Semester IV						
S.No	Course Code	Course Name	L	T	P	C
1	ME 208	Mechanical Measurements	3	0	0	6
2	ME 202	Engineering Materials	2	1	0	6
3	ME 309	Theory of Machines	2	1	0	6
4	ME 220	Heat Transfer	2	1	0	6
5	MA 407	Introduction to Numerical Linear Algebra (1st Half)	3	1	0	4
6	ME 224	Fluid Mechanics Laboratory	0	0	3	3
7	EE 226	Control Systems and Laboratory	2	0	2	6
		Total Credits				37

1	**Title of the course** (L-T-P-C)	**Mechanical Measurements** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	1. **Introduction**: generalized measurement system, static calibration, calibration, random errors, uncertainty analysis, dynamic characteristics. Zero, first and second order measurement systems. 2. **Temperature measurement**: Introduction to temperature measurement. Thermocouples: laws governing their use; Static and Dynamic characteristics. Other measurement techniques. 3. **Pressure measurement**: Manometers, elastic transducers, static and dynamic characteristics. Other devices for measurement. 4. **Flow measurement**: obstruction meters, variable area meters, velocity measurement. 5. **Strain measurement:** electrical type strain gauges, metallic resistance strain gauge, selection and installation of strain gages, circuitry for strain measurement, temperature compensation, calibration, semi-conductor strain gauges, stress analysis methods 6. **Force and torque measurement:** standards, elastic transducers, strain gage load cells, hydraulic and pneumatic systems, torque measurement, combined force and moment measurement. 7. **Measurement of motion**: LVDT, general theory of seismic instruments, vibrometers and accelerometers, piezoelectric accelerometers and vibrometers-circuitry and calibration, exciter systems, vibration test methods. 8. **Signal conditioning:** Operational amplifiers, filters. 9. **Sampling, and data acquisition:** Sampling concepts, Bits and words, number systems, Analog to digital conversion and digital to analog conversion, data acquisition systems and components, analog input/output communication, Digital input/output communication.
4	**Texts/References**	1. Measurement systems: Application and Design, “E.O. Doebelin, Fourth Ed., 1990, McGrawHill. 2. Richard S. Figliola and Donald E. Beasley, Theory and Design for Mechanical Measurements, John Wiley and Sons.

1	**Title of the course** (L-T-P-C)	**Engineering Materials** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	• Economic, Environmental and Societal Issues in Materials Science & Engineering • Basic Materials Science: Crystallography, phase diagrams, • grain boundaries, dislocation movements and their effects on Properties • Material properties: Stress-strain relationships, Tensile • strength, Toughness, Impact Strength, Ductility, Malleability, • Stress intensity, Fatigue • Failure: by Oxidation, Corrosion (Types, impact on material • Strengthening mechanisms: Solute Hardening, chemical hardening, dispersion hardening, Aluminium alloys: Properties, phase diagrams and uses • Copper alloys: Properties phase diagrams and uses • Ferrous Alloys (Steels): Types, properties, iron-carbon • phase diagrams • Material Selection: Ashby Charts • Ceramics: Structure and Properties, Mechanical Properties • of Ceramics, Types and Application of Ceramics, Fabrication and Processing of Ceramics • Polymers: Molecules, Structures and Shapes, Thermosetting & Thermoplastic, Polymer Crystals, Polymer Characteristics • and Applications, Synthesis, Processing and Degradation. • Composites: Processing of Fiber Reinforced Composites, • Structural Composites, Application of Compositescold working, strain Hardening
4	**Texts/References**	**TEXTBOOKS** **1.** W.D. Callister, Jr. & D.G. Rethwisch: 'Materials science and Engineering: An Introduction', 9th Ed., John Wiley (2014) **2.** W.F.Smith and J.Hashemi: 'Foundations of Materials Science and Engineering', 5th Ed., McGraw-Hill(2009). **REFERENCES** **1.** D.R.Askeland, P.P.Phule& W.J. Wright: 'The Science and Engineering of Materials' 7th Ed., Cengage Learning(2014). **2.** V.Raghavan: Materials Science and Engineering: A First Course' 6th Ed. PHI(2015). **3.** J.F. Shackeford: 'An Introduction to Materials Science for engineers' 8th Ed., Pearson (2016) **4.** R.A.Higgins: 'Properties of Engineering Materials' 2nd Ed., Industrial Press (1994). **5.** T.Fishcher: 'Materials Science for Engineering Students', Academics Press (2009). **6.** V.Raghavan: 'Physical Metallurgy: Principles and Practice' 3rd Ed., PHI (2015).

