ME102	Engineering Mechanics	L-T-P-Cr-CH: 3-1-0-4-4	Prerequisites: None

Contents

Unit 1: Force systems:
Force, moment of a force about a point and about an axis, couple moment as a free vector, equivalent force systems **(7L + 1T).**

Unit 2: Equilibrium:
Free body diagram, equations of equilibrium; problems in two and three dimensions, **(4L + 1T)**

Unit 3: Structural Mechanics:
Simple truss, method of joints, method of sections, frames and simple machines **(4L + 1T)**

Unit 4: Friction:
Laws of coulomb friction, angle of friction, applications to wedge, belt-pulley, power screw, journal bearing, brakes and clutches **(3L + 1T)**

Unit 5: Distributed Force System:
Centre of mass, centre of gravity, moment of inertia of an area, product of inertia of an area, mass moment of inertia, product of inertia of a mass **(8L+ 2T)**

Unit 6: Energy Methods:
Principle of virtual work, principle of minimum potential energy **(3L + 1T)**

Unit 7: Kinematics and Kinetics of particles:
Particle dynamics in rectangular coordinates and in terms of path variables; Newton's law for rectangular coordinates, Newton's law for path variables, central force motion **(4L + 1T)**

Unit 8: Energy and Momentum Methods for Particle:
Conservative force field, principle of work and energy, principle of impulse and momentum, impact. **(3L+ 1T)**

Unit 9: Kinematics and Kinetics of rigid body:
Translation and rotation of rigid body, motion relative to rotating axes, Coriolis acceleration, equations of motion for a rigid body **(3L + 1T)**

Total: 35 lectures +12 tutorials

Course Outcomes (COs): -

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

- CO1: Solve fundamental problems related to forces being applied to a body under static and dynamic conditions.
- CO2: Evaluate the kinetic and kinematic parameters of particles in motion.
- CO3: Apply the governing principles of properties of areas in determining centroid and moment of inertia of different sections.
- CO4: Identify and model various types of loading and support conditions that act on structural systems.
- CO5: Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction.

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CO6: Evaluate the motion of a particle in terms of its position, velocity and acceleration in different frames of reference and to analyze the forces causing the motion of a particle.

Text Books: -

1. Beer, F.P., Johnston, E.R., Mazurek, D.F., Cornwell, P.J., Eisenberg, and E.R., Sanghi, S. Vector Mechanics for Engineers: Statics and Dynamics. Tata McGraw Hill, 9th edition, 2011.
2. Shames, I.H. and Krishna Mohana Rao, G. Engineering Mechanics: Statics and Dynamics. Pearson Education Prentice Hall India, 4th edition, 2011.

Reference Books : -

1. Meriam, J. L., and Kraige, L.G. Engineering mechanics: Statics, Vol. 1. John Wiley & Sons, 7th edition, 2012.
2. Meriam, James L., and Kraige, L.G. Engineering mechanics: Dynamics. Vol. 2. John Wiley & Sons, 7th edition, 2012.
3. Timoshenko, S., Young, D.H. and Rao J.V., Engineering Mechanics. Tata McGraw Hill, New Delhi, 5th edition, 2010.
4. Hibbler, R.C. Engineering Mechanics: Statics and Dynamics. McMillan, 3rd edition, 2012.
5. Kumar, K.L. Engineering Mechanics. Tata McGraw Hill, New Delhi, 4th edition, 2010.

ME103	Workshop Practice	L-T-P-Cr-CH: 0-0-2-2-4	Prerequisites: Nil

Contents

Unit 1: Machining (7 Practical) Introducing to various machine tools and demonstration on various machining process. Making jobs as per drawings.

Unit 2: Fitting Practices (6 Practical)
Study of different vices, power hammer. Making jobs as per drawing.

Unit 3: Welding Practice (6 Practical)
Introduction to different welding processes. Practice on Oxy-acetylene gas welding and manual metal arc welding.

Unit 4: Wireman (7 Practical)
Introduction to different electrical hand tools and machine tools and demonstration on basic electrical components and circuits, making jobs (such as House Wiring, Switch Board etc.) as per drawing.

Total: 26

Practical Course Outcomes (COs): -

CO1: On the successful completion of the course, the student would be able to:
CO2: Perform machining operations using various manufacturing techniques.
CO3: Perform fitting practices using various types of hand tool and fitting techniques.
CO4: Perform Oxy-acetylene gas welding and manual metal arc welding on jobs.
CO5: Select appropriate electrical hand tools and circuits for the required application and making jobs (such as House Wiring, Switch Board etc.) as per specification.

Text Books: -

1. Chapman, W. A. J. Workshop Technology Part 1. CBS Publishers & Distributors, 5th edition, 2001.
2. Chapman, W. A. J. Workshop Technology Part 2. CBS Publishers & Distributors, 4th edition, 2005.

Reference Books : -

1. Thereja, B. L. and Thereja, A. K. A Textbook of Electrical Technology Vol 1. S. Chand, 22rd edition, 1999.
2. Raghuwanshi, B. S. Workshop Technology Vol. 1. Dhanpat Rai and Sons, 2014.
3. Raghuwanshi, B. S. Workshop Technology Vol. II. Dhanpat Rai and Sons, 11th edition, 2013.
4. Amstead, B. H., Ostwald, P. F. and Begeman, M. L. Manufacturing Process. Wiley, 8th Edition, 1987.

ME201	Solid Mechanics	L-T-P-Cr-CH: 3-1-0-4-4	Prerequisites: ME102

Contents

Unit 1: Simple Stress and Strain:
Introduction, Stress at a point, Types of stress, Strain, Shear and Normal strain. Stress-strain diagram, True stress and True strain, Hooke's law, Poisson's ratio, Material properties for isotropic materials and their relations, Generalized Hooke's law, Stress-strain relationship. Statically indeterminate systems, Stresses induced in compound bars, Thermal stresses and strains. **(6L + 2T).**

Unit 2: Transformations of Stress and Strain:
Components of stress, Stresses on an inclined plane or Transformation of plane stress, Principal stress and Principal planes, Maximum shearing stress and plane of maximum shearing stress, Mohr's circle for plane stress, Stresses in thin- walled sections, Principal strains, Direction of principal strains and maximum shearing strain, Mohr's circle for plane strain. **(6L + 2 T).**

Unit 3: Shear Force and Bending Moment diagrams:
Axial loaded members, beams, relation between load, shear force and bending moment, drawing of shear force and bending moment diagram for different loading condition of beams. **(4L + 2T).**

Unit 4: Torsion:
Introduction, circular shaft under torsion, stepped shaft and shaft of varying sections, shafts in series and parallel. Bending Stress in Beams: Stresses due to bending: pure Bending, transverse shear. **(4L + 2T).**

Unit 5: Bending of Beams:
Pure Bending; Neutral axis; Theory of simple bending (Bending Equation of beam); section modulus; combined stresses due to bending, torsion and axially loading. **(4L + 1T).**

Unit 6: Deflection of Beams:
Introduction, elastic curve, slope and deflection at a point - double integration method, principle of superposition, Macaulay's method, area moment method. **(4L + 2T).**

Unit 7: Energy Methods:
Strain energy; Toughness; Resilience; Strain energy due to axial, torsion, bending and transverse shear; Castigliano's theorem; Reciprocity theorem, Principle of virtual work; Minimum potential energy; statically indeterminate systems. **(4L + 1T).**

Unit 8: Column:
Introduction to buckling, Euler critical (buckling) load for long columns, effective or equivalent length, slenderness ratio. **(3L + 1T).**

Unit 9: Miscellaneous topics:
Unsymmetrical bending, shear centre and shear flow. **(3L + 1T).**

(Total: 38 lectures + 14 tutorials)

Course Outcomes (COs): -

On successful completion of this course students will be able to

- CO1: Recognize physical phenomena in the context of Solid Mechanics.
- CO2: Demonstrate understanding of the theories of Solid Mechanics for deformable bodies.
- CO3: Apply mechanics of deformable bodies to solve engineering problems.
- CO4: Demonstrate understanding of the relationships among loads, member forces and deformations with stresses and strains.
- CO5: Demonstrate understanding of the assumptions and limitations of the theories of Solid Mechanics
- CO6: Competence in problem identification, formulation and solution.

Text Books: -

1. Hearn, E., J., Mechanics of Materials 1. Elsevier, 3rd edition, 2008.
2. Hearn, E., J., Mechanics of Materials 2. Elsevier, 3rd edition, 2008.
3. Popov, E. P. Engineering Mechanics of Solids. Pearson, 2nd edition, 2010.

Reference Books: -

1. Beer, F. P. and Jhonston, E. R. Jr. et al. Mechanics of Materials. Tata McGraw Hill, New Delhi, 5th edition, 2009.
2. Pytel, A. and Singer, F. L. Strength of Materials. Addision Wesley (AWL), 4th edition, 1999.
3. Timoshenko, S. Strength of Materials Vol. I. CBS Publication, New Delhi, 3rd edition, 2004.
4. Timoshenko, S. Strength of Materials Vol. II. CBS Publication, New Delhi, 3rd edition, 2004.
5. Hibbeler, R. C., Mechanics of Materials, Prentice Hall, 8th edition, 2011.
6. Shames, I. H. and Pitarresi, J. M., Introduction to Solid Mechanics, PHI Learning, 3rd edition,
2009.

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ME203	Material Science	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: Nil

Contents

Unit 1: Classification and Properties of Engineering Materials: (5 lectures)
Bonds in solids and characteristics of metallic bonding, General classifications, properties and applications of alloy steel, stainless steel, cast iron and non-ferrous materials like copperaluminium- and nickel- based alloys.

Unit 2: (5 lectures)
Introduction to Ceramic, Polymeric and Composites materials

Unit 3: Crystal Systems and Imperfections: (5 lectures)
Crystallography, Miller Indices for directions and planes, Voids in crystals, Packing density, Crystal imperfections: point, line, surface and volume defects

Unit 4: Dislocations: (5 lectures)
Characteristics, Types and generation of dislocations, Deformation mechanisms and strengthening mechanisms in structural materials.

Unit 5: Phase Diagrams and Phase Rules: (5 lectures)
Principles and various types of phase diagrams, Fe- Fe3C diagram, TTT and CCT diagrams, Heat treatment in Steels, Pearlitic, bainitic and martensitic transformations.

Unit 6: Hot working and cold working of metals: (2 lectures)
Recovery, re-crystallization and grain growth

Unit 7: Material testing: (3 lectures)
Tensile (stress-strain diagrams and related terminologies), Hardness, and Impact testing

Unit 8: Failure of metallic materials: (2 lectures) Creep fatigue and fracture phenomena.

Unit 9: (5 lectures)
Basic Ideas of Materials Selection and Design.

Total: 37

lectures <u>Course Outcomes (COs): -</u>

On successful completion of this course, students will be able to:

CO1: identify the general and advanced engineering materials, their properties and applications.

CO2: explain the need of advanced and non-conventional materials.

CO3: identify the criteria for selection of materials during design and manufacturing.

CO4: correlate material properties with design considerations.

CO5: present the outcome carried out in the form of group projects on material characterization and different manufacturing aspects.

<u>Text Books: -</u>

1. Callister, W. D. Material Science and Engineering - An Introduction. John Wiley & Sons, 7th edition, 2007.
2. Dieter, G. E. Mechanical Metallurgy. McGraw Hill, 3rd edition, 1988.

<u>Reference Books: -</u>

1. Smith, W. F. Principles of Materials Science. McGraw Hill, 2003.
2. Raghavan, V. Materials Science and Engineering. Prentice Hall, 6th edition, 2015.

ME208	Manufacturing Technology I	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: Nil

Contents

Theory: -

Unit 1: Introduction: (2 lectures)

Introduction to manufacturing processes

Unit 1: Casting processes: (15 lectures)

Types and stages of casting processes, Various foundry casting techniques viz. sand casting, die casting, continuous casting, centrifugal casting and investment casting, Types and properties of molding materials, pattern materials and core materials, Flow properties of molten metal, Gating and rising systems, Use of chills and chaplets; Principles of solidification of molten metal during casting, Directional solidification, Casting defects and their remedies, Quality assurance.

Unit 2: Joining Processes: (10 lectures)

Principles and applications of welding, brazing, soldering and solid-state joining processes, Weldability of different materials and their metallurgical and mechanical aspects, Welding defects and inspection.

Unit 3: Metal Forming / working Processes: (10 lectures)

Principles, analysis and application of various metals forming techniques viz. forging, rolling, extrusion, drawing, sheet metal forming, super plastic deformation, Forming defects and their remedies.

