance of CRDI Engine.
6 Prepare the heat balance for diesel engine test rig.
7 Prepare the heat balance sheet for petrol engine test rig.
8 Study of a water-cooled radiator.
9 Study and experiment on catalytic convertor.
10 Performance analysis on constant/variable sped engines.
11 Valve timing diagram of IC engine.
12 Determine the volumetric efficiency of IC engine.
13 Exhaust gas analysis of an I.C. engine.
12 Performance test of I.C. engine by using Blended/Alternate fuels

Books & References

1. Fundamentals of Internal Combustion Engine - Gill, Smith,Ziurs (Oxford & IBH Publishing Co.)
2. IC Engines – Rogowsky (International Book Co.)

3. Internal Combustion Engine and Air Pollution- E.F Obert (Harper & Row, New York)
4. A Course in International Combustion Engines - Mathur & Sharma (Dhanpat Rai & Sons)
5. I.C Engine – Ganeshan (Tata McGraw Hill)
6. I.C Engine - R. Yadav (Central Publishing House)
7. Turbines, Compressors and Fans - S.M.Yahya (Tata McGraw Hill)
8. Fundamentals of Combustion – D. P. Mishra (PHI Leaning Pvt. Ltd.)
9. IC engine by JB HEYWOOD(McGraw Hill Education)

BME-34	**MACHINE TOOLS & MACHINING**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Able to understand mechanics of metal cutting, lubricants, tool materials, economics of metal cutting, etc.
2. Study the principles, construction of various parts and working of different machine tools.
3. Able to understand the grinding and super finishing operations and concepts of Standardization & Interchangeability, Limits, Fits & Tolerance and Surface roughness
4. Understand principle and working of different non-conventional machining processes.

Topics Covered	
UNIT-I	
Metal Cutting Mechanics of metal cutting. Geometry of tool and nomenclature. ASA system. Orthogonal/ oblique cutting. Mechanics of chip formation, types of chips. Shear angle relationship. Merchant's force circle diagram.Measurement of cutting forces, effect of tool geometry. Effect of cutting forces on product quality. Cutting fluids/lubricants. Machinability, dynamometer, economics of metal cutting	9
UNIT-II	
Tool materialsand Machine Tools: Tool materials, tool wear and tool life. Different tool materials and applications including effect of coating **Machine Tools** (i) Lathe: Principle, construction, types, operations, Turret/capstan, semi/Automatic, Tool layout. (ii) Shaper, slotter, planer: Construction, operations & drives. (iii) Milling: Construction, Milling cutters, up & down milling. (iv) Drilling, boring & reaming operation tools. Geometry of twist drills. Introduction to machine tool vibration and surface finish.	9
UNIT-III	
Grinding, Super finishing Grinding wheels, abrasives (bonds & cutting action). Grinding wheel specification. Mechanics of	9

grinding. Surface and cylindrical grinding. Centre less grinding. **Super finishing:** Honing, lapping, and polishing. **Jigs & Fixtures** Locating & Clamping devices & principles. Jigs and fixtures and its applications. Standardization & Interchangeability Limits, Fits, Tolerance and Surface roughness	
UNIT-IV	
Unconventional Machining Introduction. Limitations of conventional machining processes, need of Unconventional machining processes & their classifications. Principle, working and applications of Abrasive Jet Machining (AJM), Ultra sonic Machining (USM), Electro discharge machining (EDM), Electrochemical Machining (ECM), & Electron beam machining (EBM)	9

EXPERIMENTS

Minimum eight experiments are to be conducted from the following:

1. Design and Pattern making
2. Casting.
3. Hand & power forging.
4. Press work experiment such as blanking/piercing, washer, making etc.
5. Wire drawing/extrusion on soft material.
6. Shear-angle determination (using formula) with tube cutting (for orthogonal) on lathe machine
7. Bolt (thread) making on Lathe machine
8. Gear cutting on milling machine
9. Machining a block on shaper machine
10. Study of different types of tools and its materials
11. Experiment on tool wear and tool life
12. Experiments on welding (Gas, Arc & Resistance)
13. Experiment on unconventional machining

Books & References

1. Manufacturing Science - Ghosh and Mallik (EWP)
2. Production Technology - R.K. Jain (Khanna Publication)
3. Principles of Machine Tools:Sen, G. C., & Bhattacharyya, A. (New Central Book Agency)
4. Advanced Machining Process - VK Jain (Allied Publisher)
5. Fundamentals of Metal Cutting & Machine Tools – Juneja & Shekhon (New Age International)
6. Production Technology – P. C. Sharma (S. Chand)
7. Introduction to Machining Science – G. K. Lal (New Age Publisher)
8. Manufacturing Technology : Metal Cutting & Machine Tools- P. N. Rao (TMH)
9. Production Engineering Science - P.C. Pandey (Standard Publisher)
10. Modern Machining Processes - P.C. Pandey & H.S. Shan (TMH)
11. Manufacturing Engineering & Technology- Kalpakjian (Pearson)
12. Process & Materials of Manufacturing – Roy A. Lindburg (Prentice Hall)
13. Materials and Manufacturing - Paul Degarmo (TMH)
14. Workshop Technology Vol. II-B. S. Raghubanshi (Dhanpat Rai and Sons)

BME-35	**INTRODUCTION TO INDUSTRIAL ENGINEERING**

Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory

		Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the concept, function and application of Industrial Engineering, production and productivity, measurement of productivity, work study, work sampling.
2. The knowledge of job evaluation and analysis, wage-incentive payment plans, materials handling, objectives and functions of production planning and control, break-even-analysis.
3. The understanding of depreciation, service life of assets, inventory control, Control charts, acceptance plan and acceptance sampling.
4. Understand the concept and importance of organization, organizational structure, organizational chart, sole &proprietary enterprise, labour legislation, factory act, wage and insurance act.

Topics Covered

UNIT-I	
Introduction Concept of Industrial Engineering, function and techniques of Industrial Engineering, role of an industrial engineer. Application of industrial engineering **Production and Productivity** Concept of production, production function, production system, definition of productivity, difference between productivity and production, productivity efficiency and effectiveness, measurement of productivity, types of productivity, productivity index, ways to improve productivity. **Work study** Definition and concept, objectives of work study, purpose and procedure of method study, analysis of motion, micromotion study, motion economy principles, flow chart, man-machine chart, PMTS, work measurement, stop- watch time study, performance rating, standard time, work sampling.	9
UNIT-II	
Job Evaluation & Merit rating Concept of job evaluation, Job analysis, Job description, job simplification, job evaluation methods. Definition and methods of merit rating, wage-incentive payment plans. **Plant layout and loacation** Plant layout and materials handling Considerations in Plant location, definition of plant layout, types of layout, principles of Plant layout, material handling equipments **Production planning and control** Objectives of PPC, Functions of PPC, production planning, steps in PPC, Effectiveness of PPC system **Break-Even-Analysis** Introduction and purpose of BEA, Margin of safety, Angle of incidence, Profit volume graph.	9
UNIT-III	
Depreciation and Replacement Concept of depreciation, obsolescence, classification of depreciation, method of charging depreciation, service life of assets, Replacement of items. **Inventory Control** Inventory, function of inventory, inventory cost, deterministic inventory models **SQC and Acceptance Sampling** Introduction, process control, Control Charts, acceptance plan, acceptance sampling, single, double & sequential sampling plans, concept of average outgoing quality.	9
UNIT-IV	
Organization Concept and importance of organization, Principles of organization, organizational structure, Design of organization, Organizational chart. **Industrial Ownership**	9

Sole/proprietary enterprise, partnership firm, Joint stock company, classification of company, comparison of public, private and joint sector, & co-operative organization.

Factory legislation in India

Importance and principles of labour legislation, factory act, payment of wages act, minimum wages act.

Books & References

1. Production Management- S. K. Hajara Choudhary, Nirjhar Roy and A. K. Hajara Choudhary (Media Promoters and Publisher)
2. Production and Operation Management - Adam and Ebert (Pearson Education Asia)
3. Modern Production/operations Management- Buffa (Wiley Eastern, New York).
4. Industrial Engineering and operations management- S.K. Sharma & Savita Sharma (SK Kataria & sons)
5. Industrial Engineering – A.P. Verma (SK Kataria & sons)
6. Industrial Engineering – M.I. Khan (New Age International)
7. Industrial Engineering – S. Seetharaman & B. Vijayaramnath (Umesh Publications)
8. Industrial Engineering and Management – O.P. Khanna (Dhanpat Rai Publications)

BMC-40	**PROJECT PART-I**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 0, Tutorial : 0 , Practical: 10
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through three viva voce/presentation, preliminary project report, effort and regularity and end semester presentation
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Able to apply knowledge of various streams of mechanical engineering to finalize the statement of project.
2. To carry out literature review of relevant project problem using books, research papers and internet.
3. To finalize the activities to be carried out to complete the project through bar chart.