1	**Title of the course** (L-T-P-C)	**Theory of Machines** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	**Introduction**: Definitions Link or element, kinematic pairs, Degrees of freedom, Grubler's criterion (without derivation), Kinematic chain, Mechanism, Structure, Mobility of mechanism, Machine. Kinematic Chains and Inversions: Inversions of Four bar chain; Single slider crank chain and Double slider crank chain **Velocity and Acceleration Analysis of Mechanisms (Graphical & Analytical Methods)**: Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms **Gears:** Gear terminology, law of gearing, Characteristics of involute action, Path of contact. Arc of contact, Contact ratio Interference in involute gears. Methods of avoiding interference, Back lash. Gear Trains: Simple gear trains, Compound gear trains for large speed. reduction, Epicyclic gear trains, Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains **Cams:** Types of cams, Types of followers. Displacement, Velocity and, Acceleration time curves for cam profiles. Disc cam with reciprocating follower having knife-edge, roller and flat-face follower, Disc cam with oscillating roller follower. Follower motions including SHM, Uniform velocity, uniform acceleration and retardation and Cycloidal motion **Static & Dynamic Force Analysis**: Introduction: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams. Static force analysis of four bar mechanisms and slider-crank mechanism without friction. D'Alembert's principle, Inertia force, inertia torque. Dynamic force analysis of four-bar mechanism and slider crank mechanism. Dynamically equivalent systems **Balancing of Rotating Masses**: Static and dynamic balancing. Balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes **Balancing of Reciprocating Masses**: Inertia effect of crank and connecting rod, single cylinder engine, balancing in multi cylinder-inline engine (primary & secondary forces), V-type engine; Radial engine – Direct and reverse crank method **Introduction to Vibrations**
4	**Texts/References**	**1.** B. Paul, Kinematics and Dynamics of Planar Mechanisms, Prentice Hall, 1979. **2.** J.J. Uicker, G.R. Pennock, and J.E. Shigley, Theory of Machines and Mechanism (3rd edition), Oxford University Press, New York, 2005. **3.** S.S. Rattan, Theory of Machines (2nd edition), Tata McGraw Hill, New Delhi, 2005. **4.** R.L. Norton, Design of Machinery (3rd edition), Tata McGraw Hill, New Delhi, 2005.

1	**Title of the course** (L-T-P-C)	**Heat Transfer** **(2-1-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	• Introduction: Typical heat transfer situations, Modes of heat transfer, Introduction to laws, some heat transfer parameters • Conduction: Fourier's law and thermal conductivity, Differential equation of heat conduction, boundary conditions and initial conditions, Simple one dimensional steady state situations – plane wall, cylinder, sphere (simple and complex situations), concept of thermal resistance, concept of U, critical radius. variable thermal conductivity (exercise), Special one dimensional steady state situations: heat generation, pin fins, Other fin configurations (exercise), Two dimensional steady state situations, Transient conduction, Lumped capacitance model, One dimensional transient problems: analytical solutions, 1D Heisler charts, Product solutions, Numerical methods in conduction, Steady state 1D and 2D problems, 1D transient problems: Explicit and implicit • Radiation: Basic ideas, spectrum, basic definitions, Laws of radiation, black body radiation, Planck's law, Stefan Boltzman law, Wien's Displacement law, Lambert cosine law, Radiation exchange between black surfaces, shape factor, Radiation exchange between gray surfaces – Radiosity-Irradiation method, Parallel plates, Enclosures (non-participating gas), Gas radiation Forced Convection: Concepts of fluid mechanics, Differential equation of heat convection, Laminar flow heat transfer in circular pipe: constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere, flow across banks of tubes, impinging jets • Natural Convection: Introduction, governing equations, Vertical plate – Pohlhausen solution, horizontal cylinder, horizontal plate, enclosed spaces Heat Exchangers: Types of heat exchangers, LMTD approach – parallel, counter-flow, multi-pass and cross flow heat exchanger, NTU approach: parallel, counter- flow, shell and tube, cross flow heat exchanger Condensation and Boiling: Dimensionless parameters, boiling modes, correlations, forced convection boiling, laminar film condensation on a vertical plate, turbulent film condensation • Mass Transfer: Analogy between heat and mass transfer, mass diffusion, Fick's law of diffusion, boundary conditions, steady mass diffusion through a wall, transient mass diffusion, mass convection, limitations of heat and mass transfer analogy.
4	**Texts/References**	**1.** Incropera FP and Dewitt DP, Fundamentals of Heat and Mass Transfer, 5th e, John Wiley & Sons, 2010. **2.** Cengel YA, Heat and Mass Transfer - A Practical Approach, Third edition, McGraw-Hill, 2010. **3.** Holman JP, Heat Transfer, McGraw-Hill, 1997.

