COURSE STRUCTURE
&
SYLLABUS

For

B. Tech in Mechanical Engineering

(V & VI – SEMESTER)

For Academic Session 2023-24

Indian Institute of Petroleum and Energy

Visakhapatnam, Andhra Pradesh - 530 003

Semester-V				
S.No.	**Subject Code**	**Subject Name**	**L-T-P**	**Credits**
1	ME3101	Design of Machine Elements	3-1-0	4
2	ME3102	Applied Thermal Engineering-I	3-1-0	4
3	ME3103	Manufacturing Technology	4-0-0	4
4	ME3104	Production Planning and Control	3-1-0	4
5	ME3001	Optimization Engineering	3-0-0	3
6	ME3105	Mechanical Engineering lab -I	0-0-3	2
7	ME3106	Dynamics Lab	0-0-3	2
Total			**14-3-6**	**24**
Semester-VI				
S.No.	**Subject Code**	**Subject Name**	**L-T-P**	**Credits**
1	ME3201	Applied Thermal Engineering-II	3-1-0	4
2	ME3002	***Data Analytics (Syllabus Under Preparation)***	***3-0-0***	***3***
3	ME3003	CAD & CAM	3-0-0	3
4	ME3004	Robotics & Automation	3-0-0	3
5	IE3001	Elective-I	3-0-0	3
6	ME3202	Workshop II (Lab)	0-0-2	2
7	ME3203	Mechanical engineering Lab-II	0-0-3	2
8	IC3201	Project I	0-0-3	2
Total			**15-1-5**	**20**

List of electives

ELECTIVES	
Elective - I	1. Vibration Control 2. Computational Fluid Dynamics 3. Additive Manufacturing 4. Alternate Fuels and Emission Control
***Note**: Electives will be offered based on the availability of resource person**	

Semester-V

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Design of Machine Elements**	3	1	0	4

Course Objective

To teach students how to apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.

To illustrate to students, the variety of mechanical components available and emphasize the need to continue learning.

To teach students how to apply mechanical engineering design theory to identify and quantify machine elements in the design of commonly used mechanical systems.
To teach students how to apply computer based techniques in the analysis, design and/or selection of machine components.

Learning Outcomes

- The students will demonstrate the ability to apply the fundamentals of stress analysis, theories of failure and material science in the design of machine components. The students will demonstrate the ability to make proper assumptions, perform correct analysis while drawing upon various mechanical engineering subject areas. Specifically, the students will demonstrate the preceding abilities by performing correctly: • the design, analysis and sizing of shafts • the selection, sizing and analysis of springs • the selection of bearing types, and sizing and analysis of rolling element bearings • the selection of gear types, sizing, analysis and material selection of gear systems • the selection, sizing, design, and analysis of other mechanical components/systems
- Students will demonstrate the ability to seek and learn new material in addition to the class topics through the completion of an open-ended project. The amount as well as the depth of new material identified and used by the students are measurable indicators of the students' performance.
- Students will demonstrate the ability to take technical, safety, legislative and other issues such as environmental into account when selecting and/or designing mechanical systems, in particular with respect to those components and systems defined in the topical areas and performance criteria
- The breadth and depth of the issues taken into account by students are measurable indicators of their performance.

Unit No	Topics	
1.	Introduction to Design Review of Failure theories (Static and Fatigue)	The students will demonstrate the ability to apply the fundamentals of stress analysis, theories of failure and material science in the design of machine components. The students will demonstrate the ability to make proper assumptions, perform correct analysis while drawing upon various mechanical engineering subject areas. Specifically, the students will demonstrate the preceding abilities by performing correctly: • the design, analysis and sizing of shafts • the selection, sizing and analysis of springs • the selection of bearing types, and sizing and analysis of rolling element bearings • the selection of gear types, sizing, analysis and material selection of gear systems • the selection, sizing, design, and analysis of other mechanical components/systems
2.	Shafts and couplings :- Design of Shafts, keys and keyways, Couplings .	
3.	Bearings: Theories of lubrication to motivate design of rolling element bearings and hydrodynamic bearings, Design of hydrodynamic bearings for various types of shaft loadings and end conditions, Choice of rolling element bearings from charts	
5.	Design of gears: Stresses induced in gears, Lewis bending equations, AGMA based calculation of pitting and bending stresses and strengths, Calculation of appropriate safety factors and power rating, Design of spur gears for simple power transmission	
6	Design of Springs: Basic spring nomenclature:- Forces deflection and stiffness, Various spring configurations, Materials for Spring – 1 Designing of helical compression springs for static and fatigue loads	
7	Design of Belts: Nomenclature, types of drives, derivation of belting equation, Design of flat belt and ‘V’ belt for simple power transmission between shafts. Choices of pulleys appropriate for the drives	
8	Design of fasteners, rivets and dowel pins: Nomenclature for bolts and screws, Concept of friction between threads. Choice of appropriate bolts, screws for joining simple mechanical members which are then subjected to tensile, compressive and torsional loading, Preloading of bolted assembly, Design of bolts for static and dynamic loads. Concept of joint stiffness factor.	
9	Choices of rivets and dowel pins for taking shear loads, Determining shear loads, for various types of eccentric loading conditions	

