Course Curriculum

(Course Structure and Syllabi)

for

Bachelor of Technology

in

Mechanical Engineering

(Second Year Onwards)

Department of Mechanical Engineering

National Institute of Technology Hamirpur

Hamirpur – 177 005 (India)

Curriculum for B Tech Programme

Course No.	Semester 3	Credits	Course Type
BS/Engg	Basic Sciences	3	Discipline core
	Engineering Courses	14	Discipline core
	Engineering Course (Lab)	2	Discipline core
Discipline Workshop	Basic Engineering Skills	1	Discipline core
Total 20			

Course No.	Semester 4	Credits	Course Type
	Engineering Course	13	Discipline core
	Engineering Course	3	Discipline Elective
	Engineering Course (Lab)	3	Discipline core
	LA/CA	1	Institute Elective
	Total	**20**	

Curriculum for B Tech Programme

Second Year													
3rd Semester							4th Semester						
SN	Code	Subject	L	T	P	Cr	SN	Code	Subject	L	T	P	Cr
1	MA-203	Engineering Mathematics-III	3	0	0	3	1	ME-221	Kinematics of Machines	3	0	0	3
2	ME-211	Mechanics of Solids	3	1	0	4	2	ME-222	Fluid Mechanics	3	1	0	4
3	ME-212	Engineering Thermodynamics	3	1	0	4	3	ME-223	Manufacturing Processes-II	3	0	0	3
4	ME-213	Manufacturing Processes-1	3	0	0	3	4	ME-224	Industrial Engineering	3	0	0	3
5	ME-214	Metrology, Measurement and Control	3	0	0	3	5	ME-225	Machine Drawing Lab	0	0	2	1
6	ME-215	Mechanics of Solids Lab	0	0	2	1	6	ME-226	Fluid Mechanics Lab	0	0	2	1
7	ME-216	Metrology & Measurement Lab	0	0	2	1	7	ME-227	Manufacturing Processes-II Lab	0	0	2	1
8	ME-217 (Discipline workshop)	Manufacturing Process-I Lab	0	0	2	1	8	ME-241/242/243/244	Discipline Elective (I)	3	0	0	3
							9	SA-201	LA/CA (NSS/NCC/Prayas etc)				1
		Total =				20			Total =				20

Curriculum for B Tech Programme

Discipline Elective (I)

1. (ME-241) Advanced Machining Processes
2. (ME-242) Thermal Engineering
3. (ME-243) Material Science & Metallurgy
4. (ME-244) Fundamentals of Acoustics

Curriculum for B Tech Programme

Course No.	Semester 5	Credits	Course Type
	Open Elective	3	Institute Electives
	Engineering Course	**12/10**	Discipline core
	Engineering Course	3	Discipline Elective
	Engineering Course (Lab)	2	Discipline core
	HSS Course (**Non Circuital branches)**	**0/2**	Institute Core
Total 20			
Course No.	**Semester 6**	**Credits**	**Course Type**
	Engineering Course	**10/8**	Discipline Core
	Engineering Course	6	Discipline Elective
	Engineering Course	2	Stream Core
	Engineering Course (Lab)	2	Discipline Core
	HSS Course **(Circuital branches)**	**0/2**	Institute Core
Total		**20**	

Third Year													
5th Semester							**6th Semester**						
SN	**Code**	**Subject**	**L**	**T**	**P**	**Cr**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	ME-311	Machine Design-I	3	1	0	4	1	ME-321	Internal Combustion Engines	3	0	0	3
2	ME-312	Heat Transfer	3	0	0	3	2	ME-322	Machine Design-II	3	1	0	4
3	ME-313	Dynamics of Machines	3	0	0	3	3	ME-323	Operation Research	3	0	0	3
4	ME-314	Kinematics & Dynamics Lab	0	0	2	1	4	ME-324	Internal Combustion Engines Lab	0	0	2	1
5	ME-315	Heat Transfer Lab	0	0	2	1	5	ME-325	Design Lab	0	0	2	1
6	ME-301/302/303/304	Open Elective	3	0	0	3	6	ME-341/342/343	Discipline Elective (III)	3	0	0	3
7	ME-351/352/353	Discipline Elective (II)	3	0	0	3	7	ME-361/362/363	Discipline Elective (IV)	3	0	0	3
8	HS-311	HSS Course (Non-Circuital branches)	2	0	0	2	8	ME-381/382/383/384	Stream Core -I	2	0	0	2
		Total =				**20**			**Total =**				20

Curriculum for B Tech Programme

Open Elective

1. (ME-301) Introduction to Product Development
2. (ME-302) Introduction to Robotics
3. (ME-303) Total Quality Management
4. (ME-304) Renewable Source of Energy

Discipline Elective (III)

1. (ME-341) Logistic & Supply Chain
2. (ME-342) Composite Materials
3. (ME-343) Principle of Combustion

Stream Core-I

1. (ME-381) Additive Manufacturing
2. (ME-382) Computational Fluid Dynamics
3. (ME-383) Advanced Mechanics of Solids
4. (ME-384) Vibration & Noise Control

Discipline Elective (II)

1. (ME-351) Finite Elements in Engineering
2. (ME-352) Product Design & Development
3. (ME-353) Turbomachines

Discipline Elective (IV)

1. (ME-361) Design of Experiments
2. (ME-362) Industrial Tribology
3. (ME-363) Gas Turbines

Curriculum for B Tech Programme

Course No.	Semester 7	Credits	Course Type
	Engineering Course	9	Discipline Core
	Engineering Course	3	Discipline Elective
	Engineering Course	4	Stream Core
	Engineering Course (Lab)	2	Discipline Core
Vocational Training	Engineering Course	2	Discipline Core
Total		**20**	

Course No.	Semester 8	Credits	Course Type
	Free Elective/Engineering Course/Open Elective Course (Courses available in other departments in the even semester)	**6**	Free Electives/Stream Elective (offered by Department/Institute Elective (Open Elective)
	UG Project*	12	Discipline elective
General Proficiency	Holistic Assessment	2	Institute Core
Total		**20**	

***Students opting for internship will complete the UG project and the remaining credit requirements will be by fulfilled by opting Free Elective Courses**