BME-41	**AUTOMOBILE ENGINEERING**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	IC Engines (BME-33)
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Good knowledge of automotive components and machineries and Ability to absorb the concerned problem at first instance and provide the suitable remedial measure to the problem.
2. Proficient in designing innovative projects and various transmission systems for fuel efficient engine.
3. Ability to demonstrate the various braking system, chassis and suspension system and electrical systems for automobiles like ignition, horn and battery.
4. Ability to demonstrate the fuel supply, air-conditioning, cooling and lubrication and maintenance systems for automobiles.

Topics Covered

UNIT-I	
Power Unit and Gear Box Principles of Design of main components. Valve mechanism. Power and Torque characteristics. Rolling, air and gradient resistance. Tractive effort. Gear Box. Gear ratio determination, Design of Gear box	9
UNIT-II	
Transmission System Requirements. Clutches. Torque converters. Over Drive and free wheel, Universal joint. Differential Gear Mechanism of Rear Axle. Automatic transmission, Steering and Front Axle. Castor Angle, wheel camber & Toe-in, Toe-out etc. Steering geometry. Ackerman mechanism, Understeer and Oversteer. **Vehicle stability**- Stability analysis of the Linearlized model of vehicle , stability on a curve	9
UNIT-III	
Braking System General requirements, Road, tyre adhesion, weight transfer, Braking ratio. Mechanical brakes, Hydraulic brakes. Vacuum and air brakes. Thermal aspects. **Chassis and Suspension System** Loads on the frame. Strength and stiffness. Various suspension systems. **Electrical System** Types of starting motors, generator & regulators, lighting system, Ignition system, Horn, Battery etc.	9
UNIT-IV	
Fuel Supply System Diesel & Petrol vehicle system such as Fuel Injection Pump, Injector & Fuel Pump, Carburetor etc. MPFI. **Automobile Air Conditioning** Requirements, Cooling & heating systems **Cooling & Lubrication System** Different type of cooling system and lubrication system **Maintenance system** Preventive maintenance, break down maintenance and over hauling.	9

EXPERIMENTS

Minimum Eight experiments are to be conducted from the followings:

1. Study & experiment on Ignition system of I.C. Engine.
2. Study & experiment on Fuel Supply System of S.I. Engines- Carburettor, Fuel Injection Pump and MPFI.
3. Study & experiment on Fuel Supply System of C.I. Engines- Injector & Fuel Pump.

4. Study & experiment on Valve mechanism.
5. Study & experiment on Gear Box.
6. Study & experiment on Differential Gear Mechanism of Rear Axle.
7. Study & experiment on Steering Mechanism.
8. Study & experiment on Automobile Braking System.
9. Study & experiment on Chassis and Suspension System.
10. Study & experiment on Air Conditioning System of an Automobile.
11. Comparative study of technical specifications of common small cars (such as Maruti Swift, Hyundai i20, Cheverlet Aveo, Tata Indica, Ford Fusion etc.
12. Comparative study & technical features of common scooters & motorcycles available in India.
13. Visit of an Automobile factory.
14. Visit to a Modern Automobile Workshop.
15. Experiment on Engine Tuning.
16. Experiment on Exhaust Gas Analysis of an I.C. Engine
17. Determination of Indicated H.P. of I.C. Engine by Morse Test
18. Prepare the heat balance for Diesel Engine test rig
19. Prepare the heat balance sheet for Petrol Engine test rig

Books & References

1. Automotive Machines- Hietner (CBS Publisher)
2. Automobile Engineering - Kripal Singh (Standard).
3. Automobile Engineering – Narang (Khanna).
4. Automotive Mechanics- Crouse, Anglin (Career Education)
5. Motor Vehicle–Garrett, Newton and Steeds (Society of Automotive Engineers Inc).

BME-42	**COMPUTER AIDED DESIGN**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The importance, benefits, applications and essential elements of CAD such as graphics input, display and output devices.
2. The knowledge of graphics software, graphics standards, configuration and functions; skill of writing algorithm for generating 2D graphic elements; and understand the mathematics behind 2D & 3D individual and combined geometric transformations.
3. The ability of mathematical representation of parametric form of analytic planar curves and synthetic space curves such as Hermite, Bezier and B-spline curves and knowledge of their properties.
4. The knowledge of polygonal, quadric and superquadric surfaces, blobby objects, color models and different solid modeling techniques and skill of developing 3D geometric

models in CAD software.	
Topics Covered	
UNIT-I	
Introduction Computer in Engineering design, Classical vs. Computer Aided Design, Elements of CAD, Essential requirements of CAD, CAD Tools, Concepts of integrated CAD/CAM, Necessity & benefits, Engineering Applications **Computer Graphics Hardware** Graphics systems, Graphics Input devices-cursor control devices, Digitizers, Image scanner, Speech oriented devices, Graphics display devices-Cathode Ray Tube, Calligraphic display, DVST, Raster display, Color frame buffer, Color CRT monitors, Solid state monitors-emissive displays, non-emissive displays, Graphics output devices- Hard copy printers and plotters	9
UNIT-II	
Computer Graphics Software Graphics Software, Software Configuration, Coordinate system, Graphics software functions, Viewing transformations-windowing and clipping, Graphics software standards **Output primitives** Scan conversion of primitives, Line generation algorithms-DDA and Bresenham's line drawing algorithm, Circle generating algorithm-Cartesian coordinates, Polar coordinates and Bresenham's algorithm **Geometric Transformations** 2D Geometric transformations-Translation, Scaling, Shearing, Rotation & Reflection Matrix representation-homogeneous coordinates, Rotation and scaling about arbitrary point, Reflection through arbitrary line, Composite transformation, 3 D transformations, multiple transformation	9
UNIT-III	
Planar Curves Curves representation, Interpolation vs approximation, Classical representation of curves, Parametric analytic curves-lines, circles, ellipses, parabolas and hyperbolas **Space Curves** Properties for curve design, Parametric continuity, Parametric representation of synthetic curves, , Spline curves and specifications, Parametric representation of synthetic curves, Hermite curves-Blending functions formulation, shape control, properties, Bezier curves-Blending functions formulation, properties, Non-rational B-spline curves- Blending functions formulation, knot vector, B-spline blending functions, properties	9
UNIT-IV	
3D Graphics Introduction, Wireframe modeling, Surface modeling, Polygon surfaces-polygon meshes, polygon equations, Quadric and Superquadric surfaces, Blobby objects, Solid modeling-Boolean set operations, regularized set operations, Primitive instancing, Sweep representation-translational, rotational and hybrid sweeps, Boundary representation-topology, geometry, boundary models, Constructive solid geometry-unbounded and bounded primitives **Color models** Coloring in computer graphics, RGB, CMY, YIQ, HSV and HLS color models	9
EXPERIMENTS **Minimum Eight experiments are to be conducted from the followings:** 1. Understanding and use of drafting software AutoCAD 2. Sketching and solid modeling of a machine component in any CAD software 3. Sketching and solid modeling of machine assembly in any CAD software 4. Writing and validation of line drawing algorithm	

5. Writing and validation of circle drawing algorithm
6. Writing and validation of computer program for individual 2D/3D Geometric Transformation such as translation/rotation/scaling
7. Writing and validation of computer program for 2D/3D Combined Geometric Transformations
8. Writing and validation of computer program for design of shaft under the combined bending and torsional loading
9. Writing and validation of a computer program for generating planar curves
10. Writing and validation of computer program for generating space curves

Books & References

1. Computer Graphics-Hearn & Baker (Prentice Hall of India)
2. Computer Aided Engineering Design-Anupam Saxena & B. Sahay (Anamaya Publishers)
3. CAD/CAM Theory and Practice- Ibrahim Zeid & R SivasubramaniamB(McGraw Hill)
4. Mathematical Elements for Computer Graphics- DF Rogers & JA Adams (McGraw Hill)
5. CAD/CAM-HP Groover & EW Zimmers, Jr (Prentice Hall India)
6. Computer Aided Design-S.K. Srivastava (IK International Publications)
7. Computer Aided Design-R.K. Srivastava (Umesh Publications)

BME-43 COMPUTER AIDED MANUFACTURING

Course category	:	Department Core (DC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the role of computer in the areas of automation and manufacturing for improving their effectiveness and fundamentals of CNC machine tools.
2. Ability to develop manual part program and computer assisted part program for the production of components.
3. Ability to design and develop various systems such as feedback, interpolator, material handling and implementation of adaptive control.
4. Ability to apply the concept of group technology and computer assisted process planning and knowledge about Robotics.