Text Book:

Machine Design, An Integrated Approach,by, Robert L. Norton, Second Edition

Reference Books:

Shigley’s Mechanical Engineering Design, by Richard Budynas (Author), Keith Nisbett (Author)

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Applied Thermal Engineering-I**	3	1	0	4

Course Objective
1. To introduce the working of various internal combustion engines along with their thermodynamic cycles. 2. To introduce IC engine combustion processes, emission, emission control techniques and performance tests. 3. To introduce different compressors and their thermodynamic performance estimation. 4. To introduce various gas turbine thermodynamic cycles.
Learning Outcomes
Upon successful completion of this course, students will be able to: 1. Understand operation of IC engines and evaluate their ideal performances via thermodynamic cycles 2. Understand SI and CI engine combustion processes, emissions and emission control Analyze and modify the design of cams. 3. Ability to carry out performance testing of IC engines Solve balancing problems 4. Understand the thermodynamic cycles and performance of air compressors 5. Understand the working of gas turbine plant components and analyses their performance.

Unit No	Topics	Learning Outcome
1.	Evolution of IC engines; features of IC engines; Nomenclature; Classification; Construction and working of 2S, 4S, petrol and diesel engines; components of the IC engines, applications of IC engines; Valve timing and port timing diagrams. Air Standard Cycles: Carnot, Stirling, Ericsson, Otto, Diesel, and Dual cycles,P-v diagrams	LO1
2.	SI engine mixture formation, combustion, emissions, emission control, Diesel engine characteristics, fuel injection, combustion, emission and emission control. Concept of supercharging and turbocharging	LO2
3.	IC engine performance parameters, testing, performance measurement methods, engine heat transfer and heat balance	LO3
4.	Air Compressor: Classification and working principle, work of compression with and without clearance. Volumetric efficiency, Isothermal efficiency and isentropic efficiency of reciprocating air compressors. Multistage air compressor and inter cooling – work of multistage air compressor. Types of compressors and their comparison	LO4
5.	Gas Turbines: Brayton cycle - intercooling, reheating and regeneration. Air craft gas turbines, Combustion in gas turbines	LO5

Text Books:

W.W.Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt.Ltd, 2002

Ganesan.V, Gas turbines, Tata McGraw-Hill Publication, New Delhi, 1999

References:

Heywood, J. B. Internal Combustion Engine Fundamentals. New York, NY: McGraw-Hill, 1988. ISBN: 9780070286375.

Desmond E. Winterbone and Ali Turan. Advanced Thermodynamics for Engineers, Butterworth-Heinemann; 2nd edition, 2015.

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Manufacturing Technology**	4	0	0	4

Course Objective

1.To understand the fundamental of machining process and their importance for selection of proper process parameters

2. To provide knowledge about different the principle, operation and applications of different machines tools and fixtures

3. To understand the principle and applications of various advanced machining processes.

Learning Outcomes

Upon successful completion of this course, students will:

1. Have understanding of the fundamental of machining process and importance machining process parameters
2. Be able to manufacture components as per production drawing using suitable Machine tools and their process parameters.

Unit No	Topics	Learning Outcome
1.	Introduction to machining processes, Cutting tools- single and multi-point cutting tools, tool geometry and materials.	Understanding about the different types of machining processes and their tools.
2.	Mechanics of chip formation, Merchant's force circle diagram. Cutting fluids/lubricants.	Understanding of mechanics of metal cutting process. The students will able to estimate optimum machining parameters.
3.	Tool wear mechanism, and tool life. Machinability. Economics of metal cutting.	This unit will help student in understanding the fundamental of tool life and its effects on productivity.
4.	Lathe, Milling, Drilling, Boring and Grinding, machine tool drives, Principles of work holding, design of jigs and fixtures.	Students will get complete knowledge about the conventional Machine tools and their accessories.
5.	Principles of EDM and WEDM; ECM; USM; AWJ; ECG; Super finishing processes.	Students will get basic idea about the non-conventional machining process and their applications.

Text Books:

1. Machining and Machine Tools, A.B. Chattopadhyay, Willey Publishers, 2011

Reference Books:

2. Theory of Metal Cutting, A. Bhattacharya.
3. Fundamentals of Metal Machining and Machine Tools, Winston A. Knight, Geoffrey Boothroyd, CRC Press
4. Principles of Machine Tools, G. C. Sen and A, Bhattacharya, New Central Book Agency
5. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication. 3rd Edition, 2005

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**PRODUCTION PLANNING & CONTROL**	3	1	0	4

Course Objective

1. To provide students with the basic concepts related to the interactions between the operations management system parameters and their impact on production and inventory control systems design.
2. To provide students with methodology and models for the generation of company forecasts, materials management cost elements, business operations analysis, and productivity, operations strategies for competitive advantage, location strategies, and supply-chain management.