Fourth Year													
7th Semester							8th Semester						
SN	Code	Subject	L	T	P	Cr	SN	Code	Subject	L	T	P	Cr
1	ME-411	Computer Added Manufacturing	3	0	0	3	1	ME-461/462/463	Stream Electives-I	3	0	0	3
2	ME-412	Refrigeration & Air Conditioning	3	0	0	3	2	ME-481/482/483	Stream Electives-II	3	0	0	3
3	ME-413	Computer Aided Design	3	0	0	3	3	ME-498	Holistic Assessment	0	0	0	2
4	ME-414	Refrigeration & Air Conditioning Lab	0	0	2	1	4	ME-499	UG Project	0	0	0	12
5	ME-415	CAD/CAM Lab	0	0	2	1							
6	ME-419	Vocational Training*				2							
7	ME-431/432/433/434/435/436/437/438	Discipline Elective (V)	3	0	0	3							
8	ME-451/452/453	Stream Core-II	2	0	0	2							
9	ME-471/472/473	Stream Core-III	2	0	0	2							
		Total =				**20**			**Total =**				20

*The students should undergo vocational training during summer vacations after sixth semester

Note: (i) Students opting for internship will complete the UG project and the remaining credit requirements will be fulfilled by opting Free Elective Courses, (ii) In place of Stream Electives, student may opt Stream Elective offered by other Department/Engineering Course/Open Elective Course/Courses available in other departments in the even semester/Free Electives/ /Institute Elective (Open Elective)/Open Platform Course of 6 credits.

Discipline Elective (V)

1. (ME-431) Design of Heat Exchanger
2. (ME-432) Mechanics of Composite Materials
3. (ME-433) Automobile Engineering
4. (ME-434) Industrial Robotics
5. (ME-435) Optimization Methods in Engineering
6. (ME-436) Solar Energy Utilization
7. (ME-437) Exergy Analysis of Thermal Systems
8. (ME-438) Electric and Hybrid Vehicle

Stream Core-II

1. (ME-451) Smart Manufacturing
2. (ME-452) Condition Monitoring & Diagnosis
3. (ME-453) Compressible Flow

Stream Core-III

1. (ME-471) Total Quality Management
2. (ME-472) Bearing & Lubrication
3. (ME-473) Propulsion Systems

Stream Elective-I

1. (ME-461) Material Selection in Engineering Design
2. (ME-462) Mechatronics
3. (ME-463) Power Plant Engineering

Stream Elective-II

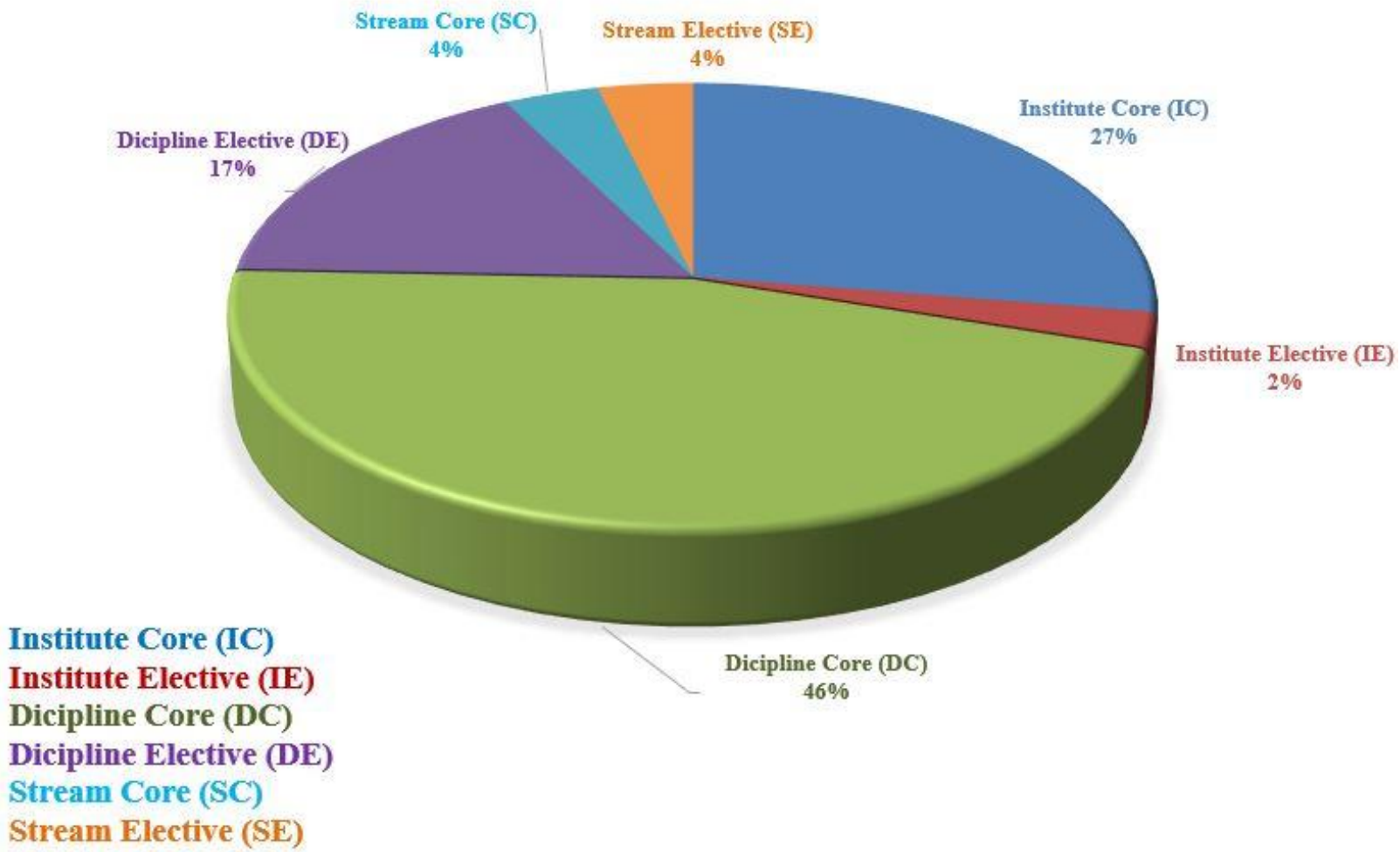
1. (ME-481) Design of Eletro-Mechanical Systems
2. (ME-482) Industrial Automation
3. (ME-483) Energy Conservation and Management

Types of Courses and credits in each Semester

	Semester								
Types of Courses	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Total**
IC	20	20	0	0	2	0	0	2	44
IE	0	0	0	1	3	0	0	6*	4/10*
DC	0	0	20	16	12	12	13	0	73
DE	0	0	0	3	3	6	3	12	27
SC	0	0	0	0	0	2	4	0	6
SE	0	0	0	0	0	0	0	6*	6/0*
Total	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**160**
Total									**160**

* Students are free to choose any combination out of Free Electives, IE, and SE for 6 credits

Share of Credits based on the Requirement of the Programme



SEMESTER III

Course Name: **Engineering Mathematics-III**
Course Code: **MA-203**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the fundamental concepts relevant to function of complex variable, numerical differentiation and integration and numerical solution of linear, non-linear and system of equations.
- To have the idea of evaluation of real integrals using complex variable.
- To understand the concept of approximating & interpolating polynomials and finding values of function at arbitrary point.
- To impart knowledge of various numerical technique to solve ODE.

