Mechanical Engineering Department

Semester - VI

Teaching Scheme

Course Code	Course Name	Lecture hours	Tutorial hours	Practical hours	Credit
HS 3001	Introduction to Economics	3	0	0	4
ME 3006#	Theory of Machines & Mechanisms	3	1	2	5
ME 3007	Refrigeration & Air − Conditioning	3	1	2	5
ME 3008#	CAD/CAM	2	1	3	4
ME 3009	Automotive Systems	3	0	2	4
ME 3010	Operations Research & Project Management	3	1	0	4
	Total	**17**	**4**	**9**	**26**

The curriculum locations of ME 3006 and ME 3008 will be exchanged with Semester V subjects ME 3004 (Introduction to Machine Design) and ME 3005 (Dynamics & Vibration) from Academic Year 2017 − 18.

Mechanical Engineering Department

Semester : VI

I	Course Code	**HS 3001**			
II	Course Title	**Introduction to Economics**			
III	Credit Structure	L	T	P	C
		3	0	0	4
IV	Prerequisite (if any for the student)	None			
V	Course Content	Exploring the subject matter of Economics, Supply and Demand: How Markets Work, Markets and Welfare, The Households, The Firm and Perfect Market Structure, Imperfect Market Structure, Input Markets, Exploring International Economics, Introduction to Macroeconomics, Introduction to National Income Accounting, The Classical System: The Full-Employment Model, The Simple Keynesian Model, Money in the Modern Economy, In ation, Exploring the Macroeconomics of an Open Economy			
VI	Text/Reference Books	1. Karl E. Case and Ray C. Fair (2007), Principles of Economics, 8th edition, Pearson Education Inc., ISBN 81-317- 1587-6 (hereafter Case & Fair, 2007, 8e). 2. Joseph E. Stiglitz and Carl E. Walsh (2006), Economics, International Student Edition, 4th Edition, W.W. Norton & Company, Inc., New York, ISBN 0-393- 92622-2 (hereafter Stiglitz & Walsh, 2006, 4e). 3. N. Gregory Mankiw (2007), Economics: Principles and Applications, 4th edition, India edition by South-Western, a part of Cengage Learning, Cengage Learning India Private Limited, ISBN-13:978-81-315-0577-9 (hereafter, Mankiw, 2007, 4e).			

Mechanical Engineering Department

Semester : VI

I	Course Code	**ME 3006**			
II	Course Title	**Theory of Machines & Mechanisms**			
III	Credit Structure	L	T	P	C
		3	1	2	5
IV	Prerequisite (if any for the student)	None			
V	Course Objective	This course introduces students to the basic concepts of mechanisms and machines and their kinematic analysis. The theoretical foundation, upon which advanced courses such as Machine Design, Dynamics and Vibration, and Robotics are built, is developed.			
VI	Course Content	**Introduction:** Definitions of Machine, Mechanism, Links, and Pairs; Classification of Mechanisms; Mobility − Kutzbach Equation and Grübler's Criterion; Kinematic Inversion; Grashof's Law **Kinematic Analysis and Synthesis:** Position and Displacement, Velocity, Acceleration − Graphical and Analytical Methods; Coupler-Curve Generation; Instantaneous Centres of Velocity and Acceleration; Aronhold-Kennedy Theorem of Three Centres; Type, Number and Dimensional Synthesis; Function Generation, Path Generation, and Body Guidance; Coupler Curve Synthesis **Cams, Gears, and Mechanism Trains:** Classification of Cams and Followers, Displacement Diagrams, Graphical Layout of Cam Profiles, Standard Cam Motions; Fundamental Law of Toothed Gearing, Spur Gears, Helical Gears, Bevel Gears, Worms, and Worm Gears; Parallel-Axis Gear Trains, Epicyclic Gear Trains, Differentials **Introduction to Robotics:** Kinematics of Open Chains, Topological Arrangement of Robotic Arms, Forward and Inverse Kinematics **Laboratory Work:** Graphical Analysis of Selected Planar Mechanisms; Cams and Gears; Computer Modelling; Mechanism Design Group Project			
VII	Textbooks/ References	1. John J. Uicker Jr., Gordon R. Pennock, and Joesph E. Shigley, Theory of Machines and Mechanisms, Fourth Edition (International Version), Oxford University Press, 2015. 2. Amitabha Ghosh, and Ashok K. Mallik, Theory of Mechanisms and Machines, Third Edition, East West Press Private Limited, 1998. 3. Robert L. Norton, Kinematics and Dynamics of Machinery, First SI Edition, McGraw Hill Higher Education, 2008. 4. S. S. Rattan, Theory of Machines, Fourth Edition, McGraw Hill Higher Education, 2014.			
VIII	Course Outcome	Upon completion of this course, students will be able to use graphical, analytical, as well as basic computational approaches to synthesize planar and simple spatial mechanisms. They will be well equipped to tackle advanced topics involving design and analysis of robots and robotic manipulators.			