Unit 4: (3 lectures)

Powder metallurgy and its applications.

Total: 40 lectures

Course Outcomes (COs): -

On successful completion of this course, students will be able to:

CO1: gain detailed knowledge on different industrial manufacturing processes, advanced or non-conventional manufacturing systems.

CO2: can correlate different engineering materials and design considerations with their manufacturing techniques.

CO3: prepare for advanced workshop practice.

CO4: initiate project based on metal casting, metal working and metal joining processes.

Text Books: -

1. Campbell, J. S. Principles of Manufacturing Materials and Processes. Tata McGraw Hill, 1st edition, 2004.
2. Kalpakjian, S. and Schmid, S.R. Manufacturing Engineering and Technology. Pearson/Prentice Hall, 7th edition, 2013.

Reference Books: -

1. Ghosh, A. and Mallik, A. K. Manufacturing Science. East West Press, 2nd edition, 2010.
2. Rao, M. J. Manufacturing Technology: Foundry, Forming and Welding. McGraw Hill Higher Ed, 4th edition, 2013.

ME209	Fluid Mechanics II	L-T-P-Cr-CH: 2-1-0-3-3	Prerequisites: ME202

Contents

Unit 1: Introduction to Boundary Layer concepts:
Boundary layer flow, Boundary layer equations, the flat plate boundary layer, definition of boundary layer, displacement, momentum and energy thickness, Blasius similarity solution, Von Karman momentum integral equation, separation of boundary layer. Flow past immersed bodies.
(4L + 2T)

Unit 2: Turbulent flow:
Laminar turbulent transition, derivation of Governing equations for turbulent flow, turbulent boundary layer equation, Prandtl's mixing length hypothesis, Universal velocity distribution law, and friction factor correlation (4L + 2T)

Unit 3: Compressible flow:
Introduction, Speed of sound; adiabatic and isentropic steady flow, Mach-number relations, isentropic flow with area changes, Normal-shock wave, Rankine-Hugoniot relations, performance of nozzles, Fanno and Rayleigh flow (9L + 4T)

Unit 4: Turbo machinery:
Euler-equation for turbo-machines, impulse turbine and reaction turbine, Pelton wheel, Francis turbine, Kaplan/propeller turbine, water hammer and surge tank, Rotodynamic and positive displacement pumps, working principle of reciprocating pump, air vessel, Centrifugal pump, its components and working principle, performance characteristics of centrifugal pump vis-à-vis system characteristics, dimensionless terms, specific speed, Cavitation and net positive suction head. (10L + 5T)

(Total: 27 lectures + 13 tutorials)

Course Outcomes (COs): -

On the successful completion of the course, the student would be able to:

CO1: Solve laminar and turbulent pipe-flow problems.

CO2: Analyze and solve laminar and turbulent boundary-layer problems.

CO3: Solve compressible-flow problems involving isentropic flows, flows with normal shocks, flow through a converging-diverging nozzle with shocks, compressibleflow problems involving friction and heat transfer

CO4: Carry out performance analysis of Pelton, Francis and Kaplan turbines, reciprocating and centrifugal pumps.

CO5: Extend the knowledge of dimensional analysis and similitude to the analysis of turbo machines.

Text Books: -

1. White, F. M. Fluid Mechanics. McGraw-Hill Education, 8th edition, 2015.
2. Anderson Jr., J. D. Modern Compressible Flow with Historical Perspective. McGraw-Hill Education (India) Pvt. Ltd., 3rd edition, 2017.

Reference Book: -

1. Chakrabarty, S., Som, S. K. and Biswas G. Introduction to Fluid mechanics and Fluid Machines. Tata McGraw Hill, 3rd edition, 2012.
2. Zucker, R. D. and Biblarz, O. Fundamentals of Gas Dynamics. John Wiley and Sons, 2nd edition, 2002.

ME214	Kinematics of Machinery	L-T-P-Cr-CH: 2-1-0-3-3 Prere	quisites: ME102

Contents

Unit 1: Introduction:

Basic kinematic concepts; Kinematic pairs; Plane and space mechanisms; Kinematic chains; Kinematic diagrams, Limit and disguise of revolute pairs; Kinematic inversion; Equivalent linkages; Mobility and range of movement. (**8L + 3T**)

Unit 2: Kinematic analysis of plane mechanisms:

Displacement analysis; Instantaneous centre of velocity; Aronhold-Kennedy theorem of three centres; Velocity and acceleration analysis (graphical and analytical); Velocity and acceleration images. (**6L + 3T)**

Unit 3: Dimensional synthesis of linkages:

Two and three position synthesis - graphical method, Freudenstein's equations; Importance of Chebyshev accuracy points in approximate synthesis. (**3L + 2T**)

Unit 4: Cams:

Classification of followers and cams; Radial cam nomenclature; Description of follower movement; Analysis of follower motion; Determination of basic dimensions of cams. (**5L + 3T) Unit 5: Gears:**

Gearing action; Fundamental law of gearing; Properties and characteristics of involute action;

Introduction to helical, Spiral, Bevel, and Worm gears; Gear trains. (**4L + 2T**)

(Total: 26 Lectures + 13

Tutorials) **Course Outcomes (COs): -**

On the successful completion of the course, the student will:

CO1: Be able to appreciate and apply the framework acquired during this course to analyze and synthesize the mechanisms and machines for real-life problems/situations,

CO2: Get help while going through higher level courses on machine design and solid mechanics,

CO3: Get motivated to take up advanced courses like robotics etc.

Text Books: -

1. Uicker, J. J., Pennock G. R. and Shigley J. E. Theory of Machines and Mechanisms. Oxford University Press, New Delhi, 5th edition, 2017.
2. Ghosh, A. and Mallik A. K. Theory of Mechanisms and Machines. EWP publications, New Delhi, 3rd edition, 2014.

Reference Book: -

1. Rattan, S. S. Theory of Machines. MacGraw Hill Education (India) Private Limited, New Delhi, 4th edition, 2014.
2. Rao, J. S. and Dukkipati R. V. Mechanism and Machine Theory. New Age International Publishers, New Delhi, 2006.
3. Bevan, T. The Theory of Machines. Pearson, New Delhi, 3rd edition, 2014.
4. Wilson C. E. and Sadler J. P. Kinematics and dynamics of Machinery. Pearson, 3rd edition, 2013.
5. Waldron K. J., Kinzel G. L. and Agrawal S.K. Kinematics, Dynamics and Design of Machinery. Wiley, 3rd edition, 2016.

ME215	Mechanical Measurements and Instrumentation	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: Nil

Contents

Unit 1: Introduction to Metrology: (3 lectures)
General concepts, Definition of different metrological terms, metrology and methods of measurement, Classification of standards, Accuracy of Measurements Precision, Accuracy, Sensitivity, Calibration, Readability, Repeatability, Magnification; Errors in measurements, Limits, Fits and Tolerances, Interchangeability.

Unit 2: Mechanical measurements: (6 lectures)
Linear measurements, Angular and Taper measurements, Screw thread measurements, Gear measurements, circularity measurements, surface finish, straightness and flatness measurements.

Unit 3: Assessing Experimental Data: (4 lectures)
Static performance characteristics: Errors in measurements: Types and sources of errors, methods of elimination or reduction of error, sensitivity, linearity, resolution etc of instruments. Uncertainty analysis.

Unit 4: Statistical analysis of Experimental Data: (6 lectures)
Gaussian distribution of error, least square method of fitting data, linear regression method.

Unit 5: Dynamic Performance Characteristics: (3 lectures)
Zero, first and second order instruments, Signal conditioners: bridge circuit, amplifiers, filters etc.

Unit 6: Sensors and Transducers: (8 lectures) Definition, classification and detail description of important transducers.

Unit 7: Measurements: (12 lectures)
Basics of measuring instruments, description of instruments used for Displacement Measurements, Pressure measurements, Force measurements, Acceleration, Torque measurements, Flow measurements, Temperature measurements, Strain measurements.

Total: 42

lectures **Course Outcomes (COs): -**

On the successful completion of the course, the student would be able to:
CO1: Learn the basics of the science of metrology.
CO2: Identify problems associated to measuring devices and measurements.
CO3: Apply their acquired knowledge to solve problems related to measurements and instrumentation.
CO4: Apply their learning and understanding in the design and working of measuring instruments according to need.

Text Books: -

1. Jain, R.K. Engineering Metrology. Khanna Publishers, New Delhi, 21st edition, 2009.
2. `Nakra, B.C. and Chaudhry, K.K. Instrumentation Measurement and Analysis. Tata McGraw Hill, New Delhi, 4th edition, 2016.

Reference Books: -

1. Beckwith, T.G. Marangoni, R.D. and Lienhard, J.H. Mechanical Measurements. Pearson Prentice Hall, 6th edition, 2007.

2. Holman, J.P. Experimental Methods for Engineers. Mc-Graw Hill, 8th edition, 2012.
3. Rajput, R.K. Mechanical Measurements and Instrumentation. S. K. Kataria and Sons, New Delhi, 2012.

ME216	Manufacturing Technology II	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: ME208

Contents

Unit 1: Metal Cutting: (10 lectures)
Classification of metal removal processes, Mechanics, Chip formation, Surface finish and Machinability, Heat generation and cutting temperature, Cutting fluids.

Unit 2: Cutting Tools: (8 lectures) Tool geometry, Tool materials and properties, Tool wear and tool life, Tooling: jigs and fixtures.

Unit 3: Setting and Operations on machine tools: (10 lectures) Lathe, Milling, Shaping, Slotting, Planning, Drilling, Boring, Broaching, Reaming, Grinding, Thread rolling and Gear cutting machines, Gear hobbing, Super finishing processes.

Unit 4: (2 lectures) Batch production.

Unit 5: CNC Machines: (4 lectures) NC, CNC, DNC and FMS.

Unit 6: Unconventional Machining: (4 lectures) Electro-chemical, Electro-Discharge, Ultrasonic, LASER, Electron Beam, Water Jet, Abrasive Jet.

Unit 7: (2 lectures)
Rapid prototyping and rapid tooling.

Total: 40 lectures

Course Outcomes (COs): -

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

CO1: Identify the different aspects of machining science and machine tools.

CO2: Explain the increased need of advanced, automated and non-conventional machining processes.

CO3: Analyze the cutting tool geometry and design a single point cutting tool for shaping operation.

CO4: Demonstrate a practical understanding of machining operations and fabrication techniques, and to be able to make realistic suggestions for the evaluation of metal cutting behaviour.

CO5: Understand the underlying principles of non-conventional machining and make sound prediction on the selection of specific techniques based on metal cutting behaviour. CO6: Identify the conditions under which exact solutions for jigs and fixture designs for effective work holding in different machining conditions.

Text Books: -

1. Kalpakjian, S. and Schmid, S.R. Manufacturing Engineering and Technology. Pearson/Prentice Hall, 7th edition, 2013.
2. Ghosh, A. and Mallik, A. K. Manufacturing Science. East West Press, 2nd edition, 2010.

Reference Books: -

1. Hazra Choudhury, S.K., Hazra Choudhury, A.K. and Roy, N. Elements of Workshop Technology Vol II. Media Promoters and Publishers Pvt. Ltd., Mumbai, 2017.
2. Lal, G.K. Introduction to machining science. New Age International Publishers, New Delhi, 3rd edition, 2015.

ME 217 ME Lab (Design) I L-T-P-Cr-CH: 0-0-2-2-4 Prerequisites: Nil

Contents

Unit 1: Engineering Mechanics Laboratory: (5 Practical)

Verification of the parallelogram and triangle law of forces; Verification of reaction forces in a simply supported beam; Verification of Hooke's law with the help of a coil spring; Determination of coefficient of friction by the inclined plane apparatus; Evaluation of centroid of different planar objects.

Unit 2: Strength of Material Laboratory: (7 Practical)

Determination of percentage of elongation, yield strength and ultimate strength employing uniaxial tensile and compression test on mild steel bar; Vickers hardness test; Brinell hardness test; Rockwell hardness test; Determination of toughness of steel by impact testing (Izod test and Charpy test).

Unit 3: Theory of Machine Laboratory: (7 Practical)

Study on the influence of inertia upon velocity and acceleration; Study on gyroscopic apparatus; Study of whirling of shafts phenomena; Study on centrifugal governor; Study of static and dynamic balancing of an unbalanced system; Demonstration of various kinematic models and their applications.