Learning Outcomes

Upon successful completion of this course, students will:

1. Develop various operating cost components and business strategies for operations management.
2. Describe and determine the effect of product, process, inventory costs, product forecasting, operations strategies, and schedule design parameters on design of materials requirements planning, inventory planning, capacity planning, and production planning/control systems.
3. Apply and analyze forecasting models to develop business enterprise forecasts for product demand, profits, sales, material requirements, capacity requirements, etc.

Unit No	Topics	Learning Outcome
1.	Course overview and Principles of Operations and Productivity, Operations Strategies.	To provide students with the basic concepts related to the interactions between the operations management system parameters and their impact on production and inventory control systems design.
2.	Forecasting Demand, Design of Goods and Services, Process Strategy and Capacity Planning, Facilities Management: Layout Strategies	Ability to use and compare various statistical forecasting models Capacity models for independent and dependent demand.
3.	Supply-Chain Management, Materials Management: Inventory Management and Problems, Production Planning for New Technologies: Just-in-time Systems, Lean Manufacturing, and Agile Manufacturing	Use and analysis of inventory models for independent and dependent demand. Application of Just-in-Time, Lean Manufacturing, Agile Manufacturing methodologies
4.	Master Production Planning and Materials Requirements Planning (MRP), Production Planning: Line Balancing Methods (Heuristic and Stochastic), Production Planning: Aggregate Scheduling, Shop Loading, Sequencing.	Design, develop, and analyze a Master Production Schedule and a resultant Materials Requirement Plan (MRP) for a complete production facility. Application and evaluation of scheduling and sequencing methodologies and line balancing methodologies.

Text book:
Principles of Operations Management: Sustainability and Supply Chain Management, Student Value Edition 10edition – Jay Heizer, Texas Luthern University – SBN.

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Optimization Engineering**	3	1	0	4

Course Objective
The course deals with the basic idea of mathematical programming (Linear and Nonlinear). We shall see how simple mathematics plays a significance role in the development of these ideas. Further, explore the different approaches to find the solution for the various Linear and Nonlinear Programming Problems.
Learning Outcomes
The student will able to identify the appropriate methods to solve the different kinds of Optimization Problems

Unit No	Topics	Learning Outcome
1.	Convex Analysis: Convex Set, Convex functions, Local and Global Extrema, Convex Hull, Supporting and Separating Hyperplane, Convex Cone, Differentiable Convex function.	Understanding the fundamental concept of the convex set and its solution set.
2.	Network Analysis: Basic Concepts, Critical Path Analysis, Program Evaluation Review Techniques.	Student will be able to construct the network diagrams with single and three time estimates of activities involving in a project.
3.	Dynamic Programming: Recursive Equation Approach, Dynamic Programming Algorithm, Solution of Discreate D.P.P., Solution of L.P.P. by Dynamic Programming.	Student will learn the new approach to solve the linear programming problem and their applications in solving a decision-problem
4.	Queueing Theory: Probability Distributions in Queueing Systems, Classification of Queueing Models, Poisson QueueingSystems:{(M/M/1):(∞/FIFO)},{(M/M/1):(∞/SIRO)},{(M/M/1):(N/FIFO)}.	This unit will help student to identify and examine all possible queuing system and description of each of them.
5.	Nonlinear Programming: General Nonlinear Programming Problem, Constrained Optimization with Equality and Inequality Constraints, Saddle Point Problems, Kuhn-Tucker Conditions with Nonnegative Constraints.	Student will be able to drive the optimality conditions for obtaining an optimal solution for nonlinear optimization with Equality and Inequality Constraints.

Text Books:

1. Kwanti Swarup, P. K. Gupta and Man Mohan: "Operations Research", Sultan Chand & Sons, 2017.

Reference Books:

1. Hamdy A. Taha: "Operations Research-An Introduction", Pearson, 2016.
2. Hadley G..: "Linear Programming", Narosa, 2002.
3. Frederick S. Hillier and Gerald J. Lieberman: "Introduction to Operations Research", McGraw Hill, 2009.