Unit Number	Course Content	Contact Hours
UNIT-01	**Functions of Complex Variable:** Functions of Complex Variable Applications of De Moivre's Theorem, Exponential, Circular, Hyperbolic and Logarithmic Functions of a Complex Variable, Inverse Hyperbolic Functions, Real and Imaginary Parts of Circular and Hyperbolic Functions, Summation of the Series - 'C+Is' Method, Limit and Derivative of Complex Functions, Cauchy-Riemann Equations, Analytic Functions and Its Applications, Complex Integration, Cauchy's Theorem, Cauchy's Integral Formula, Series of Complex Function, Taylor Series, Singularities and Laurent's Series, Cauchy's Residue Theorem and its Application for the Evaluation of Real Definite Integrals.	**12**
UNIT-02	**Interpolation:** Interpolation Least Square Curve Fit and Trigonometric Approximations, Finite Differences and Difference Operators, Newton's Interpolation Formulae, Gauss Forward and Backward Formulae, Sterling and Bessel's Formulae, Lagrange's Interpolation.	**06**
UNIT-03	**Numerical Integration:** Numerical Integration by Trapezoidal and Simpson's Rules 1/3 And 3/8 Rule, Romberg Integration, and Gaussian Quadrature Rule, Numerical Integration of Function of Two Variables.	**05**
UNIT-04	**Numerical Solution of Ordinary Differential Equations:** Numerical Solution of Ordinary Differential Equations Taylor Series Method, Picard's Method, Euler's Method, Modified Euler's Method, Runge- Kutta Method, Predictor Corrector Methods, Adam Bashforth and Milnes Method, Convergence Criteria, Finite Difference Method.	**07**
UNIT-05	**Numerical Solution of Linear and Non-Linear Equations:** Numerical Solution of Linear and Non-Linear Equations: Bisection Method, Regula Falsi Method, Newton-Raphson Method, Iteration Method. Linear Equations: Jacobi and Gauss Seidel Iteration Methods, Relaxation Method.	**06**

Course Outcomes

Upon successful completion of the course, the student will be able to:

CO1: Understand and analyze the concept of Numerical Solution of Linear and Non-Linear Equations, Ordinary Differential Equations and Function of complex variable.

CO2: Identify an appropriate technique to solve the linear, non-linear equations, ordinary differential equations.

CO3: Formulate the problems on related topics and solve analytically.

CO4: Apply the concepts of linear, non-linear equations, differential equations and complex analysis in various engineering problems.

CO5: Demonstrate the concepts through examples and applications.

Recommended Books

1. Complex variables and Applications by R. V. Churchill, J. W. Brown & R. F. Verhey, McGraw Hill.
2. A first course in complex analysis with applications by Dennis G. Zill & P. D. Shanahan, Jones and Bartlett.
3. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S. R. K. Iyenger and R. K. Jain, New Age International Publishers, New Delhi.
4. Numerical Methods for Engineers and Scientists (2nd Ed.) by J D Hoffman, CRC Press.
5. Numerical Analysis Mathematics and Scientific computing (3rd ed.) by D. Kincaid and W. Cheney, American Mathematical Society.

Course Name: **Mechanics of Solids**
Course Code: **ME-211**
Course Type: **Discipline Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart concept of stress, strain, elastic constants, and Mohr's Circle.
- To introduce the theory of shear force, bending moment, slope, and deflection of beams.
- To enable the students to learn the theory of columns, struts, and pressure vessels.

Unit Number	Course Content	Contact Hours
UNIT-01	**Stress and Strain:** Stress-Strain Relationships, Deformation of Axially Loaded Bars, Poisson's Ratio, Elastic Constants-Relationship Between Elastic Constants-Thermal Strain and Deformation, Saint-Venant's Principle and Stress Concentration, Definition of Plane Stress, Plane Strain and Axi-Symmetric Problems and Their Examples, Principal Stress and Principal Strains, Mohr's Circle Representation of Principal Stress and Strains.	**8**
UNIT-02	**Shear Force and Bending Moment:** Cantilever, Simply Supported and Overhanging Beams Subjected to Concentrated Load, UDL, UVL. Theory of Simple Bending, Bending Stress and Shear Stress Distribution, Rectangular, Circular and I Section.	**6**
UNIT-03	**Slope and Deflection:** Simply Supported Beams and Cantilevers, Relationship Between Slope, Deflection and Radius of Curvature, Slope and Deflection of Various Types of Beams with Various Loadings by Macaulay's Method, Double Integration Method, and Moment Area Method.	**6**
UNIT-04	**Theory of Columns and Struts:** Types of Columns, Failure of Column, Euler's Column Theory, Slenderness Ratio, End Conditions for Long Columns, Equivalent Length of Columns, Limitation of Euler's Formula, Factor of Safety, Empirical Relations-Rankine's Straight Line and Johnson's Parabolic Formula.	**6**
UNIT-05	**Torsion:** -Torsion of Circular Shafts, Solid and Hollow Shafts, Power Transmitted by Shafts, Thin Cylinders and Shells Subjected to Internal and External Pressures, Thick Cylinders and Spherical Shells, Lame's Equation, Compound Cylinders, Rotary Discs and Cylinders, Critical Speeds, Disc of Uniform Strength.	**6**
UNIT-06	**Theories of Failure:** Introduction to Theories of Failure, Graphical Representation of Theories of Elastic Failure and Significance, Application of Theories of Elastic Failure, Factor of Safety in Design.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the concept of stress, strain, and relations between elastic constants.