Unit 4: Vibration Laboratory: (7 Practical)

Finding location of the centre of percussion of a compound pendulum; Finding the stiffness of a spring and acceleration due to gravity g of a spring- mass system; Undamped vibration absorber; Force and free undamped vibration of a rigid body; Force and free damped vibration of a rigid body.

Total: 26 Practical

<u>Course Outcomes (COs): -</u>

After successful completion of the course, the student will

CO1: Be able to understand the measurement of mechanical properties of materials,

CO2: Have understood the importance of fundamental science and engineering skills that are needed in engineering.

CO3: Be able to characterize the dynamic behavior of mechanical systems,

CO4: Have experienced the many stages in performing, analyzing and reporting of experimental data, comparison of the results with the relevant theories and eventually reporting the results both orally and written in a team environment.

<u>Reference Books: -</u>

1. Kumar, K. L. Engineering Mechanics. Tata McGraw Hill, 4th edition, 2017.
2. Thomson W. T., Dahleh M. D. and Padmanabham C. Theory of Vibrations with Applications. Pearson, 5th edition, 2008.
3. Popov, E. P. Engineering Mechanics of Solids. Pearson, 2nd edition, 2010
4. Ghosh, A. and Mallik A. K. Theory of Mechanisms and Machines. EWP publications, New Delhi, 3rd edition, 2014.

ME311 Machine Design I **L-T-P-Cr-CH: 2-1-0-3-3** **Prerequisites: ME201**

Contents

Unit 1: Introduction to mechanical engineering design:
Overview of machine design, Need of design, Design procedure, Stress-strain, Strength, Rigidity, Engineering materials, Material considerations in design. (**3L**)

Unit 2: Design against static load:
Mode of failure, Factor of safety, Theories of failure: Maximum normal-stress theory, Maximum shear-stress theory and distortion-energy theory. (**4L + 2T**)

Unit 3: Design against fluctuating load:
Fluctuating stresses, Fatigue failure, Endurance limit, Stress concentration, Notch sensitivity, Soderberg, Goodman and Gerber diagrams, Fatigue design under combined stresses. (**4L + 2T**)

Unit 4: Design of shafts, keys and couplings:
Shaft design for stresses (axial, bending and torsional) and combined loading, Shaft materials; Introduction to axle; Types of keys, Introduction to design of keys; Design of rigid and flexible couplings. (**4L + 3T**)

Unit 5: Joints:
Permanent and detachable joints, Introduction to design of welded, bolted and riveted joint; Design of cotter and knuckle joints. (**4L + 2T**)

Unit 6: Belt and chain drives:
Flat and V-belts, Belt slip and creep, Stresses in the belts, Belt materials, Chain drives. (**3L + 2T**)

Unit 7: Mechanical springs:
Helical springs, Leaf springs, Spring materials, Design against static and fluctuating load. (**2L + 2T**)

Unit 8: Manufacturing considerations:
Standardization, Limits, Fits and Tolerance. (**2L**)

(Total: 26 Lectures + 13 Tutorials)

<u>Course Outcomes (COs): -</u>

On successful completion of the course, students will be able to

- CO1: Analyze the forces and stresses acting on various machine components, in particular shafts, shaft couplings, keys, belts, chains, and springs; as well as in welded, bolted and riveted joints.
- CO2: Analyze and design of structural joints.
- CO3: Design such machine components and joints subject to various related design considerations, such as safety factor, service factor, stress concentration, and both static and dynamic failure criteria.
- CO4: Understand, identify and quantify failure modes of mechanical parts.
- CO5: Incorporate various manufacturing issues in design, such as limits, fits, and tolerance.

Text Books: -

1. Bhandari, V. B. Design of Machine Elements. McGraw-Hill Edu. (India) Pvt. Ltd., New Delhi, 3rd edition, 2014.
2. Gope, P. C. Machine Design: Fundamentals and Applications. PHI Learning Pvt. Ltd., New Delhi, 2012.

Reference Books: -

1. Bhandari V. B. Machine Design: Data book. McGraw-Hill Edu. (India) Pvt. Ltd., New Delhi, 2014
2. Sharma P. C. and Aggarwal, D. K. A Textbook of Machine Design. S. K. Kataria and Sons, New Delhi, 13th edition, 2017.
3. Spotts, M.F., Shoup, T.E., Hornberger, L.E., Jayram, S.R., and Venkatesh, C.V. Design of Machine Elements, Pearson Education. New Delhi, 8th edition, 2006.
4. Norton, R. L. Machine Design – An Integrated Approach. Pearson, 2nd edition, 2012.

Shigley, J.E., Mischke, C.R., Budynas, R.G., and Nisbett, K.J. Mechanical Engineering Design. Tata McGraw-Hill, New Delhi, 2008

ME312 Machine Design II **L-T-P-Cr-CH: 3-0-0-3-3 Prerequisites: ME311**

Contents

Unit 1: Introduction:
Introduction to design process, morphology of design and designing methods. (**1L**)

Unit 2: Brakes:
Types of brakes, Energy absorbed by the brakes, Design of block, band and disc brakes (Internal and external shoe); Absorption, Transmission and torsion dynamometer. (**5L**)

Unit 3: Clutches:
Classification, application and design of friction clutches, Disc or plate clutches, Cone clutches. (**5L**)

Unit 4: Power screw:
Forms of thread, I.S.O. Metric screw thread, Bolted joint in tension, Torque required for bolt tightening, Stresses in screw, Efficiency of screw. (**4L**)

Unit 5: Design of gears:
Design of spur gears, Helical gears, Bevel gears and worm gears, Lewis equation, Lewis form factor, Design based on strength dynamic and wear loads. (**10L**)

Unit 6: Introduction to design of gear boxes:
Introduction to design of gear boxes, Flywheel and Pulleys. (**2L**)

Unit 7: Bearings:
Types of bearings, Ball and roller bearings, Static and dynamic load carrying capacity, Load life relationship, Taper roller bearing, Bearing materials. (**5L**)

Unit 8: Lubrications:
Basic mode of lubrication, Hydrodynamic lubrication theory, Hydrostatic and hydrodynamic bearings (e.g., Journal). (**4L**)

Unit 9: Introduction to design of IC engine components: Cylinder, Piston, Connecting rod and Crankshafts). (**2L**)

Unit 10:
Introduction to the computer aided design. (**1L**)

(Total: 39 Lectures)

Course Outcomes (COs): -

Upon completion of this course, students will be able to

CO1: Analyze stress and strain in machine components, in particular brake, clutch, power screw, gears and bearing under different loading conditions.
CO2: Design different machine components and explain the failure of such components.
CO3: Recognize the need for friction drives and positive drives
CO4: Determine load carrying capacity and related parameters of bearing.
CO5: Predict the frictional behaviour at the sliding interface in mechanical system.

Text Books: -

1. Bhandari, V. B. Design of Machine Elements. McGraw-Hill Edu. (India) Pvt. Ltd., New Delhi, 3rd edition, 2014.
2. Gope, P. C. Machine Design: Fundamentals and Applications. PHI Learning Pvt. Ltd., New Delhi, 2012.

Reference Books: -

1. Bhandari V. B. Machine Design: Data book. McGraw-Hill Edu. (India) Pvt. Ltd., New Delhi, 2014.
2. Shigley, J.E., Mischke, C.R., Budynas, R.G., and Nisbett, K.J. Mechanical Engineering Design. Tata McGraw-Hill, New Delhi, 2008.
3. Faculty of Mechanical Engineering – PSG College of Technology, Design Data (Data book of Engineering). Kalaikathir Achchagam, 8th edition, 2007.
4. Ramamurti, V. Computer Aided Mechanical Design and Analysis. Tata McGraw Hill, 3rd edition, 1996.
5. Burr, A. H. and Cheatham, J. B. Mechanical Analysis and Design. Prentice Hall Inc., 2nd edition, 1997.
6. Dixon, J. R. Design Engineering: Inventiveness, Analysis and Decision Making. TMH, New Delhi, 1980.

ME313 Dynamics of Machinery L-T-P-Cr-CH: 3-0-0-3-3 Prerequisites: ME214

Contents

Unit 1: Dynamic force and motion analysis of plane mechanisms:
Motion of a rigid body subjected to a system of forces, D'Alembert principle and dynamic equilibrium; Dynamically equivalent link. (**5L)**

Unit 2: Dynamic analysis of plane mechanisms:
Force- moment analysis of four bar mechanisms; Dynamics of slider-crank mechanism; Derivation of turning moment and turning moment diagram; Fluctuations in crankshaft speed and flywheel. (**7L**)

Unit 3: Governor:
Types of governors; Characteristics and types of centrifugal governors; Hunting of centrifugal governors, control force diagrams of gravity and spring-controlled governors. (**4L**)

Unit 4: Balancing of inertia forces and moments in machines:
Balancing of rotating masses - internal and external balancing, Static and dynamic balancing; multi-plane balancing; Determination of balancing masses; Balancing of rotors - field balancing; Balancing of internal-combustion engines (single cylinder, multi-cylinder, V-engines, direct and reverse crank method). (**8L**)

Unit 5: Vibrations in mechanical systems:
Basic features of vibratory systems; Single-degree- of-freedom systems - free and forced vibrations, Viscous and coulomb damping, Harmonic excitation; Transmissibility and vibration isolation; Two and multi-degree of freedom systems, normal modes, matrix method; orthogonally principle, modal analysis method, Continuous systems (longitudinal, torsional and transverse vibration of beam with different boundary conditions). (**11L**)

Unit 6: Gyroscopic actions in machines:
Principle of gyroscopes; Gyroscopic forces and couple; Gyroscopic stabilization, Application of gyroscope to simple rotating machines, airplane, ship, automobiles etc. (**4L**)

(Total: 39 Lectures)

Course Outcomes (COs): -

After going through this course, the students will be able to:

CO1: Develop a logical framework to analyze a dynamical system,

CO2: Develop models of spring and damping elements from the basic principles of mechanics of materials and fluid mechanics respectively,

CO3: Develop and solve the equations of motion of single- and multi-degree of freedom physical systems under forced and free conditions,

CO4: Compute the damped and undamped natural frequencies, the logarithmic decrement, the time constant and the damping factor and determine whether the system is stable or not.

Text Books: -

1. Uicker, J. J., Pennock G. R. and Shigley J. E. Theory of Machines and Mechanisms. Oxford University Press, New Delhi, 5th edition, 2017.
2. Ghosh, A. and Mallik A. K. Theory of Mechanisms and Machines. EWP publications, New Delhi, 3rd edition, 2014.

3. Thomson W. T., Dahleh M. D. and Padmanabham C. Theory of Vibrations with Applications. Pearson, 5th edition, 2008.

Reference Books: -

1. Rattan, S. S. Theory of Machines. MacGraw Hill Education (India) Private Limited, New Delhi, 4th edition, 2014.
2. Rao, J. S. and Dukkipati R. V. Mechanism and Machine Theory. New Age International Publishers, New Delhi, 2006.
3. Bevan, T. The Theory of Machines. Pearson, New Delhi, 3rd edition, 2014.