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Mechanical Engineering lab -I**	0	0	3	2

Experiment No	Title of the Experiment
1.	Valve time and port timing diagram of four stoke and two stroke engines
2.	Performance testing of four stroke diesel engine
3.	Performance testing of four stroke petrol engine
4.	Heat balance estimation in IC engines
5.	Friction power estimation in IC engines
6.	Flash and Fire point estimation of Diesel fuels
7.	Flash and Fire point estimation of lubricating oils
8.	Cloud and Pour point estimation of fuels
9.	Calorific value estimation of fuels
10.	Kinematic and dynamic viscosity estimation of lubricating oils

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**DYNAMICS LAB**	0	0	3	2

Experiment No	Title of the Experiment
1	Effect of varying the mass of central sleeve for governors.
2	Gyroscopic effect of rotating disc
3	Static and dynamic balancing of rotors
4	Journal bearing
5	Basics of 2D and 3D machine drawing in AUTOCAD
6	Draw nut and bolt in 3D and derive front view, top view and side view
7	Draw 3D-isometric view keys, cotters and pins, and derive front view, top view and side view
8	Assembly drawing of bushed pin type flanged coupling
9	Assembly drawing of Plummer block

Semester-VI

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Applied Thermal Engineering-II**	3	1	0	4

Course Objective

1. To understand various vapor based thermodynamic cycles.
2. To understand the working and design of various steam power plant components
3. To introduce refrigeration principles, methods and design of system components, psychrometry, heat load calculations for design of Heating Ventilation and Air Conditioning (HVAC)

Learning Outcomes

Upon successful completion of this course, students will have the:

1. Ability to understand and estimate the performance of various steam power plant cycles
2. Ability to carry out combustion calculations for different fuels under different conditions
3. Ability to size boilers and various waste heat recovery systems
4. Ability to understand various steam turbines, nozzles and condensers used in steam power plant
5. Ability to estimate cooling load, and performance of refrigeration and air conditioning systems

Unit No	Topics	Learning Outcome
1.	Vapor Cycles: Carnot cycle; Simple Rankine cycle, Techniques for efficiency improvement, Reheat and Regenerative cycles with open & closed feed water heater, cascaded power cycles	LO1
2.	Fuels and their properties, stoichiometric and actual air requirements, flue gas analysis, boiler energy balance, draft system. Different types of furnaces for burning coal, fuel oil and gas.	LO2
3.	Circulation theory, down-comers and risers, economizers and super heaters, air pre-heater, drum and its internals. Different types of boilers, boiler mountings, feed water treatment, boiler loading and manner of operation.	LO3
4.	Steam turbines; convergent and convergent-divergent nozzles - theory and design. Impulse and reaction turbines, compounding of turbines, optimum velocity ratio, reheat factor and condition line, parallel exhaust, losses in steam turbines, steam turbine governing. Theory and design of condensers, air ejector and cooling tower	LO4
5.	Refrigeration- vapor compression refrigeration systems, refrigerants, actual cycles, superheating, sub-cooling, vapor absorption system, Air cycle refrigeration, Psychrometry and Psychrometric properties, Psychrometric chart, air conditioning processes, Cooling load calculations and circulating systems, concept of sensible heat factor, summer and winter air conditioning systems	LO5

Text Books:

1. V. Ganapathy, Industrial Boilers and Heat Recovery Steam Generators: Design, Applications, and Calculations, CRC Press, 2002

2. Y. Cengel and MBoles, Thermodynamics - An Engineering Approach, Tata McGrawHill,
7th Edition, 2010.

3. Stoecker W F and Jones J W, Refrigeration and Air Conditioning, 2nd Edition, McGraw Hill
International Editions (1982).

References:

1. GanapathyV. Steam Generators and Waste Heat Boilers: For Process and Plant EngineersCRC Press; 1st edition, 2017

2. Arora C P, Refrigeration and Air Conditioning, 3rd Edition, Tata McGraw Hill, 2017.

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Data Analytics**	3	1	0	4

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**CAD & CAM**	3	0	0	3

Course Objective
1. The primary objective of the course is to introduce the student to working with discretised geometry in design of mechanical components and representations of Shapes. 2. To provide detailed understanding of advances in manufacturing particularly in computer numerical control. 3. To understand working principle of numerical control in computer controlled material handling system.
Learning Outcomes
Upon successful completion of this course, students will: 1. Have a broad understanding about basics of Geometric modelling of surfaces, Numerical Control and classification of automation system. 2. Be able to learn different CNC programming and simulation software.

Unit No	Topics	Learning Outcome
1.	Introduction and overview. Need and Scope of Computer Aided Machine Design. Role of Geometric Modelling, 2D and 3D Geometric transformations and projections.	Basic knowledge about the different computer graphics tools, geometric transformations.
2.	The Viewing pipeline; Geometric modelling; Modelling of curves,cubics, splines, beziers and b-splines, NURBS; Modeling of surfaces; Modeling of solids–b-rep, CSG, octree, feature based modeling.Interfacing withCAD software.	Understanding basic modelling of different geometric entities and interface with computer based designing.
3.	Introduction to Automation and mechanization, basic elements of an automated system, level of automation	Understanding basic difference between automation and mechanization. Also strategies adopted for implementation of automation.
4.	Numerical Control of machine tools, different types of controls, point to point, continuous path, NC system devices.	Understanding of different configuration and level of CNC control, Importance of FMS and CIM system, learn about simulation of machining process
5.	CNC, DNC, adaptive control of manufacturing processes, CIM, NC part programming, APT, Industrial robots, AGVs, Introduction to Additive Manufacturing process.	Basic knowledge about the different computer controlled material handling system and their control.