Mechanical Engineering Department

Semester : VI

I	Course Code	**ME 3007**			
II	Course Title	**Refrigeration & Air-Conditioning**			
III	Credit Structure	L	T	P	C
		3	1	2	5
IV	Prerequisite (if any for the student)	Knowledge of basic thermodynamics and thermodynamic cycles.			
V	Course Objective	The course is designed to give an in-depth study of theory of advanced refrigeration and air-conditioning and their applications. The techniques of analysis and design of refrigeration and air conditioning systems will also be discussed. This course will help the students to understand the underlying principles of operations in different Refrigeration & Air conditioning systems and components. It will also provide knowledge on design aspects of Refrigeration & Air conditioning systems.			

VI	Course Content	Introduction & Review, the second law interpretation, the Carnot principle, Limitation of Carnot cycle, COP, Refrigerants, Designation of refrigerants, comparative study, selection of refrigerant, Chemical and physical requirements. Gas cycle refrigeration, reversed Brayton cycle, Aircraft refrigeration, Joule-Thomson coeffi- cient and inversion curve, reversed Stirling cycle, air liquefaction. Vapour compression system, Limitations and Modification in reversed Carnot Cycle, Vapour compression cycle, Vapour compression system calculation, Effect of operating conditions on Vapour compression cycle. Actual Vapour compression cycle, Multi stage compression, Multi evaporative systems, Cascade systems, Dry Ice. Introduction and analysis to CO2 trans-critical cycle. Refrigeration components, Compressors, Principle and performance of reciprocating compressor, rotary and centrifugal compressors, selection criteria of compressor in refrigeration. Condensers Types, Heat transfer in condensers, Wilson's plot. Evaporators Types, Heat transfer in evaporators, augmentation of boiling heat transfer. Expansion Valves, Types of expansion devices, constant pressure and thermostatic expansion valve, capillary tube design. Vapor absorption system, Single effect water - Lithium Bromide absorption chiller, Vapour absorption system, Double effect H2O-LiBr2 absorption system, Electrolux refrigerator. Psychrometry of air-conditioning processes, Psychrometric properties, psychrometric chart, Basic processes in conditioning of air, Psychrometric processes in air-conditioning equipment, cooling tower, Summer air-conditioning, Winter air-conditioning. Analysis of cooling towers. Load Calculations – Cooling & Heating, Design conditions, solar radiations, heat transfer through building structure, Heat gains, cooling and heating load estimate, Psychrometric calculations and selection of air-conditioning apparatus cooling and dehumidification. Transmission and distribution of air, Friction loss and dynamic losses in ducts, Air ow through simple duct system, air duct design Transmission and distribution of air in rooms, centrifugal and axial ow fans and fan arrangements. Application of Refrigeration & Air Conditioning Systems, Food processing by refrigeration and storage, transportation refrigeration, Cooling and heating of foods, freeze drying and heat drying of foods. **Laboratory Experiments:** 1. Experiments on Vapour compressor system with Multi Condenser, Multi Evaporator Multi, and Expansion Valve to Conduct COP 2. Experiment on Ice plant. 3. Experiments on Heat pump with vapour compression systems. 4. Experiments on Trans-critical CO2 refrigeration systems for heating cooling. 5. Experiments on Vapour Absorption system. 6. Experiments on Cooling tower experiments. 7. Experiments on Air conditioning Experiments for year round application with direct and indirect operation. 8. Study / demonstration of actual domestic refrigerator and Air conditioning

VII	Course Outcome	Upon completion of this course, the students can demonstrate the operations in different Refrigeration & Air conditioning systems and also be able to design Refrigeration & Air conditioning systems.
VIII	Textbooks/ References	1. Arora, C.P., Refrigeration and Air Conditioning, 3rd edition, McGraw Hill, New Delhi, 2012. 2. Roy J. Dossat, Principles of Refrigeration, 4th edition, Pearson Education Asia, 2009. 3. Stoecker, W.F. and Jones J. W., Refrigeration and Air Conditioning, McGraw Hill, New Delhi, 1986. 4. ASHRAE Hand book, Fundamentals, 2012. 5. Jones W.P., Air conditioning engineering, 5th Edition, Elsevier Butterworth-Heinemann, 2001. 6. Manohar Prasad, Refrigeration and air-conditioning, Wiley Eastern Ltd, 1983. 7. Edward G. Pita, Air Conditioning Principles and Systems, 4th Ed., Pearson Education Asia, 2003.