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Tezpur University
Tezpur, Assam

ME314	Applied Thermodynamics	L-T-P-Cr-CH: 3-1-0-4-4	Prerequisites: ME205

Contents

Unit 1: Brief review on basic knowledge of thermodynamics (1L)

Unit 2: Vapor Power cycles:
Rankine cycle and its representation in various co-ordinate systems, deviations of actual cycle from ideal cycle, Rankine cycle performance, and modifications of ideal Rankine cycle. Low Temperature Power Cycles, ideal working fluid and binary / multi-fluid cycles, cogeneration, **(5L+ 2T)**

Unit 3: Steam Generator (Boiler):
Different types of boilers, Mountings and Accessories. **(2L + 1T)**

Unit 4: Condenser:
Types of Condensers and their working principle. **(1L)**

Unit 5: Steam turbine:

Impulse and reaction turbine, compounding of steam turbine, velocity triangle, efficiencies, degree of Reaction, reheat factor, governing of steam turbine. Steam Nozzles. **(6L + 2T)**

Unit 6: Psychrometry:
Properties of moist air: psychrometry and psychrometric charts and processes, cooling towers. **(2L + 1T)**

Unit 7: Refrigeration:
Vapor compression refrigeration cycle - in T-s and P-h plots, multi-pressure system, and Desirable properties of refrigerants. **(2L + 1T)**

Unit 8: IC engines:
SI and CI engines, two- and four- stroke engines, Engine components, and their working, engine design and operating parameters and its effect on engine performance mean effective pressure, efficiency and specific fuel consumption. Air standard cycles and Air fuel engine cycles, analysis of actual cycle and various losses. Pressure-crank angle diagram, Carburetor and fuel injection systems **(7L + 2T)**

Unit 9: Gas power cycle and gas turbines:
Basic components of Gas Turbine plant, Brayton cycle, deviations of actual cycle from ideal cycle, Reheat, intercooling, regeneration cycles. Combined gas and steam cycles, low temperature power cycles. **(5L + 2T)**

Unit 10: Introduction to jet propulsion:
Turbojet, turbofan, turboprop engines **(1L)**

Unit 11: Reciprocating air compressors:
Components and working principle, Process representation in p-V plane, calculation of work done, and multistage compression with intercooling. **(4L + 1T)**

Unit 12: Introduction to Centrifugal and Axial-Flow Compressors: (3L+ 1T)

(Total: 39 lectures + 13 tutorials)

Course Outcomes (COs): -

Towards the end of the course the student would be able to:

- CO1: Analyze the basic, reheat and bled steam power cycles in order to carry out calculations on system performance.
- CO2: Construct steam turbine velocity diagrams in order to determine stage calculations mathematically
- CO3: Use steam tables and h-s charts to carry out calculations on steam power plant system performance.
- CO4: Explain the working of different boilers, condensers and other components of a steam turbine power plant.
- CO5: Analyze various gas turbine power plant system arrangements in order to perform heat, work, efficiency, air-fuel ratio, etc. calculation
- CO6: Determine thrust developed, efficiencies and fuel consumption of jet engines
- CO7: Analyze single and multi-stage reciprocating air compressor cycles in order to carry out calculations on machine performance.
- CO8: Construct velocity diagrams for various blade designs of a centrifugal compressor to determine work input, blade efficiency etc.
- CO9: Evaluate the performance of Otto, Diesel and Dual cycle IC engines.
- CO10: Explain combustion phenomena, injection and ignition systems of IC engines.
- CO11: Draw and analyze valve timing diagrams of four stroke IC engines.
- CO12: Solve numericals related to this course in various competitive examinations like GATE, UPSC, PSU's etc.
- CO13: Study related advanced application-oriented courses such as Gas Turbine and Compressor, Heat Exchanger Design, Refrigeration and Air-conditioning, Compressible

Flow, Energy Conservation and Waste Heat Recovery, Advanced Thermodynamics etc.

- CO14: Suggest/ implement/ innovate methods of improving efficiency of a thermal power plant along with combined generation/ co-generation.

Text Books: -

1. Cengel, Y.A. and Boles, M.A. Thermodynamics, An Engineering Approach. McGraw Hill Education, 8th edition, 2014.
2. Nag, P.K. Basic and applied thermodynamics. Tata McGraw Hill, New Delhi, 2nd edition, 2010.
3. Nag, P.K. Power plant Engineering. McGraw Hill Education (India), 4th edition, 2014.

Reference Books: -

1. Borgnakke, C. and Sonntag R.E. Fundamentals of Thermodynamics. John Wiley and Sons, 8th edition, 2013.
2. Moran, M.J., Shapiro, H.N., Boettner, D.D. and Bailey, M.B., Principles of Engineering Thermodynamics. S.I. version, John Wiley and Sons, 7th edition, 2014.
3. Rogers, G. F. C and Mayhew, Y. R. Engineering Thermodynamics Work and Heat Transfer. Pearson Education, 4th edition, 1992.
4. Eastop, T. D. and McConkey, A. Applied Thermodynamics for Engineering Technologists. Longman, 5th edition, 1993.

ME315	ME Lab (Manufacturing) II	L-T-P-Cr-CH: 0-0-2-2-4	Prerequisites: ME203, ME216

Contents

Unit 1: Manufacturing:

Measurement of tool angles and radius of single point cutting tool, Determination of cutting forces and surface roughness with variation of cutting parameters, shear plane, and chip thickness ratio.

(5P) Unit 2: Machine Tools and Machining:

Selection of Cutting tools – single point cutting tool, carbide tipped tools. Tool signature Selection of cutting speeds and feeds for various machining operations.

Machining operations on lathe, shaping, slotting, milling and grinding machines.

(7P) Unit 3: Welding Process:

Gas Welding (Oxy acetylene Welding)

Shielded metal arc welding – selection of welding parameters, electrodes. Soldering, Brazing

(6P) Unit 4: Manufacturing Automation:

NC, CNC, CAM, FMS -3 NC part programming -2

Simulation and manufacturing-2

(8P)

Total: 26 Practical

Course Outcomes (COs): -

Upon completion of this course, students will be able to:

CO1: Perform machining using various manufacturing techniques. CO2: Evaluate the accuracy and tolerance of components production CO3: Perform metal arc welding operations on jobs.

CO4: Understand the advanced manufacturing techniques such as NC and CNC and write their part programming.

Reference Books: -

1. Hazra Choudhury, S.K. Hazra Choudhury A.K. and Roy N. Elements of Workshop Technology Vol II. Media Promoters and Publishers Pvt. Ltd., Mumbai, 2017.
2. Ghosh, A. and Mallik, A. K. Manufacturing Science. East West Press, 2nd edition, 2010.
3. Boothroyd, G and Knight, W.A. Fundamentals of Metal machining and Machine Tools. CRC press, Boca Raton, 3rd edition, 2005.
4. Kalpakjian, S. and Schmid, S.R. Manufacturing Engineering and Technology. Pearson/Prentice Hall, 7th edition, 2013.

ME316	Computer-Aided Engineering	L-T-P-Cr-CH: 1-0-2-3-5	Prerequisites: Nil

Contents

Unit 1: Introduction to Computer-Aided Modeling: Basic drafting, Modelling of parts and assembly drawing using standard software packages **(2 L + 3 P).**

Unit 2: Introduction to Structural Analysis: Introduction to Finite Element Analysis: Basic engineering analysis of Beams, Trusses, Plates; Stress analysis of structure with individual and combined loading under Mechanical, Thermal and Thermo-Mechanical loading **(5 L + 3 P)**. **Unit 3:** Introduction to Computational Fluid Dynamics: Mathematical nature the governing partial differential equations (PDEs) for fluid flow and heat transfer, Introduction to Finite Difference Method (FDM) and Finite Volume Method (FVM), Preprocessor, Solver and Postprocessor of a commercial CFD package, SIMPLE Algorithm, RANS Based Turbulence Models, Shear Stress Transport Model, Near Wall Treatment **(5 L + 2 P)**.

Unit 4: Modeling of fluid systems: Geometry modeling using a standard commercial package, specification of boundary conditions, free-stream conditions and flow properties, user-defined functions **(2 L + 2 P)**

Use of commercial fluid-flow solvers to solve the following problems **(16 P)**:

1. Steady and unsteady-state temperature profiles in solids under heat conduction
2. Solution of viscous, laminar, incompressible flow over immersed bodies – car bodies, airfoils
3. Solution of viscous, laminar, incompressible flow through internal passages – nozzles, flow through check valves
4. Simulation of flows through Heat exchangers- conjugate heat transfer problems
5. Estimation of Nusselt number in forced, free and mixed-convection problems,
6. Computation of viscous-supersonic flows over wedges and cones
7. Simulation of Oil-Tank Sloshing
8. Simulation of pulsating flows through mufflers
9. Modeling and analysis of beams under different loading conditions using FEM
10. Modeling of different machine components using standard software package
11. Analysis of those machine components using FEM
12. Modeling of complex structures using standard software package
13. Analysis of complex structures using FEM

(Total: 14 lectures + 26 practical classes)

Course Outcomes (COs): -

On the successful completion of the course a student will be able to:

CO1: Model and analysis of physical system involving structural and thermal applications

CO2: Use commercial-software packages to simulate engineering problems involving structural loading, fluid flow and heat transfer.

Reference Books: -

1. Bhat, N. D. and Panchal V. M., Machine Drawing. Charotar Publishing House, Court Road, Anand, India, 48th Edition, 2013.
2. Srinivas, P., K., Sambana, C. and Datti, R. J., Finite Element Analysis using ANSYS@ 11.0. PHI, New Delhi, 2012.
3. Versteeg, H. K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method. Pearson, 2nd Edition, 2009.
4. Anderson, D. A., Tannehill, J. C., and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer. CRC Press, 3rd Edition, 2012.
5. Munford, P. and Normand, P. Mastering Autodesk Inventor 2016 and Autodesk Inventor LT.
   John Wiley Sons, 2016.
6. Kent, L.L. ANSYS Workbench Tutorial Release 14. SDC Publications, 2012.
7. ANSYS FLUENT Tutorial guide Release 15.0. ANSYS Inc., 2013.

ME317	ME Lab (Thermal) III	L-T-P-Cr-CH: 0-0-2-2-4	Prerequisites: ME205, ME209

Contents

Unit 1: Fluid Mechanics:
Demonstration of Bernoulli's Theorem, Flow meter demonstration: Determination of discharge coefficients of flow meters (Venturimeter and Orificemeter), Study of Impact of jet on flat, curved and semispherical surfaces, Osborne Reynolds demonstration **(8P)**

Unit 2: Turbomachinery:
Demonstration of Centrifugal pump: (i) Introduction to pump characteristic, (ii) Effect of inlet head on pump performance, (iii) System characteristic analysis (determination of operating point), Demonstration of Pelton Turbine: (i) Comparison of Pelton wheel performance using spear and throttle valve **(6P) Unit 3: Heat Transfer:**
Demonstration of Conduction, Convection and Radiation mode of heat transfer.
Conduction: Thermal conductivity of insulating slabs
Convection: To determine heat transfer co–efficient for forced convection, dropwise and filmwise condensation apparatus and critical heat flux in pool boiling apparatus, Heat transfer in vertical cylinder natural convection apparatus

Radiation: Stefan Boltzmann apparatus
Heat exchangers, and Heat pipe: To study the heat transfer phenomena in parallel/counter flow arrangements and calculate overall heat transfer coefficient with concentric tube heat exchanger, Effectiveness of shell and tube heat exchanger apparatus, Heat pipe demonstrator, Cooling tower test rig. **(9P)**

Unit 3: Refrigeration and Air Conditioning:
Demonstration of working of refrigerating and air conditioning system: To determine the Coefficient of performance for Vapour compression refrigeration system, Vapour absorption refrigeration system. To determine psychometric properties using Air conditioning test rig. **(4P)**

(Total: 27 Practical's)

Course Outcomes (COs): -

After successful completion of course the students will be able to:

CO1: Understand and apply the laws of fluid mechanics to practical applications CO2: Understand the basic laws of heat transfer.

CO3: Understand the fundamentals of convective heat transfer process, like boiling, condensation.

CO4: Understand the working of refrigeration system and psychometric processes.

Reference Books: -

1. Chakrabarty, S., Som, S. K. and Biswas, G. Introduction to Fluid mechanics and fluid machines. Tata McGraw Hill, 3rd edition, 2012
2. Massey, B.S. and Smith, J. W. Mechanics of fluids. Taylor and Francis, 9th edition, 2012.
3. Incropera, F.P. and Dewitt, D.P. Fundamentals of Heat and Mass Transfer. John Wiley and Sons, 5th edition, 2009.

4. Stoecker, W.F and Jones, J.W., Refrigeration and Air Conditioning. McGraw-Hill International Editions, 2nd edition,1986
5. White, F. M. Fluid Mechanics. Tata McGraw Hill, 7th edition, 2010
6. Kundu, P.K. Cohen, I.M. and Dowling, D.R. Fluid Mechanics. Elsevier, 5th edition, 2012
7. Ozisik, M.N. Heat Transfer-A Basic Approach. McGraw Hill, 1985.
8. Bejan, A. Convective Heat Transfer. John Wiley and Sons, New York, 3rd edition, 2004.
9. Arora, C.P. Refrigeration and Air Conditioning. Tata McGraw-Hill, 2nd edition, 2000.

ME318	Mini Project	L-T-P-Cr-CH: 0-0-2-2-4	Prerequisites: Nil

Contents

The students will carry out mini projects in groups of 2 or 3 students under the supervision of a faculty member or joint supervision by some Industry Personnel. The Mini Project is likely to be extended as the final-year project work of the individual groups

Course Outcomes (COs): - successful completion of the course students will be able to:

CO1: Develop innovative thinking and skills required for final-year project execution.

CO2: Apply the principles of science and engineering for project identification and development.

CO3: Demonstrate effective team work, sense of ownership and project planning.

CO4: Communicate and report effectively project activities and findings.

