Revised curriculum structure of BTech (Mechanical Engineering)

Curriculum :: Semester-wise distribution of courses

Sem	Course detail								Total credits in the semester
	SN	Code	Title	L	T	P	Cr	CH	
I	1	CH1xx	Chemistry	3	0	1	4	5	18
	2	MS1xx	Mathematics I	3	1	0	4	4	
	3	PH1xx	Physics I	2	0	1	3	4	
	4	EE1xx	Basic Electrical Engineering	3	0	0	3	3	
	5	EE1xx	Basic Electrical Engineering Lab	0	0	1	1	2	
	6	EG1xx	English	2	0	1	3	4	
	7	SE100	Induction Program	-	-	-	-	8	
II	1	PH1xx	Physics II	2	0	0	2	2	24
	2	MS1xx	Mathematics II	3	1	0	4	4	
	3	EC1xx	Basic Electronics	2	1	1	4	5	
	4	ME103	Workshop Practice	0	0	2	2	4	
	5	CO1xx	Introductory Computing	3	0	0	3	3	
	6	CO1xx	Computing Laboratory	0	0	2	2	4	
	7	ME102	Engineering Mechanics	3	1	0	4	4	
	8	CE1xx	Engineering Graphics	1	0	2	3	5	
III	1	MS2xx	Mathematics III	3	0	0	3	3	21
	2	BA2xx	Economics	3	0	0	3	3	
	3	ME201	Solid Mechanics	3	1	0	4	4	
	4	ME202	Fluid Mechanics I	2	1	0	3	3	
	5	ME203	Material Science	3	0	0	3	3	
	6	ME208	Manufacturing Technology I	3	0	0	3	3	
	7	ME217	ME Lab (Design) I	0	0	2	2	4	
	8	ES2xx*	Environmental Science	1	0	1	0	3	
IV	1	BT2xx	Biology	3	0	0	3	3	19
	2	ME205	Thermodynamics	3	1	0	4	4	
	3	ME209	Fluid Mechanics II	2	1	0	3	3	
	4	ME214	Kinematics of Machinery	2	1	0	3	3	
	5	ME215	Mechanical Measurements and Instrumentation	3	0	0	3	3	
	6	ME216	Manufacturing Technology II	3	0	0	3	3	
V	1	ME308	Heat and Mass Transfer	3	1	0	4	4	22
	2	ME311	Machine Design I	2	1	0	3	3	
	3	ME313	Dynamics of Machinery	3	0	0	3	3	
	4	ME314	Applied Thermodynamics	3	1	0	4	4	
	5	ME315	ME Lab (Manufacturing) II	0	0	2	2	4	
	6		ME-Elective I	3	0	0	3	3	
	7		Open Elective I	3	0	0	3	3	
	8	LW3xx*	Indian Constitution	1	0	0	0	1	
VI	1	BA3xx	Accounting and Finance Management	3	0	0	3	3	22
	2	ME312	Machine Design II	3	0	0	3	3	
	3	ME316	Computer-Aided Engineering	1	0	2	3	5	
	4	ME317	ME Lab (Thermal) III	0	0	2	2	4	
	5	ME318	Mini Project	0	0	2	2	4	
	6		ME-Elective II	3	0	0	3	3	
	7		ME Elective III	3	0	0	3	3	
	8		Open Elective II	3	0	0	3	3	
VII	1	XXxxx	HSS/Management Elective	3	0	0	3	3	21
	2	ME401	Industrial Systems Engineering	3	0	0	3	3	
	3	ME471**	Industrial Summer Training #	-	-	-	2	-	
	4	ME483	Project I	0	0	4	4	8	
	5		ME Elective IV	3	0	0	3	3	
	6		ME Elective V	3	0	0	3	3	
	7		Open Elective III	3	0	0	3	3	
	8	CT4xx*	Essence of Indian Traditional Knowledge	1	0	0	0	1	
	# Industrial Training: Training shall be of 8 weeks duration carried out during the summer break after the 6th semester. The report will be submitted in the 7th semester.								
VIII	1		ME Elective VI	3	0	0	3	3	14
	2		Open Elective IV	3	0	0	3	3	
	3	ME484	Project II	0	0	8	8	16	
Total*				**114**	**12**	**33**	**161**	**205**	**161**

***ES2XX, LW3XX and CT4XX** are Mandatory-Non-Credit courses as per the revised-AICTE guidelines. The lectures and laboratory classes assigned for these courses are not considered in the calculation of total credit structure. However, these courses are considered while calculating the number of hours.

**The credit-break up for ME471 (Industrial Summer Training) is not shown in the table. But its contribution of 2 credits is considered while calculating the total credit of 161 for the curriculum.

List of already-approved courses that have been adopted in the revised curriculum from the curricula of 2016 and its previous versions

SN	Sem	Course detail						
		Code	Title	L	T	P	Cr	CH
1	II	ME103	Workshop Practice	0	0	2	2	4
2		ME102	Engineering Mechanics	3	1	0	4	4
3	III	ME201	Solid Mechanics	3	1	0	4	4
4		ME202	Fluid Mechanics I	2	1	0	3	3
5		ME203	Material Science	3	0	0	3	3
6		ME208	Manufacturing Technology I	3	0	0	3	3
7	IV	ME205	Thermodynamics	3	1	0	4	4
8		ME209	Fluid Mechanics II	2	1	0	3	3
9	V	ME308	Heat and Mass Transfer	3	1	0	4	4
10		ME311	Machine Design I	2	1	0	3	3
11	VI	ME312	Machine Design II	3	0	0	3	3
12	VII	ME403	Industrial Engineering and Operation Research	3	0	0	3	3