Topics Covered

UNIT-I	
Automation Need of automation, basicelements of automation, levels of automation, automation strategies, advantages & disadvantages of automation, historical development and future trends, automated manufacturing system Introduction to computer integrated manufacturing (CAM). **Features of NC Machines** Fundamental of Numerical Control, elements of NC machine tools, classification of NC machine	9

tools, Advantages, suitability and limitations of NC machine tools, Application of NC system, Methods for improving Accuracy considering the factors such as tool deflection and chatter, Methods for improving productivity.	
UNIT-II	
CNC Part Programming Part programming fundamentals, Manual programming for drilling, turning and milling operations, canned cycles, Do loops, Subroutine, and Macros. Computer aided part programming, APT programming. Geometry, Motion and additional statements, Macro- statement	9
UNIT-III	
System Devices Introduction to DC motors, stepping motors, feedback devices such as encoder, counting devices, digital to analog converter and vice versa. **Interpolators** Digital differential Integrator-Principle of operation, exponential decelarion, DDA Hardware Interpolator- Linear, Circular; DDA Software Interpolator **Control of NC Systems** Open and closed loops. Control of point to point systems- Incremental open loop control, Incremental close loop, Absolute close loop; Control loop in contouring systems; Adaptive control.	9
UNIT-IV	
Computer Integrated Manufacturing system Group Technology, Flexible Manufacturing System, Computer aided process planning; Concept of Mechatronics, Computer aided Inspection. **Robotics** Types and generations of Robots, Structure and operation of Robot, Robot applications. Economics, Robot programming methods. VAL and AML (with examples)	9

EXPERIMENTS

Minimum Eight experiments are to be conducted from the followings:

1. To study the characteristics features of CNC lathe trainer.
2. To study the characteristics features of CNC Turning machine.
3. To study the characteristics features of CNC Milling machine.
4. To write Manual part program for a job for turning operation and prepare the component.
5. To prepare Manual part program for a job for drilling operation.
6. To write Manual part program for a job for milling operation and prepare the component.
7. Study of retrofitting.
8. Study of a pick and place robot.
9. Write a program for a pick and place robot to shift the work piece from one location to another.
10. To prepare a part program in APT for drilling operation.
11. To prepare a part program in APT for milling operation.

Books & References

1. Automation, Production Systems and Computer Integrated Manufacturing by Mikell P. Groover (PHI)
2. Computer Aided manufacturing- P. N. Rao , N. K. Tewari & T. K. Kundra (Tata McGraw Hill).
3. CAD/CAM/CIM – P. Radhakrishnan, S. Subrmanyam and V. Raju (New Age International)
4. Computer Aided Manufacturing – Chang, Wysk and Wang (Pearson)
5. Computer Control of Manufacturing systems – Koren (McGraw Hill)
6. Numerical control and Computer aided manufacturing- - P. N. Rao , N. K. Tewari & T. K. Kundra (Tata McGraw Hill)
7. Computer Aided Design & Manufacture – C. B. Besant & C. W. K. Lui (East West Press)
8. NC Machines – S. J. Martin (English Language Book Society)

9. CAD/CAM – Ibraheim Zeid (Tata McGraw Hill)
10. CAD/CAM- P. N. Rao (Tata McGraw Hill)
11. Principles of Computer Integrated Manufacturing – S. Kant Bajpai (PHI)

BME-45	**INDUSTRIAL / PRACTICAL TRAINING**	
Course category	:	Audit Course (AC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 0, Tutorial : 0 , Practical: 2
Number of Credits	:	1
Course Assessment methods	:	Continuous assessment through technical quality of the work, attendance, discipline, involvement and interest, project work, viva voce, project report and presentation
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. An ability to apply knowledge of mathematics, science and engineering in the development of product and process.
2. An ability to design and conduct experiments as well as to analyze and interpret data.
3. An ability to perform multidisciplinary task for the professional development in the field of engineering.
4. Ability to identify sources of hazards, and assess/identify appropriate health & safety measures
5. Ability to demonstrate the use, interpretation and application of an appropriate international engineering standard in a specific situation

BME-50	**PROJECT PART-II**	
Course category	:	Department Core (DC)
Pre-requisite Subject	:	Project Part-I (BME-40)
Contact hours/week	:	Lecture : 0, Tutorial : 0 , Practical: 10
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through three viva voce/presentation, final project report, contribution made to literary world and Major examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Able to design the various component/subsystem of project using basic and advanced knowledge of science and engineering courses.
2. Able to analyse the various components/process of project problem.
3. Able to fabricate the hardware through different fabrication techniques available.
4. Able to make computer programme to design and analyse different components of product.
5. Able to make conclusion of given project.

BME-51	HYDRAULIC MACHINES	
Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	Fluid Mechanics (BME-16)
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Define basic principles of operation of different types of Hydraulic Turbines and estimate hydrodynamics thrust of jet on fixed and moving plate.
2. Principles, construction, working and design of Francis Turbine and Kaplan Turbines, and its performance characteristics.
3. Classification, Principles, construction, working and design of centrifugal pumps and its performance characteristics.
4. Principles, construction, working of positive displacement reciprocating and rotary pumps and basic aspects of its design. Principles, construction and working of hydraulic accumulator, hydraulic press, hydraulic lift cranes, hydraulic ram, jet pumps, etc.

Topics Covered	
UNIT-I	
Introduction Impulse Momentum Principle, Application of momentum and momentum equation to flow through hydraulic machinery, Euler's fundamental equation, Introduction to hydro electric power plants, major components, surge tanks, etc. **Impact of Free Jets** Force exerted by the jet on stationary flat and curved, hinged plate, moving plate and moving curve vanes, effect of inclination of jet with the surface,jet propulsion of ship **Impulse Turbine** Classification of turbines, Impulse turbines, Pelton wheel, Constructional details, Working, Work done, Power and efficiency calculations, Design aspects, Governing of Impulse Turbines	9
UNIT-II	
Reaction Turbines Francis and Kaplan turbines, Constructional details, Velocity triangles, Power andefficiency calculations, Degree of reaction, Draft tube, Cavitations in turbines, Principlesof similarity, Unit and specific speed, Performance characteristics, Selection of waterturbines, Governing of reaction turbine	9
UNIT-III	
Centrifugal Pumps Classifications of centrifugal pumps, Construction, Working, Work done by impellor, Heads, Efficiencies of centrifugal pumps, Specific speed, Model testing, Multistage pumps, Pump in series and parallel, Performance characteristics. Net positive Section Head, Cavitations and Separation	9
UNIT-IV	
Reciprocating Pumps: Classification, Components and Working, Single acting and double acting,	9

Discharge, Work done and power required, Coefficient of discharge and slip, Effect of acceleration of Piston, Indicator Diagram, Air Vessels

Fluid system: Hydraulic accumulator, Hydraulic intensifier, Hydraulic Press, Hydraulic crane, Hydraulic lift, Hydraulic Ram, Hydraulic coupling, Hydraulic torque converter, Air lift pumps, Jet pumps

EXPERIMENTS

Minimum Eight experiments are to be conducted from the followings:

1. Impact of Jet experiment.
2. Conducting experiments and drawing the characteristics curves of Pelton wheel.
3. Conducting experiments and drawing the characteristics curves of Francis turbine.
4. Conducting experiments and drawing the characteristics curves of Kaplan turbine.
5. Conducting experiments and drawing the characteristics curves of Reciprocating pump.
6. Conducting experiments and drawing the characteristics curves of centrifugal pump.
7. Experiment on Hydraulic Jack/Press
8. Experiment on Hydraulic Brake
9. Experiment on Hydraulic Ram
10. Experiment on Compressor
11. Experiment for measurement of drag and lift on aerofoil in wind tunnel
12. Study through detailed visit of any water pumping station/plant

Books & References

1. Mechanics of Fluid – Massey B.S.(English Language Book Society, U.K.)
2. Hydraulic Machines - Jagdish Lal (S.K. Kataria & Sons)
3. Introduction to Fluid Mechanics and Fluid Machines – S.K. Som & G. Biswas (TMH)
4. Hydraulics and Fluid Mechanics – Modi P.N, Seth S.M. (Standard Book House)
5. A Treatise on Applied Hydraulics –Addison (Chapman and Hall)

BME-52 PRINCIPLES OF MACHINE TOOLS DESIGN

Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	Manufacturing Science (BME-29)
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The knowledge of developments in machine tools, construction and operations of basic machine tools, tool wear and force analysis.
2. Understand the elements ofmechanical and hydraulic transmission system, fundamental of kinematic structure of machine tools.
3. Demonstrate an understanding of regulation of speed, feed rates and design of machine tool structure – bed, column and housing.
4. The knowledge of designing guideways and power screw,dynamic stability of cutting process, machine tool installation and maintenance.

