Detailed Syllabus
Revised B.Tech. Curriculum
AY 2024-25

Department of Mechanical Engineering, TU

1 Syllabus

1.1 MEBT100 :: Manufacturing Practices Workshop

- **Type** :: Engineering Science Course (ESC)
- **L-T-P-CR-CH** :: 0-0-2-2-4
- **Prerequisite** :: None

Objectives

1. To provide exposer with hands on experience on basic machining and welding operations.
2. To provide hands-on experience on basic Carpentry operations.
3. To have a practice on Fittings and power tools.
4. To develop the ability for basic electrical wireman operations.
5. To provide exposure to the practice of plastic molding.

Syllabus

Module I : Manufacturing Methods Machining, Welding

Module II : CNC Machining

Module III : Fitting Operations and Power tools

Module IV : Electrical

Module V : Carpentry

Module VI : Plastic Molding

Practicals

1. **Machine shop**: Basic machining operations on Machine Lathe, Drilling, Grinding, and Milling machines, making jobs as per drawings, hands-on exposure on CNC milling and CNC lathe machines (6 practicals)
2. **Fitting shop**: Study of different vices, power hammer. Making jobs as per drawing (4 practicals)
3. **Carpentry shop**: Study of different hand tools and their use for basic carpentry operations and wooden joints (4 practicals)
4. **Electrical wireman**: 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 (7 practicals)
5. **Welding shop**: Introduction to different welding processes. Practice on Oxy-acetylene gas welding and manual metal arc welding (6 practicals);
6. **Plastic moulding**: Demonstration of plastic moulding practice (1 practical)

Outcomes

At the end of this course students will demonstrate the ability to

CO1: Perform machining operations using various manufacturing techniques.

CO2: Perform fitting practices using various types of hand tool and fitting techniques.

CO3: Perform Oxy-acetylene gas welding and manual metal arc welding on jobs.

CO4: Select appropriate electrical hand tools and circuits for the required application and making jobs (such as House Wiring, Switch Board etc.) as per specification.

CO5: Make basic wooden joints using carpentry hand-tools.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	2	1	1	1	1	2	2	1	1	2	3	2	2
CO2	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2
CO3	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2
CO4	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2
CO5	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2

Textbooks

1. Hazra Choudhury, S.K., Hazra Choudhury, A.K. and Roy, N. , *Elements of Workshop Technology Vol I*, Media Promoters and Publishers Pvt. Ltd., Mumbai, 15th edition, 2012.

2. Hazra Choudhury, S.K., Hazra Choudhury, A.K. and Roy, N. , *Elements of Workshop Technology Vol II*, Media Promoters and Publishers Pvt. Ltd., Mumbai, 14th edition, 2014.

3. Gupta, J. B., *Course in Electrical Installation Estimating & Costing*, S. K. Kataria and Sons, New Delhi, 9th edition, 2012.

1.2 MEBT201 :: Measurements and Metrology

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-0-1-4-5
- **Prerequisite** :: None

Objectives

This course is designed to provide the students a sound knowledge and understanding of the fundamentals concepts of measurements and metrology. The course is closely associated with mechanical engineering and will provide understanding of the different types of mechanical measurements and measuring instruments. From this course, students will be able to learn and acquire the required concepts that will enable them to analyse and assess both statistical and experimental data. The students will also learn the basics of sensors and transducers. This course will serve as a fundamental requirement to undertake industrial practices and advanced courses in measurements. The main objectives of this course are summarized in the following:

1. To introduce the basic concepts and methods of mechanical measurements, measuring instruments and equipment, and their proper usage and maintenance.
2. To learn the techniques of flow and thermal measurements, electrical and statistical measurements including identification of quality assurance techniques and process optimization.
3. To understand the role of metrology in manufacturing and design using the concepts of limits, fits and tolerances.
4. To build confidence to solve problems of measurements and metrology in theory and practice.

Syllabus

Module I : Introduction **[6L+2T]**
General concepts, definitions of different metrological terms: accuracy, precision, range, resolution, readability, repeatability, uncertainty and sources of errors in measurements; classification of standards; straightness, flatness, roundness, etc.; displacement, force, speed, torque, flow, level, pressure, temperature, acceleration; regression analysis.
Module II : Principles of Measurement **[6L+2T]**
Measurement systems and its structure; calibration of measuring instruments; calibration principles; linear and angular measurements; comparators; gauges and its types; gauge design; interferometry.
Module III : Limits, Fits and Tolerances **[5L+2T]**
Definitions; concepts of tolerance, allowance and interference, tolerance zone and grades; hole and shaft basis systems; fundamental deviation; Taylor's principle; tolerance analysis; design of tolerances; use of limits, fits and tolerances in design and manufacturing.
Module IV : Metrology in Mechanical Measurements and Measuring Instruments [7L+2T]
Dimensional metrology: vernier, micrometers, LVDT; Form metrology: form tester, surface profiler, CMM, 3D scanning; Surface metrology: optical microscopes, laser scanning microscopes, electron microscopy (SEM/TEM), x-ray microscopy, Raman spectroscopy; tool wear, workpiece quality and process metrology.
Module V : Thermal and Flow Measurement **[4L+1T]**

Temperature, thermal conductivity and diffusivity measurement; flow measurements: orificemeter, pitot tube, venturimeter; magnetic flow meters.

Module VI : Electrical Measurements and Instruments [6L+2T]

Signal generators and analysis; analyzers: wave and spectrum analyzers; Frequency measurement: frequency counters; measurement errors, frequency range; Transducers: types, strain gauges, displacement transducers; Data acquisition system: interfacing transducers to electronics control and measuring system; Amplifiers: instrumentation and isolation types; computer-controlled test systems.

Module VII : Design of Experiments and Statistical Analysis [5L+2T]

DOE techniques: steps, important considerations and approaches; Taguchi orthogonal arrays; data acquisition, signal processing and conditioning; error of a system of ideal and non-ideal elements; error probability density function; methods of error reduction; quality control and quality assurance.

Outcomes

After successful completion of the Course, students would be able to

CO1: Demonstrate the acquired fundamental knowledge about measurement systems and their related components

CO2: Compare instruments used for measurement of mechanical and electrical parameters, integrate measurement systems for process monitoring and control

CO3: Distinguish among the different forms of metrology

CO4: Solve problems of thermal, flow, electrical and statistical measurements

CO5: Identify the design of experiment techniques

CO6: Design tolerances, limits, and fits

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	1	1	×	×	×	×	1	×	3	3	×	1
CO2	3	2	2	1	×	1	×	×	×	1	×	3	3	×	1
CO3	3	3	3	2	1	1	×	×	×	1	×	3	3	1	2
CO4	3	3	3	2	1	1	×	×	×	1	×	3	3	1	2
CO5	3	3	3	2	×	×	×	×	×	1	×	3	3	×	1
CO6	3	3	3	2	1	1	×	×	×	1	×	3	3	2	3

Textbooks

1. Jain, R.K. *Engineering Metrology*, Khanna Publishers, New Delhi, 21st edition, 2009.

2. Doebelin, E.O., and Manik , D., *Measurement Systems*,McGraw Hill, 2017.

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. Bewoor, A.K., and Kulkarni, V.A. *Metrology & Measurement*, Tata McGraw Hill, 2009.

Online Resources

- https://nptel.ac.in/courses/112/106/112106138/NPTEL
- https://nptel.ac.in/courses/112/103/112103261/NPTEL

1.3 MEBT202 :: Engineering Mechanics

- **Type** :: Engineering Science Course (ESC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

This is a fundamental course that is designed to provide students a sound understanding of the basic principles of mechanics in order to enable them to endeavour a first-hand analysis for static and dynamical systems. The concepts learned in this course will serve as a prerequisite for higher level courses in mechanics such as Solid Mechanics. The primary objectives of this course are as follows:

1. To introduce the basic principles of mechanics, idealizations to solid bodies with emphasis on their analysis and application to practical engineering problems.
2. To understand the concepts of forces and moments and their effects on rigid bodies.
3. To introduce the concept of free body diagrams.
4. To understand the equilibrium conditions of particles and rigid bodies.
5. To understand and apply different techniques for analyzing the forces and reactions in interconnected rigid bodies and mechanical structures such as trusses and frames.
6. To understand friction between two sliding surfaces and analyze systems involving friction.
7. To determine the centroid and moment of inertia of simple and composite areas.
8. To illustrate the laws of motion, kinematics and kinetics of particles/rigid bodies in rectilinear and polar coordinates.

Syllabus

Module I : General Principles **[2L]**
Mechanics and its relevance in engineering, Review of vector algebra; Transformation of vectors under rotation of coordinate system, Newton's laws, Inertial and non-inertial frames of reference, Idealization in engineering mechanics, General procedure for analysis.
Module II : Force and Force Systems **[5L+2T]**
Concept of force, Concept of rigid body, Transmissibility of force, Classification of force systems with real life example, Composition of forces, Resolution of forces, Surface and body forces, Distributed and concentrated force, Moment of a force about a point, Moment about an axis, Varignon's theorem, Couple, Moment of a couple, Resolution of a force into a force and couple, Resultant of a force system.
Module III : Equilibrium of particles and rigid bodies **[4L+2T]**
Necessary and sufficient conditions for equilibrium, Equilibrium condition for two-force and three-force members, Equilibrium conditions for coplanar force system, Interconnected rigid bodies, Free body diagram, Different types of constraints/support reactions for two-dimensional structure, Equilibrium analysis of interconnected rigid bodies, Statically determinate and indeterminate system.
Module IV : Friction and its applications **[5L+2T]**
concept of friction, Coulomb's dry friction model, Laws of friction, Angle of friction, Cone of

friction, Experimental determination of coefficient of friction, body on inclined plane involving friction, ladder friction, applications of friction to simple machines (wedge, simple screw jack), rolling resistance.

Module V : Analysis of Planar Structures **[6L+2T]**
Degrees of freedom, Virtual displacement and virtual work, principle of virtual work and its application to structures/machines.

Module VI : Method of Virtual Work **[3L+1T]**Degrees of freedom, Virtual displacement and virtual work, principle of virtual work and its application to structures/machines.