1	**Title of the course** (L-T-P-C)	**Introduction to Numerical Linear Algebra (3-1-0-4)**
2	**Pre-requisite courses(s)**	Calculus, MA 101 & Linear Algebra, MA 106
3	**Course content**	Floating point number system, Big O notation Matrix and vector norms, ill conditioned problems Solution of a system of linear equations, Gauss elimination, LU factorization, Cholesky method, Classical iterative methods: Jacobi and Gauss-Seidel Eigenvalue problems, Power method, QR method, Gershgorin theorem. Exposure to MATLAB
4	**Texts/References**	S. D. Conte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic Approach (3rd Edition), McGraw-Hill, 1980

1	**Title of the course** (L-T-P-C)	**Fluid Mechanics Lab** **(0-0-3-3)**
2	**Pre-requisite courses(s)**	Exposure to Fluid Mechanics
3	**Course content**	**List of Experiments:** • Stability of floating bodies for determining the metacentre and buoyancy • Reynolds experiment for laminar/turbulent flow visualisation • Measurement of discharge coefficient for different shaped orifices with varying head • Demonstration of Bernoulli's principle • Visualisation of Free and Forced vortices • Demonstration of linear momentum and impact forces of Jet for different deflection angles • Pressure loss in pipe friction for laminar/turbulent flow • Minor losses in Pipe system (fittings: bend, elbow, contraction/expansion) • Major losses in Pipe system: Effect of pipe material, dimensions • Fluidized Granular Bed • Submerged Jet • Flow Measurement by Venturi-meter, Orifice-meter & Rota-meter • Heleshaw Apparatus • Hydraulic Jump • Course project set-up
4	**Texts/References**	**1.** Yunus A. Cengel, John M. Cimbala, Fluid Mechanics, Tata McGraw Hill Education, 2011. **2.** F.M.White, Fluid Mechanics, Seventh Edition, Tata McGraw Hill Education, 2011. **3.** Philip J.Pritchard, Alan T.Mcdonald,RobertW.Fox, Introduction to Fluid Mechanics, Wiley, 2009. **4.** John F. Douglas, J. M. Gasoriek, Lynne Jack and John Swaffield, Fluid Mechanics, Pearson, 2008.

1	**Title of the course** (L-T-P-C)	**Control Systems and Laboratory** **(2-0-2-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	• **Basic concepts:** Notion of feedback, open- and closed-loop systems. • **Modeling and representations of control systems:** Transfer function models of for suitable mechanical, electrical, thermal and pneumatic systems, Ordinary differential equations, Transfer functions, Block diagrams, Signal flow graphs, State-space representations. • **Performance and stability:** Time-domain analysis, Second-order systems, Characteristic-equation and roots, Routh-Hurwitz criteria. • **Basic modes of feedback control:** Proportional, Integral, Derivative. • **Root locus** method of design. • **Frequency-domain techniques:** Root-locus methods, Frequency responses, Bode-plots, Gain- margin and phase-margin, Nyquist plots. • **Compensator design:** Proportional, PI and PID controllers, Lead-lag compensators. • **State-space concepts:** Controllability, Observability, pole placement result, Minimal representations. Laboratory involves set of experiments following the theory component covered in the class
4	**Texts/References**	**1.** Norman Nise, Control System Engineering, Wiley, 6th Edition, 2011 **2.** K. Ogata, Modern Control Engineering, Pearson, 5th edition, 2010. **3.** Gene franklin et. al., "Feedback Control of Dynamic Systems", 7th Edition, Pearson **4.** B. Kuo, Automatic Control System, Wiley, 9th Edition, 2014