Text Books:

1. Computer control of Manufacturing system, Yoramkoren, McGraw Hill Publication.

Reference Books:

1. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication.
2. Machining and CNC Technology, M. Fitzpatrick, McGraw-Hill Publication.

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**ROBOTICS & AUTOMATION**	3	0	0	3

Course Objective
1. To expose the students in both the aspects of analyses and applications of robotics. 2. To understand the need and differentiate between different types of automation systems. 3. To understand various components of state-of-art automation technologies encountered in modern manufacturing industries. 4. To introduce the design and practical aspects of automatic control of machines, processes and systems.
Learning Outcomes
Upon successful completion of this course, students will: 1. Have a broad understanding of classification of robots and robotic manipulators used in automation industry. 2. Learn application of robots and programming for the specific case study 3. Comprehend and differentiate between various types of automation systems. 4. Analyse and solve an engineering problem using proper automation technology applicable. Apply gathered knowledge to synthesize i.e. design and formulate an industrial automation system. 5. Evaluate i.e. test, detect and monitor the working of different automation systems used in the industry.

Unit No	Topics	Learning Outcome
1.	Introduction: Robot definition, application, robot anatomy; robot classifications and specifications, serial robots. Actuators: Pneumatic, hydraulic and electric actuators, Stepper motors, DC and AC motors, Selection of motors, Robot end-effectors	Understanding robot classifications and general applications Learning the actuator sizing procedure and different types of end-effectors
2.	Robot sensors: Contact and non-contact sensors; position, velocity, acceleration and force sensors; Robot vision and their interfaces.	This unit provides an overview of robotic sensors, vision and interfaces
3.	Transformations: Grubler-Kutzbach Criterion; DOF of a Robot Manipulator; Pose or Configuration; Denavit-Hartenberg (DH) Parameters; Homogeneous transformation	Understanding the analytical procedure involved in motion transformation from fixed base to the end-effector
4	Robot kinematics: forward and inverse kinematics, link velocity and acceleration analysis: Jacobian matrix; Singularity.	This unit demonstrates the kinematic analysis of serial chain robots
5.	Applications: Robots in materials handling, machine loading/unloading and programming for case study.	Understanding robotic applications and learning code for real-time controlling of Simple robots.
6.	Introduction of automation technologies, applications in manufacturing, Types of automation systems – hydraulic, pneumatic, electrical, and electronic with comparison. Role of energies in automation – fluid power and electrical.	Student will be able to understand and differentiate between various types of automation systems
9.	Programmable logic controllers (PLCs): Introduction to PLCs, inputs and outputs and their types. Interfacing of I/O devices with a PLC. Programming languages and instruction sets, ladder logics, structured text, functional blocks and applications. Example of sensor, actuator and controller integration for common microcontrollers.	This module emphasizes on the need and use of PLCs as the state-of-art automation technology to solve various types of industrial automation problems

Text books:

1. Introduction to Robotics by S. K. Saha, McGraw Hill,2ndEdition,2014
2. Introduction to Industrial Automation, StamatiosManesis and George Nikolakopoulos, CRC press.
3. Mechatronics. W. Bolton, Pearson publishers, 4th Edition9

References books:

1. Introduction to Robotics: Mechanics and Control by John J. Craig,, Prentice Hall
2. Robot Modeling and Control by Mark W. Spong Wiley
3. Industrial Automation: Hands-On, Frank Lamb, McGraw Hill publisher.
4. Fluid power with applications. Anthony Esposito, Pearson Education, 4th Edition.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC 3119		Principles of Energy Conversion	3	0	0	3

Course Objective

1. compare competing energy conversion technologies on an economic and efficiency basis;
2. be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy conversion;
3. be familiar with thermodynamic processes and power cycles (thermal and mechanical energy);
4. be familiar with basic principles of energy storage.

Learning Outcomes

1. At the end of the course students will learn and understand the fundamentals of nuclear energy. principle involved in energy conversion.
2. Students will get to know about energy conversion efficiency.
3. Students will learn about thermodynamic processes and power cycles
4. Students will get to know about Thermal, nuclear, combined cycle, hydro and renewable power plants
5. Students will get to know about the basic principles of energy storage.