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Tezpur University
Tezpur, Assam

ME401	Industrial Systems Engineering	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: None

Contents

Unit 1: Industrial Engineering:
Introduction, Production Planning and Control, Product design, Value analysis and value engineering, Plant location and layout, Equipment selection (**8 lectures)**

Unit 2:
Plant location and layout; Equipment selection, Maintenance planning; Job, batch and flow production method, Group technology, Work study, Time and Motion study; Work/Job Evaluation, Inventory control
(8 lectures)

Unit 3: Concept of TPM and TQM, Job, batch, and flow production methods, Group technology, Work study, Time and motion study, Incentive schemes, Work/job evaluation, Inventory controldeterministic model only (8 **lectures)**

Unit 4: Manufacturing planning: MRP, MRP-II, JIT, CIM, Quality control - Statistical process control, Acceptance sampling, Total quality management, Quality engineering; (**6 lectures)**

Unit 5: Forecasting, Scheduling and loading, Line balancing, Break-even analysis, Network
Analysis – PERT and CPM, Inventory Control (**10 lectures)**

(Total: 40 lectures)

Course Outcomes (COs): -
Upon the completion of the course, the students will be able to:

CO1: Explain the basic underlying concepts of product design, plant layouts, and value analysis.

CO2: Create and solve problems related to Forecasting, Scheduling, Network analysis and breakeven analysis.

CO3: Explain the mechanisms of Maintenance planning, Quality control, Inventory control and Operations Research.

CO4: Apply and analyze various techniques of sales forecasting, linear programming transportation problem, and queuing theory for solving industrial problems.

CO5: Explain the basic underlying concepts of product design, plant layouts, and value analysis.

Text Books: -

1. Telsang, M. T. Industrial Engineering and Production Management. S Chand and Company Limited, 2nd edition, 2006.
2. Paneerselvam, R. Productions and Operations Management. PHI learning Pvt. Ltd, 3rd edition, 2012.

Reference Books: -

1. Sharma, S. K. and Sharma, S. Industrial Engineering & Organization Management. S. Kataria and Sons, 3rd edition, 2016.

ME429	Gas Turbine and compressor	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: None

Contents

Unit 1: Introduction:
Development, classification and field application of gas turbine.

Unit 2: Gas Turbine Cycle:
Ideal and actual cycles, multi-stage compression, reheating, regeneration, combined and cogeneration.

Unit 3: Energy transfer and fluid flow characteristics:
Energy transfer between fluid and rotor, axisymmetric flow in compressor and gas turbine.

Unit 4: Centrifugal Compressor:
Principles of operation; compressor losses adiabatic efficiency; slip factor; pressure coefficient; power unit; design consideration for impeller and diffuser system; performance characteristics.

Unit 5: Axial Flow Compressors:
Elementary theory; vortex theory; degree of reaction; simple design; elementary air-foil theory; isolated air foil and cascade theory; three-dimensional flow; stages; stage efficiency and overall efficiency; performance characteristics.

Unit 6: Turbines:
Axial flow and radial flow turbine; impulse and reaction turbine; fundamental relations and velocity triangles; limiting factors in turbine design; application of air foil theory to the study of flow through turbine blades; aerodynamic and thermodynamics design consideration; blade attachments and blade cooling.

Unit 7: Gas Turbine Power Plants:
Fuel and fuel feed system; combustion system-design considerations and flame stabilization regenerator types and design; gad turbine power; plant performance and matching; application.

Course Outcomes (COs): -

Upon the completion of the course, the students will be able to:
CO1: Discuss the basic energy equation and thermodynamics law behind the gas turbine
CO2: Understand the improvements brought to gasturbine plants in terms of performance.
CO3: Evaluate the performance characteristics of gas turbines under different operation conditions CO4: Analyze the surging and choking conditions of compressor and gas turbine CO5: Discuss the elementary theories for compressor and turbine. CO6: Design the gas turbine units and its blades.

Text Books : -

1. Cohen and Rogers. Gas Turbine Theory (Longman, 4/e, 1996)
2. Dixon, S.L. Fluid Mechanics, Thermodynamics of Turbomachinery (Pergamon Press, 5/e, 2005).

Reference Books: -

1. Vincent, Theory & Design of Gas Turbine and Jet Engines (McGraw Hill, 1950)
2. Gas Turbine Principles and Practice (Cox Newnes, 1955)

ME 434	Composite Materials	L-T-P-Cr-CH: 3-0-0-3-3	

Contents

Unit 1: Introduction:
Introduction and overview of composite materials and their need, Enhancement of properties, classification of composites, Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Application of composites.

Unit 2: Reinforcements Materials:
Metallic, Polymer, Ceramic and Composite fibres, Whiskers and Particulates, Nano-fillers used in polymer composites, Reinforcement fibres, Woven fabrics and Nonwoven random mats. Course Code Course Name Lecture Tutorial Practical Credit ME 434 COMPOSITE MATERIALS 3 0 0 3
Types of matrix: Commonly used Matrices (Metal matrix, Polymer matrix, Ceramic matrix, Intermetallic matrix, Carbon-Carbon composites), Basic Requirements in Selection of constituents.

Unit 3: Production techniques and Properties:
Processing of cast composites - XD process, Spray processes (Osprey Process, Rapid solidification processing), In-situ Dispersion Processes (Stir-casting & Compo casting, Screw extrusion), Liquidmetal impregnation technique (Squeeze casting, Pressure infiltration, Lanxide process). Hand lay-up processes – Spray up processes, Compression moulding, Reinforced reaction injection moulding, Resin transfer moulding, Pultrusion, Filament winding, Injection moulding.

Unit 4: Mechanics of Composite Materials:
Continuous fibres – iso-stress and iso-strain conditions, discontinuous fibres, Nature of stress vs. strain curves for different composite materials. Mechanical Properties: Mechanical testing of composites – tensile, flexure (3 point and 4-point bend tests), interfacial tests of laminates; Modes of fracture; Toughening mechanisms in composites.

Unit 5: Recent developments in Composites:
Self-healing composites, Molecular composites, Micro and Nanocomposites, Biocomposites, Lefthanded composites, Stiffer than stiff composites, Carbon / carbon composites (Advantages and limitations of carbon matrix).

Text Books : -
1. Chawla K.K., Composite materials, Springer, New York, 1998.

Reference Books: -
1. Mathews F.L. and Rawlings R.D., Composite materials: Engineering and Science, Chapman and Hall, London, England, 1st edition, 1994.
2. Strong A.B., Fundamentals of Composite Manufacturing, SME, 1989.
3. Sharma S.C., Composite materials, Narosa Publications, 2000.
4. Mallick, P.K, Composite Materials Technology: Process and Properties, Hanser, New York, 1990.

ME 439	Refrigeration and Air Conditioning	L-T-P-Cr-CH: 3-0-0-3-3	

Contents

Vapour-compression cycles; Absorption refrigeration; Vapour-compression-system analysis; AirCraft refrigeration cycle; multi-pressure systems; Refrigerants; Condensers and evaporators; Compressors; Expansion devices, Psychrometry, Psychrometric Processes; Heating- and cooling-load calculations; Air-conditioning systems; Fan and duct systems; Pumps and pumping; Cooling and dehumidifying coils; Air-conditioning controls; Heat pumps; Cooling towers and evaporative condensers.

CO1: Illustrate the fundamental terminology associated with refrigeration and air conditioning

CO2: Understand the components of vapour compression systems and other types of cooling systems and analyse the performance using Mollier charts

CO3: Evaluate the properties, applications and environmental issues of different refrigerants

CO4: Apply the concept of thermodynamic laws and heat transfer to understand the components of refrigeration and air conditioning

CO5: Analyze the air conditioning processes using principles of Psychrometry

CO6: Evaluate cooling and heating loads in an air conditioning system

Text Books : -

1. Stoecker, W.F and Jones, J.W., Refrigeration and Air Conditioning (McGraw-Hill International Editions, 3/e, 1986.
2. Threkeld, J.L. Thermal Environmental Engineering (Prentice Hall Inc, 2/e., 1970).

Reference Books: -

1. Arora, C.P. Refrigeration and Air Conditioning (Tata McGraw-Hill, 2/e, 2000).
2. Air conditioning Design Handbook (Carrier Corpn, McGraw Hill, 1965)
3. ASHRAE Handbooks (ASHRAE, 2007)

ME471	Industrial Summer Training	L-T-P-Cr-CH: 0-0-0-2-0	Prerequisites: Nil

Contents

Training will be of 12 weeks duration carried out during the summer break after the 6th semester. The students will submit their reports in the 7th semester.

Course Outcomes (COs): -

At the end of the Industrial Summer Training

CO1: Students will be able to acquaint themselves with the contemporary industrial practices and research.

CO2: Students will be able to establish the important links between theoretical study and practical engineering operations and problem solutions.

CO3: Students will be able to develop confidence in dealing with newer engineering environment.

CO4: Students will be able to perform their task efficiently in relevant engineering based organisations in the near future.

CO5: Students will be able to identify and work on problems of engineering interest while opting for higher studies.

ME483	Project I	L-T-P-Cr-CH: 0-0-4-4-8	Prerequisites: ME318

Contents

The students will carry out project works in groups of 2 or 3 students each under the guidance of a faculty member or joint supervision with some Industry Personnel. The project shall consist of research/ design/ development/ implementation work.

Course Outcomes (COs): -

On successful completion of the course, the students will be able to:
CO1: Demonstrate a sound technical knowledge on the project topic.
CO2: Identify, formulate and solve complex engineering problem.
CO3: Design engineering solutions to complex problems using modern tools and techniques.
CO4: Display of effective team-work and project-planning.
CO5: Communicate with engineers and the community at large in written and oral forms. CO6: Acquire the knowledge, skills and attitudes of a professional engineer.

ME484	Project II	L-T-P-Cr-CH: 0-0-8-8-16	Prerequisites: ME483

Contents

The students will carry out project works in groups of 2 or 3 students each under the guidance of a faculty member or joint supervision with some Industry Personnel. A provision is present for a group to work for the entire semester in some Industry, if suitable opportunity arises. In that case the concerned students will be allowed to complete the course works for ME Elective VI and Open Elective IV through MOOCs. The project shall consist of research/ design/ development/ implementation work.

Course Outcomes (COs): -

On successful completion of the course, the students will be able to:
CO1: Demonstrate a sound technical knowledge on the project topic.
CO2: Identify, formulate and solve complex engineering problem.
CO3: Design engineering solutions to complex problems using modern tools and techniques.
CO4: Display of effective team-work and project-planning.
CO5: Communicate with engineers and the community at large in written and oral forms. CO6: Acquire the knowledge, skills and attitudes of a professional engineer.

ME-501: Advanced Solid Mechanics **L-T-P-CH-CR: 3-1-0-4-4**

Analysis of stress: Introduction, Cauchy's formula, principal stresses, stress invariants, three- dimensional Mohr's circle, octahedral stresses, hydrostatic and deviatoric stresses, differential equations of equilibrium in rectangular and polar coordinates, stress boundary conditions, plane stress and plane stress problems; Analysis of strain: Introduction, definitions of normal and shear strains, principal strains, strain invariants, plane strain in rectangular and polar coordinates, compatibility conditions;
Stress-strain relations for linearly elastic bodies: Generalized Hooke's law, relations between elastic constants;
Axisymmetric problems: Thick and thin-walled cylinders, composite tubes, rotating disks;
Energy methods: Introduction, principle of superposition, elastic strain energy and complementary energy, reciprocal relations, Maxwell-Betti theorem, Castigliano's theorem, principle of virtual work, statically indeterminate structures, Kirchoff's theorem;
Bending of beams: Bending of symmetrical and unsymmetrical straight beams, shear stresses in beams, shear center and shear flow, curved beam;
Torsion: Torsion of circular, elliptical and rectangular bars, thin walled sections; Elastic stability: Euler's buckling load, beam column, eigenvalue problem; Assignment and mini-project.

Course outcomes:

CO1:Understand advanced stress-strain correlations.
CO2:Obtain simple mathematical and physical relationships between mechanics and materials.
CO3:Critical thinking and critical judgment of assumptions adopted.
CO4:Establish links between theoretical and practical applications.
CO5:Identify, formulate, model and analyze the complex engineering structural problem.