Module VIII : Centroid and Moment of Inertia **[4L+2T]**
First moment and centroid of area, Centroid of simple and composite areas, Second moment of area, Parallel and perpendicular axes theorems, Radius of Gyration, Moments of inertia of simple and composite bodies.

Module IX : Kinematics of Particles and Rigid Bodies **[6L+2T]**
Rectilinear motion, Curvilinear motion, Velocity and acceleration in cylindrical and path coordinate system, Relative and constrained motion, Rate of change of a vector in a rotating frame, Three-dimensional motion of a particle relative to a rotating frame, kinematics of rigid bodies.

Module X : Kinetics of Systems particles and Rigid Bodies **[6L+2T]**
Linear and angular momentum of a system of particles and a rigid body, Newton's second law in rectangular and polar coordinates, D'Alemberts Principle, Work, Kinetic Energy, Power, Potential Energy, conservative force field, Work-Energy principle, linear and angular momentum principles, linear and angular impulse, impulse-momentum principle, Work-Energy principle.

Outcomes

After successful completion of the Course, students would be able to

CO1: Solve fundamental problems related to forces being applied to a body under static and dynamic conditions.

CO2: Identify various types of loading and support conditions that act on structural systems and solve for unknown reactions.

CO3: Analyze and solve planar structures such as trusses and frames.

CO4: Analyze and solve various engineering systems involving friction.

CO5: Determine the centroid and second moment of area of composite sections.

CO6: Evaluate the motion of particles and rigid bodies in terms of position, velocity and acceleration in different frames of reference and to analyze the forces causing the motion.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	1	1	×	×	×	×	1	×	3	3	×	1
CO2	3	2	2	1	×	1	×	×	×	1	×	3	3	×	1
CO3	3	3	3	2	1	1	×	×	×	1	×	3	3	1	2
CO4	3	3	3	2	1	1	×	×	×	1	×	3	3	1	2
CO5	3	3	3	2	×	×	×	×	×	1	×	3	3	×	1
CO6	3	3	3	2	1	1	×	×	×	1	×	3	3	2	3

Textbooks

1. Hibbeler R.C., and Gupta A., *Engineering Mechanics: Statics & Dynamics*, Pearson Education Prentice Hall India, New Delhi, 11th edition, 2010.

2. Kumar, K.L., *Engineering Mechanics*, Tata McGraw Hill, New Delhi, 4th edition, 2010.

Reference Books

1. Meriam, J. L., and Kraige, L.G. *Engineering mechanics: Statics, Vol. 1*, John Wiley & Sons, 7th edition, 2012.

2. Shames, I.H., and Krishna Mohana Rao, G. *Engineering Mechanics: Statics and Dynamics*, Pearson Education Prentice Hall India, 4th edition, 2011.

3. Meriam, James L., and Kraige, L.G. *Engineering mechanics: Dynamics*, Vol. 2. John Wiley & Sons, 7th edition, 2012.

4. 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.

5. Timoshenko, S., Young, D.H., and Rao, J.V., *Engineering Mechanics*, Tata McGraw Hill, New Delhi, 5th edition, 2010.

Online Resources

- https://nptel.ac.in/courses/112103108NPTEL
- https://nptel.ac.in/courses/115104094NPTEL

1.4 MEBT203 :: Basic Thermodynamics

- **Type** :: Engineering Science Course (ESC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

1. To introduce the students to the thermodynamic laws (1st law, 2nd law, 3rd law).
2. To familiarize the students with the concept of heat, work, cyclic heat engine, heat pump, refrigerator etc.
3. To introduce the students to the change of state, properties, processes and cycles.
4. To make the students enable in using Steam tables for estimating the thermodynamic properties of substances in gas and liquid states.
5. To be able to apply ideal cycle analysis.

Syllabus

Module I : Review of fundamentals **[5L+2T]**
Thermodynamic systems, boundary, states, equilibrium, change of state, processes. Zeroth law, temperature measurements, international temperature scale. Heat and Work transfer.
Module II : Properties of pure substances and gas mixtures **[8L+2T]**
p-v, T-s and h-s diagram of pure substance (water), properties of steam, use of steam tables and charts (Mollier diagram). Gases-Equation of state of an Ideal Gas, Specific Heats, Internal Energy, Enthalpy and Entropy change of Ideal Gases. Equation of state of Real Gases, Principle of corresponding state, Compressibility Factor.
Module III : First law of thermodynamics **[6L+2T]**
First law for a closed system undergoing a cycle and change of state , internal energy, enthalpy, PMM-I, limitations of first law, non-flow and flow processes; steady state, steady flow and transient flow processes; application of first law to steady flow process, steady flow energy equation(SFEE)
Module IV : Second law of thermodynamics **[6L+3T]**
Kelvin Plank statement, Claussius statement, Irreversibility, Carnot Cycle, Corollaries of Carnot's theorem, Applications of Second Law to closed and open systems, heat engine, heat pump and refrigerator, PMM-II, entropy, Claussius theorem, Claussius inequality, T-ds Relations, entropy principle and its application, entropy generation in closed and open system, absolute entropy and third law of thermodynamics
Module V : Exergy **[3L+1T]**
Definition, quality concept of energy, Reversible work and irreversibility, Exergy balance in closed and open system, Second law efficiency, Guoy Stodola theorem
Module VI : Thermodynamic property relations **[2L+1T]**
Maxwell relations, T-ds equations, Clausius Clapeyron equation, General relations for change in internal energy, enthalpy, entropy, C_p, C_v etc., Gibbs phase rule.
Module VII : Thermodynamic Cycles **[8L+3T]**
Vapour power cycle-Rankine cycle and its modifications such as reheat and regenerative cycles. Air-standard cycles- Otto, Diesel, and Dual and Brayton cycles and calculation of air standard efficiency, Vapour compression refrigeration cycle and COP calculation.

Outcomes

After successful completion of the Course, students would be able to

CO1: State the various thermodynamic laws and apply those in various thermal system.

CO2: Define thermodynamic properties, processes and determine energy transfer in various processes.

CO3: Apply the steady-flow energy equation to various steady flow devices such as pumps, turbines, compressors etc.

CO4: Draw P-v and T-s diagrams of thermodynamic cycles and evaluate their efficiency, entropy, exergy etc.

CO5: Use steam tables for determining temperature of steam and water at various states.

CO6: Understand the interrelationship between different thermodynamics cycles.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	×	×	×	×	1	×	×	×	1	3	2	×	1
CO2	3	2	×	×	×	×	1	×	×	×	1	3	2	×	1
CO3	3	2	×	×	×	×	1	×	×	×	1	3	2	×	1
CO4	3	2	×	×	×	×	1	×	×	×	1	3	2	×	1
CO5	3	2	×	×	×	×	1	×	×	×	1	3	2	×	1
CO6	3	2	×	×	×	×	1	×	×	1	1	3	2	×	1

Textbooks

1. Cengel, Y.A., and Boles, M. A., *Thermodynamics, An Engineering Approach*, McGraw Hill Education, 8th Ed., 2017.

2. Nag, P. K., *Engineering Thermodynamics*, McGraw Hill, 6th Ed., 2017.

Reference Books

1. Borgnakke, C., Sonntag, R.E. *Fundamentals of Thermodynamics*, John Wiley & Sons, 8th edition,2014.

2. Moran, M. J., Shapiro, H. N., Boettner, D. D. and Bailey, M. B., *Principles of Engineering Thermodynamics*, S.I. version, John Wiley & Sons, 8th edition, 2011.

1.5 MEBT204 :: Engineering Materials and Applications

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

1. To understand different types of engineering materials and their applications
2. To correlate between the internal structure of materials and their mechanical properties
3. To understand various methods to quantify the mechanical integrity of materials and their failure criteria
4. To interpret equilibrium phase diagrams of alloys
5. To understand different heat treatment processes to tailor the alloys properties

Syllabus

Module I : Engineering Materials and Classification
Metals, Polymers, Ceramics and Composites - Relevant properties (physical, mechanical, thermal, electrical, chemical), Cost, Range of applications, Ashby diagrams, Material selection criteria.
Module II : Metal and Alloys
Aluminium & its alloys; Copper & its alloys; Nickel based superalloys; Titanium alloys; Iron and Steel; Crystallography; Phase diagrams and interpretation of microstructure; Iron-carbide phase diagram and cooling (TTT) diagrams.
Module III : Heat Treatments
Precipitation strengthening heat treatment; Heat treatment of Steel - Annealing, Tempering, Normalizing, Spheroidising, Austempering, Martempering.
Module IV : Mechanical Properties and Testing
Tensile, compression, fatigue, fracture and wear tests; Young's modulus, Generalized Hooke's law, Relations between true and engineering stress-strain curves, Yielding and yield strength, Ductility, Resilience, Toughness; SN curve, Endurance and fatigue limits.
Module V : Polymers, Ceramics and Composites
Polymers and Ceramics – classifications, properties, examples, and applications. Composites – classifications based on morphology and materials, properties, examples, and applications.
Module VI : Advanced Materials
High temperature materials; Biomaterials; Nanomaterials; Superconductors and Dielectric materials, Magnetic materials; Smart Materials - sensors and actuators, Piezoelectric, Magnetostrictive and Electrostrictive materials, Shape memory alloys, Optical materials.

Outcomes

After successful completion of the Course, students would be able to

CO1: Identify different basic and advanced engineering materials, their properties and applications.

CO2: Process engineering materials of tailored and improved properties.

CO3: Evaluate different physical and mechanical properties of materials.

CO4: Identify criteria for selecting materials during design and manufacturing.