Topics Covered	
UNIT-I	9
Introduction Developments in machine tools, surface profiles and path produced by machine tools, features of construction and operations of basic machine tools such as lathe, drill, milling, shaper and grinding machine, General requirement of machine tool design & process, tool wear, force analysis.	
UNIT-II	9
Machine Tools Drives Classification of machine tool drives, group & individual drives, selection of electric motor, A brief review of the elements of mechanical transmission such as gear, belt, and chain drives, slider crank mechanism, cam mechanism, nut and screw transmission, devices for intermittent motion, reversing & differential mechanisms, Coupling and clutches. Elements of hydraulic transmission system- pumps, cylinder, directional valves, pressure valves etc. Fundamentals of Kinematic structure of machine tools	
UNIT-III	9
Regulation of Speed and Feed rates Laws of stepped regulation, selection of range ratio, standard progression ratio, selection of best possible structural diagram, speed chart, Design of feed box, Developing gearing diagrams. Stepless regulation of speed and feed in machine tools. **Design of Machine Tool Structure** Requirements and design criteria for machine tool structures. Selection of material's Basic design procedure for machine tool structures—bed, column & housing.	
UNIT-IV	9
Design of Guideways and Power Screws Basic guideway profiles. Designing guideways for stiffness a wear resistance & hydrostatic and antifriction guideways. Design of sliding friction power Screws. Design of spindlier & spindle supports. Layout of bearings, selection of bearings machine tools. **Dynamics of Machine Tools** General procedure for assessing the dynamic stability of cutting process, closed loop system, chatter in machine tools. Machine tool installation and maintenance	
Books & References	
1. Machine Tools Design & Numerical Controls –N.K. Mehta (Tata McGraw Hill) 2. Design of Machine Tools – S.K. Basu (Allied Publishers) 3. Principles of Machine Tools –A. Bhattacharya and G.C. Sen (New Central book Agency) 4. Machine Tool Design Handbook (CMTI, Bangalore)	

BME-53	**PRODUCTION PLANNING & CONTROL**	
Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Recognize the objectives, functions, applications of Production Planning and Control and forecasting techniques.
2. Summarize various aggregate production planning techniques.
3. Solve routing and scheduling problems.
4. Knowledge of various process planning approaches.
5. Explain different inventory control techniques.
6. The importance of productivity, productivity patterns, role of ergonomics in productivity.

Topics Covered

UNIT-I	
Introduction Types and characteristics of production systems. Functions of Production and Process Planning, production equipment and tooling selection **Preplanning** Forecasting- characteristics of demand over time; Forecasting qualitative model- Delphi; naïve quantitative models; simple average, simple moving average, weighted moving average, exponential smoothing; Selection of forecasting models, Market Analysis, Plant Layout, Equipment policy and replacement, Capacity planning.	9
UNIT-II	
Production Planning Aggregate Planning: concept, strategies for aggregate planning, master production scheduling (MPS), procedure for developing MPS; Routing, Scheduling and priority dispatching; scheduling techniques for job shop, load charts and machine loading charts, dynamic sequencing rules, Line Balancing.	9
UNIT-III	
Process Planning Approaches to process planning, Process planning activities, Set of documents for process planning, Developing manufacturing logic and knowledge. **Inventory Control** Progress control through records and charts, Inventory Classification, Deterministic and probabilistic inventory models, Quantity discounts, Economic Order Size, Economic lot size. JIT production, MRP & MRP II, Push and Pull systems.	9
UNIT-IV	
Cost Estimation Introduction to cost estimation- importance of costing and estimation, methods of costing, elements of cost estimation, types of estimates, estimating procedure, estimation of labor cost, material cost and overheads, allocation of overhead charges, calculation of depreciation cost, **Productivity & Ergonomics** Importance, Productivity patterns, productivity measurements, improvement measures. Ergonomics -principles and application, workplace design.	9

Books & References

1. Operation Management-Lee J. Krajewski, Larry P. Ritzman, Manoj K Malhotra (Pearson Publication)
2. Modern Production Operations Management – Buffa (John Wiley & Sons Inc)
3. Elements of Production Planning & Control –Eilon (Universal Publishing Corporation)
4. Manufacturing Processes and Systems- Ostwaal P.F. and Munez J, John Wiley
5. Product Design and Manufacturing- Chitale A.V. and Gupta R.C,Prentice Hall
6. Production Planning Control and Industrial Management – Jain and Agrarwal (Khanna Publishers)

BME-54	**INDUSTRIAL TRIBOLOGY**

Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0

Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the scope of tribology and its applications in manufacturing and machining processes.
2. The knowledge of theory of friction and its mechanisms in metals, ceramics and polymers.
3. The knowledge of wear, its classification, different theories, wear models and its engineering applications.
4. The understanding of lubrication, types of lubricant and their flow, and different lubrication mechanisms.

Topics Covered

UNIT-I	
Introduction Definition and Scope of tribology, Contact of solids, Surface topology, Surface interaction. **Applications** Application of tribology in manufacturing processes, Metal machining, Metal cutting, Tool wear, Action of lubricants, Friction welding, Extrusion process	9
UNIT-II	
Friction Definitions, Types, Friction laws, Modern theory of dry solid friction, Mechanism of rolling friction, measurement of friction, friction of metals ceramics and Polymers	9
UNIT-III	
Wear Classifications, wear models, factors affecting wear, Theories of adhesives, Abrasives, Surface fatigue and corrosive wear, Miscellaneous wear theory such as Erosive, cavitations and Fretting wear, Wear of miscellaneous machine components such as gears, Plane bearings and rolling elements.	9
UNIT-IV	
Lubrication Lubrication of bearing, Lubricant, Mineral Oil, Grease, Solid lubricant, Lubrication regime, Viscous flow, Reynolds equation and its limitations, Hydrodynamic lubrication, Hydrostatic lubrication, Elastohydrodynamic lubrication, Boundary lubrication, Squeeze films.	9

Books & References

1. Engineering Tribology – P Sahoo (Prentice Hall of India)
2. Principles and Applications of Tribology- D.F. Moore(Pergamon Press)
3. Fundamentals of Tribology- Basu, Sengupta&Ahuja(Prentice Hall of India)
4. Friction and Wear of Engineering Materials- I.M. Hutchings (Edwar Arnold, London)
5. Friction and Lubrication- E.P. Bowden and Tabor (Oxford Clarendon Press)
6. Engineering Tribology- Stachowiak &Batchelor (Butterworth-Heinemann)

BME-55	TOTAL QUALITY MANAGEMENT	
Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Acquire the basic knowledge of quality and its evolution.
2. The knowledge of Organization structure and design and Total Quality Management principles for continuous improvement.
3. The understanding of quality management tools to evaluate the quality.
4. The knowledge of ISO-9000, ISO 14000 and TQM implementation.

Topics Covered

UNIT-I	
Quality Concepts Introduction, need for quality, evolution of quality; Definitions of quality, product quality and service quality; Methods and techniques for inspection and control of product, Basic concepts of TQM, TQM framework, contributions of Deming, Juran and Crosby. Barriers to TQM; Quality statements, customer focus, customer orientation & satisfaction, customer complaints, customer retention; costs to quality.	9
UNIT-II	
TQM principles Organization structure and design, Leadership, strategic quality planning; Quality councils-employee involvement, motivation; Empowerment; Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCA cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating & selection.	9
UNIT-III	
Quality Management Tools The seven traditional tools of quality; New management tools; Six sigma- concepts, methodology, applications to manufacturing, service sector including IT, Bench marking process; FMEA- stages, types. TQM tools and techniques, control charts, process capability, concepts of six sigma, Quality Function Development (QFD), Taguchi quality loss function; TPM- concepts, Building Reliability in product, evaluation of reliability.	9
UNIT-IV	
Quality systems Need for ISO 9000, ISO 9001-9008; Quality system- elements, documentation, Quality auditing, QS 9000, ISO 14000- concepts, requirements and benefits; TQM implementation in manufacturing and service sectors.	9

Books & References

1. Total Quality Management- Besterfield D.H. et al, Pearson Education Asia.
2. The Management and Control of Quality- Evans J.R. and Lindsay W.M., Cengage Learning.
3. TQM in new Product Manufacturing- Menon, H.G., McGraw Hill.
4. Total Quality Management- Janakiraman B. and Gopal R.K., Prentice Hall India.
5. Total Quality Management- Suganthi L. and Samuel A., Prentice Hall India.

BME-56	**ENERGY MANAGEMENT**

Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The importance and applications of renewable energy sources their utilization and energy management.
2. Students will be able to apply the 1st and 2nd law of thermodynamics for energy audit performance analysis of different solar systems.
3. The student will be able to convert the electrical energy for comfort of human being in a building and energy audit of combustion process.
4. Student will be able to understand the effect of pollution in environment and government's regulation to control them.