Textbooks

1. Srinath L.S. *Advanced Mechanics of Solids* (Tata McGraw-Hill, New Delhi, 2009)
2. Raymond P. Solid Mechanics in Engineering (Willey, 2001)

References

1. Sadd M.H. *Elasticity: Theory, Applications, and Numerics* (Academic Press, 2009)
2. Budynas R.G. *Advanced Strength and Applied Stress Analysis* (McGraw Hill, 1999)
3. Boresi A.P. and Schmidt, R.J. *Advanced Mechanics of Materials* (John Willey & Sons, 2003)

ME-502: Finite Element Methods **L-T-P-CH-CR: 3-1-0-4-4**

Introduction, basic concept, comparison with finite difference method; Variational methods: Calculus of variation, Rayleigh-Ritz and Galerkin methods;
One-dimensional problems: Formulation by different approaches, derivation of elemental equations, assembly, solutions and post-processing, bending of beams, analysis of truss and frame, other problems of solid mechanics, fluid mechanics and heat transfer;
Two-dimensional problems: Modeling of single variable problems, triangular and rectangular elements, applications in solid mechanics, fluid mechanics and heat transfer;
Numerical considerations: Numerical integration, error analysis, mesh refinement;
Plane stress and plane strain problems; Bending of plates; Eigenvalue and time dependent problems;
Discussion about preprocessors, postprocessors;
Application of commercial software packages; Assignment and mini-project.

Course outcomes:

CO1:Learn the behaviour and uses of different types of elements.
CO2: Find stress, strain and deformation of engineering problems of any dimensions using FEM.
CO3:Understand the concepts behind variation methods in FEM.
CO4:Solve complicated integration problem by using numerical integration technique.
CO5: Built FE model, analyze, solve and design of complex geometric problems using the commercial
FE software package.
CO6:Pursue research in the field of FEM.

Textbooks

1. Chandrupatla T.R. and Belegundu, A.D. *Introduction to Finite Elements in Engineering*, Vol.1 (Prentice Hall, 2002)
2. Bathe K.J. *Finite Element Procedures in Engineering Analysis* (Prentice Hall, 1996)

References

1. Reddy J.N. *An introduction to the Finite Element Method* (McGraw-Hill, 2006)
2. Cook R.D., Malkus, D.S. and Plesha, M.E. *Concepts and Applications of Finite Element Analysis* (Wiley, 2007)
3. Hughes T.J.T. *The Finite Element Method* (Dover Publications, 2000)
4. Zienkiewicz C. and Taylor, R.L. *The Finite Element Method* (McGraw-Hill, 1989)

ME-503: Mechanics of Composite Materials **L-T-P-CH-CR: 3-1-0-4-4**

Introduction - classifications, terminologies, manufacturing processes and applications of composite materials;
Macro-mechanical behavior of lamina - stress-strain relations, engineering constants for orthotropic materials, transformation of stress and strain, strength and stiffness of lamina, biaxial strength theories;
Micro-mechanical behavior of lamina – volume and mass fractions;
Macro-mechanical behavior of laminates – single-layered configurations, symmetric laminates, antisymmetric laminates, strength of laminates; Hygro-thermal analysis of lamina and laminates;
Design of laminates – symmetric, cross-ply, angle-ply and anti-symmetric laminates;
Failure analysis – failure criteria and failure modes, buckling and vibration of laminated beams, plates and shells; Assignment and mini-project.

Course outcomes:

CO1: Acquire knowledge on the types, advantages, applications, and manufacturing processes of composite materials.
CO2: Analyze macro-mechanical and micro-mechanical behavior of lamina.
CO3: Analyze macro-mechanical behavior of laminate.
CO4: Design and analyze of laminated composites materials.
CO5: Design and analyze of laminated composite structure using software packages.
CO6: Acquire knowledge on recent advancement of composite materials and do research on such advanced material in future.

Textbooks

1. Daniel, I.M. and Ishai, O. Engineering Mechanics of Composite materials (Oxford University Press, 2005)
2. Jones, R.M. Mechanics of Composite Materials (Taylor & Francis, 1999)

References

1. Agarwal, B.D., Broutman, L.J. and Chandrashekhara, K. Analysis and Performance of Fiber Composites (John Willey &Sons, 2006)
2. Kaw, A.K. Mechanics of Composite Materials (Taylor & Francis, 2006)
3. Reddy, J.N. Mechanics of Laminated Composite Plates (CRC Press, 1997)

ME-504: Failure Analysis of Materials **L-T-P-CH-CR: 3-0-0-3-3**

Introduction, common causes of failure, failure investigation, principle of failure analysis; Fracture mechanics – energy approach and stress intensity factor approach to linear elastic fracture mechanics, concept of crack tip opening displacement and J-integral fracture criteria, mechanisms of fracture, evaluation of fracture toughness, fracture in composite materials, computational fracture mechanics analysis, fracture mechanics in nano materials and structures;

Creep - stress-time-temperature relations, creep curve;

Fatigue - stresses in cyclic loading, fatigue testing, S-N curves and endurance limit, mechanisms of fatigue crack initiation and propagation, influence of stress concentration on fatigue strength, notch sensitivity, factors influencing fatigue behavior, prevention of fatigue failure; Assignment and mini-project.

Course outcomes:

CO1: Identify the different principles, causes and modes of fracture and failure.
CO2: Apply knowledge of fracture and failure in the field of mechanical design.
CO3: Present the outcome in the form of group projects on advanced design of mechanical/structural components considering the in-depth knowledge of material failure.
CO4: Correlate design considerations with material strength and properties of failure.

Textbooks

1. Kumar, P. *Elements of Fracture Mechanics* (McGraw-Hill, 2009)
2. Anderson, T.L. Fracture Mechanics: Fundamentals and Applications (CRC Press, 2004)

References

1. Bruck, D. Elementary Engineering Fracture Mechanics (Springer, 1986)
2. Barson, J.M. and Rolfe, S.T. *Fracture and Fatigue Control in Structures* (Butterworth-Heinemann, 1999)
3. Dieter, G. *Mechanical Metallurgy* (McGraw-Hill, 1986)
4. Calister, W.D. *Material Science and Engineering: An Introduction* (John Wiley & sons, 2009)
5. Gdoutos, E.E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

ME-505: Advanced Dynamics **L-T-P-CH-CR: 3-1-0-4-4**

Newton and Euler equations of motion for constrained systems; D'Alembert's principle, Lagrange's equations, Hamilton's equations; Rigid body kinematics and dynamics;
Differential approaches for equations of motion;
Integral approach for equations of motion - Hamilton's principle, Boltzmann-Hamel equation; Stability analysis of dynamic systems;
Numerical solutions of nonlinear algebraic and differential equations governing the behaviour of multiple degree of freedom systems;
Computer simulation of multi-body dynamic systems; Assignment and mini-project.

Course-outcomes:

Towards the end of the course the student would be able to

CO1: Application focus on developing and using equations of motion for dynamic systems to address engineering problems.

CO2: Methods for developing governing equations of motion for discrete systems are developed.NewtonEuler and Lagrangian formulations are emphasized with only brief introduction given to other methods.

CO3: Knowledge on extraction of dynamic equilibrium configurations, linear stability analysis,frequency response analysis, and generation of transient time-domain responses using both direct numerical integration and modal superposition techniques.

CO4: Classical methods for deriving equations of motion for continuous systems motivates a more thorough treatment of the finite element method demonstrated using beam elements.

CO5:Numerical methods associated with advanced dynamics and application.

CO6:Get experimental exposure on advanced dynamics and stability analysis problems.

Textbooks

1. Meirovitch, L.M. Methods of Analytical Dynamics (McGraw-Hill, 1988)
2. Baruh, H. Analytical Dynamics (McGraw-Hill, 1999)

References

1. Greenwood, D.T. Principles of Dynamics (Prentice Hall, 1988)
2. Shabana, A.A. Computational Dynamics (John Wiley & Sons, 2010)

ME-506: Theory of Elasticity and Plasticity **L-T-P-CH-CR: 3-0-0-3-3**

Basic elasticity - cartesian tensor, three-dimensional stress and strain systems, Navier's equations, Airy's stress function, Mohr's circle for three-dimensional stress and strain systems, viscoelasticity; Torsion torsion of noncircular bars, elastic analysis, membrane analogy;
Introduction to plasticity - mechanical behaviour in the plastic range, fundamentals of plasticity theory, solution of elastoplastic problem, Bausschinger effect-yield locus, yield surface;
Yield criteria and flow rules - Tresca theory and von Mises yield criterion, their geometrical representation, experimental evidence for the criteria;
Slip line field theory – two-dimensional plasticity, slip lines, basic equations, Hencky's first theorem, Geiringer's velocity equation, application of slip line field theory to plane strain problems; Application to metal forming, plastic analysis of structures; Assignment and mini-project.

Course outcomes:

On successful completion of the course, the graduates will be able to

CO1: Understand the basic concepts of fundamental variables such as stress, strain, and displacement under the application of load, equations of equilibrium and compatibility.

CO2: Solve the 2-D elasticity problems using stress function.

CO3: Understand the plastic yield criterions and elastic-plastic constitutive relations.

CO4: Apply the plasticity models in the analysis of components/systems subjected to plastic deformation.

CO5: Use the principles of plasticity to analyze axisymmetric elastic-plastic problems of practical importance such as autofrettage and indentation problem.

Textbooks

1. Timoshenko, S.P. and Goodier, J.N. *Theory of Elasticity* (McGraw-Hill, 1970)
2. Chakroborty, J. Theory of Plasticity (McGraw Hill, 1987)

References

1. Sokolnikoff, I.S. *Mathematical Theory of Elasticity* (McGraw-Hill, 1957)
2. Khan, A. and Huang, S. *Continuum Theory of Plasticity* (Wiley, 1995)

ME-509: Advanced Dynamics and Vibration **L-T-P-CH-CR: 3-0-0-3-3**

Principles of dynamics: Generalized co-ordinates, degrees of freedom, constraints; equations of motions,
Hamilton's principle, Lagrange's equations,
Single, two and multiple degrees of freedom systems,
Free and forced Vibration, transverse and torsional vibrations of two and three rotor systems, critical speeds,
Vibration isolation and measurements, normal mode vibration, coordinate coupling.
Vibration absorbers. Effect of damping; Continuous systems: vibration of strings, beams, bars; RaleighRitz and Galerkin's methods.
Measurement techniques, vibration measuring instruments- design and working principle.

Course outcomes:

CO1:Solve complex engineering problem in the field of Dynamics and Vibration.
CO2:Understanding the role of dynamics and vibration in engineering problem and to know the physical approach to both.
CO3:To derive and obtain mathematical and physical relationships in problems related to vibration analysis.
CO4:Critical thinking and critical judgment of assumptions adopted in practical problem from the field of dynamics and vibration.
CO5:To model a vibration control system and knowledge about design of realistic system.
CO6:Establish links between theoretical and practical applications of dynamics and vibration.

Textbooks:

1. Meirovitch L. *Elements of Vibration Analysis* (McGraw Hill, Second edition, 2006)
2. Meirovitch L. *Principles & Techniques of Vibrations* (Prentice Hall, New Jersey, 1997) 3. Thomson W. T. *Theory of Vibration with Applications* (CBS Publ., 5th edition, 1997)

References:

1. Rao J. S. and Gupta K. *Theory and Practice of Mechanical Vibrations* (New Age Publication, 1999)
2. Inman D. J. *Engineering Vibrations* (Prentice Hall, New Jersy, 4th Edition, 2013)
3. Tse F. S., Morse I. E. and Hinkle R. T. *Mechanical Vibrations* (CBS Publ., 2nd edition, 2004)

ME-510: Engineering Design Laboratory **L-T-P-CH-CR: 0-0-3-6-3**

Introduction to Computer-Aided Design and Analysis: Basic Drafting, Modelling of Parts, Assembly. Introduction to Finite Element Programmimg: Basic engineering analysis of Beams, Trusses, Plates; Stress analysis of structure with individual and combined loading; Sensitivity analysis; Solution to problem with Mechanical, Thermal and Thermo-Mechanical loading.

Introduction to computational modeling: Introduction to MATLAB; MATLAB Basics: Arrays and Matrix

Operations; Programming with MATLAB; Calling MATLAB in-built Functions; User-defined Functions; Plotting with MATLAB; Introduction to different tool-boxes & Simulink.

Experiments with Solids: Material properties; Experimental measurement of force, torque, stress, strain, and displacement in solids and structures; Photo-elasticity and strain gauges; Investigation of the microstructure of materials; Digital image correlation technique.

Analysis of Experimental Data: Error analysis, Uncertainty analysis, Data reduction techniques, Statistical analysis of data, Probability distributions and curve fitting.

Course outcomes:

CO1:Use of Design software for drawing drafting and modeling of engineering parts

CO2: Use of FEM packages like ANSYS for solving any engineering problems from basic to complex type.