CO2: Understand The Concept of Mohr's circle and its construction.
CO3: Understand the theory of shear force, bending moment and its construction.
CO4: Learn the underlying theory of slope and deflection of beams and failure of columns and struts.
CO5: Understand the different stresses and strains in thin and thick pressure vessels.

Recommended Books

1. Strength of Materials by Timoshenko, Mc Graw Hill.
2. Mechanics of Materials by E.J. Hearn, Butterworth-Heinemann.
3. Mechanics of Materials by Beer & Johnston, Mcgraw Hill.
4. Advanced Mechanics of Solids by L.S. Srinath, Mcgraw Hill.
5. Engineering Mechanics of Solids by Egor P Popov, PHI.

Course name**: Engineering Thermodynamics**
Course Code: **ME-212**
Course type: **Discipline Core**

Contact Hours/Week: **3L + 1T** Course credits: **04**

Course Objectives

- To impart knowledge about work, heat, energy, and laws of thermodynamics.
- To develop analytical skill with the introduction of thermodynamic properties like; entropy, enthalpy, and specific heat.
- To introduce different thermodynamic cycles.

Unit Number	Course Content	Contact Hours
UNIT-01	**Fundamental Concepts:** Basic Concepts: Macroscopic and Microscopic Viewpoints, Concept of Continuum, Thermodynamic equilibrium, Quasi-static Processes, Zeroth Law of Thermodynamics, Energy, Types, Work and Heat, Point and Path function.	**5**
UNIT-02	**Pure Substances**: Phase Transformations, Triple Point and Critical Point of Pure Substances, State Properties During Change of Phase, Dryness Fraction, Property Diagrams, Steam and Refrigeration Tables, Mollier Charts, Various Thermodynamic Processes and Energy Transfer, Measurement of Dryness Fraction, Perfect Gas Laws: Equation of state, Specific and Universal Gas Constants, Deviations from Perfect Gas Model, Compressibility Factor, Vander Waals Equation of State.	**8**
UNIT-03	**First and Second Law of Thermodynamics**: First Law of Thermodynamics for Flow and Non-flow Processes, Steady and Unsteady Flow Energy Equation and its applications, Specific Heat at Constant Pressure and Volume, Heat Engine, Heat Pump, Refrigerator, Efficiency and COP, Second Law of Thermodynamics, Kelvin Planck and Clausius Statements and their Equivalence/Corollaries, PMM-1 and II, Reversibility, Carnot Cycle, Thermodynamic Temperature Scale, Clausius Inequality, Entropy, Principle of increase in entropy, Third Law of Thermodynamics, Introduction to Exergy.	**10**
UNIT-04	**Thermodynamic Property Relations:** Gibbs and Helmholtz Functions, Maxwell Relations, Clapeyron Equation, Joule-Thomson Coefficient, and Inversion curve.	**4**
UNIT-05	**Non-Reacting Mixtures of Perfect Gases:** Mole Fraction, Mass fraction, Dalton 's Law of Partial Pressure, Equivalent Gas Constant, Internal Energy, Enthalpy, Specific Heats, and Entropy of Mixture of Ideal Gases, Introduction to Real Gas Mixtures.	**4**
UNIT-06	**Power Cycles:** Rankine Cycle, Otto, Diesel, Dual cycles, Thermal Efficiency, Mean Effective Pressures, Comparison of Cycles, and Brayton cycle.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Analyse the performance of thermodynamic systems.
CO2: Apply the laws of thermodynamics for non-flow and flow processes.
CO3: Determine properties of pure substances and mixture of gases.
CO4: Analyse the performance of various power cycles.

Books and References

1. Engineering Thermodynamics by P. K. Nag, Tata McGraw-Hill.
2. Thermodynamics - An Engineering Approach by Yunus Cengel, Tata McGraw-Hill.

3. Engineering Thermodynamics by Van Wylen, Sonntag, John Wiley.
4. Engineering Thermodynamics by Wark and Richards, McGraw Hill.

Course Name: **Manufacturing Processes-I**
Course Code: **ME-213**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the different manufacturing processes to produce products from raw materials.
- To introduce the fundamental concepts of metal casting, plastic moulding, powder metallurgy, metal forming and joining processes.
- To enable the students to understand about the different types of defects in casting, plastics moulding, rolling, forging, drawing, extrusion, and welding processes.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction to Manufacturing; General Trends in Manufacturing; Responsibility of Manufacturing Engineer; Processes in Manufacturing: Shaping, Joining and Treatment; Materials in Manufacturing: Metals and Alloys, Plastics and Rubbers, Ceramics and Glasses, Introduction to Composites.	**03**
UNIT-02	**Metal Casting Processes:** Need and Classification; **Expendable Green Sand Mould Casting:** Composition, Preparation, Properties and Testing of Green Sand; Materials, Allowances and Types of Patterns; Cores, Core Prints and Chaplets; Moulding Methods; Gating Design; Cooling and Solidification-Mechanism and Rate; Riser Design and Placement; Various Casting Techniques; Casting Defects and Inspection of Casting.	**09**
UNIT-03	**Powder Metallurgy Processes:** Production of Metal Powders; Blending and/or Mixing of Powders, Compacting and Sintering of metal powders; Hot Isostatic Pressing (HIP), Powder Injection Moulding (PIM), and Electro-Spark Pressing.	**05**
UNIT-04	**Metal And Sheet Metal Forming Processes:** Introduction, Elastic and Plastic Deformation, Yield Criterion, Hot Working and Cold Working; **Rolling:** Classification, Process Geometry and Analysis Using Slab Method For Load and Power; Rolling Mills and Roll Pass Design; Defects; **Forging:** Classification, Process Geometry and Analysis of Strip and Disc Forging Using Slab Method For Load and Power; Defects; **Drawing:** Process Geometry and Analysis Using Slab Method For Load and Power, Maximum Reduction, Defects; **Extrusion:** Classification, Process Geometry and Analysis of Rod Extrusion Using Slab Method For Load and Power, Maximum Reduction; Defects; **Sheet Metal Forming:** Need and Classification; Blank Preparation by Sheet Cutting.	**09**
UNIT-05	**Atomic Joining Processes:** Need and Classifications; **Solid Welding:** Diffusion, Friction, Forge and Roll Welding; Explosive and Ultrasonic Welding; **Resistance Welding:** Spot, Projection and Seam Welding, Resistant Butt and Flash Butt; High-Frequency Resistance and High-Frequency Induction; **Arc Welding:** Non-	**07**

	Consumable Electrode - CAW, GTAW, PAW and Consumable Electrode - SMAW and GMAW, SAW and ESW; **Gas Welding:** Oxy Acetylene and Oxy Hydrogen; Thermit Welding; **Beam Welding:** LBW and EBW; Welding Defects and Inspection; Special Welding Applications: Brazing and Soldering**.**	

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Identify the process requirements to manufacture a specific product by casting, plastic moulding, powder metallurgy and metal forming processes.