Topics Covered

UNIT-I	9
Introduction to energy, Sources of energy, Forms of energy, Energy reserves, renewable energy sources, Unites of energy and the laws of thermodynamics. Definition & objective of energy management, importance, Indian need of energy management, duty and responsibility of energy management. Energy consumption and GDP, energy database, Energy demand analysis, Costs of exploration and utilization of depletable resources, energy pricing, National energy plan.	
UNIT-II	9
Energy audit concepts, Energy audit based on 1st law and 2nd law of thermodynamics, Mass and Energy balances, Availability analysis, Evaluation of energy conserving Opportunities, Economic analysis and life cycle costing. Energy conservation areas, Energy transmission and storage, Plant wide energy optimization Models, Data base for energy management	
UNIT-III	9
Energy conservation through controls, Computer aided energy management, Program organization and methodology. Electrical energy conservation in building lighting, heating, ventilating and air conditioning, Energy efficient motor, power factor improvement in power systems, Energy audit of Combustion process, Boilers, Turbines, compressors, Pumps, Heat exchangers, Condensers, Use of industrial, wastes.	

UNIT-IV	9
Energy environment interaction, Environmental issues, Global warning, Carbon dioxide emissions, Depletion of ozone layer, Government's regulations, and Energy economy interaction. Organizing the management: location of energy management, top management support, managerial function, accountability, motivation of employees, marketing and communication, training and planning	

Books & References

1. Energy Management and Convention - Clive Beggs, ButterwothHeinemann (Elsevier Science)
2. Optimising Energy Efficiency in the Industry – Rajan (Tata McGraw Hill)
3. Guide to Energy Management - C.L Capehart (Fairmont Press)
4. Renewable Energy Sources and their Environment Impact - Abbasi & Abbasi (Prentice Hall of India)
5. Environmental Risks and Hazards – Cutter (Prentice Hall of India)
6. Energy and Power Risk Management: New Developments in Modeling, Pricing and Hedging - Alexander Eydeland (John Wiley & Sons)
7. Energy Management Handbook - Wayne C. Turner (John Wiley & Sons Inc).
8. Thermodynamics - Kenneth Wark (Tata McGraw Hill)
9. Exergy Analysis of Thermal, Chemical and Metallurgical Process - Jan Szargut, David R. Morris, Frank R. Steward, Hemisphere Pub (Springer Verlag Publisher)

BME-57 MECHANICAL VIBRATIONS

Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand different types of vibration and mathematical analysis of single degree freedom system under free vibration and damped vibration.
2. The mathematical analysis of single degree freedom system subjected to forced vibration; understand the principles and working of vibration measuring instruments and able to calculate the critical speeds of shaft.
3. Understand the analysis of two degree freedom system under free, damped and forced vibrations and principle and working of different types of vibration absorbers.
4. The ability to carry out exact and numerical analysis of multi degree freedom system subjected to different types of vibration.

Topics Covered

UNIT-I	
Introduction Periodic motion, Harmonic motion, Superposition of simple harmonic motions, Beats, Fourier analysis	9

Single Degree Freedom System: Free Vibration Free vibration-spring mass system, torsional system, Natural frequency, Equivalent systems, Energy method for determining natural frequency, Response to an initial disturbance, Phase plane method **Single Degree Freedom System: Damped Vibration** Damping models, Vibrations of spring-mass system with viscous damping, Logarithmic decrement	
UNIT-II	
Single Degree Freedom System: Forced Vibration Forced vibration, Harmonic excitation with viscous damping, steady state vibrations, Forced vibrations with rotating and reciprocating unbalance, Support excitation, Vibration isolation, Force Transmissibility, Vibration measuring instruments, Displacement, velocity and acceleration measuring instruments **Critical Speed of Shaft** Shaft with one disc with and without damping, Multi-disc shafts, Secondary critical speed	9
UNIT-III	
Two Degree Freedom systems Introduction, Free vibration-spring-mass system, principal modes, double pendulum, torsional system, Coupled rectilinear and angular modes, Damped Vibration-spring-mass system, Force vibration-spring mass system with harmonic excitation **Vibration absorbers** Introduction, Undamped dynamic vibration absorber, Torsional absorber, Centrifugal pendulum absorber, Dry friction damper	9
UNIT-IV	
Multi Degree Freedom system: Exact Analysis Undamped free and forced vibrations of multi-degree freedom systems, influence number, Maxwell's reciprocal theorem, Torsional vibration of multi-degree rotor system, Principal coordinates, Continuous systems- longitudinal vibrations of bars, torsional vibrations of circular shafts **Multi Degree Freedom system: Numerical Analysis** Rayleigh's, Dunkerely's, Holzer's and Stodola methods	9

Books & References

1. Elements of Vibration Analysis– L. Meirovitch (McGraw-Hill Company)
2. Mechanical Vibrations – P. Srinivasan (Tata McGraw Hill)
3. Mechanical Vibrations – G. K. Grover (Jain Brothers, Roorkee)
4. Mechanical Vibrations – W. T. Thomson (George Allen & Unwin)
5. Theory and Practice of Mechanical Vibrations – J S Rao & K Gupta (New Age International)
6. Mechanical Vibrations – Tse, Morse &Hinkle (CBS Publishers & Distributors Pvt. Ltd)
7. Mechanical Vibrations – V. Rama Murthy (Narosa Publications)
8. Mechanical Vibrations- V. P. Singh (Dhanpat Rai & Co.)

BME-58	**RENEWABLE ENERGY TECHNOLOGIES**	
Course category	:	Programme Electives (PE1 & PE2)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the

		following knowledge, skills and attitudes after completing this course

1. The importance and applications of renewable energy sources their utilization and collection of solar energy.
2. Student will be able to understand the application of solar energy and wind energy, its conversion, performance analysis of different solar collectors and solar photovoltaic system.
3. The understanding of photosynthesis, bio gas production aerobic and anaerobic bio conversion process, bio gas applications and energy recovery from urban waste and bio mass resource development in India.
4. The knowledge of the fundamentals and application of tidal power, ocean thermal energy, wave energy, geo thermal energy and hydro energy.

Topics Covered

UNIT-I	
Energy resources Introduction to various sources of energy, Solar thermal, Photovoltaic, Water power, Wind energy, Biomass, Ocean thermal, Tidal and wave energy, Geothermal energy, Hydrogen energy systems, Fuel cells, Decentralized and dispersed generation. **Solar Energy** Sun as Source of Energy, Availability of Solar Energy, Nature of Solar Energy, Solar Energy & Environment. Various Methods of using solar energy –Photothermal, Photovoltaic, Photosynthesis, Present & Future Scope of Solar energy. **Collection of Solar Energy** Solar thermal power and it's conversion, Solar collectors, Flat plate, Performance analysis of flat plate collector, Solar concentrating collectors, Types of concentrating collectors, Thermodynamic limits to concentration, Cylindrical collectors, Thermal analysis of solar collectors, Tracking CPC and solar swing .	9
UNIT-II	
Solar Energy Applications Application of solar energy- Solar water and air heaters, distillation, drying of materials, power generation, cookers, solar refrigeration. Photo voltaic technology. **Wind Energy** Properties of wind, Availability of wind energy in India, wind velocity, Wind machine fundamentals, Types of wind machines and their characteristics, Horizontal and Vertical axis wind mills, Elementary design principles, Coefficient of performance of a wind mill rotor, Aerodynamic considerations in wind mill design, Selection of a wind mill, Wind energy farms, Economic issues, Recent development.	9
UNIT-III	
Bio-mass Energy Biomass: Generation and utilization, Properties of biomass, Agriculture Crop & Forestry residues used as fuels. Biochemical and Thermo-Chemical Conversion, Combustion, Gasification, Biomass gasifiers and types etc., Applications of Gasifiers to thermal power and Engines, Biomass as a decentralized power generation source for villages. **Fuel Cell** Fuel cell – Principle of working, construction and applications	9
UNIT-IV	
Geothermal Energy	9

Geological setting, different geothermal systems, utilization of geothermal energy, its economic and environmental comparison. Brief description of different utilization techniques for ocean thermal energy, and tidal and wave energy. **Hydel Energy** Hydro power: Potential, Hydropower Generation and Distribution, Mini and Micro-hydel Power (MHP) Generation: Classification of hydel plants, Concept of micro hydel, merits, MHP plants: Components, design and layout, Turbines, efficiency, Status in India.	

Books & References

1. Renewable Energy Sources and Conversion Technology -Bansal Keemann, Meliss (Tata McGraw Hill)
2. Renewable Energy Resources and Emerging Technologies - Kothari D.P. (Prentice Hall of India)
3. Nonconventional Energy - Ashok V. Desai (New Age International Publishers Ltd.)