List of new courses introduced into the revised curriculum

SN	Sem	Course detail						
		Code	Title	L	T	P	Cr	CH
1	III	ME217	ME Lab (Design) I	0	0	2	2	4
2	IV	ME214	Kinematics of Machinery	2	1	0	3	3
3		ME215	Mechanical Measurements and Instrumentation	3	0	0	3	3
4		ME216	Manufacturing Technology II	3	0	0	3	3
5	V	ME313	Dynamics of Machinery	3	0	0	3	3
6		ME314	Applied Thermodynamics	3	1	0	4	4
7		ME315	ME Lab (Manufacturing) II	0	0	2	2	4
9	VI	ME316	Computer-Aided Engineering	1	0	2	3	5
10		ME317	ME Lab (Thermal) III	0	0	2	2	4

Detailed syllabus

Semester II

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

Objectives:

i. Applying their knowledge of 12th level mathematics and physics to solve practical engineering problems dealing with mechanics.
ii. Student will be able to identify the basic principles that govern the dynamics of particles and rigid bodies.
iii. Student will be able to develop various types of loading and support conditions that act on structural system.
iv. Student will be able to extend their knowledge to take on higher level courses in Solid Mechanics, Theory of Machines and Structural Analysis.

Contents:

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

Equilibrium: Free body diagram, equations of equilibrium; problems in two and three dimensions, **(4 lectures + 1 tutorial)**

Structural Mechanics: Simple truss, method of joints, method of sections, frames and simple machines **(4 lectures + 1 tutorial)**

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

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 **(8 lectures + 2 tutorial)**

Energy Methods: Principle of virtual work, principle of minimum potential energy **(3 lectures + 1 tutorial)**

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 **(4 lectures + 1 tutorial)**

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

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 **(3 lectures + 1 tutorial)**

(Total: 37 lectures + 12 tutorials)

Course Outcomes:

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

i. Apply the knowledge of mechanics for solving related application-oriented problems.
ii. Solve fundamental problems related to rigid body mechanics
iii. Gain prerequisite knowledge to take on higher level courses in solid mechanics, structural analysis and mechanical design.
iv. Identify and model various types of loading and support conditions that act on structural systems.

Textbooks:

1. Beer, F.P. & Johnston, F.R. *Mechanics for Engineering*, Tata McGraw Hill, New Delhi, 1986.
2. Shames, I.H. *Engineering Mechanics*, Prentice Hall India, New Delhi, 1997.
3. Timoshenko & Young. *Engineering Mechanics*, 5th Ed., McGraw Hill, New Delhi, 2010.

Reference:

1. Hibbler, R.C. *Engineering Mechanics*, 3rd Ed., McMillan, 2012.
2. Kumar, K.L. *Engineering Mechanics*, 4th Ed., Tata McGraw Hill, New Delhi, 2010.

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

Objectives:

i. To familiarize students with the various types of machines and an understanding different machining operations.
ii. To provide an understanding the physical significations and use of welding and fitting in manufacturing process.
iii. To provide an understanding on different electrical hand tools, machine tools and circuits and introduce them to different type of jobs (such as House Wiring, Switch Board etc.).

Machining: Introducing to various machine tools and demonstration on various machining process. Making jobs as per drawings;
(Contact hour: 7)

Fitting Practices: Study of different vices, power hammer. Making jobs as per drawing;
(Contact hour: 6)

Welding Practice: Introduction to different welding processes. Practice on Oxy-acetylene gas welding and manual metal arc welding;
(Contact hour: 6)

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.
(Contact hour: 7)

(Total: 26 Contact hours)

Course Outcomes:

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

i. Perform machining operations using various manufacturing techniques.
ii. Perform fitting practices using various types of hand tool and fitting techniques.
iii. Perform Oxy-acetylene gas welding and manual metal arc welding on jobs.
iv. Select appropriate electrical hand tools and circuits for the required application and making jobs (such as House Wiring, Switch Board etc.) as per specification.

Textbooks

1. W. A. J. Chapman, *Workshop Technology Part 1*, 5th Edition, CBS, 2001.
2. W. A. J. Chapman, *Workshop Technology Part 2*, 4th Edition, CBS, 2005.

References

1. B. L. Thereja and A. K. Thereja, *A Textbook of Electrical Technology Vol. I*, 23rd Edition, S. Chand, 1959.
2. B. S. Raghuwanshi, *Workshop Technology Vol. 1,* Dhanpat Rai & Sons, 2014.
3. B. S. Raghuwanshi, *Workshop Technology Vol. II* , 11th Edition, Dhanpat Rai & Sons, 2013.
4. B. H. Amstead, P. F. Ostwald and M. L. Begeman, *Manufacturing Process,* 8th Edition, Wiley, 1987.

Semester III

ME201	Solid Mechanics	L-T-P-Cr-CH: 2-1-0-3-3	Prerequisites: ME102

Objectives:

i. To introduce and motivate the students to the subject of Solid Mechanics through real life application examples in Industry and research.
ii. To provide the basic concepts and principles of strength of materials.
iii. To give an ability to calculate stresses and deformations of objects under external loadings such as axial tensile load, thermal load, internal pressure, bending and torsion.
iv. To give an ability to apply the knowledge of strength of materials on engineering applications and design problems.

Contents:

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. **(6 lectures + 2 tutorial)**

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. **(6 lectures + 2 tutorials)**

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. **(4 lectures + 2 tutorial)**

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. **(4 lectures + 2 tutorials)**

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. **(4 lectures + 1 tutorial)**

Deflection of Beams: Introduction, elastic curve, slope and deflection at a point - double integration method, principle of superposition, Macaulay's method, area moment method. **(4 lectures + 2 tutorial)**

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. **(4 lectures + 1 tutorial)**

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

Miscellaneous topics: Unsymmetrical bending, shear center and shear flow. **(3 lectures + 1 tutorial)**

(Total: 38 lectures + 14 tutorials)

Course Outcomes:

On successful completion of this course students will be able to

i. Recognize physical phenomenon in the context of strength of materials
ii. Demonstrate an understanding of the solid mechanics theory for deformable bodies
iii. Apply mechanics of deformable bodies to solve engineering problems
iv. Demonstrate an understanding of the relationships between loads, member forces and deformations and stresses and strains at a material point.
v. Demonstrate an understanding of the assumptions and limitations of the solid mechanics theory
vi. Competence in problem identification, formulation and solution.