CO2: Describe the effects of various parameters on the quality of the product produced.

CO3: Apply principles of solidification, sintering and yielding in the production of any product.

CO4: Assess the quality of joints made by different types of welding operations.

Recommended Books

1. Fundamentals of Modern Manufacturing: Materials Processes and Systems by M. P. Groover, John Wiley and Sons, New Delhi.
2. Manufacturing Science by Ghosh and Mallik, East West Press Pvt. Ltd., New Delhi.
3. Fundamentals of Metal Forming Processes by Juneja, New Age Inc. Publisher.
4. Manufacturing Engineering and Technology by Kalpakjian and Schmid, Pearson Education Pvt. Ltd. New Delhi.
5. Welding Processes and Technology by R.S. Parmar, Khanna Publishers, New Delhi.

Course Name: **Metrology, Measurement and Control**
Course Code: **ME-214**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about different types of measurement methods.
- To introduce different measuring techniques for identifying behavior of the systems.
- To understand the different principles of Control System.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Concept and Need of Measurements, Systems and Instruments, Classification of Methods of Measurement, Standards, Units, Precision and Accuracy, Repeatability and Reproducibility, Sensitivity, and Readability, Linear and Angular Measurement, Comparators, Angle Measuring Instruments, Sources of Error in Measurement.	**6**
UNIT-02	**Measurements of Geometric Forms and Finish:** Form Measurement, Tool Maker's Microscope, Optical Measuring Microscope, Evaluation of Surface Roughness, Measurement of Threads and Gears, Systems of Limits and Fits.	**6**
UNIT-03	Measurement of Displacement, Speed, Force, Acceleration, Torque, Pressure, Flow, Temperature and Strain.	**7**
UNIT-04	Data Acquisition & Signal Conditioning, Analog and Digital Devices, Amplification, Analog filters, Digital signals, Analog to digital, Operational Amplifiers, Data Transmission Elements, Indicating, Recording and Display Elements, Data Acquisition Systems.	**7**
UNIT-05	**Control System:** Block Diagram of Control System, Closed Loop System, Open Loop System Feedback Control System, Feed Forward Control, Comparison of Hydraulic, Pneumatic, Electronic Control System, Proportional Control Action, Stability of Control Systems, Measurements and Control for Different Engineering Application.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the role of different measurements techniques.
CO2: To analyse and measure different physical parameters using modern measurement methods.
CO3: Understand the different control system for engineering application.

Books and References

1. Engineering Metrology and Measurements by N.V. Raghavendra and L.Krishnamurthy, Oxford University Press.
2. Instrumentation, Measurement &analysis, B.C Nakra & K.K Chaudhary, Tata McGraw Hill
3. Measurement and Control Basics 2nd Ed.,T.A hughes
4. Modern Control System Engineering by K.Ogata,, Pearson education
5. Engineering Metrology by R.K. Jain, Khanna Publisher.
6. Mechanical Measurements by Backwith, Marangoni and Lienhard Pearson Education.
7. A textbook of Measurement and Metrology by A.K. Sawhney, and M. Mahajan Dhanpat Rai & Co.

Course Name: **Mechanics of Solids Lab**
Course Code: **ME-215**
Course Type: **Discipline Core**

Contact Hours/Week: **2** Course Credits: **01**

Course Objectives

- To gain practical knowledge about properties and testing of materials
- To acquire the knowledge and operating skills about different testing machines and setups.
- To learn the principles and methodology involved in testing of materials.

List of Experiments

1.	To find Young's Modulus of a given bar (brass) using Deflection Beam Apparatus.
2.	To find the value of Young's Modulus of a given wire using Searle's Apparatus.
3.	To determine the Stiffness of Spring using Dead weight and elongation method.
4.	Study of Universal Testing Machine and to perform Tensile Test.
5.	To perform compression test on Universal Testing Machine.
6.	To determine the Shear strength of a given specimen on Universal Testing Machine.
7.	Study of torsion testing machine and to perform test on a given specimen for determination of Modulus of Rigidity
8.	Study of Impact Testing Machine and to perform Izod Test to find the Impact strength of the given specimen.
9.	Study of Brinell Hardness Testing Machine and to find out Brinell Hardness Number (HBN) of the given specimen.
10.	Study of Rockwell Hardness Testing Machine and to find out Rockwell Hardness Number (HR) of the given specimen.
11.	To measure the stress and strain using strain gauges mounted on cantilever beam.
12.	To perform Bending Test on Cantilever Beam set up and calculate the Bending Stress.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the methodology of testing and measurements of different properties of materials.

CO2: Understand and analyze principles and techniques of testing.

CO3: Develop skills on different machines and instruments to measuring properties of materials.

Course Name**: Metrology and Measurement Lab**
Course Code: **ME-216**
Course Type**: Core**

Contact Hours/ Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge about different types of measuring systems.
- To acquire knowledge about different physical parameters measurement.
- Learn the usage of different measurement principles.

List of Experiments

1.	Study of different types of gauges (Vernier caliper, Vernier Height gauge, Vernier depth gauge, Micrometer, filler gauge, go-no-go gauge, plug gauge, go-no-go snap gauge, bourdon tube, pressure gauge).
2.	Calibrations of linear measuring instruments by using slip gauges and calculation of percentage error.
3.	Measurement of the included angle of a given specimen using Sine Bar and Clinometers.
4.	Measurement of diameter of small size hole using Tool Maker's Microscope.
5.	Measurement of pitch diameter of a screw thread by vertical Profile Projector.
6.	Determination of RPM and Torque of a given motor using RPM Measurement Tutor and calculation of percentage error.
7.	Determination of velocity of given velocity transducer (Magnetic sensor UGM3140) using velocity Tutor and calculation of percentage error.
8.	Measurement of Temperature of a given sample using Temperature Measurement Tutor and calculation of percentage error.
9.	Calibration of pressure gauge using Dead Weight Tester.
10.	Measurement of strain of a given metallic strip using Strain Measurement Tutor.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Evaluate the phenomenon of measurements system.