CO5: Able to conduct group projects on material processing, characterization and application.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	1	2	1	1	1	3	×	×	×	×	3	2	1	2
CO2	1	1	2	1	1	1	2	×	×	×	×	2	2	1	2
CO3	2	2	3	1	2	1	1	×	×	×	×	2	3	2	2
CO4	2	2	3	1	2	2	3	×	×	×	×	2	3	2	2
CO5	3	3	3	2	3	2	3	3	3	3	3	3	3	3	3

Textbooks

1. Callister, W. D., *Materials Science & Engineering*, Wiley India, 2014.

2. Budinski, K. G. and Budinski, M.K., *Engineering Materials*, PHI India, 2002.

3. Raghavan, V., *Material Science and Engineering*, PHI India, 2015.

Reference Books

1. Jindal, U. C., *Engineering Materials and Metallurgy*, Pearson, 2011.

2. Ashby, M. F. and Jones, D.R.H., *Engineering Materials 1 - An Introduction to Properties*, Applications and Design, Butterworth-Heinemann, USA, 2011.

Online Resources

https://onlinecourses.nptel.ac.in/noc22$_m$e90/*previewNPTEL*

1.6 MEBT205 :: Applied Thermodynamics

- **Type** :: Engineering Science Course (ESC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: Basic Thermodynamics (MEBT203)

Objectives

1. To learn thermodynamic analysis of vapour and gas cycles
2. To learn basics of IC engines and contextual first law analysis of reacting systems and heating value of fuels
3. To learn the basic principles of refrigeration, physchrometry, and air-conditioning.
4. To learn gas dynamics of air flow and steam through nozzles and diffusers
5. To learn working principle of reciprocating and rotary compressors
6. To get familiarized with the basics of steam turbines, gas turbines, centrifugal compressors, and axial flow compressors.
7. To learn working principle of batteries and fuel cells and their types

Syllabus

Module I : Vapour power cycles **[6L+2T]**
Ideal and actual Rankine cycle, Reheat-regenerative Rankine cycle, Cogeneration systems, Thermodynamic analysis of reheat-regenerative Rankine and cogeneration cycles, super- critical Rankine cycle, low temperature power cycles, binary vapour power cycle, Types of boilers, Boiler mountings and accessories.
Module II : Gas power cycles **[3L+1T]**
Review of air standard Otto, Diesel, Dual and Brayton cycles, Ideal and actual Brayton cycle Effect of reheat, regeneration and intercooling on performance of air standard Brayton cycle, Combined gas and vapour power cycles.
Module III : Combustion Stoichiometry and reactive systems **[3L+1T]**
Introduction to solid, liquid and gaseous fuels–Stoichiometry, exhaust gas analysis- First law analysis of combustion reactions- Heat calculations using enthalpy tables- Adiabatic flame temperature- Chemical equilibrium and equilibrium composition, calculations using free energy.
Module IV : IC Engines **[6L+2T]**
Classification, Engine parts, Spark ignition (SI), compression ignition (CI), two- and four-stroke engines, mean effective pressure, Indicated and brake thermal efficiencies, and specific fuel consumption, Alternative fuels, Pressure-crank angle diagram, Fuel injection systems, Ignition systems.
Module V : Refrigeration systems **[2L+1T]**
Vapour compression refrigeration system and vapour absorption refrigeration system. Types of refrigerants and their properties.
Module VI : Psychrometry **[3L+1T]**
Properties of moist air, use of psychometric chart, processes involving heating/cooling and humidification/dehumidification.
Module VII : Compressible flow in Nozzles and Diffusers **[3L+1T]**

Stagnation properties, Isentropic flow of a perfect gas through a nozzle, Choked flow, Subsonic and supersonic flows, Normal shocks- use of ideal gas tables for isentropic flow and normal shock flow, Flow of steam and refrigerant through nozzle, Supersaturation- compressible flow in diffusers, Efficiency of nozzle and diffuser.

Module VIII : Reciprocating and rotary compressors [6L+2T]

Types of compressors, Working principle of reciprocating air compressor, Process representation in pressure-volume diagram, Staging of reciprocating compressors, Optimal stage pressure ratio, Volumetric efficiency, Isothermal efficiency, Intercooling and its effect, Calculation of minimum work for multistage reciprocating compressors, Working principle of centrifugal and axial flow compressors.

Module IX : Steam and gas turbines [6L+2T]

Impulse and reaction steam turbines, Velocity diagrams, Velocity and pressure compounding of steam turbines, Centrifugal and axial flow gas turbines, Introduction to jet propulsion.

Module X : Battery and Fuel Cells [2L]

Working principle of Battery and Fuel cell, Types of batteries and Fuel Cells, Lithium ion battery.

Outcomes

At the end of this course students will demonstrate the ability to

CO1: Understand the thermodynamic cycles and systems used in the power plants, internal combustion engines, and refrigeration and air conditioning plants, and evaluate their performance.

CO2: Analyse energy conversion in various thermal devices such as combustors, air coolers, nozzles, diffusers, steam turbines, gas turbines, fuel cell, reciprocating and rotary compressors.

CO3: Understand and analyse the phenomena occurring in high speed compressible flows.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	2	1	×	1	2	1	1	3	1	2
CO2	3	3	3	2	2	2	×	×	2	2	1	2	3	2	1
CO3	3	3	3	2	2	2	×	×	1	2	1	2	2	3	2

Textbooks

1. Cengel, Y.A., Boles, M. A., Kanoglu, M., *Thermodynamics: An Engineering Approach*, 9th Edition, McGraw-Hill Education, 2019.

2. Rogers, G.F.C, and Mayhew, Y.R., *Engineering Thermodynamics*, Pearson, 2002.

3. Eastop, T.D., and McConkey, A., *Applied Thermodynamics for Engineering Technologists*, Pearson, 2002.

Reference Books

1. Nag, P.K., *Basic and Applied Thermodynamics*, 2nd Edition, McGraw-Hill Education, 2017.

2. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 6th Edition, John Wiley and Sons, 2003.

3. Jones, J. B. and Duggan, R. E., *Engineering Thermodynamics*, Prentice-Hall of India, 1996.

4. Moran, M. J. and Shapiro, H. N., *Fundamentals of Engineering Thermodynamics*, John Wiley and Sons, 1999.

1.7 MEBT206 :: Mechatronics, Robotics and Control

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-0-1-4-5
- **Prerequisite** :: None

Objectives

1. Model and analyze mechatronic systems for an engineering application
2. Identify sensors, transducers and actuators to monitor and control a process or product.
3. Develop PLC programs for an engineering application.
4. Evaluate the performance of mechatronic systems.

Syllabus

Module I : Introduction **[2L]**
Electro-mechanical systems; Typical applications; Examples: automobiles, home appliances, medical instruments, etc.

Module II : Sensors **[9L+2P]**
Transduction principles; Sensitivity, accuracy, range, resolution, noise sources; Sensors for common engineering measurements: proximity, force, velocity, temperature, etc.; Signal processing and conditioning; Selection of sensors.

Module III : Actuators **[8L+2P]**
Pneumatic and hydraulic actuators; Electric motors including DC, AC, BLDC, servo and stepper motors; Solenoids and relays; Active materials: piezoelectric and shape memory alloys.

Module IV : Machine Controls **[7L+2P]**
Microprocessors and their architecture; Memory and peripheral interfacing; Programming; Microcontrollers; Programmable Logic Controllers; PLC principle and operation; Analog and digital input/output modules; Memory module; Timers, internal relays, counters and data handling; Industrial automation systems; Basic PLC programming; Industry kits (Arduino, Raspberry Pi, etc.)

Module V : Robotics **[9L+2P]**
Robot configurations: serial and parallel; Denavit–Hartenberg parameters; Manipulators kinematics; Rotation matrix, Homogeneous transformation matrix; Direct and inverse Kinematics for robot position and orientation; Workspace estimation and path planning; Robot vision; Motion tracking; Robot programming and control; Industrial robots: Pick and place robots, sorting, assembly, welding, inspection, etc.

Module VI : Control Theory and Systems **[8L+2P]**
Basic control concepts; Feedback; Open and closed loop control; Concept of block diagrams; P, PI and PID controllers; Tuning the gain of controllers; System models, transfer functions, system response, frequency response; Root Locus method and Bode plots.

Module VI : Computational Tools **[4P]**
Use of softwares such as RoboAnalyzer for visualizing and understanding the concepts of robot mechanics; MATLAB and SIMULINK for modelling and simulating control systems; Arduino IDE for programming of microncontrollers and OpenPLC editor for PLC programming and developing prototypes/models of mechatronic systems.

Outcomes

After successful completion of the Course, students would be able to

CO1: Recognize and analyze electro-mechanical systems in daily lives.

CO2: Understand the role of sensors, actuators, and controllers in mechatronic systems.

CO3: Understand the basic theory of robot kinematics.

CO4: Become familiarize with control theory and controller design.

CO5: Understand the measurement of various quantities using instruments, their accuracy and range, and the techniques for controlling devices automatically.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	3	×	2	3	3	3	3	3	3	2	3
CO2	3	2	2	2	2	×	×	×	2	1	1	2	3	1	3
CO3	3	2	2	2	2	×	×	×	2	1	1	2	2	1	3
CO4	3	2	2	2	2	×	×	×	2	1	1	2	2	1	3
CO5	3	2	2	2	3	×	×	×	2	1	1	3	3	1	3

Textbooks

1. Bolton, W., *Mechatronics*, Addison Wesley Longman, 2010.

2. Craig, J. J., *Introduction to Robotics Mechanics and Control*, Addison Wesley, 1999.

Reference Books

1. McMillan, G.K. , *Process/Industrial Instruments and Controls Handbook*, McGraw-Hill, 1999.

2. Mukherjee, S., *Essentials of Robotics Process Automation*, Khanna Book Publishing, 2021.

1.8 MEBT207 :: Mechanics of Deformable Solids

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: Engineering Mechanics (MEBT202)

Objectives

1. To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads.
2. To calculate the elastic deformation occurring in various simple geometries for different types of loading.

Syllabus

Module I : Concept of Stress and Strain **[9L+3T]**
Deformation of bars: Hooke's law, stress, strain, and elongation; Tensile, compressive and shear stresses in 2D solids; Elastic constants and their relations; Volumetric, linear and shear strains; Principal stresses and strain; Principal planes; Mohr's circle.