Textbooks:

1. Hearn, E.,J., *Mechanics of Materials I*. Butterworth Heinemann, Jordan Hill, Oxford OX28DP, 3rd edition, 1997.
2. Hearn, E.,J., *Mechanics of Materials II*. Butterworth Heinemann, Jordan Hill, Oxford OX28DP, 3rd edition, 1997.
3. Popov, E. P. *Engineering Mechanics of Solids*. PHI Learning, New Delhi, 2nd edition, 2009.

References:

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. & Singer, F. L. *Strength of Materials*. Addision Wesley (AWL), 4th edition, 1999.
3. Timoshenko, S. *Strength of Materials*, (*Vol. I and II*). CBS Publication, New Delhi, 3rd edition, 2004.
4. Hibbeler, R. C., *Mechanics of Materials*, Prentice Hall, 8th edition, 2011.
5. Shames, I. H. and Pitarresi, J. M., *Introduction to Solid Mechanics*, PHI Learning, 3rd edition, 2009.

ME202	Fluid Mechanics I	L-T-P-Cr-CH: 2-1-0-3-3	Prerequisites: ME102

Objectives:

i. Introduce the students to the subject of Fluid Mechanics and its applications in Industry and research.
ii. Train the students to apply the principles of Mechanics for finding different forces on fluid elements.
iii. Introduce the principles and applications of fluid kinematics.
iv. Understand the governing equations of fluid mechanics and learn to apply the same for solving various problems of engineering applications.
v. Introduce the concept and importance of similarity and dimensional analysis.
vi. Make the students capable of applying the Navier-Stokes equations for solving problems on viscous incompressible flows through ducts

Contents:

Introduction: Definition of fluid, concept of fluid continuum, fluid properties (viscosity, surface tension, vapour pressure and compressibility etc.), types of fluid, Newton's Law of viscosity, power law model for non-Newtonian fluid **(2 lectures + 1 tutorial)**

Fluid Statics: 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 **(6 lectures + 3 tutorials)**

Fluid kinematics: Velocity field, description of fluid motion by Lagrangian and Eulerian method, steady and unsteady, uniform and non-uniform flow, laminar and turbulent, material derivative, streamline, path line, streak line, translation, deformation and rotation of fluid element **(4 lectures + 1 tutorial)**

Governing equations and its applications: Conservation of mass, momentum and energy, governing equations in differential and integral form, Reynolds transport theorem, application of momentum theorem for determination of forces on plane and curved surf aces due to impact of liquid jet and on pipe bends due to flow of fluid, Euler's equation and Bernoulli's equation, Application of Bernoulli's equation, measurement of flow through pipes using venturimeter, orificemeter and pitot tube, flow through orifice and mouthpiece **(6 lectures + 2 tutorials)**

Physical similarity and dimensional analysis: Importance, geometric, kinematic and dynamic similarity, dimensional analysis, Buckingham's Pi-theorem with applications, Important dimensionless numbers **(4 lectures + 1 tutorial)**

Potential flow theory: 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 **(4 lectures + 1 tutorial)**

Viscous incompressible flow in duct: Stokes law and determination of viscosity, Navier stokes equations in Cartesian and polar coordinates; exact solution of Navier stokes equations, parallel flow in straight channels, Couette flow and Hagen Poiseuille flow, major and minor loss, friction factor, turbulent pipe flow, Moody's diagram, pipe network analysis of multiple pipe system, Hardy- Cross method
(6 lectures + 3 tutorials)

(Total: 32 lectures + 12 tutorials)

Course Outcomes:

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

i. Apply the knowledge of fluid properties for solving related application-oriented problems.
ii. Calculate the hydrostatic forces on fluid elements and submerged/floating objects.
iii. Evaluate the kinematic parameters of fluids like velocity, acceleration and rotation.
iv. Apply the governing equations of fluid flow to find out the forces due to impact of jet on solid surfaces, and solve problems related to pipe flows and flow-measurements.
v. Apply the principles of physical similarity and dimensional analysis to engineering problems.
vi. Identify the conditions under which exact solutions of the incompressible Navier-Stokes equations can be found and solve viscous incompressible flow problems through ducts.

Textbooks:

1. White, F. M. *Fluid Mechanics*. McGraw-Hill Education, 8th edition, 2015.
2. Chakrabarty, S., Som, S. K. and Biswas, G. *Introduction to Fluid mechanics and Fluid Machines.* Tata McGraw Hill, 3rd edition, 2012

References:

1. Pritchard, P. J. *Fox and McDonald's Introduction to Fluid Mechanics.* John Wiley & Sons Inc., 8th edition, 2011.

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

Objectives:

i Introduce the students to different materials and their various applications.
ii Increase interest on Advanced Materials Engineering.
iii Understand the criteria for selection of materials during Design and Manufacturing.

Contents:

Classification and Properties of Engineering Materials: 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 copper-aluminum- and nickel- based alloys. **(5 lectures)**

Introduction to Ceramic, Polymeric and Composites materials **(5 lectures)**

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

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

Phase Diagrams and Phase Rules: Principles and various types of phase diagrams, Fe- Fe3C diagram, TTT and CCT diagrams, Heat treatment in Steels, Pearlitic, bainitic and martensitic transformations **(8 lectures)**

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

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

Failure of metallic materials: Creep fatigue and fracture phenomena **(2 lectures)**

Basic Ideas of Materials Selection and Design **(5 lectures)**

(Total: 40 lectures)

Course Outcomes:

On the successful completion of the course, the student would be able to:
i Identify the general and advanced Engineering Materials, their properties and applications.
ii Explain the need of advanced and non-conventional materials.
iii Identify the criteria for selection of materials during Design and Manufacturing.
iv Correlate material properties with design considerations.
v Present the outcome carried out in the form of group projects on material characterization and different manufacturing aspects.