CO2: Understand and analyze measurement techniques.

CO3: Use different systems and instruments to measure parameters with precision.

CO4: Develop basic concept of the various comparators and interference.

Recommended Books

1. Engineering Metrology and Measurements by N.V. Raghavendra and L. Krishnamurthy, Oxford University Press.

2. Engineering Metrology by R.K. Jain, Khanna Publisher.

Course Name: **Manufacturing Processes -I Lab**
Course Code: **ME-217**
Course Type: **Discipline Core**

Contact Hours/Week: 2**P** Course Credits: **01**

Course Objectives

- To study the fundamentals and have practical exposure to basic manufacturing processes.
- To familiarize the students with the basics of machining, welding, fitting, smithy, carpentry, foundry and sheet metal-related operations and handling/working of equipment and processes.
- To familiarize students with various handling/working of Soldering and Brazing processes.

List of Experiments

1.	Preparation of job as per given drawing for T Joint using Arc and Gas Welding Setup, Soldering & Brazing Job Practice (2T).
2.	Preparation of job as per given drawing using Tungsten Inert Gas (TIG) Welding (1T).
3.	Preparation of job as per given drawing using Metal Inert Gas (MIG) Welding (1T).
4.	Preparation of Green Sand Mould using tools of the Foundry Shop by various methods (2T).
5.	Measurement of sand particle size (grain fineness number) of a given sand sample using a mechanical sieve shaker.
6.	Determine the moisture and clay content of a given sand sample.
7.	To estimate the permeability of a given green sand sample using a permeability tester and estimate the compressive and shear strength of green sand using a sand strength tester.
8.	Preparation of job as per drawing for cutting practice and Dovetail Joint in Carpentry Shop using Carpentry Tool (2T).
9.	i) Preparation of job as per given drawing related to Fitting shop (1T) ii) Preparation of job in sheet metal shop for Riveting operation (1T)
10.	Preparation of job as per given drawing (Chisel) using tools of Smithy Shop (2T).

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Learn the basics of metal machining, Welding, fitting, forging, carpentry, foundry, and sheet metal-related operations.

Recommended Books

1. A Course in Workshop Technology by B.S. Raghuwanshi, Dhanpat Rai & Company(P) Limited.
2. Elements of Workshop Technology by Hajra Choudhary &Nirjhar Roy, Media Promoters and Publishers Pvt. Ltd.

SEMESTER IV

Course Name: **Kinematics of Machines**
Course Code: **ME-221**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart concept and terminology associated with mechanisms and introduction to computer aided mechanisms.
- To understand velocity and acceleration diagrams for different mechanisms.
- To discuss the theory and underlying principles for different friction devices.
- To understand the theory of cam, follower, gears, and gear trains.

Unit Number	Course content	Contact Hours
UNIT-01	**Simple Mechanisms** Kinematic Links, Kinematic Pairs, Constrained Motions, Degree of Freedom Classification of Kinematic Pairs, Kinematic Chain, Mechanism, Planar Mechanism, Grubler's Criteria for Plane Mechanisms, Four Bar Chain, Inversion of Mechanism.	**8**
UNIT-02	**Velocity And Acceleration in Mechanism** Relative Velocity Method, Velocities in Slider Crank Mechanism, Rubbing Velocity at Pin Joint, Instantaneous Centre Method, Acceleration Diagram, Coriolis Component of Acceleration.	**7**
UNIT-03	**Friction Devices (Clutch, Belt, Rope, Brakes and Dynamometer)** Friction And Its Types (Pivot and Collar Friction, Uniform Wear and Uniform Pressure Theory), Laws of Friction, Introduction to Clutches, Belt Drives, Rope Drives, Brakes and Dynamometer.	**6**
UNIT-04	**Cams and Followers** Classification of Cams and Followers, Nomenclature, Types of Follower Motion, Generation of Cam Profile with Uniform Velocity, Simple Harmonic Motion, Uniform Acceleration and Retardation, Cycloidal Motion of the Follower, Cam Applications and Manufacturing.	**6**
UNIT-05	**Gears and Gear Trains** Types of Gears, Terminology, Fundamental Law of Gearing, Gear Profiles, Minimum Number of Teeth, Length and Arc of Contact, Gear Trains: Simple, Compound Reverted and Epicyclic Gear Trains, Automotive Transmission Gear Trains, Differential.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify link, pair, chain, joints and inversions of mechanisms.

CO2: Construct the velocity and acceleration diagrams for different mechanisms.
CO3: Understand the underlying theory and principles for various friction devices and their applications.
CO4: Understand Cam profile generation and their applications.
CO5: Learn the concept of gear and gear train and various automotive transmissions.

Recommended Books

1. Theory of Machines by S.S Rattan, McGraw Hill.
2. The Theory of Machines by Thomas Bevan, CBS Publishers & Distributors.
3. Theory of Mechanisms and Machines by Jagdish Lal, Metropoliton Book Co. Pvt. Ltd.
4. Theory of Machines and Mechanism by J.J Uicker, Oxford International.

Course Name: **Fluid Mechanics**
Course Code: **ME-222**
Course Type: **Discipline Core**

Contact Hours/Week: **3L+1T** Course Credits: **04**

Course Objectives

- To impart basic concepts of fluid flow.
- To introduce the concepts of Euler's and Navier Stokes Equation of motions and their applications.
- To provide the student with some specific knowledge regarding fluid-flow phenomena observed in mechanical engineering systems, such as flow in a pipe, boundary-layer flows, drag, etc.