Unit No	Topics	Learning Outcome
1	Energy, Growth Rate & Energy Economics energy, energy classification, units, energy conversion, conversion efficiency · energy information and perspectives	students will learn and understand the basic principle involved in energy conversion.
2	Thermal-to-Mechanical Conversion · Early engines & efficiency · Thermodynamics & power cycles & efficiency · Rankine Cycle · Brayton Cycle	students will learn about thermodynamic processes and power cycles
3	Chemical-to-Thermal Conversion · principles of combustion, fuels: coal, petroleum, gas.	students will be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy conversion;
4	Electromagnetic-to-Thermal Conversion principles of solar insolation · solar collectors · thermal energy storage	
5	Electromagnetic-to-Electrical Conversion principles of photovoltaics	
6	Nuclear-to-Thermal Conversion · principles of nuclear energy · pressurized water reactors · boiling water reactors · boiling water, graphite-moderated reactors · Gen-IV reactors	
7	Mechanical-to-Mechanical Conversion · principles of wind energy,	
8	Chemical-to-Electrical Conversion · principles of fuel cells	
9	Introduction to Energy Storage · hydrogen · flow batteries · compressed gas, flywheel	Students will be familiar with basic principles of energy storage

Text Books:

1. Energy Conversions by Kenneth Weston.
2. Principles of Energy Conversion by Culp, McGraw-Hill Companies

Reference Books:

1. BEI International, Hambling, P., (Ed.), Modern Power Station Practice: Nuclear Turbines, and Associated Plant, Pergamon Press, 1992.
2. Drbal, L. F., Boston, P. G., Westra, K. L., Black and Veatch, Power Plant Engineering, Kluwer Academic, 1995.
3. Elliott, T. C., Chen, K., and Swanekamp, R., Standard Handbook of Power Plant Engineering, McGraw-Hill Professional, 2nd ed., 1997 El-Wakil, M. M.,
4. Power Plant Technology, McGraw-Hill, 1984. Jog, M., Hydro-electric and Pumped Storage Plants, John Wiley, 1989. Fritz, J. J., Small and Mini Hydropower Systems, McGraw-Hill, 1984. Central Board for Irrigation and Power (CPIB), India, Design and Construction Features of Selected Dams in India, 1983. Borbely, Anne-Marie, and Kreider, Jan J., (Eds.), Distributed Generation: The Paradigm for the New Millennium, CRC Press, 2003. Larminie, J., and Dicks, A., Fuel Cell Systems Explained, John Wiley, 2003. Vielstich, W., Lamm, A., and Gasteiger, H., Handbook of Fuel Cells: Fundamentals, Technology, Applications, John Wiley, 2003 Appleby, A. J., and Foulkes, F. R. Fuel Cell Handbook, van Nostrand Reinhold, 1996. Harrison, R., Hau, E., and Snel, H., Large Wind Turbines: Design and Economics, John Wiley, 2001.)

Elective-1

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective-I		Vibration Control	3	0	0	3
Course Objective						
• To develop the bridge between the structural dynamics and control communities • To providing an overview of the potential of smart materials for sensing & actuating purpose in active vibration control. • To understand the passive damping techniques.						
Learning Outcomes						
Upon successful completion of this course, students will: • Understand the smart material, actuator sensor • Understand the design consideration to suppress the vibration • Understand the active control of space vehicle, satellite submarine etc.						

Unit No.	Topics to be Covered	Learning Outcome
1	Review of Basics of Mechanical Vibrations. Basics of Vibrations for Simple Mechanical Systems, Introduction to Damping in Free and Force Vibrations, Free and Forced Vibrations of Two Degree of Systems, Multi Degree of Freedom Systems	Understand the basics of Vibration and its types
2	Basics of Vibrations Control: Reduction at source , Feedback Control System, Shunt Damping Basics of Vibrations Control: Reduction at source , Feedback Control System, Shunt Damping	Understand the preliminary Vibration control strategies.
3	Vibration Isolation, Vibration Generation Mechanism,: Source Classification, Self-Excitation Vibration, Flow Induction Vibration, Damping: Models and Measures	Understanding the source of vibrations and Isolation of the source & use of damper
4	Design Considerations in Material Selection: Design Sensitivity ,Design Specification, Design for Enhanced Material Damping	Understanding the design consideration to suppress the vibration
5	Principles of Passive Vibration Control: Basics of Passive Vibration Control. Design of Absorber, Shock Absorber, Isolators with Stiffness and Damping	Understanding the passive vibration control strategy
6	Principles of Active Vibration Control: Basics of Active Vibration Control, Piezoelectric Material , Piezoelectric Accelerometers	Understanding the Use active material, actuator and sensor for vibration control
7	Electro-rheological (ER) Fluids , Magneto-rheological (MR) Fluids, Magneto and Electrostrictive Materials, Shape Memory Alloy	Understanding the advanced active control units and materials

Text books:

Principles of Vibration Control by A.K. Mallik, East-West Press

Reference books:

1. Vibration Control of Active Structures - An Introduction by André Preumont, springer
2. Passive and Active Structural Vibration Control in Civil Engineering, edited by T.T. Soong, M.C. Costantinou, Springer
3. Mechanical Vibrations: Active and Passive Control by Tomasz Krysinski and François Malburet

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective-I		Computational Fluid Dynamics	3	0	0	3

Course Objective

1. The prime objective of this course is to provide the students with in depth understanding of the computational approach for modelling and solving fluid dynamics as well as heat transfer problems.
2. To enable the students to mathematically represent a physical phenomenon, so that they can generate a mathematical model and finally, a numerical statement of a given problem and solve the problem via implementation of the theoretical knowledge gained.
3. To make the students initially believe and then understand that many of the results in heat transfer/fluid flow that they have studied in undergraduate/post-graduate courses can be generated accurately by themselves using CFD.