Textbooks:

1. Callister, W. D. *Material Science and Engineering - An Introduction.* Wiley, 9th edition, 2002.
2. Dieter, G. E. *Mechanical Metallurgy*. McGraw Hill, 3rd edition, 1988.

References:

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

ME208	Manufacturing Technology I	L-T-P-Cr-CH: 3-0-0-3-3	Prerequisites: ME 203

Objectives:

i Give detailed knowledge in metal casting, metal working and metal joining processes.
ii Correlate different materials with their manufacturing applications.
iii Increase interest on Advanced Manufacturing Technology.
iv Increase interest in automated and non-conventional manufacturing systems.

Contents:

Introduction to manufacturing processes **(2 lectures)**

Casting processes: 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 **(15 lectures)**

Joining Processes: 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 **(10 lectures)**

Metal Forming / working Processes: 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 **(10 lectures)**

Powder metallurgy and its Applications **(3 lectures)**

(Total: 40 lectures)

Course Outcomes:

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

i Gain detailed knowledge on different industrial manufacturing processes, advanced or non-conventional manufacturing systems.

ii Prepare them for advanced workshop practices.

iii Initiate project based on metal casting, metal working and metal joining processes.

iv Can correlate design considerations with manufacturing options.

Textbooks:

1. Campbell, J. S. *Principles of Manufacturing Materials and Processes*. Tata McGraw Hill, 1st edition, 1995.
2. Kalpakjian, S. & Schmid, S.R. *Manufacturing Engineering and Technology*. Pearson/Prentice Hall, 7th edition, 2013.

References:

1. Ghosh, A. & Mallik, A. K. *Manufacturing Science.* East West Press, 2nd edition, 2010.
2. Rao, M. J. *Manufacturing Technology: Foundry, Forming and Welding*. Tata McGraw Hill, 2nd edition, 2009.

ME 217	Mechanical Engineering Laboratory (Design) I	L-T-P-Cr-CH: 0-0-2-3-6	Prerequisites: Nil

Objectives:

i. To understand the physical verification of different theories related to engineering mechanics, solid mechanics, theory of machine and mechanical vibration,

ii. To estimate mechanical properties of material,

iii. To understand the deformation behavior of material,

iv. To understand the kinematic and dynamic characteristics of mechanical device,

v. To design, perform, analyze, and report writing on experiment or on different prototypes of engineering systems as a group.

Contents:

Engineering Mechanics Laboratory:

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. **(5)**

Strength of Material Laboratory:

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). **(7)**

Theory of Machine Laboratory:

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. **(7)**

Vibration Laboratory:

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. **(7)**
(Total: 26 classes)

Course Outcomes: After successful completion of the course, the student

i. will be able to understand the measurement of mechanical properties of materials,
ii. will have understood the importance of fundamental science and engineering skills that are needed in engineering.
iii. will be able to characterize the dynamic behavior of mechanical systems,
iv. will 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.

Semester IV

ME205	**Thermodynamics**	**L-T-P-Cr-CH: 3-1-0-4-4**	**Prerequisites: Nil**

Objectives:

i. To introduce the students to basic thermodynamic laws
ii. Familiarize the students to the idea to be able to heat, work and thermal efficiency and state the different forms of energy.
iii. To be able to apply the steady-flow energy equation or the First Law of Thermodynamics to a system of thermodynamic components (heaters, coolers, pumps, turbines, pistons, etc.) to estimate required balances of heat, work and energy flow.
iv. Orient the students towards ability to estimate thermodynamic properties of substances in gas and liquid states.
v. To be able to apply ideal cycle analysis.

Contents:

Introduction and basic concepts: Basic definitions, thermodynamic systems and control volumes, properties, states, thermodynamic equilibrium, change of state, processes and cycles **(3 lectures+ 1 tutorial)**

Temperature: Zeroth law, thermometers and thermocouple, international temperature scale Energy transfer: Work transfer, pdV and other types of work transfer, heat transfer, specific heat at constant pressure and volume, latent heat, comparison of heat and work **(4 lectures+2 tutorials)**

First law of thermodynamics: 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) **(6 lectures+ 4 tutorials)**

Second law of thermodynamics: 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 **(7 lectures+ 5 tutorials)**

Availability: Definition, quality concept of energy, Reversible work and irreversibility, Exergy balance in closed and open system, Second law efficiency, Guoy Stodola theorem **(4 lectures+ 3 tutorials)**
Properties of pure substance: Definition, p-v, T-s and h-s diagram of pure substance (water), properties of steam, use of steam tables and charts (Mollier diagram) **(3 lectures+ 2 tutorials)**
Introduction to IC Engines: Introduction to Power Cycle: Carnot, Rankine and Modified Rankine Cycle. **(2 lectures+ 2 tutorials)**

(Total: 29 lectures + 19 tutorials)

Course Outcomes:

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

i. Discuss the use of boundaries in open and closed systems.
ii. Define the meaning of the state of a working substance.
iii. Understand concepts of heat, work, and energy.
iv. Explain basic thermodynamic properties and units.
v. Develop and apply the continuity equation for open and closed systems.
vi. Derive and discuss the first law of thermodynamics.
vii. Explain properties of solids, liquids, and vapors.
viii. Use thermodynamic diagrams.
ix. Discuss basic thermodynamic cycles and systems.
x. Apply the second law of thermodynamics to thermal cycles.

Textbooks:

1. Cengel, Y. A. and Boles, M. A. *Thermodynamics, an Engineering Approach*, McGraw-Hill Education, 2014, 8th edition.
2. Nag, P.K. *Engineering Thermodynamics*, Tata McGraw Hill, 2013, 5th edition.