Unit Number	Course Content	Contact Hours
UNIT-01	**Fluid Properties and Fluid Statics:** Definition of Fluid, Fluid as A Continuum, Types of Fluid, Properties of Fluid, Viscosity, Compressibility, Surface Tension, Capillarity and Vapor Pressure, Pascal's Law, Hydrostatic Law of Pressure, Total Pressure, Centre of Pressure, Buoyancy, Metacentre, Condition of Equilibrium of Floating and Submerged Bodies.	**08**
UNIT-02	**Fluid Kinematics:** Eulerian and Lagrangian Approach of Fluid Flow, Flow Visualization, Total or Material Derivative for Velocity Field, Concepts of Streamline, etc., Velocity, Acceleration, Euler's Equation, Circulation, Vorticity and Rotation, Irrotational Flow, Velocity Potential Stream Function, Continuity Equation.	**06**
UNIT-03	**Fluid Dynamics:** Reynolds Transport Theorem, Integral Form of Continuity, Momentum and Energy Equation, Bernoulli's Equation and Its Application, Venturi Meter, Orifice, Mouth Pieces, Weirs and Notches, Linear Momentum Equation and Its Applications, Forces on Pipe Junction, Bends, Stationary Flat and Curved Vanes, Moment of Momentum Equation, Dimensional Homogeneity, Dimensionless Ratios, Dimensions and Units, Dimensionless Parameters, Similitude and Model Studies.	**09**
UNIT-04	**Viscous Flow:** Equation of Motion for Laminar Flow through Pipes-Hagen Poiseuille Formula, Flow Between Parallel Flat Plates, Couette Flow, Plane Poiseuille Flow, Flow Through Pipes, Minor and Major Losses, Transition from Laminar to Turbulent, Reynolds Experiment, Eddy Viscosity, Mixing Length Concept and Velocity Distribution in Turbulent Flow, Unsteady Motion of Flat Plates.	**06**
UNIT-05	**Boundary Layer Concepts:** Boundary Layer Equations, Estimation of Laminar Boundary Layer Thickness for Flat Plate and Drag by Momentum Integral Method, Boundary Layer Separation.	**04**
UNIT-06	**Compressible Flow:** Basic Equations for One Dimensional Compression, Pressure Wave Propagation, Sound Velocity in Fluid, Mach Number, Stagnation Properties.	**03**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Possess a sound knowledge of fundamental properties of fluids and fluid continuum.
CO2: Analyse forces on partially or fully submerged bodies.

CO3: Analyse laminar and turbulent flow.
CO4: Understand the Boundary Layer concepts and Flow through pipes.

Books and References

1.Fluid Mechanics by F.M. White, McGraw Hill Publications.
2.Fluid Mechanics by Yunus Cengel and, John M. Cimbala, Tata McGraw Hill.
3.Fundamentals of Fluid Mechanics by Munson, Young, Okiishi & Huebsch, John Wiley Publications.
4.Foundations of Fluid Mechanics by S. W. Yuan, Prentice Hall of India.

Course Name: **Manufacturing Processes-II**
Course Code: **ME-223**
Course Type: **Discipline core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the various metal removal and layer laminating processes.
- To introduce the fundamental concepts and mechanics of cutting machining, abrasive machining, and erosive machining.
- To enable the students to understand the technology and science of layer lamination and surface coating processes.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction to Metal Cutting, Machining, Machinability, Need and Classification of Machining and Material Additive Processes, Tool materials.	**02**
UNIT-02	**Machining Processes:** Mechanism and Mechanics of Machining, Chip Formation, Types of Chips, Orthogonal and Oblique Cutting, Cutting Forces and Merchant Circle Diagram, Shear and Friction Angle, Shear and Chip Velocity, Length of Shear and Friction Plane, Energy in Shear and Friction Plane, Shear Stress and Strain, Heat Generation and Temperature in Shear and Friction Plane. **Tool Materials and Life of Cutting Tool:** Composition and Properties of Tool Materials, Tool Failure Mechanisms and Calculation of Tool life, **Description of Practical Cutting Machining Processes:** Tool Geometry, Process Geometry, Process Parameters, Performance Parameters for Turning and related operations, Shaping and Planning, Drilling and Related Operations, Milling and Gear Cutting, Broaching and Sawing, Economics of Cutting.	**10**
UNIT-03	**Abrasive Machining Processes**: Need and Classifications; Abrasive Grinding: Wheel Specification, Wheel Life, Balancing, Truing and Dressing of Wheels, Classifications of Abrasive Grinding Processes, Chipping action in grinding, Calculation of Material Removal Rate, Forces and Power, Heat and Temperature in Abrasive Grinding, Working Principle and Applications of Grinding Processes for Prismatic and Rotational Parts, Abrasive Finishing: Conventional Abrasive Finishing: Honing, Lapping, Polishing and Buffing, Modern Abrasive Finishing: Abrasive Flow Finishing, Magnetic Abrasive Finishing and Magnetic Float Finishing.	**06**
UNIT-04	**Advanced Machining Processes:** Need and Classification of Advanced Machining Processes, Need and Classification of Erosion-based Machining Processes, Process Principles, Equipment, and Applications of Electro-Discharge Machining (EDM) and Beam Machining Processes (e.g. LBM, EBM, IBM), Electro-Chemical Machining (ECM) and Chemical Machining Processes (e.g. CHM, PCM, BCM), Ultrasonic Machining and Jet Machining Processes (AJM, WJM, AWJM), Introduction to Machining of Composites.	**12**

UNIT-05	**Material Additive Processes:** Layer Lamination Processes: Stereo Lithography (SLA), Solid Ground Curing (SGC), Selective Laser Sintering (SLS) and Three-Dimensional Printing (TDP), Fused Deposition Modelling and Laminated Object Manufacturing (LOM), Layer Coating Processes: Physical Vapour Deposition, Chemical Vapour Deposition, Electro-Chemical Deposition, Atmospheric Plasma Spraying, Vacuum Plasma Spraying, Detonation Gun Spraying.	**04**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the requirements for the selection of different process parameters to perform any machining operation.

CO2: Describe the effects of various forces acting during different machining processes.

CO3: Apply principles of advanced machining processes in the machining of difficult-to-machine materials.

CO4: Assess the quality of the surface produced after applying the layer additive processes.

Recommended Books

1. Fundamentals of Modern Manufacturing: Materials Processes and Systems by M. P. Groover, John Wiley and Sons.
2. Manufacturing Science by Ghosh and Mallik, East West Press.
3. Introduction to Machining Science by G. K. Lal, New Age International.
4. Advanced machining processes by V. K. Jain, Allied Publishers Private Limited.
5. Fundamentals of Machining Processes by Hassan El-Hofy, Taylor and Francis.
6. Rapid Prototyping: Principles and Applications by Rafiq Noorani, Wiley International.