Module II : Mechanics of Beams **[8L+3T]**
Transverse loading on beams, point and distributed loads; Shear force and bend moment diagrams; Types of beam supports – simply supported, over-hanging, cantilevers, fixed and guided beams; Static determinacy and indeterminacy; Theory of bending of beams, pure bending stress distribution and neutral plane, second moment of area; Different cross-sections of beams; Shear stress distribution.

Module III : Deflection of Beams **[6L+2T]**
Deflection of a beam using the double integration method; Computation of slopes and deflection in beams using moment-area method and Macaulay's method; Myosotis method for computing deflections and slopes.

Module IV : Column Buckling **[3L+1T]**
Critical loads using Euler's theory; Different boundary conditions; Eccentric columns.

Module V : Torsion **[6L+2T]**
Torsion stresses and deformation of circular solid and hollow shafts; Polar moment of area, stepped shafts; Deflection of shafts fixed at both ends; Stresses and deflection of helical springs.

Module VI : Energy Methods **[4L+1T]**
Principle of virtual work; Minimum potential energy theorem; Castigliano's theorems; Maxwell reciprocity theorem.

Module VII : Pressure Vessels **[6L+2T]**
Axial and hoop stresses in cylinders subjected to internal pressure; Deformation of thin and thick cylinders; Deformation in spherical shells subjected to internal pressure; Combined thermomechanical stress; Examples and case studies (boilers).

Outcomes

At the end of this course students will demonstrate the ability to

CO1: Recognize various types loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components.

CO2: Evaluate stresses in simple geometries such as bars, beams, torsional members, springs, columns, cylinders and sphers under simple loading situations.

CO3: Evaluate the strains and deformations that will result due to the elastic stresses developed within the materials for simple types of loading.

CO4: Analyse and design beams, shafts and hollow cylinders.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	1	×	1	×	1	×	1	×	3	3	×	1
CO2	3	3	3	2	2	1	×	1	1	1	×	3	3	×	2
CO3	3	3	3	3	2	1	×	1	1	1	×	3	3	×	3
CO4	3	3	3	3	2	1	×	1	1	1	×	3	3	×	3

Textbooks

1. Popov, E.P., "Engineering Mechanics of Solids," Pearson, 2015.

2. Timoshenko, S. and Gere, G.M., "Mechanics of Materials", CBS Publishers, 2011.

3. Dixit U.S., Muthu N. and Kamal S.M., Strength of Materials, AICTE, New Delhi, 2023 (a textbook for undergraduate Civil and Mechanical engineering students).

Reference Books

1. Hibbeler, R.C., Mechanics of Materials, 10th Edition, Pearson, 2016.

2. Beer, F. P. & Jhonston, E. R. Jr. et al. Mechanics of Materials, 5th ed., Tata McGraw Hill, New Delhi, 2009.

3. Timoshenko, S., Strength of Materials, Vol. 1: Elementary Theory and Problems, CBS; 3rd Edition, 2004

4. Srinath, L.S., Advanced Mechanics of Solids, McGraw Hill, 2017.

Online Resources

https://nptel.ac.in/courses/105/105/105105108NPTEL Course
https://nptel.ac.in/courses/105/106/105106172NPTEL Course
https://nptel.ac.in/courses/112/102/112102284 NPTEL Course

1.9 MEBT208 :: Kinematics and Dynamics of Machines

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: Engineering Mechanics (MEBT202)

Objectives

1. To understand the kinematics and rigid-body dynamics of kinematically driven machine components
2. To understand the motion of linked mechanisms in terms of the displacement, velocity and acceleration at any point in a rigid link
3. To be able to design linkage mechanisms and cam systems to generate specified output motion
4. To understand the kinematics of cams & followers and gear trains

Syllabus

Module I : Mechanisms **[5L+2T]**
Basic kinematic concepts; Higher and lower kinematic pairs; Classification of mechanisms based on function and constraints; Common mechanisms such as slider crank and 4-bar mechanisms and their inversions; Quick return mechanism, straight line generators, rocker mechanisms, universal joints, steering mechanisms, etc.

Module II : Basic Kinematic Concepts and Definitions **[3L+1T]**
Degree of freedom and Grübler's formula; Grashof's rule and rotatability limits; Mechanical advantage; Transmission angle; Limit positions.

Module III : Geometric Design of Mechanisms **[4L+2T]**
Graphical synthesis of dyads and crank-rocker for two- and three-position synthesis for path and motion generation.

Module IV : Kinematic Analysis of Simple Mechanisms **[8L+3T]**
Displacement, velocity, and acceleration analysis; Velocity analysis using instantaneous centers; Position, velocity and acceleration analysis using loop closure equations; Coincident points; Coriolis component of acceleration.

Module V : Static and Dynamic Force analysis of Simple Mechanisms **[6L+2T]**
Two and three force members; Force and moment equilibrium; Inertial forces; Equations of motion for force-bar and slider-crank mechanisms.

Module VI : Cams and Followers **[6L+2T]**
Classification and terminology; Displacement, velocity, acceleration and jerk diagrams; Uniform velocity, parabolic, simple harmonic and cycloidal motions; Derivatives of follower motions; Circular and tangent cams; Pressure angle and undercutting; Graphical and analytical disc cam profile synthesis for roller and flat face followers.

Module VII : Gears **[6L+2T]**
Involute and cycloidal profiles; gear parameters; Fundamental law of gearing and conjugate action; Spur gear contact ratio and interference; Helical, bevel, worm, rack and pinion gears; Epicyclic and regular gear train kinematics; Force analysis of spur, helical, bevel and worm gearing.

Outcomes

At the end of this course students will demonstrate the ability to

CO1: appreciate and apply the framework acquired during this course to analyze the mechanisms and machines in real-life problems.

CO2: evaluate kinematic parameters related to motion of planar mechanisms using graphical and analytical methods.

CO3: solve synthesis problems related to motion generation and path generation.

CO4: understand and analyze the use of cams and gears for generating complex coordinated movements.

CO5: perform force analysis of planar mechanisms.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	2	1	1	1	1	2	2	1	1	2	3	2	2
CO2	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2
CO3	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2
CO4	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2
CO5	3	1	2	1	1	1	×	×	×	1	1	2	3	×	2

Textbooks

1. Bevan, T., *The Theory of Machines*, Pearson, New Delhi, 2014.

2. Ghosh, A., Mallik, A. K., *Theory of Mechanisms and Machines*, EWP publications, New Delhi, Reprint 2014.

3. Norton, R. L., *Kinematics and Dynamics of Machinery*, Tata McGraw Hill, 2009.

Reference Books

1. Rao, J. S., Dukkipati R. V., *Mechanism and Machine Theory*, New Age International Publishers, New Delhi, 2006.

2. Uicker, J.J., Pennock, G. R. and Shigley, J. E., *Theory of Machines and Mechanisms*, Oxford University Press, New Delhi, 2007.

1.10 MEBT209 :: Fluid Mechanics & Hydraulic Machines

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: Engineering Mechanics (MEBT202)

Objectives

1. To understand the elementary fluid properties, and the governing equations of fluid dynamics.
2. To get familiarized with the essence of dimensional analysis.
3. To get introduced to fluid kinematics and related flow parameters.
4. To understand the behaviour of laminar and turbulent flows and their flow characteristics.
5. To understand the working principles and performance characteristics of water pumps and turbines

Syllabus

Module I : Basic Concepts **[2L+1T]**
Definition of fluid; Newton's law of viscosity; Units and dimensions; Physical properties of fluids; Control volume; Continuity equation and momentum equation; Incompressible flow; Bernoulli's equation and its applications.
Module II : Fluid Statics **[4L+1T]**
Forces on fluid element (body force and surface force), pressure force on a fluid element, units and scales in pressure measurement, pressure measurement by Barometer, pressure/vacuum gauges and manometers, hydrostatic forces on plane and curved surfaces, Buoyancy and stability of submerged and floating bodies.
Module III : Fluid Kinematics **[3L+1T]**
Different approaches; Reynolds transport theorem; Flow visualization; Types of flow; Strain rate, stream line, streak line, path lines and stream tubes; Continuity equation in Cartesian coordinates in 3D forms; Velocity and acceleration of fluid particles; Velocity potential function and stream function.
Module IV : Momentum Equation **[3L+1T]**
Momentum equation; Nervier Stoke equation; Development of Euler's equation; Bernoulli's equation and application; Steady and unsteady flow through orifice; Orifice placed in pipe; Venturimeter; Flow over triangular and rectangular notches; Pitot tube.
Module V : Dimensional Analysis **[3L+1T]**
Dimensionally homogeneous equations; Buckingham Pi Theorem; Calculation of dimensionless parameters. Similitude and complete similarity; Model scales; Basic boundary layer theory and analysis.
Module VI : Potential flow theory **[3L+1T]**
Stream function, vorticity, velocity potential, uniform flow, source flow; sink flow, vortex flow, superposition of elementary flows, Rankine half body, doublet, and flow past a cylinder.
Module VII : Laminar and Turbulent Flow **[6L+2T]**
Viscous/Laminar flow – Plane Poiseuille flow and Coutte flow; Laminar flow through circular pipes; Loss of head and power absorbed in viscous flow; *Turbulent flow* – Reynolds experiment; Frictional losses in pipe flow; Shear stress in turbulent flow; Major and minor losses (Darcy's and Chezy's equation); Flow through siphon pipes; Branching pipes and equivalent pipe.

Module VIII : Introduction to Boundary Layer concepts **[6L+2T]**
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.

Module IX : Turbo machinery **[9L+3T]**
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.

Outcomes

After successful completion of the Course, students would be able to

CO1: Evaluate the kinematic parameters of fluids like velocity, acceleration and rotation.

CO2: Apply the governing equations of fluid flow to analyse flows through basic engineering systems

CO3: Apply the principles of physical similarity and dimensional analysis to engineering problems

CO4: Solve and analyse laminar and turbulent pipe-flow problems.

CO5: Solve and analyse laminar and turbulent-boundary-layer problems.