CO3:Write program in C language to solve a class of engineering problems.

CO4:Write program in MATLAB to solve a class of engineering problems.

CO5:Understand different experimental process and techniques for different experimental analysis.

CO6:Analyze experimental data to conclude on their significance and basic of statistical tool

Textbooks

1. Wheeler A.J. and Ganji, A.R. *Introduction to Engineering Experimentation* (Pren-tice Hall, 2003)
2. Chapman S. J. *MATLAB Programming for Engineers* (Cengage Learning, 2007)

References

1. Munford P., Normand, P. *Mastering Autodesk Inventor 2016 and Autodesk In-ventor LT 2016* (John Wiley Sons, 2016)
2. Kent L.L. *ANSYS Workbench Tutorial Release 14* (SDC Publications, 2012)
3. Doeblin E.O., *Engineering Experimentation* (McGraw-Hill, 1995).
4. Chapra S.C., *Applied Numerical Methods with MATLAB for Engineering and Science* (McGrawHill Science, 2004).
5. MATLAB Handbook

ME-511: Experimental Stress Analysis for Design **L-T-P-CH-CR: 3-0-1-5-4**

Review of Stress and Strain Analysis: Stress-strain relations and general equations of elasticity; Strain Measuring Devices: Various types of strain gauges, Electrical resistance strain gauges: gauge factor, types, gauge materials, backing materials, adhesives, protective coatings, bonding of strain gauges, lead wires and connections, Semiconductor strain gauges,

Performance of Strain Gauges: Temperature compensation, transverse sensitivity, gauge length, response, excitation level, stability;

Strain gauge circuits, recording instruments for static and dynamic applications, strain gauge rosettes analysis, stress gauge;

Photoelasticity: Theory of photoelasticity, analysis techniques, three dimensional photoelasticity; Brittle coating methods of strain indication; Introduction to Moiré fringe technique;

Residual Stress Analysis: Analytical and numerical solution of residual stresses in metal working processes (autofrettage, welding etc.), Experimental methods for assessing residual stresses: Sachs boring, X-ray diffraction, neutron diffraction and hole drilling method, inference of residual stresses from microhardness test.

Course-outcomes:

CO1: Understand the basic difference among analytical, numerical and experimental stress analysis techniques and their need.

CO2: Understand the different experimental measurement techniques for in-service stresses and the underlying physical principle of each of the technique.

CO3: Understand the different destructive and non-destructive techniques for experimental measurement of residual stresses and the underlying physical principle of each of the technique.

CO4: Select a suitable method for experimental determination of stresses for a problem on hand.

CO5: Interpret and Analyze the experimental data obtained from different experimental stress measurement methods.

CO6: Understand the different influential parameters affecting the measurement in each experimental stress analysis method and associated errors.

Textbooks

1. Dove R.C. and Adams P. H. *Experimental Stress Analysis* (McGraw Hill, 1992)
2. Dally J.W. and Riley W.F. *Experimental Stress Analysis* (McGraw-Hill Inc., New York, 1998) 3. Srinath, L.S. and Raghavan M.R. *Experimental Stress Analysis* (Tata McGraw-Hill, 1998).

References

1. Freddi A. Olmi G. and Cristofolini L. *Experimental Stress Analysis for Materials and Structures* (Springer,Switzerland, 2015)
2. Timoshenko S.P. and Goodier J.N. *Theory of elasticit*, (McGraw-Hill International Editions, 1970)
3. Sharpe W.N. *Handbook of Experimental Solid Mechanics* (Springer, 2008)
4. Noyan I.C. and Cohen J.B. *Residual Stress* (Springer, 1987)

5. Kandil F.A., Lord J.D., Fry A.T. and Grant P.V. *A review of residual stress measurement methods—A guide to technique selection* (NPL Report MATC(A)04, February 2001, NPL Materials Centre Queens Road, Teddington, Middlesex, UK)
6. Kamal S.M. Borsaikia A. and Dixit U.S. Experimental assessment of residual stresses Induced by the thermal autofrettage of thick-walled cylinders, *Journal of Strain Analysis*, Vol. 51(2), pp.144160,2016

ME-512: Theory of Plasticity **L-T-P-CH-CR: 3-0-0-3-3**

Stresses and Strain: Stress and strain behavior of materials, plastic and tangent modulus, strain hardening, plastic instability in tensile test, empirical stress-strain equations, effect of pressure, strain-rate and temperature. Analysis of stress tensor, eigenvalues, decomposition of stress tensor into deviatoric and hydrostatic components, octahedral stresses. Analysis of strain and strain-rates. Stress equilibrium and virtual work, objective stress rates.

The criteria of yielding. Isotropic and anisotropic hardening. Rules of plastic flow: Levy-Mises and Prandtl-Reuss equations. Hill's 1948 and 1979 yield criteria for anisotropic yielding. Anisotropic flow rule. Upper bound and lower bound theorems with a few applications.

Axisymmetric elastic-plastic problems: Hydraulic autofrettage, Swage autofrettage and Thermal autofrettage; Expansion of hole in a plate.

Plane stress elastic-plastic problems: Bending of beam. Indentation problem: by upper bound and cavity method

Dynamics Elasto-plastic problems: Longitudinal stress wave propagation in a rod, Taylor rod problem. Introduction to Updated Lagrangian and Eulerian formulations.

Course-outcomes:

CO1: Understand the basic concepts of fundamental variables such as stress, strain and displacement tensor under the application of load, strain-rate, strain-hardening.

CO2: Understand typical plastic yield criteria established in constitutive modeling.

CO3: Understand the anisotropic yield criterion, e.g., Hill's 1948 and 1979 criterion.

CO4: Apply basic analytical equations and constitutive models in the analysis of structures subjected to plastic deformation.

CO5: Analyze axisymmetric elastic-plastic problems of practical importance and indentation problems using the principles of plasticity theory.

CO6: Understand the principles of new autofrettage techniques such as thermal and rotational autofrettage.

Textbooks

1. Dixit P.M. and Dixit U.S. *Plasticity: Fundamentals and Applications* (CRC Press, 2015) 2. Chakrabarty J. *Theory of Plasticity* (Elsevier Butterworth-Heinemann, 2006)

References

1. Dixit P.M. and Dixit U.S. *Modeling of Metal Forming and Machining Processes by Finite Element and Soft Computing Methods* (Springer, 2008)
2. Rees D.W.A. *Basic Engineering Plasticity* (Elsevier Butterworth-Heinemann, 2006)
3. Lal G.K. and Reddy N.V. *Introduction to Engineering Plasticity* (Narosa, 2009)
4. Kamal S.M. and Dixit U.S. Feasibility study of thermal autofrettage of thick-walled cylinders, *ASME Journal of Pressure Vessel and Technology*, Vol. 137(6), pp. 061207-1−061207-18, 2015.

ME513: Introduction to Fracture Mechanics **L-T-P-CH-CR: 3-0-0-3-3**

Fatigue: Mechanisms of fatigue crack initiation and propagation; Notch sensitivity; Factors influencing fatigue strength, Prevention of fatigue failure.
Introduction to fracture: Failure and fracture, Types of fracture, Modes of fracture failure.
Energy of Fracture: Energy balance during crack growth, Griffith's theory, Crack stability, Fracture criterion, Strain energy release rate.
Linear Elastic Fracture Mechanics: Analysis of crack tip stress, Irwin's fracture criterion, Determination of stress intensity factor, Fracture toughness.
Elastic-Plastic Fracture Mechanics: Crack tip opening displacement, J-Integral and its applications; Computational Fracture Mechanics: Finite element method, Virtual crack extension, Virtual crack closer integral;
Advanced Topics: Fracture in composite, Fracture in nanometer scale. Case studies on fracture failure.

Course Outcomes:

Towards the end of the course the student would be able to:
CO1: Identify the different principles, causes, modes of fatigue crack initiation and propagation.
CO2: Gain detailed knowledge of the theories and mechanics behind fracture of different materials.
CO3: Apply knowledge of fracture and failure in the field of mechanical design through different case studies.
CO4: Present the outcome carried out in the form of group projects on advanced designing of mechanical/structural components considering the in-depth knowledge of material fracture and failure.
CO5: Correlate design considerations with material fracture toughness.

Textbooks

1. Kumar, P. *Elements of Fracture Mechanics* (Tata McGraw-Hill, New Delhi, 2009)
2. Anderson, T.L. *Fracture Mechanics: Fundamentals and applications* (3rd ed., CRC Press, 2005)

References

1. Sanford R.J. *Principles of Fracture Mechanics* (Prentice Hall, 2003)
2. Bolotin V.V. *Mechanics of Fatigue* (CRC Press, 1999)
3. Broek, D. *Elementary Engineering Fracture Mechanics* (Kluwer Academic Publishers, 1986)
4. Rolfe S.T. and Barsom J.M. *Fracture and Fatigue Control in Structures: Applications of Fracture Mechanics* (Butterworth-Heinemann, 2000)
5. Maiti S.K. *Fracture Mechanics: Fundamental and Applications* (Cambridge University Press, 2015)
6. Kundu T, *Fundamental of Fracture Mechanics* (CRC Press, Taylor & Francis, 2008)
7. Kuna M. *Finite Elements in Fracture Mechanics* (Springer, 2013)
8. Gdoutos E. E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

ME442: Interal Combustion Engine	L-T-P-CH-CR: 3-0-0-3-3

Unit 1: Introduction: Basic components and terminology, classification and application of IC engines, working of twoand four-stroke engines. SI and CI engine components and their working, engine design and operating parameters and their effects on engine performance, mean effective pressure, efficiency and specific fuel consumption. **(3 lectures)**

Unit 2: Fuel Air Cycles and Actual Cycles: Assumptions for fuel–air cycles, Reasons for variation of specific heats of gases, change of internal energy and enthalpy during a process with variable specific heats, isentropic expansion with variable specific heats, effect of variable specific heats on Otto, Diesel and Dual cycle, dissociation, comparison of air standard and fuel air cycles, effect of operating variables, comparison of air standard and actual cycles, effect of time loss, heat loss and exhaust loss in Petrol and Diesel engines, Pressure-crank angle diagram, valve and port timing diagrams. **(5 lectures)**

Unit 3: Combustion stoichiometry: Combustion equations, stoichiometric air fuel ratio, enthalpy of formation, adiabatic flame temperature, determination of calorific values of fuels. Calorimeters. **(5 lectures)**

Unit 4: Fuels and its supply system for SI and CI engine: Important qualities of IC engine fuels, rating of fuels, Carburetion, mixture requirement for different loads and speeds, carburetor and its working, Injection systems in CI engine. Nozzles and spray formation. **(4 lectures)**

Unit 5: Ignition and Governing System: Battery and magneto ignition system, spark plug, firing order, quality, quantity. Governing systems. **(3 lectures)**

Unit 6: Supercharging: Need for supercharging, Effect of supercharging, types of supercharger, methods of supercharging, thermodynamic analysis of supercharged engine cycle, limitations of supercharging, turbocharging.

(4 lectures)

Unit 7: Combustion in SI and CI Engines: Stages of combustion in SI engines, abnormal combustion and knocking in SI engines, factors affecting knocking, effects of knocking, control of knocking, combustion chambers for SI engines, Stages of combustion in CI engines, detonation in C.I. engines, factors affecting detonation, controlling detonation, combustion chamber for SI and CI engine. (**4 lectures)**

Unit 8: Engine Lubrication and Cooling: Lubrication of engine components, Lubrication system – wet sump and dry sump, crankcase ventilation, Types of cooling systems – liquid and air cooled, comparison of liquid and air cooled systems. **(3 lectures)**

Unit 9: Measurement and Testing of IC engines: Measurement of indicated power, brake power, fuel consumption and emission, Measurement of friction power, calculation of brake thermal efficiency, brake power and brake specific fuel consumption, heat balance sheet of IC Engines. **(3 lectures)**

Unit 10: Engine Emission and their control: Air pollution due to IC engine emissions, Euro I to VI norms, BS VI norms. Formation of NOx, HC, CO and particulate emissions. Methods of controlling emissions; Catalytic convertors; particulate traps. Exhaust Gas Recirculation. Modern concepts of HCCI and GDI engines. **(3 lectures)**

Unit 11: Alternative Fuels: Alcohol, Hydrogen, Natural Gas, LPG, CNG, Biodiesel, batteries, fuel cell etc. and their behavior in engines. **(2 lectures)**

ME523: Non-Conventional Energy	L-T-P-CH-CR: 3-0-0-3-3

Introduction: Importance of non-conventional energy, sources of non-conventional energy and their application. Advantages of non-conventional energy over fossil fuel.