BME-61	**POWER PLANT TECHNOLOGIES**

Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	Engineering Thermodynamics (BME-12)
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the magnitudes of conventional and renewable energy resources and economics of power plants.
2. Able to understand steam power plant with its components.
3. Able to understand diesel engine power plant and gas turbine power plant with their components.
4. Able to understand nuclear power plant and hydro-electric power plant with their components.

Topics Covered

UNIT-I	
Introduction Power and energy, sources of energy, review of thermodynamic cycles related to power plants, fuels and combustion calculations. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant units Power plant economics and selection Effect of plant type on costs, rates, fixed elements, energy elements, customer elements and investor's profit; depreciation and replacement, theory of rates. Economics of plant selection, other considerations in plant selection	9
UNIT-II	
Steam power plant General layout of steam power plant, Power plant boilers including critical and super critical boilers. Fluidized bed boilers, boilers mountings and accessories, Different systems	9

such as coal handling system, pulverizers and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power plant.	
UNIT-III	
Diesel power plant General layout, Components of Diesel power plant, Performance of diesel power plant, fuel system, lubrication system, air intake and admission system, supercharging system, exhaust system, diesel plant operation and efficiency, heat balance, Site selection of diesel power plant, Comparative study of diesel power plant with steam power plant. Gas turbine power plant Layout of gas turbine power plant, Elements of gas turbine power plants, Gas turbine fuels, cogeneration, auxiliary systems such as fuel, controls and lubrication, operation and maintenance, Combined cycle power plants, Site selection of gas turbine power plant	9
UNIT-IV	
Nuclear power plant Principles of nuclear energy, Lay out of nuclear power plant, Basic components of nuclear reactions, nuclear power station, Nuclear waste disposal, Site selection of nuclear power plants. Hydroelectric station Hydrology, Principles of working, applications, site selection, classification and arrangements, hydro-electric plants, run off size of plant and choice of units, operation and maintenance, hydro systems, interconnected systems.	9

Books & References

1. Power Plant Engineering - F.T. Morse (Affiliated East-West Press Pvt. Ltd)
2. Power Plant Technology – ElVakil (McGraw Hill)
3. Power Plant Engineering - P.K. Nag (Tata McGraw Hill)
4. Steam & Gas Turbines & Power Plant Engineering - R.Yadav (Central PubHouse)

BME-62 TURBO MACHINERY

Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	Engineering Thermodynamics (BME-12)
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Student will be able to understand the working and construction of impulse steam turbine, velocity triangles and designing of blades.
2. Student will be able to understand the working and construction of reaction steam turbine, velocity triangles, degree of reaction and various losses.
3. Student will be able to understand the working and construction of centrifugal and axial flow compressor and their velocity triangles and performance calculations.
4. Students will be able to demonstrate the working of gas turbine plants and efficiency calculations. Further mechanical design consideration followed by turbine blade cooling.

Topics Covered	
UNIT-I	
Impulse Turbines Steam turbine– Principal of operation of steam turbine, Types, Impulse turbine compounding of steam turbine- pressure compounded velocity compounded and pressure – velocity compounded impulse turbine, Velocity diagram for impulse turbine, Force on the blade and work done, Blade or diagram efficiency, Gross stage efficiency. Influence of ratio of blade to steam speed on blade efficiency in a single stage impulse turbine. Efficiency of multi-stage turbine, Impulse blade sections, Choice of blade angle. Blade height in velocity compounded impulse turbine. State Point Locus and Reheat Factor**,** Governing of steam turbine	9
UNIT-II	
Impulse Reaction Turbines Velocity diagram, Degree of reaction, Impulse-reaction turbine with similar blade section and half degree of reaction (Parson's turbine), Height of reaction Turbine blade section, Internal losses in steam turbine Nozzle, Losses, Blade friction losses, Disc friction losses, Blade windage losses or partial admission losses, Gland leakage or clearance losses, Leaving velocity or residual loss, Carry loss.	9
UNIT-III	
Centrifugal compressors Introduction, Classifications of Centrifugal compressors – components, Working, Work done, Velocity Diagrams, Calculations of power and efficiencies, Slip factor, Surging and choking power and Efficiencies, Stage pressure rise, Loading coefficient, Diffuser, degree of reaction, Effect of impeller blade profile, Pre-whirl and inlet guide vanes, Centrifugal Compressor characteristic curves. **Axial flow compressor-** Construction, Principle of operation and working, Energy transfer, Velocity Diagram, Factors affecting Stage Pressure Rise, Blockage in Compressor Annulus, Degree of reaction, 3-D flow, Design Process, Blade Design, Calculation of Stage Performance, Axial flow Compressor Characteristic Curves.	9
UNIT-IV	
Gas Turbine: Classification of gas turbine, Simple open cycle gas turbine, Ideal and actual cycle (Brayton Cycle) for gas turbine, Optimum pressure ratio for maximum specific output in actual gas turbine, Regeneration, Reheat and inter cooling and effect of these modification on efficiency and output, Closed cycle gas turbine. **Turbine Blade cooling:** Different cooling techniques, Types of coolants, Comparativeevaluation of different cooling techniques. **Mechanical Design consideration:** Overall design choices, Material selection, Designwith traditional materials.	4 5
Books & References	
1. Steam and Gas turbine – By R. Yadav (Central Publishing House) 2. Gas Turbine – V. Ganeshan (TMH) 3. Thermal Turbomachines – Onkar Singh (Wiley India Pvt. Ltd.) 4. Turbine Compressors and Fans – S.M. Yahya (TMH) 5. Turbines, Compressors and fans - S.M. Yahya (Tata McGraw-Hill) 6. Gas turbine theory - Cohen & Rogers, Addison Weslay (Longman Ltd.) 7. Design of high efficiency turbomachinery and gas turbines - David Gordon (Wilson)	

BME-63	**PROJECT MANAGEMENT**	
Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	NIL

Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Knowledge of various phases of project management.
2. Knowledge of structure of different types of organization and its selection.
3. Know about project appraisal and cost estimation.
4. Understand the various aspects of CPM and PERT and their implementation in Project.

Topics Covered

UNIT-I	9
Project Management Concepts: Introduction, project characteristics, taxonomy of projects, project identification and formulation. Establishing the project and goals, Nature & context of project management; phases of PM, A framework for PM issues, PM as a conversion process, project environment & complexity, Organizing human resources, organizing systems & procedures for implementation	
UNIT-II	9
Project Organization & Project Contracts: Introduction, functional organization, project organization, matrix organization, modified matrix organization, pure project organization, selection of project organization structure, project breakdown structures, project contracts, types of contracts, types of payments to contractors.	
UNIT-III	9
Project Appraisal & Cost Estimation: Introduction, technical appraisal, commercial appraisal, economic appraisal, financial appraisal, management appraisal, social cost/benefit analysis, project risk analysis, Cost analysis of the project, components of capital cost of a project, modern approach to project performance analysis.	
UNIT-IV	9
Project Planning & Scheduling: Introduction to PERT & CPM, planning and scheduling networks, time estimation, determination of critical path, CPM model, slacks & floats, PERT model, , PERT & CPM cost accounting systems, lowest cost schedule, crashing of networks, linear programming formulation of event oriented networks, updating of networks, LOB technique, Complexity of project scheduling with limited resources.	

Books & References

1. Project Management - K. Nagarajan (New Age International)
2. Operation Research for Executive – L. S. Srinath (EWP)
3. Guide to the Project Management Body of Knowledge - Project Management Institute (Project Management Inst)
4. Project Management - Greer Michael (Jaico Publications)
5. Successful Project Management - Trevor Young (Kogan page)

BME-64	**ADVANCED WELDING TECHNOLOGY**	
Course category	:	Programme Electives (PE3 & PE4)

Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the importance and application of welding, conventional welding, weld design and inspection/testing.
2. Develop good knowledge about Thermal and Metallurgical consideration of welding, HAZ, automation and safety in welding.
3. Student will have through knowledge about plasma arc, laser beam, electron beam, ultrasonic and diffusion welding.
4. Develop good knowledge about explosive welding, underwater welding, metal spraying and surfacing.

Topics Covered

UNIT-I	9
Introduction Importance and application of welding, problems and drawbacks associated with conventional welding processes, Selection of welding process,Brief review of conventional welding process **Weld Design** Welding machines/equipments and its characteristics, Heat input and heat flow, Weld defects and distortion, Inspection/testing of welds, Life prediction	
UNIT-II	9
Thermal and Metallurgical considerations Thermal considerations for welding, temperature distribution, Analytical/Empirical analysis/formulae, heating & cooling, curves. Metallurgical consideration of weld, HAZ and Parent metal, micro & macro structure. Solidification of weld and properties Automation in welding, Economics of Welding, Safety in welding	
UNIT-III	9
Advanced welding Techniques-1 Principle, equipment, working and applications of Plasma Arc welding, Laser beam welding, Electron beam welding, Ultrasonic welding and Diffusion welding	
UNIT-IV	9
Advanced welding Techniques-2 Principle, equipments, working and applications of explosive welding/ cladding, underwater welding, metal spraying and surfacing.	