Reference Books:

1. Borgnakke, C. Sonntag, R.E. *Fundamentals of Thermodynamics*, John Wiley & Sons, 2014, 8th edition.
2. Moran,M.J., Shapiro,H.N., Boettner,D.D. & Bailey, M.B., *Principles of Engineering Thermodynamics*, S.I. version, John Wiley & Sons, 2011, 8th edition.

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

Objectives:

i. To introduce the students to the principles and applications viscous laminar and turbulent fluid flows.
ii. To provide an insight into boundary-layer flows.
iii. Familiarize the students with the principles and applications of hydraulic machines
iv. To give exposure of compressible flow problems.
v. Enable the students to solve practical engineering problems related to fluid dynamics
vi. Orient the students towards research fields in experimental and computational fluid dynamics

Contents:

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. **(4 lectures + 2 tutorials)**

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 **(4 lectures + 2 tutorials)**

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 **(9 lectures + 4 tutorials)**

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. **(10 lectures + 5 tutorials)**

(Total: 27 lectures + 13 tutorials)

Course Outcomes:

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

i. Solve and analyze laminar and turbulent-pipe-flow problems.
ii. Solve and analyze laminar and turbulent-boundary-layer problems.
iii. Solve compressible-flow problems involving isentropic flows, flows with normal shocks, flows through converging-diverging nozzles with shocks, compressible-flow problems involving friction and heat transfer.
iv. Carry out performance analysis of Pelton, Francis and Kaplan turbines, reciprocating and centrifugal pumps.
v. Extend the knowledge of dimensional analysis and similitude to the analysis of turbo machines.

Textbooks:

1. White, F. M. *Fluid Mechanics*. McGraw-Hill Education, 8th edition, 2015.
2. Anderson Jr., J. D. *Modern Compressible Flow with Historical Perspective*, 3rd edition, McGraw-Hill Education (India) Pvt. Ltd., 2012.

References:

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 & Sons, 2nd edition, 2002.

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

Objectives: This is a fundamental course for the undergraduate students in Mechanical Engineering. The objectives of the course are

i. to introduce the important concepts like kinematic pairs, degrees of freedom, kinematic chains, kinematic inversions, etc.,
ii. to introduce analytical and graphical methods for kinematic analysis of planar mechanisms,
iii. to introduce various problems related to the dimensional synthesis of the linkages,
iv. to introduce fundamentals of cams and different types of gears and gear trains.

Contents:

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**)

Kinematic Analysis of Plane Mechanisms: Displacement Analysis; Instantaneous Centre of Velocity; Aronhold-Kennedy Theorem of Three Centres; Velocity and Acceleration Analysis (Graphical & Analytical); Velocity and Acceleration Images. (**6L+3T)**

Dimensional Synthesis of Linkages: Two and Three Position Synthesis - Graphical Method, Freudenstein's Equations; Importance of Chebyshev Accuracy Points in Approximate Synthesis. (**3L+2T**)

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)**

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:

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

i. would 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,
ii. would get help while going through higher level courses on machine design and solid mechanics,
iii. would get motivated to take up advanced courses like robotics etc.

Textbooks

1. Uicker, J. J., Pennock G. R. and Shigley J. E. *Theory of Machines and Mechanisms*. Oxford University Press, New Delhi, 3rd edition, 2007.
2. Ghosh, A. and Mallik A. K. *Theory of Mechanisms and Machines*. EWP publications, New Delhi, 3rd edition, 2014.

References

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*. 3rd edition, Wiley, 2016.

ME215	**Mechanical Measurements and Instrumentation**	**L-T-P-CH-CR: 3-0-0-3-3**	**Prerequisites: EL 202 (Electrical Technology)**

Objectives:

i. To introduce students with the fundamentals of measuring devices and provide exposure to various measuring instruments.
ii. To enable the students to solve practical engineering problems related to metrology.
iii. To enable the students to be academically and industrially competitive in assessing and analysing measurement related activities.

Contents:

Introduction to Metrology: 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 **(3)**

Mechanical measurements: Linear measurements, Angular and Taper measurements, Screw thread measurements, Gear measurements, circularity measurements, surface finish, straightness and flatness measurements **(6)**

Assessing Experimental Data: 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 **(4)**

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

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

Sensors and Transducers: Definition, classification and detail description of important transducers **(8)**

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

(Total: lectures 42)

Course Outcomes:

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

i. Learn the basics of metrology.
ii. Identify the problems governing measurements.
iii. Solve practical problems of measurements and instrumentation.
iv. Apply their knowledge in the design and working of measuring instruments and
v. experimental set up.

Textbooks:

1. R.K.Jain, *Engineering Metrology*, 19th ed., Khanna Publishers, New Delhi, 2005.
2. B.C.Nakra & Chaudhury, K.K.Chaudhury, *Instrumentation Measurement and Analysis*, 3rd ed., Tata McGraw Hill, New Delhi, 2009.

References:

1. T.G.Beckwith, R.D. Marangoni & J.H.Lienhard, *Mechanical Measurements*, 6th ed., Pearson Prentice Hall, 2007.
2. J.P.Holman, *Experimental Methods for Engineers*, 6th ed. Tata Mc-Graw Hill, New Delhi, 2001.
3. R.K.Rajput, *Mechanical Measurements and Instrumentation*, S. K. Kataria & Sons, New Delhi, 2012.

ME216	**Manufacturing Technology II**	**L-T-P-Cr-CH: 3-0-0-3-3**	**Prerequisites: ME 208**

Objectives:

i Give detailed knowledge on metal cutting processes.
ii Give detailed knowledge on various machine tools.
iii Give detailed knowledge on automated and non-conventional machining processes.
iv Increase interest on Advanced Machine Tools.