CO6: Analyse the performance of hydraulic machines.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	×	×	×	×	×	1	1	2	2	3	2	1	2
CO2	3	3	×	×	×	×	×	1	1	2	2	3	2	1	2
CO3	3	3	×	×	×	×	×	1	1	2	2	3	2	1	3
CO4	3	3	×	1	×	×	×	×	×	×	3	1	3	1	2
CO5	3	3	×	×	×	×	×	×	×	×	3	1	3	1	2
CO6	3	3	×	×	×	×	×	×	×	×	3	2	3	1	2

Textbooks

1. Pritchard, P. J., McDonald, A. T., and Fox, R.W. , *Introduction to Fluid Mechanics*, Wiley India, 2012.

2. White, F. M., *Fluid Mechanics*, Tata McGraw Hill, 2011.

Reference Books

1. Som, S. K., Biswas, G., and Chakraborty, S., *Introduction to Fluid Mechanics and Fluid Machines*, Tata McGraw Hill, 2017.

2. Çengel, Y.A., Cimbala, J.M., *Fluid Mechanics Fundamentals and Applications*, McGraw-Hill Education, 2018.

Online Resources

https://onlinecourses.nptel.ac.in/noc22$_{c}$e85/$previewNPTELCourse$

1.11 MEBT210 :: Mechanical Engineering Laboratory 1 (Design)

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 0-0-2-2-4
- **Prerequisite** :: None

Objectives

1. To understand the measurement of mechanical properties of materials.
2. To understand the deformation behaviour of materials.
3. To understand the kinematic and dynamic characteristics of mechanical devices.

Experiments and Demonstrations

1. Uniaxial tension test on mild steel rod.
2. Impact test on a metallic specimen.
3. Brinnell hardness tests on metallic specimen.
4. Rockwell hardness tests on metallic specimen.
5. Vickers micro-hardness tests on metallic specimen.
6. Study of influence of inertia upon velocity and acceleration.
7. Study of Gyroscopic mechanism.
8. Study of whirling of shaft phenomenon.
9. Study of static and dynamic balancing of an unbalanced system
10. Model demonstration of velocity ratios of simple, compound, epicyclic and differential gear trains.
11. Model demonstration of kinematics of four bar, slider crank, crank rocker, double crank, double rocker and oscillating cylinder mechanisms.
12. Model demonstration of cam & follower and motion studies.
13. Determination of time period, radius of gyration, center of percussion, and acceleration due to gravity by means of compound pendulum.
14. Determination of vibration absorptivity of a double cantilever beam.
15. Determination of natural frequency of free and force undamped vibration of a rectangular section beam.
16. Determination of natural frequency of single degree of freedom spring mass system.
17. Verification of Hooke's law.
18. Measurement of coefficient of friction between two sliding surfaces.
19. Verification of parallelogram law of force addition.

20. Determination of support reactions in a simply supported beam.
21. Deflection of cantilever beam.
22. Torsion test on mild steel rod.
23. Measurement of strain using a single strain gauge or strain rosette.
24. Determination of two-body sliding wear using pin-on-disk wear test apparatus.
25. Microscopic examination of heat-treated and untreated metallic samples.

Outcomes

After successful completion of the Course, students would be able to

CO1: Understand the measurement of mechanical properties of materials.

CO2: Understand the principle of different mechanism through demonstration of working model.

CO3: Characterize the dynamic behaviour of mechanical systems.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	3	3	3	3	1	2	1	3	×	×	3	2	1	2
CO2	×	×	1	1	1	×	×	1	2	×	×	2	2	×	2
CO3	1	3	3	3	3	1	2	1	3	×	×	3	2	1	2

Textbooks and References

1. Popov E.P., *Engineering Mechanics of Solids*, Pearson Education India, 2nd ed., 2015.
2. Dally J. W., and Riley W.F., *Experimental Stress Analysis*, McGraw-Hill Education, 3rd ed., 1991.
3. Bhandari V.B., *Design of Machine Elements*, 3rd ed, Tata McGraw-Hill, New Delhi, 2010.
4. Ghosh, A., Mallik, A. K., *Theory of Mechanisms and Machines*, EWP publications, New Delhi, Reprint 2014.
5. Thomson W. T., Dahleh M. D. and Padmanabham, C., *Theory of Vibrations with Applications*, Pearson, 5th edition, 2008.

1.12 MEBT301 :: Machine Element and System Design

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

1. To understand safe design of machine components using various failure criteria.
2. To understand the origins, nature and applicability of empirical design principles, relevant codes, standards and design guidelines for different machine elements.
3. To realize the relationships between component level design and overall machine system design, and their performance

Syllabus

Module I : Introduction **[8L+2T]**
Anatomy of machines; Functional dissection of bicycle, motorcycle, washing machine, sewing machine, etc. into machine elements including gears, rack and pinions, cams, chains, belts, pulleys, flywheels, bearings, shafts, keys, brakes, etc.; Design considerations – Limits, fits and standardization, Impact of strength, toughness and fatigue resistance of materials on machine element design, Influence of cost and manufacturing methods in design; Friction and lubrication.
Module II :Free-body Diagrams – Force Analysis **[3L+1T]**
Force analysis of machine elements and machine systems; Application to power screws and couplings, clutches, and brakes.
Module III : Failure Theories **[10L+4T]**
Static failure theories include normal stress theory, shear stress theory, distortion energy theory; von Mises stress; Factor of safety; Stress concentration factors; Fatigue failure theories: mean and alternating stresses, yield, ultimate, and endurance strength; Goodman, modified Goodman, Gerber, and Soderberg lines; Introduction to fracture mechanics, creep and thermal stresses.
Module IV : Design of Machine Elements **[12L+5T]**
Springs – Helical compression, tension, torsional and leaf springs; Fasteners – threaded fasteners, bolted joints, preloaded bolts, rivets and welded joints; Shafts – shafts under static and fatigue loadings; Keys; Sliding and rolling contact bearings; Transmission elements – transmission ratio and efficiency of spur, helical, bevel and worm gears; belt and chain drives; Flywheels.
Module V : Vibrations of Machine Elements **[6L+2T]**
Single degree-of-freedom systems; Natural frequency and critical damping; Forced vibration; Resonance; Balancing of reciprocating and rotating masses; Torsional vibration and critical speeds of shafts.
Module VI : Mechanical Systems **[3L]**
Case studies on automobile suspensions, automatic transmissions, material conveyor systems, construction machinery, etc.

Outcomes

After successful completion of the Course, students would be able to

CO1: Understand the principles of machine elements and how they can be combined to function as a system.

CO2: Analyze the safe design of machine elements.

CO3: Apply codes, standards and design guidelines for different elements.

CO4: Analyze mechanical systems.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	1	×	1	1	1	1	×	×	3	1	1	1
CO2	3	3	3	3	2	2	×	1	2	×	×	3	3	1	2
CO3	3	3	2	1	×	2	×	1	1	×	×	3	2	1	2
CO4	3	3	3	3	2	2	1	1	3	×	×	3	3	1	2

Textbooks

1. Bhandari V.B, *Design of Machine Elements*, 3rd ed, Tata McGraw-Hill, New Delhi, 2010.

2. Gope P.C., *Machine Design: Fundamentals and Applications*, PHI, New Delhi, 2011.

3. Shigley J.E. and Mischke C.R., *Mechanical Engineering Design*, Tata McGraw-Hill, New Delhi, 2008.

Reference Books

1. Norton R.L., *Mechanical Design – An Integrated Approach*, Pearson Education India, 5th ed., 2013.

2. Faculty of Mechanical Engineering – PSG College of Technology, *Design Data: Data book of Engineering*, Kalaikathir Achchagam, Coimbatore, 2020.

3. Deutschman D., Michel W.J. and Wilson, C.E., *Machine Design: Theory and Practice*, Macmillan, New York, 1992.

4. Spotts M.F., Shoup T.E. and Hornberge L.E., *Design of Machine Elements*, 8th ed., Pearson Education India, Delhi, 2019.

5. Sharma P.C. and Aggarwal D.K., *A Textbook of Machine Design*, 13th ed., S. K. Kataria & Sons, Delhi, 2017.

Online Resources

https://archive.nptel.ac.in/courses/112/105/112105124/NPTEL

1.13 MEBT302 :: Heat Transfer

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: Applied Thermodynamics (MEBT205) and Fluid Mechanics & Hydraulic Machines (MEBT209)

Objectives

1. To build a solid foundation in heat transfer, expose students to the three basic modes: conduction, convection, and radiation.
2. To train the students about governing equations of heat transfer and their solution procedures, while solving some practical heat transfer problems using standard correlations.
3. To explain the students about the principles of boiling and condensation heat transfer.
4. To train the students about thermos-hydraulic designing of Shell and Tube type, and Double Pipe Heat Exchangers etc.

Syllabus

Module I: Introduction **[3L]**
Definitions of three modes of heat transfer viz. Conduction, Convection, and Radiation. Examples of heat transfer equipment (like heat exchangers, condensers, evaporators, and air cooler etc); Derivation of heat balance equation (Energy Equation).
Module II: Conduction Heat Transfer **[6L+2T]**
Steady one-dimensional (1-D) and 2-D heat conduction in large plane walls and cylinders with and without internal heat generation; Concept of thermal (conduction, convection, and radiation) and film resistances, Critical insulation thickness; Heat transfer through pin fins, Unsteady Heat Conduction: Lumped system approximation, Biot Number and Fourier Number, Unsteady 1-D heat conduction in large plane walls and semi-infinite solids. Solution of some specific conduction heat transfer problems.
Module III: Convection Heat Transfer **[9L+2T]**
Derivation of Differential Convection Equations; External Forced convection; Solutions of Convection Equations for laminar and turbulent flow over a Flat Plate for using integral method, Velocity and Thermal Boundary layers; Internal Forced convection, Approximate solutions of Convection Equations for laminar and turbulent flow in a circular pipe. Natural convection in a vertical plate; Dimensionless parameters related to forced and free convection heat transfer. Solution of some specific convective heat transfer problems.
Module IV: Boiling and Condensation Heat Transfer **[3L]**
Pool boiling; Flow boiling; Condensation Heat Transfer; Film and Drop wise condensation; Nusselt's theory on laminar film wise condensation.
Module V: Radiation Heat Transfer **[6L+2T]**
Fundamentals of thermal radiation; Stefan Boltzmann's law; Black and grey body radiation; Definitions of radiative properties; Calculation of radiation heat transfer between surfaces using radiative properties; View factors and the radiosity method; Examples for two-body enclosures; Radiation shields and radiation Effect.
Module VI: Heat Exchangers **[8L+3T]**
Classification of heat exchangers; Overall Heat Transfer Coefficient; Heat exchanger effectiveness; Analysis, Design and selection of heat exchangers using Log mean temperature difference

(LMTD) and effectiveness NTU method. Preliminary design of Shell and Tube Heat Exchangers and Double pipe heat exchangers.