Learning Outcomes

1. The students will be familiar to a powerful tool for solving flow and heat transfer problems. This experience will enable them to numerically model a thermo-fluids problem using FDM and FVM.
2. The students will have the feel of the essential role the matrix algebra plays in approximate computations of ODEs and PDEs.
3. The students will be more inclined towards computer programming which will turn out to be very helpful in their Masters research and thereafter.

Unit No.	Topics to be Covered	Learning Outcome
1	Review of governing equations for conservation of mass, momentum and energy in primitive variable form	After this revision module, the students will be able to derive the conservation equations using Reynolds transport theorem and will also be able to interpret each equation
2	Mathematical behaviour of the conservation equations, equilibrium and marching problems	This important module will enable the students to distinguish given equations based on their characteristics (mathematical nature) and also to choose later, the appropriate differencing schemes as applicable
3	The finite difference method (FDM) and the variational methods, discretization, comparison of finite difference method, finite volume method (FVM) and finite element method (FEM)	The students will be acquainted with the brief history of development of the three basic discretization techniques as well as foundation of discretization
4	Review of Taylor's series, implicit, explicit and semi-implicit schemes, alternate direction implicit method	This module deals with the foundation of FDM; the students will be able to logically approximate a derivative and a differential equation
5	Convergence, stability analysis of a numerical scheme	This module will provide the concept of numerical error and guidelines for using or not using a differencing scheme while solving a CFD problem
6	Solution of linear matrix equation system and programming	This module will familiarize the students with the role of linear algebra in solving fluid dynamics problems
7	Application of FDM in one- and two dimensional steady and unsteady heat conduction and computer programming, artificial viscosity, upwinding	Practical implementation of all the topics covered up to module VI, introduction to numerical diffusion and CFD in fluid flow, students will be able to differentiate between CFD in heat conduction and CFD in fluid dynamics
8	Stream function-vorticity formulation	The students will learn the alternate flow equations as well as their solution methods used in early days of numerical treatment of flow problems

9	The finite volume method in orthogonal and non-orthogonal meshes, Green Gauss theorem, application of FVM for heat conduction and convection diffusion problem	The students will be able to discretize a given equation via direct integration on orthogonal and non-orthogonal meshes. This module will make the limitations of FDM more obvious to the students
10	Implementation of SIMPLE algorithm in two dimensions, Introduction to commercial package ANSYS-FLUENT	The students will have the flavor of a segregated fluid flow solver. In this context, they will learn the difficulties posed by the nonlinear convective terms and coupling between pressure and velocity. Thus, they can appreciate the depth and involvement in numerical treatment of a flow problem compared to a heat conduction problem

Text Books:

John D. Anderson, Computational Fluid Dynamics The basics with applications, McGraw-Hill Education, 1st Edition, 2017.

References:

Richard H. Pletcher, John C. Tannehill and Dale A. Anderson, Computational Fluid Mechanics and Heat Transfer, CRC Press, 3rd Edition, 2012.

Joel H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer, 3rd Edition, 2002.

Clive A. J. Fletcher, Computational Techniques for Fluid Dynamics, Springer, 1st Edition, 1988.

T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2nd Edition, 2010.

K. Muralidhar and T. R. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 2nd Revised Edition, 2003.

S. V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 1st Edition, 1980

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective-I		Additive Manufacturing	3	0	0	3

Course Objective

To provide detailed understanding of additive manufacturing processes. The prospect of future research will also discuss in the course which will encourage the PG students to carryout research in the advance area.

Learning Outcomes

Upon successful completion of this course, students will:

• Broad understanding of Additive Manufacturing processes using different technologies.

• Students will be able to think about the possibility of combining different process to develop more efficient AM process.

• It will help the students to select the best process among various alternative.

Unit No.	Topics to be Covered	Learning Outcome
1	Introduction to Additive Manufacturing and classification. Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	Understanding the evolution and need of AM processes. It will develop the ability of select the process for particular application.
2	Introduction to 3D-printing, Stereo lithography apparatus (SLA), Fused deposition modelling (FDM), Laminated Object Manufacturing (LOM))	Understanding the basic principle of curing type, extrusion and layer deposition type AM processes. The students will learn the pros & cons of these processes and their applications.
3	Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM)	Understanding of thermal based AM processes (UMP). The students will learn the importance of controlled high energy source to manufacture the complex profile components.
4	Pre-Processing in Additive Manufacturing: Preparation of 3D-CAD model, Reverse engineering and Reconstruction of 3D-CAD model, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	The students will understand the use of pre requirement of AM process. Basic knowledge about the software requirement and processing of drawing.
5	Post-Processing in Additive Manufacturing: Support material removal, improvement of surface texture, accuracy and aesthetic; property enhancements.	The students will learn about the post processing requirements of different AM processes.