Contents:

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

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

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

Batch production **(2 lectures)**

CNC Machines: NC, CNC, DNC and FMS **(4 lectures)**

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

Rapid prototyping and rapid tooling **(2 lectures)**

(Total: 40 lectures)

Course Outcomes:

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

i Gain detailed knowledge on different industrial machining processes, advanced or non-conventional machining systems.

ii Prepare them for advanced workshop practices.

iii Initiate project based on metal cuttings.

iv Can correlate design considerations with machinability.

Textbooks:

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

References:

1. Hazra Choudhury, S.K., Hazra Choudhury, A.K. & Roy, N. *Elements of Workshop Technology*. Media Promoters & Publishers Pvt. Ltd., 16th edition, Mumbai, 2013.
2. Lal, G.K. *Introduction to machining science*. New Age International Publishers, 3rd edition, New Delhi, 2015.

Semester V

ME308	**Heat and Mass Transfer**	**L-T-P-Cr-CH: 3-1-0-4-4**	**Prerequisites: ME211**

Objectives:

i. To have a sound knowledge about different modes, mechanisms, laws and equations related to heat and mass transfer and its practical applications.

ii. To make the students know about the application of numerical methods in solving heat transfer problems, eg., 1-D, 2-D and 3-D heat conduction, convection and radiation.

iii. To make the learner able to design and model various parts and machineries such as heat exchanger, fin, boiler, condenser etc., involving heat and mass transfer.

iv. To make the foundation of students to perform research work based on the heat and mass transfer related problems in further study.

Contents:

Modes of heat transfer, Conduction; Convection; Radiation, steady and unsteady heat transfer **(1 lecture)**

Fourier law of heat conduction, general heat conduction equation, 1-D and 2-D steady state conduction, conduction though plane and composite wall, critical thickness of insulation, conduction with heat generation, 1-D unsteady conduction-Lumped capacitance and analytical methods **(7 lectures + 3 tutorial)**

Fins, generalized equation for fins, fin performance and design considerations, heat flow through various types of fins (e.g. circular, rectangular and triangular fins) **(5 lectures + 2 tutorial)**

Fundamentals, free and forced convection; external and internal flows; laminar and turbulent flow; Forced convection through pipe and over cylinder, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary layers; dimensional analysis, Nusselt number; Prandtl number, Stanton number, Reynolds-Colburn analogy, Free convection from a vertical, horizontal and inclined plate, Free convection from vertical and horizontal cylinders; heat transfer with phase change (boiling and condensation) **(10 lectures + 3 tutorial)**

Stefan-Boltzmann law; Planck's law; emissivity and absorptivity; radiation heat exchange between black and gray surfaces, Electric network approach for radiation heat exchange, view factor **(6 lectures + 2 tutorial)**

Parallel and counter flow heat exchangers, LMTD and effectiveness-NTU methods of heat exchanger design; correction factor for multipass arrangement, heat transfer enhancement techniques **(5 lectures + 2 tutorial)**

Molecular diffusion; Fick's law; analogy between heat and mass transfer; evaluation of mass transfer coefficients by dimensional analysis **(3 lectures + 1 tutorial)**

(Total: 37 lectures + 13 tutorials)

Course Outcomes:

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

i. The learners will know the mechanisms of conduction, convection and radiation heat transfer with relevant laws and governing differential equations in one and multidimensional forms.
ii. The students will be able to solve steady and transient conduction problems involving simple to complex geometries both analytically and numerically.
iii. The learner will be able to learn and analyse the free and forced convection along with boiling and condensation in the practical applications.
iv. Heat exchanger problems will be able to handle using NTU and LMTD methods.
v. The knowledge of radiation heat transfer such as shape factor, electrical approach and radiation shield will help the learner in performing solar energy related design and modelling.
vi. Students will get a foundation platform to carry out much heat and mass transfer related experimental and computational based projects as well as research works in future.

Textbooks:

1. Incropera, F.P., Bergman, T.L., Dewitt, D.P. and Lavine, A.S. *Fundamentals of Heat and Mass Transfer*. 7th edition, John Wiley and Sons, 2012.
2. Holman, J.P. *Heat Transfer*. 10th edition, McGraw Higher Ed., 2011.

References:

1. Ozisik, M.N. *Heat Transfer-A Basic Approach.* McGraw-Hill International Editions, 1985.
2. Bejan, A. *Convective Heat Transfer*. 4th edition, John Wiley and Sons, 2013.
3. Kreith, F., Bohn, M. and Manglik, R. *Principles of Heat Transfer*, 7th edition, Cengage Learning, 2011.
3. Cengel, Y.A., Ghajar, A.J. and Kanoglu, M. *Heat and Mass transfer.* 4th edition, McGraw Hill Education, 2011.

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

Objectives:

i. To make students familiar with different design and manufacturing considerations.
ii. To teach students how to apply the concepts of stress analysis and theory of failure to analyze and design of machine components
iii. To analyze different forces and stresses acting on machine components and their joints.
iv. To design various machine components and their joints.

Contents:

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**)

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**)

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**)

Design of shafts, keys and couplings: Shaft design for stresses (axial, bending & 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**)

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

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

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

Manufacturing considerations: Standardization, Limits, Fits and Tolerance. (**2L**)
(Total: 26 Lectures + 13 Tutorials)

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

i. to 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.
ii. to analyze and design of structural joints.
iii. to 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.
iv. to understand, identify and quantify failure modes of mechanical parts.
v. to incorporate various manufacturing issues in design, such as limits, fits, and tolerance.

Textbooks:

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.

References:

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

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

Objectives: The main aim of this course is to provide a foundation for the modeling and analysis of dynamic systems. The objectives of the course are

i. to introduce and discuss various methods of formulating the dynamic equations of a given mechanical system,
ii. to discuss the dynamic force and motion analysis of slider-crank mechanism and the balancing of inertia forces and moments in machines in detail,
iii. to introduce one of the simplest mechanical feedback systems in the form of governors,
iv. to introduce the concepts of stiffness and damping and discuss the methods of modeling the spring

and damper elements in a mechanical system in case of single-dof and multi-dof systems,
v. to consider the free and forced response of linear vibratory systems,
vi. to introduce the phenomenon and concepts like beats, critical speed, vibration isolation, etc.