Outcomes

After successful completion of the Course, students would be able to

CO1: Apply concepts of thermal resistance, critical insulation thickness and solve steady and unsteady conduction problems in plane walls, cylinders, and fins.

CO2: Derive and apply governing equations for solving external and internal forced convection heat transfer problems.

CO3: Apply natural convection principles to vertical plates and understand the significance of dimensionless numbers in convection.

CO4: Differentiate between pool boiling and flow boiling heat transfer processes, explain film-wise and drop-wise condensation and analyse condensation heat transfer using Nusselt's theory.

CO5: Apply fundamental radiation laws to calculate radiative heat exchange between surfaces, use view factors and the radiosity method to compute radiation heat transfer in enclosures; assess the impact of radiation shields and surface emissivity on thermal performance.

CO6: Classify types of heat exchangers and perform selection; understand LMTD and Effectiveness-NTU methods; perform thermo-hydraulic design of shell-and-tube heat exchangers, condensers, and evaporators.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	1	1	1	×	×	×	2	1	1	2	2	1	1
CO2	3	3	2	2	2	×	×	1	2	1	1	2	2	1	1
CO3	3	3	1	×	×	×	×	×	1	1	×	2	2	1	1
CO4	3	3	×	×	×	×	×	×	1	2	×	2	1	1	1
CO5	3	3	1	2	×	2	2	2	2	1	2	2	2	1	1
CO6	3	3	3	3	3	3	2	2	2	1	2	3	3	2	2

Textbooks

1. Cengel, Y.A. *Heat Transfer: A Practical Approach.* McGraw Hill, New Delhi, 2007.
2. Incropera, F.P. and Dewitt, D.P. *Fundamentals of Heat and Mass Transfer.* John Wiley, New Delhi, 2019.

Reference Books

1. Bejan, A. *Heat Transfer.* John Wiley, Hoboken 2nd Edition, 2022.
2. Kaviany, M. *Principles of Heat Transfer.* John Wiley, New York, 2002.
3. Kays, W. M. and London, A. L. *Compact Heat Exchangers.* McGraw-Hill, New York, 2nd Edition, 1998.

4. Shah, R. K. and Sekulic, D. P. *Fundamentals of Heat Exchanger Design.* John Wiley and Sons, New Jersey, 2003.

5. Holman, J.P. and Bhattacharyya, S. *Heat Transfer.* McGraw Hill, New Delhi, 2017.

Online Resources

https://nptel.ac.in/courses/112/105/112105248/NPTEL

1.14 MEBT303 :: Manufacturing Processes

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

1. To motivate and challenge students to comprehend the various manufacturing processes, both conventional and non-conventional.
2. To help students appreciate the correlation between these processes and material properties.
3. To enable students to understand how raw materials are transformed in shape, size, and form into desirable products.
4. To foster an appreciation for the diverse manufacturing methods and their impact on the final product.

Syllabus

Module I : Manufacturing Processes and Classification [5L+2T]
Additive, subtractive and shaping processes; Relative advantages and limitations; Inter-dependency of geometry, material and process; Effect on product quality and cost; Part design for manufacturability; Process selection criteria.
Module II : Material Shaping Processes [8L+2T]
Metal casting (sand, die and investment casting), Bulk forming (forging, rolling, extrusion, drawing) and sheet forming (shearing, deep drawing, bending); Thermoplastic and thermoset plastic processes (ex. injection and blow molding); Powder metallurgy; Metal injection molding; Glass and composite materials manufacturing processes.
Module III : Material Removal Processes [8L+2T]
Turning, Drilling, Milling, Grinding and other finishing processes; Single and multi-point cutting tools; Cutting tool materials; Cutting fluids; Material removal rates, surface finish, accuracy, integrity and machinability.
Module IV : Nonconventional Machining Processes [6L+2T]
Abrasive Jet Machining, Water Jet Machining; Ultrasonic Machining; Electrical Discharge Machining, Wire EDM; Electro- Chemical Machining; Laser Beam Machining, Plasma Arc Machining and Electron Beam Machining; Micro and nano manufacturing.
Module V : Additive Manufacturing Processes [5L+2T]
Extrusion; vat polymerization, powder bed fusion; material jetting, binder jetting; direct energy deposition and lamination processes.
Module VI : Joining Processes [6L+2T]
Arc welding, gas welding, shielded metal arc welding; Gas Metal Arc Welding/ Metal Inert Gas Welding (GMAW/MIG) and Gas Tungsten Arc Welding/ Tungsten Inert Gas Welding (GTAW/TIG); Friction stir welding (FSW), plasma welding (PAW), Electron beam Welding (EBM), Laser Welding (LW), Brazing and soldering; Solid state joining; Adhesive bonding.
Module VII : Modeling Manufacturing Process [4L+2T]
(for any one process, including simulation and industrial case study): Casting - metal flow, solidification and cooling; application to design of gating and feeding systems for quality and yield

optimization; OR Forming - Plastic deformation and yield criteria; load estimation; OR Machining - Orthogonal cutting, various force components; Chip formation, Tool wear and tool life.

Outcomes

At the end of this course students will demonstrate the ability to

CO1: Understand and classify various manufacturing processes, and evaluate their advantages and limitations.

CO2: Understand and apply material shaping processes and assess their impact on product quality and cost.

CO3: Develop proficiency in material removal processes understand the use of cutting tools and fluids, and evaluate material removal rates, surface finish, accuracy, integrity, and machinability.

CO4: Understand and apply unconventional manufacturing processes and evaluate their applicability and benefits in various manufacturing scenarios.

CO5: Develop the ability to model manufacturing processes through simulation and industrial case studies.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	1	2	1	×	×	1	×	2	×	2	2	×	2
CO2	3	1	×	×	×	×	1	2	1	2	2	2	2	2	×
CO3	3	×	1	2	×	1	×	×	1	2	×	2	1	2	2
CO4	3	1	×	2	×	1	×	1	1	2	×	2	1	×	2
CO5	×	2	1	2	×	3	×	×	1	2	×	2	1	2	×

Textbooks

1. Ghosh, A., Mallik, A. K., *Manufacturing Science*, Affiliated East-West Press Pvt. Ltd., 2010.
2. Kalpakjian, S., and Schmid, S., *Manufacturing Processes for Engineering Materials*, Pearson India, 2014.

Reference Books

1. Groover, M. P., *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, John Wiley & Sons, 2010.

Online Resources

https://www.mooc-list.com/tags/manufacturingMOOC list

1.15 MEBT304 :: Production and Operation Management

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

1. To provide knowledge on machines and related tools for manufacturing various components.
2. To understand the relationship between process and system in manufacturing domain.
3. To identify the techniques for the quality assurance of the products and the optimality of the process in terms of resources and time management.

Syllabus

Module I : Introduction **[3L+1T]**
Scope of production management. Production system and resources (machines, tooling, etc.); Types of production (batch, flow and unit), Roles of line supervisors and production managers.
Module II : Project Management **[14L+5T]**
Project life cycle: concept phase (RFQ, Quotations, Proposals), Project initiations, DPR preparation (project value, business case development and feasibility study); Project planning (obtaining resources, acquiring financing and procuring required materials); Project team, producing quality outputs, handling risk, acceptance criteria; Project execution (allocation of resources, scheduling, building deliverables); Project Monitoring and control: Project networks, progress review (physical and financial), CPM and PERT, critical path, re-scheduling; Project closure: acceptance of project deliverable; Analytics: Performance, capability aggregation, cost benefit analysis, variability analysis, Output-outcome analysis, project documentation, best practices, and depository.
Module III : Production Planning and Control **[7L+3T]**
Production planning, Process planning, Resource planning, demand-utility mapping (production capability index, forecasting models, aggregate production planning, materials requirement planning); Inventory Management: Economic order Quantity, discount models, stochastic inventory models, practical inventory control models, JIT; Supply chain and management.
Module IV : Factory Management **[8L+1T]**
Factory layout: line balancing, material flow and handling, Lean and green manufacturing, Human resource management, Training need analysis, Advantage and opportunities for Digitalization, Advanced factory systems: TQM; Important acts, regularities and safety norms, Reliability assessment of processes, Block chain, Energy management, Efficiency & throughput, Overall equipment effectiveness. Process capability, lean manufacturing.
Module V : Operation Management **[6L+4T]**
Linear programming, objective function and constraints, graphical method, Simplex and duplex algorithms, transportation assignment; Simple queuing theory models; Traveling Salesman problem; Network models: shortest route, minimal spanning tree, maximum flow model.

Outcomes

After successful completion of the Course, students would be able to

CO1: Initiate projects with clearly identified scope, requirements, constraints, risks, deliverables and stakeholders.

CO2: Analyze the aggregate planning and master production schedule based on the periodic demand of an organization

CO3: Implement TQM principles and techniques to measure, assess and audit Quality of process/product.

CO4: Apply the necessary operations management tools for decision making, forecasting in sales demand.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	×	3	2	3	2	3	×	1	3	3	3	1	2
CO2	3	2	×	3	1	3	×	×	×	1	3	3	3	2	×
CO3	3	1	×	3	×	3	2	×	2	1	3	3	3	2	×
CO4	3	1	×	3	×	2	×	3	×	1	3	3	3	2	1

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. Chase, R.B., Jacobs, F.R., and Aquilano, N.J., *Operations Management for Competitive Advantage*, Tata McGraw Hill, 2011.