Books & References

1. Welding Processes and Technology – Dr. R. S. Parmar (Khanna Publication)
2. Manufacturing technology – Foundry, Forming and Welding- P. N. Rao (Tata McGraw Hill).
3. Welding and Welding Technology – Richard L. Little (Tata McGraw Hill).
4. Workshop Technology Vol1-B. S. Raghuvanshi (Dhanpat Rai and Sons)

BME-65	ADVANCED MANUFACTURING TECHNOLOGY

Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the need of unconventional manufacturing processes and familiar with abrasive water jet cutting and machining process.
2. Knowledge of working principle, advantages, limitations and applications of Electro-chemical Machining, Electric Discharge machine and chemical machining.
3. Understand working, effect of process variables and applications of Laser beam machining, Electron beam machining, Ultrasonic machining, Plasma arc machining.
4. Knowledge High energy forming processes, and Diffusion and Photo- Lithography process.

Topics Covered

UNIT-I	9
Introduction Limitations of conventional manufacturing processes, need of unconventional manufacturing processes & its classification and its future possibilities. **Water Jet Cutting (WJC):** WJC machine, Process characteristics and application. **Abrasive Jet machining:** Machining setup, parametric analysis and applications. **Abrasive Water Jet machining:** Working principle, process variables, Cutting parameters and process capabilities.	
UNIT-II	9
Advanced Machining Processes-1 Working principle, machine/equipment, process variables, advantages, limitations and applications of Electro-Discharge machining (EDM), Electrochemical machining (ECM), Chemical machining (CM), Electro chemical grinding and Electro discharge grinding.	
UNIT-III	9
Advanced Machining Processes-2 Working principle, machine/equipment, process variables, advantages, limitations and applications of Laser beam machining (LBM), Electron beam machining (EBM), Ultrasonic machining (USM), Plasma arc machining (PAM)	
UNIT-IV	
Unconventional Forming processes Principle, working and applications of High energy forming processes such as Explosive Forming, Electromagnetic forming, Electrodischarge forming, water hammer forming, explosive compaction etc. **Electronic-device Manufacturing** Brief description of Diffusion and Photo- Lithography process for electronic-device manufacturing	9

Books & References

1. Advanced Machining Processes– Vijay K.Jain (Allied Publishers Pvt Ltd.)
2. Modern Machining Process- Pandey and Shan (Tata McGraw Hill).
3. Non-Conventional Machining – P.K. Mishra (Narosa Publishing House).
4. Non Traditional Manufacturing Process – Gary F. Benedict (Marcel Dekker)
5. Machining Process :Conventional and Non-Conventional Process-Hassan Abdel-Gawad El-Holy (CRC Press –Taylor and Francis)

BME-66	**ADVANCED ENGINEERING MATERIALS**

Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. To understand the basic structures, atomic bonding, and importance of materials for different applications.
2. To understand the surface behavior of materials with their phase diagrams.
3. The knowledge of ferrous and nonferrous materials with the inclusion of advanced materials.
4. The knowledge and applications of Mechanical and thermal behavior of different materials.

Topics Covered

UNIT-I	
Introduction Brief history of engineering materials, Importance of materials, Classification of Materials, Engineering Materials, Advanced Materials and Future Materials **Crystallography** Atomic Structure, Atomic Bonding in Solids, Bravais Lattices, Crystal Structures, Crystalline, Quasi Crystalline and Non-Crystalline Materials, Miller Indices, Miller-Bravais Indices for Planes and Directions of Cubic and Non-Cubic Structures.	9
UNIT-II	
Structural Analysis of Materials Microstructural phenomenon for different materials, Diffusion Mechanisms, Fick's Laws, Steady & Non-steady State Diffusion, Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM). **Phase Diagrams** Phase Rule, Equilibrium Phase Diagrams, Phase Systems. Iron-Carbon Phase Diagram, TTT Diagram Imperfections in Solids, Recovery, Recrystallization and Grain Growth, Mechanisms of Strengthening, Solid Solution Strengthening.	9
UNIT-III	
Ferrous &Non ferrous alloys	9

Ferrous Alloys: Low Alloy and High Alloy Steels, Tool Steels, Stainless Steels, Cast irons etc. Non-ferrous alloys: Copper and its alloys, Aluminum and its alloys, Nickel, Zinc, Shape Memory Phenomenon and Alloys; Ceramics, Cermets, Glass and Carbon Products; Failure Prevention; and The Selection Process. **Advanced Materials** Composite materials, Nano materials, Smart materials, Optical materials etc.	
UNIT-IV	
Mechanical Behavior of Materials Study about Stress strain diagram for brittle & Ductile materials (Mild steel), elastic constants, work hardening ,Hot and cold working, Fracture, Ductile and Brittle Fracture, Griffith's theory of brittle fracture, Ductile-Brittle Transition, Stress Intensity Factor (SIF), Hardness, Impact Testing, Bending, Fatigue, Creep etc. **Thermo-Mechanical Behavior of Materials** Thermo-gravimetric analysis (TGA), Dynamic mechanical analysis (DMA), Thermal conductivity etc.	9

Books & References

1. A Materials and processing approach - G.E. Dieter(McGraw Hill)
2. Materials selection in Mechanical Design- M.F Ashby(Pergamon press)
3. Engineering Materials Properties and Selection- Kenneth G. Budinski (Prentice Hall of India)
4. Engineering Metallurgy Part 1- R.A. Higgins (Edward Arnold)
5. Selection of Engineering Materials- Gladius Lewis (Prentice-Hall)

BME-67	**ADVANCED MECHANICS OF SOLIDS**

Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	Mechanics of Solids (BME-14)
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding and application of three dimensional stress and strain, principal stresses and principal strains, Mohr circle.
2. Understanding of generalized Hooke's law, relation between elastic constants, equations of equilibrium and determination of stresses & deflection due to unsymmetrical bending.
3. Determine stresses due to rotation of uniform and variable thicknesses of solid disc, rotating shafts and cylinders. Design of thick cylindrical shell and compound cylinders subjected to internal and external pressure.
4. Determine stresses in curved beams such as crane hooks and circular ring under tension and compression. Torsional stresses of prismatic, circular, elliptical bars and thin walled tubes & rolled section.

Topics Covered

UNIT-I	
Analysis of Stress and Strain	9

Stress at a point and state of stress, Stress and Strain tensor, Principal stresses and principal planes, Stress invariants, Mohr's stress circle for 3D state of stress, Planes of maximum shear, Octahedral stresses, State of pure shear, Plane state of stress, Differential equations of equilibrium **Analysis of strain** Introduction, Deformations, Deformation in the neighborhood of a point, State of strain at a point, Shear strain components, Cubical dilatation, Principal axes of strain and principal strains, Plane state of strain, Compatibility conditions.	
UNIT-II	
Stress Strain relations for Linearly Elastic Solids Generalized statement of Hooke's law, Stress-strain relationships for isotropic materials, Modulus of rigidity, Bulk Modulus, Young's modulus and Poisson's ratio, Relation between the elastic constants, Displacement equations of equilibrium, Thermoelastic stress-strain relations **Unsymmetrical bending and Shear centre** Stresses due to unsymmetrical bending, Deflection of beams due to unsymmetrical bending, Determination of shear centre and flexural axis for I-section and channel section	9
UNIT-III	
Stresses in Axi-symmetric Bodies due to Rotation Stresses due to rotation of solid discs of uniform thickness and disc with a hole, Disc of variable thickness, Rotating shafts and cylinders **Thick cylindrical shell** Stresses in thick cylinders subjected to internal or external pressures, Design of thick cylindrical shell, Compound cylinders, Stresses due to interference fits	9
UNIT-IV	
Curved Beams Bending of beams with large initial curvature, Position of neutral axis for rectangular, circular, triangular and trapezoidal cross-sections, Stresses in crane hooks and circular rings under tension and compression **Torsion of Non Circular Bars** Torsion of Prismatic, circular and elliptical bars, Torsion of rectangular bars, Torsion of thin walled tubes, Torsion of rolled sections	9

Books & References

1. Advanced Mechanics of Materials - P. Boresi (Wiley)
2. Mechanics of Materials – Popov (Pearson US Imports & PHIPEs)
3. Advanced Mechanics of Solids-L S Srinath (Tata McGraw Hill)
4. Mechanics of materials-Pytel (CL Engineering)
5. Strength of Materials-Ryder (Mcmillan Publishers India Limited)
6. Strength of Materials-Timoshenko and Young (Tata McGraw Hill)
7. Strength of Materials-S. Ramamurtham (Dhanpat Rai Publishing Co.)
8. Strength of Materials-R. K. Rajput (S. Chand)
9. Strength of Materials–R. K. Bansal (Lakshmi Publications)

BME-68	**GAS DYNAMICS AND PROPULSION**	
Course category	:	Programme Electives (PE3 & PE4)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination

Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Student will understand the concept of gas dynamics, fundamental equations and isentropic flow.
2. Ability to get the knowledge of compressible flows and pertaining calculations.
3. Student will be able to demonstrate the wave phenomena and make calculations for variable flow area like nozzle design pressure and efficiency.
4. Able to understand and demonstrate the basics of jet propulsion, various jet propulsion engines and their efficiency calculations.