Mechanical Engineering Department

Semester : VI

I	Course Code	**ME 3008**			
II	Course Title	**CAD/CAM**			
III	Credit Structure	L	T	P	C
		2	1	3	4
IV	Prerequisite (if any for the student)	None			
V	Course Objective and Scope	1.Basic introduction on hardware and software requirement of CAD. 2.Understand the mathematical and physical principles underlying geometric modelling. 3.Complete practical exposure on geometric modelling using CAD modelling tools. 4.Understanding in brief about Computer aided manufacturing.			
VI	Course Content	**Computer Aided Design** 1. Introduction of Computer Aided Design; The Design Process 2. Product Life Cycle; Application of CAD 3. Hardware Requirements of CAD: Principles of interactive computer graphics; Overview of hardware available for use in CAD 4. Geometric Modeling – Curves: Types of mathematical representation of curves; Analytical Curves – Lines, Circle, Ellipse, Parabola, Hyperbola; Synthetic Curves – Hermite cubic splines, Bezier Curves, B-splines, NURBS 5. Geometric Modeling – Surfaces: Analytical Surfaces; Surfaces of Revolution; Mathematical Representation of Surfaces, Surface Model, Surface Entities, Surface Representation; Parametric Representation of Surfaces, Plane Surface, Rule Surface; Surface of Revolution; Tabulated Cylinder 6. 6. Solid Modeling: Solid Representation; Boundary Representation (B-rep); Constructive Solid Geometry (CSG) 7. 2-D and 3-D Geometric Transformations: Translation, Rotation, Scaling; Mirror Concatenation; Coordinate Tranformations **Computer Aided Manufacturing** 1. Product Data Exchange: Graphics Standards – GKS, Bitmaps, Open GL; Data Standards – IGES, STEP, CALS, DXF, STL; Communication Standards – LAN, WAN 2. Engineering Tolerance and Geometric Tolerance 3. Computer Aided Process Planning: CAPP Benefits, Models, Approach; Hybrid CAPP 4. Computer Integrated Manufacturing: Integrating CAD/CAM/NC; Machine Tools; NC Programming; Tool Path Generation; Tool Path Verification			

VII	Textbooks/ References	1. Rogers D. F. and J. A. Adams, "Mathematical Elements of Computer Graphics", Tata McGraw-Hill, New York, 2004. 2. Ibrahim Zeid, "Mastering CAD/CAM", Tata McGraw-Hill, New Delhi, 2005. 3. P. Radhakrishnan, S. Subramanyan, V. Raja, "CAD/CAM/CIM" New Age international Publishers. 4. CAD/CAM by Chirs McMohan and Jimmy Browne, Pearson.

Mechanical Engineering Department

Semester : VI

I	Course Code	**ME 3009**			
II	Course Title	**Automotive Systems**			
III	Credit Structure	L	T	P	C
		3	0	2	4
IV	Prerequisite (if any for the student)	None.			
V	Course Content	1. General layout of automobile, Engine classification, Engine geometry Brake Performance, Indicated Performance, Friction Relationships among performance parameters, Constant volume (Otto) Constant pressure (Diesel) Limited pressure (Dual) Comparisons of ideal cycle results. 2. Air and Fuels Combustion Stoichiometry Dissociation Equilibrium combustion products Practical chemical equilibrium First law analysis of closed reacting systems Heating value and enthalpy of formation Adiabatic ame temperature First law analysis of open reacting systems Combustion efficiency, Fuel/Air Cycle Analysis. 3. SI Engine Fuel System: Carburettor working principle. Requirements of an automotive carburettor; Starting, idling, acceleration and normal circuits of carburettors, compensation, Maximum power devices, constant choke and constant vacuum carburettors. Fuel feed systems, Mechanical and electrical pumps. Petrol injection. 4. Spark-Ignition Engine Combustion Features of process Flame structure and propagation Factors affecting burning rate Abnormal combustion and knock Combustion chamber design, Nature and extent of SI engine Emissions problems and control strategies. 5. Cooling and Lubrication System: Need for cooling system. Types of cooling system, Liquid cooled system, Thermosyphon system, Pressure cooling system. Lubrication system, Mist lubrication system, Wet sump and dry sump lubrication. Properties of lubricants. Properties of coolants. 6. Fuel Injection System: Requirements, Air and solid injection, function of components, Jerk and distributor type Pumps. Pressure waves, Injection lag, Unit injector, Mechanical and Pneumatic governors. Fuel injector-types of injection nozzle, Spray characteristics, injection timing, pump calibration. 7. Diesel Engine Combustion Features of diesel combustion process Ignition delay Knock in diesel engines Nature and extent of CI engine Emissions problems and control strategies. 8. Automotive: The Future Engine development prospects Stratified charge, direct injection systems Homogeneous charge, compression ignition Low temperature diesel combustion Advanced electronic-controlled engines Hybrids and fuel cells.			