3. Hopp, W. J. and Spearman, M. L., *Factory Physics: Foundations of Manufacturing Management*, McGraw Hill International Edition, 2008.

4. Taha, H. A., *Operations Research*, 6th Edition, PHI India, 2003.

5. Poonia, M.P., *Total Quality Management*, Khanna Publishing House, 2022.

Reference Books

1. Krajewski, L. J., and Ritzmen, L.P., *Operations Management: Strategy and Analysis*, Pearson, 2010.

2. Mahadevan, B., *Operations Management: Theory and Practice*, Pearson, 2015.

1.16 MEBT305 :: Mechanical Engineering Laboratory 2 (Thermal & Fluid)

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 0-0-2-2-4
- **Prerequisite** :: None

Objectives

1. To understand the principles and performance characteristics of fluid-flow devices.
2. To learn the basic measurement techniques of heat transfer parameters.
3. To learn the parametric evaluation performance parameters of refrigeration and air-conditioning devices.
4. To learn the practical operation of a four-stroke diesel engine.

Experiments and Demonstrations

Fluid Mechanics (6 P):

1. Demonstration of Bernoulli's Theorem and finding unknown cross-sectional areas of a converging-diverging duct
2. Determination of discharge coefficients of a Venturi meter and Orifice meter.
3. Study of the impact of jet on flat, curved, and semi-spherical surfaces.
4. Finding the critical Reynolds number using the Osborne Reynolds Apparatus.
5. Determination of friction factor for flow through a pipe under different Reynolds numbers.
6. Minor losses through large bend, medium bend, elbow, enlargement, and contraction in a pipe.

Turbomachinery (4 P):

[start=7]Determination of a Centrifugal pump performance characteristics. Determination of a Pelton Wheel performance characteristics. Determination of a Francis Turbine performance characteristics. Determination of a Reciprocating pump characteristics.

3. **Heat Transfer** (9 P):

[start=11]Determination of the thermal conductivity of insulating slabs. Determination of the convective heat transfer coefficient for forced convection. Determination of the heat transfer coefficient in a dropwise and filmwise condensation apparatus. Determination of the critical heat flux in a pool boiling apparatus. Determination of the heat transfer coefficient in a vertical cylinder natural convection apparatus. Determination of emissivity of a black surface using a Stefan-Boltzmann apparatus. Determination of the overall heat transfer coefficient in parallel/counter flow arrangements with concentric tube heat exchanger. Determination of the overall heat transfer coefficient in parallel/counter flow arrangements with shell and tube heat exchanger apparatus. Determination of the effectiveness of a heat-pipe apparatus.

4. **Refrigeration and Air Conditioning** (4 P):

[start=20]Determination of the coefficient of performance of a Vapour compression refrigeration system. Determination of the coefficient of performance of a Vapour absorption refrigeration system. Determination of the psychrometric properties using a cooling-tower test rig. Determination of the COP of an air-conditioning test rig.

3. **IC Engine Lab** (2 P):

   [start=24]Determination of the $p-V$ diagram and the performance of a multi-cylinder 4-stroke diesel engine Demonstration of IC-Engine components/sub-assembly.

Outcomes

After successful completion of the Course, students would be able to

1. **CO1**: Measure and analyse energy losses, flow rate, velocity, and forces in fluid flow systems.

   CO2: Experimentally determine the performance characteristics of hydraulic turbines and pumps.

   CO3: Measure the heat transfer rate due to conduction, convection, or radiation and evaluate heat-exchanger performance.

   CO4: Evaluate the performance of a refrigerator and an air-conditioner.

   CO5: Measure the performance parameters of a four-stroke diesel engine.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	×	×	×	×	3	3	2	×	2	2	×	2
CO2	3	1	1	1	×	×	2	3	3	2	×	2	3	1	2
CO3	3	2	2	1	×	×	1	3	3	2	×	3	3	2	2
CO4	3	2	1	×	×	×	1	3	3	2	×	2	3	2	2
CO5	3	1	×	×	×	×	2	3	3	2	×	1	2	×	1

1.17 MEBT306 :: Computer Aided Engineering

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 2-0-2-4-6
- **Prerequisite** :: None

Objectives

1. To impart knowledge to the students related to solid modeling and system modeling of thermo-fluid systems.
2. To train the students on modern techniques for solving real-life-engineering problems using commercial-software packages.
3. To train the students for writing and presenting a technical report by giving assignments and mini projects.
4. To encourage students for higher education.

Syllabus

Module I : Introduction to computer-aided modelling **[4L]**
Basic drafting, Modelling of parts and assembly drawing using standard software packages.
Module II : Introduction to structural analysis **[8L]**
Introduction to finite element analysis (FEA): Basic engineering analysis of Beams, Trusses, Plates; Stress analysis of structure with individual and combined loading under Mechanical, Thermal and Thermo-Mechanical loading.
Module III : Introduction to CFD **[6L]**
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.
Module IV : Modelling of fluid systems **[2L]**
Geometry modelling using a standard commercial package, Specification of boundary conditions, Free-stream conditions and flow properties, User-defined functions.
Module V : Use of commercial fluid-flow solver **[4L]**
Use of commercial fluid-flow solver (ANSYS Fluent and programming package) to solve the following problems:

[label=()]Lid-driven cavity flow problem Natural and mixed convection in a lid-driven cavity Forced convective flow and heat transfer in a channel for laminar and turbulent flow conditions Unsteady flow through a channel with pulsatile inlet velocity profile Steady and unsteady-state temperature profiles in solids under heat conduction Conjugate heat transfer in a duct with constant heat flux and axially varying heat flux Solution of viscous, laminar, incompressible flow over immersed bodies – airfoils.

List of Practical

1. Computer modelling of engineering components using software packages [5P]
2. Structural load analysis of beam, plate and trusses with individual and combined loading under mechanical, thermal and thermo-mechanical conditions. [5P]

3. Steady and unsteady -state temperature profile in solids under heat conduction [3P]
4. Numerical simulation and analysis of laminar and turbulent flows over immersed bodies-cylinder/car body/airfoil [3P]
5. Numerical simulation and analysis for flows through heat exchangers [3P]
6. Numerical simulation of oil tank sloshing [2P]
7. Computation of supersonic flow over wedges and cones [3P]
8. Numerical solution and analysis of pulsating flow through mufflers [2P]

Outcomes

After successful completion of the Course, students would be able to

CO1: Model physical systems involving structural and thermal applications.

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

CO3: Write and present their assignments as a technical report or document.

CO4: Pursue research in the field of FEM and CFD.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	×	×	×	×	1	1	1	×	×	3	1	2	×
CO2	2	3	1	×	×	×	1	1	2	×	×	3	2	2	×
CO3	3	×	2	2	1	×	2	1	1	×	×	3	2	×	×
CO4	1	3	2	2	1	×	1	1	1	×	×	3	1	2	×

Textbooks

1. Dixit, U. S., *Finite Element Methods for Engineers*, Cengage Learning, 2009.
2. Versteeg, H. K. and Malalasekera, W., *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson, 2nd Edition, 2009.
3. Anderson, D. A., Tannehill, J. C., and Pletcher, R. H., *Computational Fluid Mechanics and Heat Transfer*, CRC Press, 3rd Edition, 2012.

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. Munford, P. and Normand, P.,*Mastering Autodesk Inventor 2016 and Autodesk Inventor LT*, John Wiley Sons, 2016.
4. Kent, L.L. *ANSYS Workbench Tutorial Release 14*, SDC Publications, 2012.
5. *ANSYS FLUENT Tutorial guide Release 15.0*, ANSYS Inc., 2013.

Online Resources

NPTEL Lecture Series

https://nptel.ac.in/courses/112/102/112102101/NPTEL Course
https://nptel.ac.in/courses/112/104/112104031/NPTEL Course

MIT OCW

,https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/MIT

1.18 MEBT307 :: Manufacturing Automation

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-0-1-4-5
- **Prerequisite** :: None

Objectives

1. To understand the importance of automation in the of field machine tool-based manufacturing
2. To get the knowledge of various elements of manufacturing automation – CAD/CAM, sensors, pneumatics, hydraulics and CNC
3. To understand the basics of product design and the role of manufacturing automation.

Syllabus

Module I : Introduction **[6L]**
Definition; Reasons for automating; Industry 4.0, Strategies; Types of automation; Numerical control (NC, CNC, DNC); Introduction to CNC programming and computer-aided process planning.

Module II : Machine and Process Automation **[6L]**
CNC machines, Automated flow lines (types, selection); Work part transport and transfer mechanisms; Feedback systems and control; Modular and reconfigurable machines, adaptive machine controls.

Module III : Automated Assembly Systems **[6L]**
Historical developments; Choice of assembly methods; Design for automated assembly; Transfer systems; Vibratory and non-vibratory feeders; Feed tracks, part orienting and placing mechanisms.

Module IV : Factory Automation **[6L]**
Lean manufacturing, Automation scalability (fixed, programmable, flexible and reconfigurable); Design and analysis of automated flow lines; Average production time, production rate, line efficiency; Analysis of transfer lines without storage; Partial and full automation.

Module V : Automation Tools and Techniques **[10L]**
Mechanical, electro-mechanical, pneumatic and hydraulic systems; Sensor integration; Process monitoring, data analysis and control using actuators; Programmable Logic controllers (PLC), Robots (pick, place, assembly, welding, painting, etc.); Automatic Guided Vehicles; Automated inspection and measurement (CMM and 3D Scanning); AI and machine learning; Human machine interfaces (HMI).

Module VI : Advanced Automation Trends **[8L]**
Digital, inclusive, smart and distributed manufacturing; Industry 4.0; Digital transformations in shop-floors (CIM to Smart factory; Intelligent machines to Smart Machines; Factory automation to Distributed automation; Human sense to system sensed).

Module VII : Demonstration and Practice **[5P]**
Pick and place robots, testing and sorting based systems, etc; Orientation of parts: in-bowl and out-of-bowl toolings; Manufacturing equipment embedded with digital data and driven by adoptive controls; PLC controllers.