Biomass energy: types of biomasses- plant waste and animal waste, conversion techniques of biomass into energy, biogas plant, modern techniques of biomass conversion, advantages and disadvantages of biomass energy, gobar gas. **Hydroelectric energy**: mechanism of hydroelectric power generation, hydroelectric dam, sizes and capacities of hydroelectric plant, present and future scenario of hydroelectric energy and its positive and negative aspect in society.

Wind energy: types of wind turbine, wind mill, offshore and onshore wind power, capacity factor.

Solar energy: Application of solar energy as heating electricity generation and fuel production, solar panel, development of solar energy techniques, energy storage methods.

Tidal power: tide mills, generating method of tidal power, tidal barrage and dynamic tidal power, tidal power issuesecological and corrosion.

Geothermal energy: geothermal gradient, hot springs, electricity generation, direct application of geothermal energy, environmental effects.

Fuel cell: types of fuel cell, Phosphoric acid fuel cell (PAFC), high temperature fuel cell-SOFC, MCFC, applicationfuel cell electric vehicle (FCEV), Hydrogen energy.

Textbooks and references

1. Non-Conventional Energy Resources, B H Khan, McGraw Hill Education (India) Private Limited, New Delhi.
2. Non-Conventional Energy Resources, G S Sawhney, PHI Learning, Delhi.
3. Reviews of Renewable Energy Sources, M S Sodha, S S Mathur, and M A S Malik, Wiley Eastern. New Delhi.
4. Renewable energy technologies, R Ramesh, Narosa Publishing House, New Delhi
5. Renewable energy and environment, proceedings of the National Solar Energy Convention, 1989, N S Rathore,Himanshu Publications, New Delhi.
6. Solar Energy: Principles of Thermal Collection and Storage, K Sukhatme and S P Sukhatme, Tata McGraw Hill, NewDelhi.
7. Wind Energy Technology, John F. Walker and Nicholas Jenkins, John Wiley and sons Canada, Limited.

ME528: Energy Conservation and Waste Heat Recovery	**L-T-P-CH-CR: 3-0-0-3-3**

Prerequisites: **ME308** Energy resources and use. Potential for energy conservation. Optimal utilization of fossil fuels. Total energy approach.

Coupled cycles and combined plants. Cogeneration systems. Exergy analysis. Utilization of industrial waste heat. Properties of exhaust gas. Gas-to-gas, gas-to-liquid heat recovery systems. Recuperators and regenerators. Shell and tube heat exchangers. Spiral tube and plate heat exchangers. Waste heat boilers: various types and design aspects. Heat pipes: theory and applications in waste heat recovery. Prime movers: sources and uses of waste heat. Fluidized bed heat recovery systems. Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems. Thermoelectric system to recover waste heat. Heat pump for energy recovery. Heat recovery from incineration plants.

Utilization of low grade reject heat from power plants. Need for energy storage: Thermal, electrical, magnetic and chemical storage systems. Thermo-economic optimization.

References

1. Harlock, J.H. *Combined Heat and Power* (Pergaman Press, 1997)
2. Kreith, F. and West, R.E. *Energy Efficiency, CRC handbook* (CRC Press,1999)
3. Kays and London, *Compact Heat Exchangers* (McGraw-Hill, New York, 3/e, 1958)

ME531: Project Management	L-T-P-CH-CR: 3-0-0-3-3

Unit 1: Introduction and basic fundamental: Importance of Project management, Project selection, Project
Definition/Project Charter (SOW), Project Goal, Types of project, Project Life-cycle model, Project stakeholders, Organizational influences, Project management processes and mapping, Project Process flow diagrams, Project idea generation and acceptance; Modelling the project system.

Project analysis and feasibility report.

Unit 2: Project Scope: scope definition, scope planning, Project Breakdown Structure (WBS), Scope verification, scope control.

Unit 3: Project Planning and Scheduling techniques, Resource Scheduling: Resource allocation method, splitting and multitasking, Multi-project resources scheduling, Critical chain scheduling- Concept, method, application and limitations. Project integration management, PMP, Direct and manage project execution, Performance measurement and control, Project monitoring and Control, earned value method and milestone monitoring. PERT/CPM.

Unit 4: Project Time management, activity definition, activity sequencing, resource estimating, duration estimating, schedule development and control, Project cost estimating, cost budgeting and cost control.

Unit 5: Human resource management, HR planning, acquire, develop and manage project team, performance reporting and manage stakeholders. Project risk management.

Overview of software project management. Software for project management.

Textbooks

1. Gray, C. F., Larson, E. W. and Desai G. V. Project Management -The Managerial Process. McGraw Hill Education Private Limited, New Delhi, 4th edition, 2010.
2. Maylor, H. Project Management. Pearson Education Limited. New Delhi, 3rd edition, 2003.

References

1. Chandra, P. Project Preparation, Appraisal and Implementation. Tata McGraw Hill Publishing Company, New Delhi, 7th edition, 2009.
2. Burke, Rory. Project management - Planning and Control Techniques. John Wiley & Sons, Inc., 5th edition, 2013.
3. Lientz, B. P. and Rea, K. P. Project Management – for 21st Century, Academic Press, 4th edition, 1995.
4. Heerkens, G. R. Project Management, McGraw-Hill, 2nd edition, 2013.

ME532: Power Plant Engineering	L-T-P-CH-CR: 3-0-0-3-3

Introduction: economics of power generation, load curves, load and load types, load factor, base and peak loads, reserved capacity, plant capacity, annual depreciation, energy cost calculations.

Steam cycle analysis: Rankine cycle, work and heat interactions, steam and heat rate, thermal efficiency, ideal reheat and regenerative rankine cycles, feedwater heaters, deaeration, cogeneration, topping and bottoming cycles.

Combined cycle power generation: working fluid, coupled cycles, series and parallel combination with heat loss, steam and other working fluids.

Steam Generators: Boilers, economisers, superheaters, reheaters, air preheaters, FBB, electrostatic precipitators, boiler efficiency, blowdown.

Steam turbines: high pressure and low pressure turbines, condensing and noncondensing turbines, nozzle flow, nozzle efficiency, choked flow, impulse and reaction turbines, compounding of steam turbines, diagram efficiency, governing of steam turbines.

Condensers, feedwater and circulating systems: Theory and analysis of condensers, feedwater heaters, cooling towers. .

Nuclear power plants: Half-life, nuclear fission, reflectors, nuclear reactors, PWR, BWR, heavy water reactors, liquid metal fast breeder reactors.

Hydroelectric power plants: Overview of pelton wheel, francis turbine, propeller and kaplan turbines, specific speed, cavitation, surge tanks, performance characteristics, turbine size, turbine selection.

Textbooks and references

1. Power Plant Engineering, P.K.Nag, Tata McGraw Hill Education Pvt.Ltd.,3e, New Delhi
2. Power Plant Technology, M.M.El-Wakil, McGraw Hill.
3. Power Plant Engineering, Arora & Domkundwar, Dhanpat Rai & Co., Delhi.
4. Power Plant Engineering, C.Elanchazhian, I.K. International, Delhi.
5. Power Plant Engineering, Nagpal, Khanna Publishers, Delhi
6. Boiler Operator’s Handbook, Kenneth E. Heselton, Fairmont Press, Inc, 2e.

Thermodynamics: An Engineering Approach Hardcover – Feb 2014, M.Boles & Y. Cengel, McGraw Hill Education,8e

ME538: Computer-Aided-Design in Engineering	L-T-P-CH-CR: 3-1-0-4-4

Overview of computer aided engineering design;
Transformation - representation and transformation of points, homogeneous coordinates, rotation, reflection, translation, scaling and sharing of lines, combined transformation, solid body transformation;
Projections - orthographic, axonometric, oblique and perspective projections;
Plane curves - parametric and nonparametric curves like circle, ellipse, parabola and hyperbola; Conic sections;
Space curves - cubic splines, parabolic blending, Bézier curves and B-spline curves;
Surface Generation - surface of revolution, sweep surface, quadric surface, bilinear surface, ruled and developable surfaces, Coons linear surface, Coons bicubic surface, Bézier surface, B-spline surface and composite surface; Solid body modeling - designing three-dimensional models like machine parts, hidden line and surface removal; Application of commercial solid modelers; Assignment and mini-project.

Textbooks

1. Rogers, D.F. and Adams, J.A. *Mathematical Elements for Computer Graphics* (Tata McGraw-Hill, 2002)
2. Mortenson, M.E. *Mathematics for Computer Graphics Applications* (Industrial Press, 1999)

References

1. Plastock, R.A. and Kalley, G. *Computer Graphics* (McGraw-Hill, 1986)
2. Mortenson, M.E. *Geometric Modeling* (John Wiley & Sons, 1985)
3. Ryan, D.L. *Computer-Aided Graphics and Design* (Marcel Dekker, 1994)

ME575: Advanced Materials for Design	L-T-P-CH-CR: 3-0-0-3-3

Advanced materials for modern Engineering Design: Metals, Polymers, Composites and Ceramics; Proper material selection for design considerations

Structure-property correlation for design purposes: Role of crystal structure, substructure and microstructure on material properties and machine design

Metallic alloys for high performance structural design and their applications, Surface engineering of materials and their applications

Applications of Piezoelectric materials, Shape memory alloys, Smart materials and Composite materials in design of modern engineering components

Micro-electro-mechanical systems (MEMS) for design: Characteristics of materials for MEMS applications and MEMS components

Designing components for high temperature applications: Various alloys and composites, Diffusion bond coating Application of Powder metallurgy technique in design: Selection of materials, Cost, Design and Manufacturing considerations involved

Advanced materials for design of Automobile and Transport vehicles, Aerospace, Power generation, Armament, Marine environment and Ocean structures, Materials for other specialized applications Advanced material testing for machine design considerations Assignment and mini-project.

ME582:Heat Treatment Technology	**L-T-P-CH-CR: 3-0-0-3-3**

Significance of heat treatment in material processing for manufacturing industries: Concepts of processing-structureproperty co-relation Phase diagrams:

Binary and ternary equilibrium diagrams; Phase rule and Lever rule; Nucleation and growth of phases; Determination of grain size; Fe-C phase diagrams; Decomposition of austenite: Diffusion controlled and diffusionless transformations; Pearlitic and Bainitic and Martensitic transformations; TTT and CCT curves Heat treatment processes:

Recrystallization annealing: Effect of working on structure and properties of metals and alloys; Microstructural evolution and control; Recovery, Recrystallization and Grain growth; Recrystallization temperature, Critical deformation; Annealing and its classifications: Full annealing, Isothermal annealing, Diffusion annealing, Partial annealing, Subcritical annealing; Normalizing, Hardening, Tempering, Thermo-mechanical treatment; Surface Hardening: Carburizing, Nitriding, Electron Beam Hardening, Laser Hardening Heat Treatment of tool and alloy steels, cast irons; Heat treatment of weldments Heat treatment of non-ferrous metals and alloys:

Cast and heat-treatable alloys; Theory of age-hardening and precipitation; Aging time and precipitation temperature on mechanical properties of alloys

Heat Treatment defects and their remedial measures

Heat treating furnace atmosphere: Automation and computerization of heat treating process & equipment

ME608: Mechatronics and Industrial Automation	L-T-P-CH-CR: 3-0-0-3-3

Introduction to Mechatronics: Introduction, Elements of Mechatronics system, Applications. Sensors and Actuators: Sensing principle, Electrical actuators, Hydraulic and Pneumatic actuators. Signal Processing: Signal conditioning devices, Protection, Conversion and pulse width modulation, Data conversion devices.

Microprocessors: Introduction to microprocessors, Introduction to microprocessor programming, Internal architecture of 8085 microprocessor.

Principles of Automation Technology: Automation system components, Discrete manufacturing automation, Continuous process automation.

Programmable Logic Controllers (PLC): Industrial Control, Structure of PLC, Programming languages for PLC, Boolean logic for process control, Timers, Counters and other functions. Feedback Control: Continuous and Time- Discrete control, On/Off control, PID control, Distributed Control System (DCS)

Man machine communication: Supervisory control and data acquisition (SCADA) Assignment and mini-project.

Textbooks

1. Bolton W. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (Pearson education,2007)
2. Lamb F. Industrial Automation: Hands-On (McGraw-Hill Education, 2013)

References

1. Appukuttan K.K. Introduction to mechatronics (Oxford University Press, 2007)
2. Stenerson J. Industrial automation and process control (Prentice Hall, 2003)

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