VI	Text/Reference Books	1. Internal Combustion Engine Fundamentals by John B. Heywood. 2. The Internal Combustion Engine in Theory and Practice: Volumes 1 & 2, by Charles Fayette Taylor. 3. Engineering Fundamentals of the Internal Combustion Engine by Willard W. Pulkabrek. 4. Fundamentals of Internal Combustion Engines by P. W. Gill, J. H. Smith, and E. J. Ziury. 5. Internal Combustion Engines by V. Ganesan.

Mechanical Engineering Department

Semester : VI

I	Course Code	**ME 3010**			
II	Course Title	**Operations Research & Project Management**			
III	Credit Structure	L	T	P	C
		3	1	0	4
IV	Prerequisite (if any for the student)	None			
V	Course Objective	To understand the different types of decision making environments and the appropriate decision making approaches and tools to be used and to develop critical thinking and objective analysis of decision problems. This course will provide students with: • ability to understand and analyze managerial problems in industry so that they are able to use resources (capitals, materials, staffing, and machines) more effectively • knowledge of formulating mathematical models for quantitative analysis of managerial problems in industry			

VI	Course Content	**UNIT I** **Introduction:** Origin and development of operations research, general methodology of OR, applications of OR to industrial problems. **UNIT II** **Introduction to linear programming:** Different types of models, formulation of linear programming problems (LPPs), productmix problems, deterministic models, graphical solution. **Linear Programming (Simplex Method):** Various steps in solving or problems using simplex method (a) Maximization problems, (b) Minimization problems, minimisation problems (all constraints of the type $<$), BIG 'M' method. Minimising case $-$ constraints of mixed types ($<$ and $>$), Maximisation case-constraints of mixed type. **Duality and Sensitivity:** Duality and its concept, dual linear programming, application of elementary sensitivity analysis. **UNIT III** **Transportation problem:** Balanced Transportation Problem, Unbalanced Transportation Problem, Method of Solution, Degeneracy and the Transportation Problem, Testing the Solution for Optimality, Solution of Unbalanced Transportation Problem, Maximization and the Transportation Techniques. **Assignment Model:** Assignment Table, Method of Solving Assignment Problems. **UNIT IV** **Network optimization:** Network Optimization Models,Example, The Terminology of Networks, The Shortest-Path Problem, The Minimum Spanning Tree Problem , The Maximum Flow Problem. **PERT/CPM:** Using a Network to Visually Display a Project, Scheduling a Project with PERT/CPM, Dealing with Uncertain Activity Durations, An Evaluation of PERT/CPM. **UNIT V** **Queuing Theory:** Queuing systems and concepts, classification of queuing situations; Kendall's notation, solution of queuing problems, single channel, single stage, finite and infinite queues with Poisson arrival and exponential service time, applications to industrial problems. **Forecasting:** Judgmental Forecasting, Time Series, Forecasting Errors **Inventory Model:** Components, Deterministic, Continuous-Review, Models, Deterministic, Periodic-Review Model
VII	Textbooks/ References	1. Taha H. A., 2008. Operations Research, 8th edition, Pearson Education, New Delhi. 2. Hillier F. S., Lieberman G. J., 2012. Introduction to Operations Research, 9th edition, McGraw-Hill Higher Education, New Delhi. 3. Ronald L. Rardin, 1997. Optimization in Operations Research, Pearson Education, Prentice Hall. 4. Sharma S. D., 2010. Operations Research, 16th edition, Merrath: Kedarnath Ramnath Publication.

VIII	Course Outcome	Upon completion of the subject, students will be able to: • recognize the importance and value of Operations Research and formulate a managerial decision problem into a mathematical model in solving practical problems in industry. • understand Operations Research models and apply them to real-life problems.