Contents:

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. (**5)**

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. (**7**)

Governor: Types of Governors; Characteristics and Types of Centrifugal Governors; Hunting of Centrifugal Governors, control force diagrams of gravity and spring controlled governors. (**4**)

Balancing of Inertia Forces and Moments in Machines: Balancing of Rotating Masses - Internal and External Balancing, Static and Dynamic Balancing; Multy 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). (**8**)

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). (**11**)

Gyroscopic Actions in Machines: Principle of Gyroscopes; Gyroscopic Forces and Couple; Gyroscopic Stabilization, Application of gyroscope to simple rotating machines, airplane, ship, automobiles etc. (**4**)
(Total: 39 Lectures)

Course Outcomes: After going through this course, the students,

i. would be able to develop a logical framework to analyze a dynamical system,
ii. would be able to develop models of spring and damping elements from the basic principles of mechanics of materials and fluid mechanics respectively,
iii. would be able to develop and solve the equations of motion of single- and multi-degree of freedom physical systems under forced and free conditions,
iv. would be able to 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.

Textbooks

1. Uicker, J. J., Pennock G. R. and Shigley J. E. *Theory of Machines and Mechanisms*. Oxford University Press, New Delhi, 3rd edition, 2007.
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.

References

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.

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

Objectives:

i. To understand the theoretical and fundamental aspects of various thermal power plant components starting from analysis of basic thermodynamic cycle employed to various advanced methods for improving efficiency.
ii. To understand the details about Internal Combustion (IC) engine fundamentals, engine components and their working including engine performance analysis under various design and operating conditions.
iii. To understand the Gas power cycle (Brayton cycle) and various methods used for improvement of cycle efficiency and applications.
iv. To understand the basic working principles of reciprocating and centrifugal compressors and Axial-Flow Gas turbines and their applications in various fields.
v. To study thermodynamic systems such as compressor, refrigeration and air conditioning systems.

Contents:

Brief review on basic knowledge of thermodynamics (1)
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, **(7)**
Steam Generator (Boiler): Different types of boilers, Mountings and Accessories. **(3)**
Condenser: Types of Condensers and their working principle. **(1)**
Steam turbine: Impulse and reaction turbine, compounding of steam turbine, velocity triangle, efficiencies, degree of Reaction, reheat factor, governing of steam turbine. Steam Nozzles. **(8)**
Psychrometry: Properties of moist air: psychrometry and psychrometric charts and processes, cooling towers. **(3)**
Refrigeration: Vapor compression refrigeration cycle - in T-s and P-h plots, multi-pressure system, and Desirable properties of refrigerants. **(2)**
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 **(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. **(7)**
Introduction to jet propulsion: Turbojet, turbofan, turboprop engines **(1)**
Reciprocating air compressors: Components and working principle, Process representation in p-V plane, calculation of work done, and multistage compression with intercooling. **(5)**
Introduction to Centrifugal and Axial-Flow Compressors: (5) **Break-up of lectures and tutorials to be provided**

(Total: 39 lectures + 13 tutorials)

Course Outcomes:

The contents which are covered in Applied Thermodynamics are very relevant to industries employing all these thermal systems particularly thermal power plants, Gas based plant systems, IC engines, refrigeration and air conditioning systems.
Students will get exposure to the basic underlying principles behind these systems which will add to the scientific knowledge base and help them in future in process innovations when they work in the relevant industries as professionals.

The Course Outcomes are to be written in bulleted form.

Textbooks

1. Cengel, Y.A. & Boles, M.A. *Thermodynamics, An Engineering Approach*, 5th ed., Tata McGraw Hill, New Delhi, 2006
2. Nag, P.K. *Basic and applied thermodynamics*, 2nd ed., Tata McGraw Hill, New Delhi, 2010.
3. Nag, P.K. *Power plant Engineering*, Tata McGraw Hill, New Delhi, 2008.

Reference Books

1. Borgnakke, C. & Sonntag R.E. *Fundamentals of Thermodynamics*, 8th ed., John Wiley & Sons, 2013.

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

Objectives:

i. To provide an understanding of manufacturing methods through metal cutting, machining and welding.
ii. To get an idea of the dimensional & form accuracy of products.

Contents:

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.

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.

Welding Process:

- Gas Welding (Oxy acetylene Welding)
- Shielded metal arc welding – selection of welding parameters, electrodes.
- Soldering
- Brazing

Manufacturing Automation:

- NC, CNC, CAM, FMS
- NC part programming
- Simulation and manufacturing

The number of contact hours per module is to be specified.

Course Outcomes:

Upon completion of this course, students will be able to

i. Perform machining using various manufacturing techniques.
ii. Evaluate the accuracy & tolerance of components produced.
iii. Perform metal arc welding operations on jobs.
iv. Understand the advanced manufacturing techniques such as NC and CNC and write their part programming.

Textbooks

1. Chapman, W.A.J. *Workshop Technology Vol. I & II*, 5th ed., Arnold publishers, New Delhi, 1972.
2. Raghuwanshi, B.S. *Workshop Technology Vol. I & II*, 10th ed., Dhanpat Rai & Sons, New Delhi, 2009.

Reference Books

1. Hazra Choudhury, S.K. Hazra Choudhury A.K. & Roy N. *Elements of Workshop Technology*, 12th ed., Media Promoters & Publishers Pvt. Ltd., Mumbai, 2007.
2. Ghosh, A & Mallik, A.K., *Manufacturing Science*, 2nd ed., East-West Press, New Delhi, 1998.
3. Boothroyd, G & Knight, W.A. *Fundamentals of Metal machining and Machine Tools*, 3rd ed., CRC press, Boca Raton, 2005.
4. Kalpakjian, S & Schmid, S.R., *Manufacturing Engineering and Technology*, 4th ed., Pearson Education, New Delhi, 2001.