Text books:

Gibson, I, Rosen, D W., and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2015

Reference books:

Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

Chua C.K., Leong K.F., and Lim C.S., “Rapid prototyping: Principles and applications”, Third Edition, World Scientific Publishers, 2010

Gebhardt A., “Rapid prototyping”, Hanser Gardener Publications, 2003

Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007

Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006

Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective-I		Alternate fuels and emission Control	3	0	0	3

Learning Outcomes

Upon successful completion of this course, students will:

- Categorize, interpret and understand the essential properties of fuels for IC engines
- Identify the need for alternate fuels and characterize prospective alternate fuels
- Evaluate the storage and dispensing facility requirements.
- Analyze the implement limitations with regard to performance, emission and materials compatibility Develop strategies for control of emissions as per the legislation standards

Unit No.	Topics to be Covered
1	Introduction: Estimation of petroleum reserve – Need for alternate fuels – Availability and properties of alternate fuels, ASTM standards
2	Alcohols: General Use of Alcohols – Properties as Engine fuel – Gasolene and alcohol blends – Performance in SI Engine – Methanol and Gasolene blend – Combustion Characteristics in engine – emission characteristics
3	Vegetable oils: Soybean Oil, Jatropha, Pongamia, Rice bran, Mahua, etc. as alternate fuel and their properties, Esterification of oils
4	Natural Gas, LPG: Availability of CNG, properties, modification required to use in engines – performance and emission characteristics of CNG using LPG in SI & CI engines.
5	Hydrogen:Hydrogen production, Hydrogen as an alternative fuel, fuel cell
6	Automobile emissions & its control: need for emission control -Classification/ categories of emissions -Major pollutants - control of emissions – Evaluating vehicle emissions – EURO I,II,III,IV standards – Indian standards

References:

1. Alternate Fuels Guide Book Authors:Richard L. Bechhold P.E. Publisher: Society of Automotive Engineers, 1997
2. Hydrogen fuel for surface transportation Authors: Norbeck, Joseph M. Publisher: Society of Automotive Engineers, 1996
3. History of the Electric Automobiles: Hybrid Electric Vehicles Authors: Wakefield, Earnest Henry
4. Engine Emissions: Pollutant formation and advances in control Technology Authors: NorbePundir B.R. Publisher: Narosa Publishing House

Text books / References:

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Workshop II**	0	0	2	2

Course Objective

- To provide in-hand exposure on the technologies involved in manufacturing processes like metal casing,forming, welding and machining.
- To provide knowledge about the principle, operation and applications of different machines tools and fixtures

Learning Outcomes

Upon successful completion of this course, students will:

- have a complete idea about the different manufacturing processes, the requirement of specific equipmentand tools, and safety measures for making a component.
- be able to manufacture components as per production drawing using suitable machine tools and their process parameters.

Unit No	Topics
1.	Metal cutting tool grinding operation on tool and cutter grinder.
2.	Measurement and analysis of cutting forcesand temperature in turning operation.
3.	Gear manufacturing (with measurement) on milling/gear hobbing/gear shaping machinetool.
4.	Sand preparation and testing: specimen preparation for testing permeability, clay content, grain fineness number, moisture content, green compression strength, greenshear strength, splitting strength, hardness, etc.
5	Casting of metals after preparation of mould and demonstration on gravity die casting process.
6	Experiments on welding process: MIG, TIG and demonstration of other advanced weldingand brazing processes.
7	Inspection and analysis of welded joints: HAZ, grain structure
8	Formability tests of sheet metals and product preparation.
9	Mini project work on manufacturing

References

Manufacturing Engineering and Technology, Kalpakjian and Schmid, Pearson Publishers, 7th Edition, 2014

Course Type	Course Code	Name of Course	L	T	P	Credit
CORE		**Mechanical engineering Lab-II**	0	0	3	2

Experiment No	Title of the Experiment
1.	Performance testing of a vapor compression refrigeration unit
2.	Performance testing of an air-conditioning unit
3.	Performance testing of a heat pump unit
4.	Performance testing of a reciprocating compressor
5.	Performance testing of a blower
6.	Determination of heat transfer coefficient in fluidized bed combustion
7.	Pressure drop and holdup studies for a fluidized bed
8.	Characteristics of a convergent-divergent nozzle
9.	Determination of flame velocity and burner loading in premixed combustion of gaseous fuel
10.	Determination of boiler efficiency and condenser heat transfer coefficient of an electrical boiler