Outcomes

After successful completion of the Course, students would be able to

CO1: identify and understand the importance of automation in manufacturing value chain.

CO2: apply their knowledge of various elements of automation tools and techniques.

CO3: develop their proficiency on the emerging digital manufacturing trends with respect to the industry/market.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	1	2	1	×	1	1	×	3	3	1	2
CO2	3	3	2	2	1	2	1	×	1	1	×	3	3	1	2
CO3	3	3	2	2	1	2	1	×	1	1	×	3	3	1	2

Textbooks

1. Groover, M. P., *Automation, Production Systems and Computer-integrated Manufacturing*, Prentice Hall, 2018.

Reference Books

1. Kalpakjian S., and Schmid, S. R., *Manufacturing – Engineering and Technology*, Pearson, 2006.

2. Koren, Y., *Computer Control of Manufacturing Systems*, McGraw Hill, 2005

3. Rao, P. N., *CAD/CAM Principles and Applications*, Tata McGraw Hill, 2010.

1.19 MEBT308 :: Product Innovation, Marketing and Finance

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 3-1-0-4-4
- **Prerequisite** :: None

Objectives

To expose aspiring student entrepreneurs to various elements of a technology venture starting from market need identification to innovative solution development and its commercialization through business planning and start-up company incubation.

Syllabus

Module I : Entrepreneurship **[9L+3T]**
Role of entrepreneurship in economic development; Entrepreneurial mindset, motivation and competencies; Market pull and technology push factors; New product development lifecycle; Technology readiness levels; Product-market fit validation; Commercialization pathways; Business vision & leadership; Team composition & management.
Module II : Product Innovation **[10L+3T]**
Opportunity scanning, market survey, need identification and problem definition; Creative design thinking for concept generation; Detailed design & prototyping; Functionality & manufacturability; Bill of materials & components supply chain; Manufacturing & assembly plan; Product testing & quality assurance; Intellectual property rights management.
Module III : Marketing and Finance **[8L+3T]**
Market segmentation & market sizing; Customer persona & value proposition; Marketing (Go-to-market) strategy; Distribution channels and sales network; Funding requirement (based on stage); Source of funding for startup ventures; Financial projections and accounting; Startup to scale up financing.
Module IV : Venture Creation **[8L+3T]**
Sustainable business options & pathways; Business model & business canvas; Startup team & business partners; Startup ecosystem and stakeholders; Technology business incubators & parks; Proposal pitching & agreements; Startup company incorporation; Social impact & responsibility.
Module V : Applied Entrepreneurship Project **[4L+1T]**
Problem Validation & Ideation, Business Model Design, Go-to-Market Strategy.

Outcomes

After successful completion of the Course, students would be able to

CO1: Understand how to identify an unmet need through market research

CO2: Learn how to create an innovative solution and check problem-solution fit

CO3: Practice business planning, including marketing, fund-raising and start-up incubation.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	×	×	×	1	×	2	×	×	1	1	×	×	1	3	×
CO2	×	2	2	1	1	×	1	1	1	×	×	×	1	×	2
CO3	×	×	×	×	×	×	×	1	1	2	3	1	×	×	×

Textbooks

1. Aulet, B., *Technology Entrepreneurship*, Tata McGraw Hill, 2014.
2. Drucker, P. F., *Innovation and Entrepreneurship*, Harper Business, 2006.
3. Bhuvanachandran, C., *Innovision*, Khanna Book Publishing, 2022.
4. Byers, T. H., Dorf, R. C., and Nelson, A. J., *Technology Ventures: From Ideas to Enterprise*, McGraw Hill, 2019.

Reference Books

1. Blank, S., and Dorf, B., *The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company*, Wiley, 2020.
2. Rao, T. V., and Kuratko, D. F., *Entrepreneurship: A South Asian Perspective*, Cengage, 2012.

Online Resources

https://onlinecourses.nptel.ac.in/noc22$_g$e03/$previewNPTELCourse$

1.20 MEBT309 :: Mechanical Engineering Laboratory 3 (Manufacturing)

- **Type** :: Professional Core Course (PCC)
- **L-T-P-CR-CH** :: 0-0-2-2-4
- **Prerequisite** :: None

Objectives

1. To understand the principles of different advanced manufacturing methods.
2. To learn the performance parameters of casting, joining, forming and machining technology.
3. To learn the dimensional & form accuracy of products, and basic measurement techniques in manufacturing.

Experiments and Demonstrations

1. Taper turning and external thread cutting using lathe
2. Contour milling using vertical milling machine
3. Spur gear cutting in milling machine
4. Measurement of cutting forces in Milling / Turning process
5. CNC part programming
6. Drilling of a small hole using wire EDM
7. Microprocessor controlled pick & place robot
8. Use of Tool Maker's Microscope
9. Comparator and sine bar
10. Surface finish measurement
11. Bore diameter measurement using micrometer and telescopic gauge
12. Use of Autocollimator
13. Metal casting and Foundry practice
14. Welding: SMAW, Gas welding, Oxy-acetylene welding, and TIG/MIG welding
15. Metal working: Die forging, Rolling, Extrusion
16. Metrology: Use of different tools such as digimatic micrometer, external micrometer, indicating micrometer, inside tubular micrometer, plunger and lever type dial indicator, universal bevel protractor, depth gauges (micrometer and digital), sine vice and slip gauge, radius gauge, pitch gauge, filler gauge, sine bar, V-block, C-clamp etc.
17. Measurement of included angle of a V-block and a wedge block using Sine bar.
18. Measurement of the angle of V-block with Universal Bevel Protractor and to distinguish the terms accuracy & precision.

Outcomes

After successful completion of the Course, students would be able to

CO1: Apply the principles of different advanced manufacturing methods.

CO2: Identify the performance parameters of casting, joining, forming and machining technology.

CO3: Evaluate the accuracy & tolerance of components produced by different measurement techniques.

CO4: Able to conduct group projects on advanced manufacturing techniques.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	2	2	2	1	1	×	×	×	×	3	3	1	1
CO2	3	3	2	3	3	1	1	×	×	×	×	2	3	1	1
CO3	2	2	3	3	2	2	2	×	×	×	×	2	3	1	1
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

1.21 MEBT310 :: Engineering Project-I (Literature Review)

- **Type** :: Project, Seminar and Internship in Industry or elsewhere (Pr)
- **L-T-P-CR-CH** :: 0-0-2-2-4
- **Prerequisite** :: None

Objectives

This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry, or even a minor practical project. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course. The students will carry out the project 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 individual groups.

Outcomes

After successful completion of the Course, students would be able to

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

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.

Course Articulation Matrix

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	×	×	×	3	×	×	2	2	×	×	3	2	3
CO2	×	3	3	3	×	3	×	×	2	2	×	2	2	3	2
CO3	×	×	×	×	×	×	2	×	×	1	×	×	×	2	1
CO4	×	×	×	×	×	×	2	3	×	1	×	×	1	3	2

1.22 MEBT401 :: Engineering Project-II (Design and Analysis)

- **Type** :: Project, Seminar and Internship in Industry or elsewhere (Pr)
- **L-T-P-CR-CH** :: 0-0-6-6-12
- **Prerequisite** :: MEBT310

Objectives

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/analysis work.

Outcomes

After successful completion of the Course, students would be able to

CO1: Demonstrate solid technical knowledge on the project topic.

CO2: Identify, formulate, and solve complex engineering problems.

CO3: Design engineering solutions to complex problems using modern tools and techniques.

CO4: Display effective team-work and project-planning.

CO5: Communicate with engineers and the general public in written and oral form.

CO6: Acquire the knowledge, skills, and attitudes of a professional engineer.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	1	1	2	2	3	2	3	1	2	3	3	2	3
CO2	3	3	1	×	3	3	3	2	3	1	2	3	3	2	3
CO3	2	2	3	3	3	2	3	3	3	1	1	2	2	3	2
CO4	×	×	×	×	×	×	×	3	3	3	3	3	×	2	1
CO5	×	×	×	×	×	×	×	×	3	3	2	3	1	3	2
CO6	3	3	3	3	3	2	2	2	3	1	3	3	3	2	2

1.23 MEBT402 :: Seminar

- **Type** :: Project, Seminar and Internship in Industry or elsewhere (Pr)
- **L-T-P-CR-CH** :: 0-0-1-1-2
- **Prerequisite** :: None

Objectives

1. To give students an exposure to the emerging trends and technologies in the field of Mechanical Engineering and allied areas.
2. To equip students with essential professional skills, such as technical writing and communication; presentation skills; resume building and interview preparation; networking and teamwork.
3. To encourage students to explore research methodologies and innovative thinking by introducing research tools and techniques and discussing case studies of successful innovations.

Outcomes

After successful completion of the Course, students

CO1: will be able to identify and describe emerging trends and technologies in Mechanical Engineering, such as additive manufacturing, renewable energy systems, and robotics.

CO2: will demonstrate an understanding of how these technologies are applied in real-world engineering scenarios.

CO3: will develop effective technical communication skills, including writing reports and delivering presentations.

CO4: will create a professional resume and demonstrate preparedness for job interviews and internships.

1.24 MEBT403 :: Engineering Project-III (Prototype and Testing)

- **Type** :: Project, Seminar and Internship in Industry or elsewhere (Pr)
- **L-T-P-CR-CH** :: 0-0-8-8-16
- **Prerequisite** :: MEBT401

Objectives

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. In that case the concerned students will be allowed to complete the course work related to Professional and Open Electives through MOOCs. The project shall consist of design/development/testing work.

Outcomes

After successful completion of the Course, students would 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.

Course Articulation Matrix

	PO												**PSO**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	1	1	2	2	3	2	3	1	2	3	3	2	3
CO2	3	3	1	×	3	3	3	2	3	1	2	3	3	2	3
CO3	2	2	3	3	3	2	3	3	3	1	1	2	2	3	2
CO4	×	×	×	×	×	×	×	3	3	3	3	3	×	2	1
CO5	×	×	×	×	×	×	×	×	3	3	2	3	1	3	2
CO6	3	3	3	3	3	2	2	2	3	1	3	3	3	2	2