Semester VI

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

Objectives:

i. An overview of code, standards and design guidelines for mechanical design.
ii. Ability to the design of machine components and systems.
iii. Improve problem solving and decision making abilities.
iv. An appreciation of parameter optimization and design iteration.
v. Importance of the use of lubricant at the contact surface in mechanical systems.

Contents:

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

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**)

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

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**)

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**)

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

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

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

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

Introduction to the computer aided design. (**1L**)
(Total: 39 Lectures)

Course Outcomes: Upon completion of this course, students will be able

i. to analyze stress and strain in machine components, in particular brake, clutch, power screw, gears and bearing under different loading conditions.
ii. to design different machine components and explain the failure of such components.
iii. to recognize the need for friction drives and positive drives
iv. to determine load carrying capacity and related parameters of bearing.
v. to predict the frictional behaviour at the sliding interface in mechanical system.

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Textbooks:

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

References:

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. V. Ramamurti, *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.

ME316: Computer-Aided Engineering

ME317	**Mechanical Engineering laboratory-III**	**L-T-P-Cr-CH: 0-0-4-4-2**	**Prerequisites: ME205, ME202, ME209**

Objectives:

i. To discuss and practice standard measurement techniques of fluid mechanics and their applications

ii. Determination of amount of heat transfer in various modes of heat including condensation and boiling

iii. Familiarize the basic working principle and components of vapour compression, vapour absorption refrigeration system.

iv. To cover the terminology associated with psychrometry.

Content:

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 **(8)**

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 **(6)**

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. **(9)**

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. **(4)**

(Total: 27 practical classes)

Course Outcomes:

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

i. Understand and apply the laws of fluid mechanics to practical applications

ii. Understand the basic laws of heat transfer.

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

iv. Understand the working of refrigeration system and psychometric processes.

Textbooks

1. Chakrabarty, S., Som, S. K. & Biswas, G. *Introduction to Fluid mechanics and fluid machines*, 3rd ed., Tata McGraw Hill, 2012
2. Massey, B.S. *Mechanics of fluids*, 7th ed., Taylor and Francis, 2006.
3. Incropera, F.P. & Dewitt D.P. *Fundamentals of Heat and Mass Transfer*, 5th ed., John Wiley and Sons, 2009.
4. Stoecker, W.F and Jones, J.W., *Refrigeration and Air Conditioning*, 3rd ed ,McGraw-Hill International Editions, 1986

Reference Books

1. White, F. M. *Fluid Mechanics*, 7 th ed., Tata McGraw Hill, 2010
2. Kundu, P.K. Cohen, I.M. & Dowling, D.R. *Fluid Mechanics*, 5th edition, Elsevier, 2012
3. Ozisik, M.N. *Heat Transfer-A Basic Approach*, McGraw Hill, 1985.
4. Bejan, A. *Convective Heat Transfer*, 3rd ed., John Wiley and Sons, New York, 2004.
5. Arora, C.P. *Refrigeration and Air Conditioning*, 2nd ed., Tata McGraw-Hill, 2000.

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

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.

Semester VII

ME401	**Industrial Systems Engineering**	**L-T-P-Cr-CH: 3-0-0-3-3**	**Prerequisites: Nil**

Objectives:

i. Applying their knowledge of mathematics in solving practical industrial engineering problems dealing with forecasting, breakeven analysis and network analysis.
ii. Introduce the basic principles that govern the principles of product design, plant layouts, and value analysis.
iii. Establish the underlying principles related to mechanisms of Maintenance planning, Quality control and Inventory control.
iv. Student will be able to extend their knowledge to take on higher level problems related to operations research.

Contents:

Industrial Engineering: Introduction, Production Planning and Control, Product design, Value analysis and value engineering, Plant location and layout, Equipment selection (**3 lectures)**

Concepts of maintenance and its philosophy (Breakdown maintenance, preventive maintenance, predictive maintenance, total productive maintenance, world class maintenance), Maintenance planning (**7 lectures)**

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 control- deterministic model only (**8 lectures)**

Manufacturing planning: MRP, MRP-II, JIT, CIM, Quality control - Statistical process control, Acceptance sampling, Total quality management, Taguchi's Quality engineering; (**5 lectures)**

Forecasting, Scheduling and loading, Line balancing, Break-even analysis (**6 lectures)**

Operation research: Introduction to operations research, linear programming, Graphical method, Simplex method, Dual problem -statement, Transportation problems and Network models: CPM and PERT, Queuing theory – basic concepts and a simple model (**11 lectures)**

(Total: 40 lectures)

Course Outcomes:

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

i. Explain the basic underlying concepts of product design, plant layouts, and value analysis.
ii. Create and solve problems related to Forecasting, Scheduling, Network analysis and Breakeven analysis.
iii. Explain the mechanisms of Maintenance planning, Quality control and Inventory control.
iv. Apply and analyze various techniques of sales forecasting for solving industrial problems.
v. Analyze problems related to operations research.

Textbooks

1. Narasimhan, S.L. McLeavey, D.W. & Billington, P.J. *Production, Planning and Inventory Control*, Prentice Hall, 1997
2. Riggs, J.L., *Production Systems: Planning, Analysis and Control*, 3rd ed., Wiley, 1981.

Reference Books

1. Muhlemann, Oakland, J & Lockyer, K. *Productions and Operations Management*, Macmillan, New Delhi, 1992.
2. Taha, H.A., *Operations Research - An Introduction*, Prentice Hall of India, New Delhi, 1997
3. Sharma, J.K. *Operations Research*, Macmillan, New Delhi, 1997.

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

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.

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

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.

Semester VIII

ME484	**Project II**	**L-T-P-Cr-CH: 0-0-8-8-18**	**Prerequisites: ME483**

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.