Topics Covered

UNIT-I	
Concept of Gas Dynamics Introduction, Applications **Fundamental Equations of Steady Flow** Introduction, Assumption, Equation of Continuity, Control Volume, Momentum Equation, Bernoulli's Equation, Steady Flow Energy Equation. **Isentropic Flow** Introduction, Acoustic Velocity, Flow from a Reservoir, Flow Parameters	9
UNIT-II	
Diabetic Flow Introduction, Stagnation Temperature, Rayleigh Line, Pressure Ratio, Temperature Ratio. **Flow with Frication and No Heat Transfer Adiabatic Flow** Introduction, Frication Loss, The Fanning Equation, Frication Factor, Fannoline.	9
UNIT-III	
Wave Phenomena Introduction, Normal Shock Waves, Oblique Shocks. **Variable Area Flow** Introduction, Velocity, Criteria for Acceleration and Deceleration, Effect of Back Pressure on Nozzle Flow, Over-expanding and Under-expanding Nozzles, Design Pressure, Nozzle Efficiency.	9
UNIT-IV	
Jet Propulsion Introduction, Types, Pulse jet, Ram jet, Turbo-jet, Efficiency and Horse Power of Propulsion, Flying Unit.	9

Books & References

1. The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. I – Shapiro (Ronald Press Co.)
2. Gas Dynamics - Cambel and Jennings (McGraw Hill)
3. Elements of Gas Dynamics – Mattingly (Tata McGraw-Hill Education)
4. Fundamental of gas dynamics – Zucker,and Biblarz (John Wiley & Sons, Inc)
5. Dynamics of compressible flow- Yahya (New Age Publishers, Delhi)

New Course Introduced

BME- 69	**COMPUTATIONAL TOOLS FOR MECHANICAL ENGINEERING**	
Course category	:	DC
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

5. Acquire the basic knowledge of Programming with MATLAB & numerical methods
6. The knowledge of different optimization method
7. The understanding of direct numerical integration methods
8. The knowledge of engineering mechanics and Mechanical Vibration

Topics Covered	
UNIT-I	
Introduction to programming with MATLAB **NUMERICAL METHODS:** Introduction, System of Linear Algebraic Equations, Gauss Elimination Method, LU Decomposition Methods, Choleski's Decomposition, Gauss-Seidel Method.	9
UNIT-II	
OPTIMIZATION: Introduction, Conjugate Gradient Methods, Newton's Method,The Concept of Quadratic Convergence, Powell's Method, Interior Penalty Function.	9
UNIT-III	
DIRECT NUMERICAL INTEGRATION METHODS: Introduction, Single-degree of Freedom System, Multi-degree of Freedom System, Explicit Schemes, Implicit Schemes	9
UNIT-IV	
ENGINEERING MECHANICS: Introduction, Newtonian Mechanics, Newton's Laws of Motion, Resultants of Coplanar Force Systems, Resultants of Non-coplanar Force Systems, Equilibrium of Coplanar and Non-coplanar Force Systems, Trusses. **MECHANICAL VIBRATIONS:** Vibration Analysis, Components of Vibrating Systems , Free Vibration of Single Degree of Freedom Systems, Forced Vibration of Single-degree of Freedom , Two-degrees of Freedom Systems ,Multi-degree of Freedom Systems , Free Vibration of Damped, Modal Analysis for Undamped Systems, Lagrange's Equation, Principle of Virtual Work, D'Alembert's Principle, Lagrange's Equations of Motion, Variational Principles, Hamilton's Principle.	9
Practicals:	

1. Generate an overlay plot for plotting three lines given bY three different equations. Use (i) the plot command (ii) the hold command (iii) the line command 2. Solve the set of 3 variable algabraic equations using Gaussian elimination scheme 3. Solve above equation using Choleski's method of solution 4. Solve above equation using Jacobi method 5. Solve the system of equations given by [A]{X}={b} using Gauss-Seidel method 6. Minimize the following function f (x) subjected to several constraints by the any optimization method 7. Find the response of a viscously damped single degree of freedom system subjected to a force. Compare the results obtained using different numerical Integration methods. 8. Write a MATLAB script for plotting undamped free vibration system 9. Write a MATLAB script for plotting damped vibration system 10. Write a MATLAB script for plotting forced vibration system	

Books & References

6. Applied Numerical Methods with MATLAB,Chapra, S.C., 2nd ed., McGraw-Hill, New York, 2008.
7. Solving Engineering Mechanics Problems with MATLAB, Dukkipati, R.V. and Srinivas, J., New Age International Publishers, New Delhi, India, 2007.
8. Numerical Methods in Engineering with MATLAB, Kiusalaas, J.,Cambridge University Press, Cambridge,UK, 2005.
9. Getting started with MATLAB—A Quick Introduction for Scientists and Engineers, Pratap Rudra, Oxford University Press, New York, NY, 2002.

BME- 59 FINITE ELEMENT METHOD

Course category	:	**Programme Electives (PE1 & PE2)**
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial : 1 , Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the fundamental concepts of Finite Element method and different approaches used in FEM
2. Able to solve two-dimensional problem
3. Able to solve the problem related to Beams & Frames
4. The knowledge of Heat Transfer and able to formulate the FE Program for critical speeds of a shaft.

Topics Covered

UNIT-I	
Fundamental Concepts: Introduction; Historical Background, Stresses and Equilibrium, Boundary Conditions, Strain-displacement, Relations, Stress- strain Relations, Temperature Effects, Potential Energy and Equilibrium; The Rayleigh-Ritz Method, Galerkin's method. Saint Venant's Principle, Matrix Algebra, Gaussian Elimination. One-Dimensional Problems: Introduction; Finite Element Modeling, Coordinates and a Shape Functions, The Potential Energy Approach; The Galerkin Approach, Assembly of the Global Stiffness Matrix and Load Vector. Properties of Stiffness	9

Matrix, The Finite Element Equations; Treatment of Boundary Conditions, Quadratic Shape Functions; Temperature effects.	
UNIT-II	
Two-Dimensional Problems using Constant Strain Triangles: Introduction, Finite Element Modeling, Constant Strain Triangle, Problem Modeling and Boundary conditions; Axis Symmetric Solids subjected to Axis Symmetric Loading:- Introduction, Axis Symmetric Formulation, Finite Element Modeling; Triangular Element, Problem Modeling and Boundary conditions.Two Dimensional Isoparametric Elements and Numerical Integration: Introduction, The Four- Node quadrilateral, Numerical Integration Stress Calculations, High – Order Element; Nine-Node quadrilateral, Eight-Node Quadrilateral, Six-Node triangle, Comment on Midside Node; Problems.	9
UNIT-III	
Beams & Frames: Introduction, Finite Element formulation, Load Vector, Boundary considerations, ShearForce and Bending Moment, Beams on Elastic supports, Plane Frames, Simple Numerical.Three-Dimensional Problems in Stress Analysis: Introduction, Finite Element Formulation, StressCalculations, Mesh Preparation, Hexahedral Elements and Higherorder Elements, Problem Modeling.	9
UNIT-IV	
Transfer, Introduction One-Dimensional Heat Conduction, Heat transfer in thin Fins, Two-dimensionalsteady-state Heat conduction, Potential Flow, Seepage, Fluid flow in Ducts. Dynamic Considerations:Introduction, Formulation, Element Mass Matrices: Evaluation of Eigen values and Eigenvectors, Interfacing with previous Finite Element Programs and a program fordetermining critical speeds of Shafts.	9
Books & References	
1. Introduction to Finite Elements in Engineering Analysis by Tirupathi R. Chandruipatala and Ashok R.Belagundu. (Prentice Hall) 2. The Finite Element Method in Engineering by S.S.Rao, (Peragamon Press, Oxford). 3. Finite Element Procedures, by Klaus Jurgen Bathi, (Prentice Hall). 4. Concepts and Applications of Finite Element Analysis, by Cook, Malkus and Plesha, (John Wiley). 5. The Finite Element Method by Zienkiewicz published (Mc Graw Hill). 6. An Introduction to Finite Element Method by J.N. Reddy published (Mc Graw Hill).	