Course Name: **Industrial Engineering**
Course Code: **ME-224**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To enable the students to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- To impart an ability to identify, formulate, and solve engineering problems.
- To introduce the importance of various industrial functions such as forecasting, product design, inventory control, sales, and quality, etc., in an organization.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Concept of Industrial Engineering; Functions of Industrial Engineering; Role of Industrial Engineering in the plant; Concept of Productivity, Productivity Measures, Productivity Measurement Models, Principles and Types of Organization-Line, Functional, Line and Staff; Organization Chart.	**3**
UNIT-02	**Facilities System Design:** Production System Facilities, Concept and Factors Governing Plant Location, Locational Economics, Types of Plant Layout-Process, Product, Combination, Fixed Position, Methods of Plant and Factory Layout, Functions and Principles of Material Handling, Relationship to Plant Layout, Selection of Material Handling Equipment, Types of Material Handling Equipment, Concept and Importance of Line Balancing, Line Balancing Heuristics.	**6**
UNIT-03	**Work System Design:** Concept of Work Study, Techniques of Work Study, Scope & Procedure of Method Study; Elements of Method Design; Flow Process Chart, Flow Diagram; String Diagram, Multiple Activity Charts; Work Sampling; Objectives of Work Measurement, Basic Procedure of Time Study; Standard Time, Job Evaluation and Merit Rating.	**5**
UNIT-04	**Production Planning and Control:** Definition of PPC, Concept of Production Planning and Production Control, Objectives and Functions of PPC, Comparison Among Production Planning and Production Control, Information Requirement for PPC, Methods of Sales Forecasting, Forecasting of New and Established Products, Functions of PPC: Routing, Scheduling, Sequencing, Master Scheduling, Machine Loading, Dispatching: Centralized and Decentralized Dispatching, Progress Reporting, Corrective Actions.	**6**
UNIT-05	**Product Development and Design:** Concept of Product Development and Design; Product Life Cycle, Steps of New Product Development, Product Design Considerations; Standardization, Simplification and Specialization; Ergonomic Considerations; Product Cost Considerations, Design for Manufacturing, Concurrent Engineering, Concept of Break-Even Analysis, Calculations of Break-Even Points, Advantages, and Application of Break-Even Analysis.	**6**

UNIT-06	**Quality and Reliability Engineering:** Introduction and Definition of Quality, Quality of Design, Quality of Performance and Quality of Conformance, Difference Between Inspection and Quality Control, Customer Orientation: Internal & External Customer Concept, Life Cycle Approach to Quality Cost-Prevention; Appraisal and Failure Costs (PAF Model), Seven QC Tools (Histogram, Check Sheets, Ishikawa Diagrams, Pareto, Scatter Diagrams, Control Charts), Reliability Evaluation, Maintainability, and Availability Concepts.	**5**
UNIT-07	**Latest Tools of Industrial Engineering:** Material Requirement Planning, Enterprise Resource Planning, JIT Production System; TQM, Benchmarking; ISO Standards; Supply Chain Management, Business Process Reengineering, Industry 4.	**3**

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

CO1: Design, develop, implement, improve integrated systems that include people, materials, information equipment & people.

CO2: Use the techniques, skills, and modern engineering tools necessary for engineering practice.

CO3: Design and conduct experiments, as well as analyse and interpret data.

Recommended Books

1. Production Planning & Inventory Control by Narsimhan,PHI.
2. Production and Operations Management by Adam Ebert, Pearson.
3. Industrial Engineering and Management by Ravi Shankar,Galgotia Publication.
4. Modern Production/ Operation Management by Buffa, Wiley.

Course Name: **Machine Drawing Lab**
Course Code: **ME-225**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain knowledge about drawings of different machine components.
- To get familiarized with standards, conventions of machine drawing.
- To learn and visualize the assembly of different machine elements.

List of Experiments

1.	Preparation of drawing sheet related to Limits, Fits and Tolerances.
2.	Preparation of drawing sheet related to Rivets and Riveted joints.
3.	Preparation of drawing sheet related to Welds and Welded joints.
4.	Preparation of drawing sheet related to Screw Threads and Threaded fasteners.
5.	Preparation of drawing sheet related to Keys, Cotters and Shaft Joints.
6.	Preparation of drawing sheet related to Shaft Couplings.
7.	Preparation of drawing sheet related to Assembly of Plummer Block.
8.	Preparation of drawing sheet related to Assembly of Footstep Bearing.
9.	Preparation of drawing sheet related to Assembly of Screw Jack.
10.	Preparation of drawing sheet related to Assembly of Connecting Rod.
11.	Preparation of drawing of Crane Hook using Auto CAD/CATIA.
12.	Preparation of drawing of Connecting Rod using Auto CAD/CATIA.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the concept of machine elements and their drawings.
CO2: Learn the standard conventions and notations for machine drawings.
CO3: Visualize different machine elements and draw their different views.
CO4: Learn basic concept of assembly drawing.

Course Name: **Fluid Mechanics Lab**
Course Code: **ME-226**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by applying the experimental methods to correlate with theory.
- To learn the usage of instruments for various measurements.
- Apply analytical techniques and graphical analysis to experimental data.

List of Experiments

1.	To find the metacentric height of the floating body.
2.	To determine co-efficient of discharge (Cd) of Orifice/Venturimeter.
3.	To determine the co-efficient of discharge (Cd) of the given rectangular/V notch.
4.	To verify Bernoulli's theorem using Venturimeter.
5.	To find the friction loss and frictional factor of given pipelines.
6.	To study the inception and growth of Cavitation.
7.	To study the impact of Jets on Vanes.
8.	To study the characteristics of a Pelton Turbine.
9.	To study the characteristics of a Francis Turbine.
10.	To study the characteristics of a Kaplan Turbine.
11.	To study the characteristics of a Centrifugal Pump.
12.	To study the characteristics of a Reciprocating Pump.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Explain the effect of fluid properties on a flow system.
CO2: Select and analyse an appropriate turbine with reference to given situation in power plants.
CO3: Estimate performance parameters of a given Centrifugal and Reciprocating pump.

Course Name: **Manufacturing Processes-II Lab**
Course Code: **ME-227**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge of various machine tools.
- To learn the motion mechanism of different machine tools such as shaper, planer, slotter, etc.
- To learn the usage of milling machine to make the gears and slots.
- To develop the skills of using grinding machines to machine the prismatic and cylindrical workpieces.

List of Experiments

1.	Preparation of single point cutting tool using Tool-grinder machine.
2.	To measure the different components of cutting forces at various cutting speed, feed, and depth of cut.
3.	To study tool wear and tool life at various cutting speed, feed, and depth of cut.
4.	To measure the cutting temperature at different cutting speed, feed, and depth of cut.
5.	To study the construction and motion mechanism of shaper, planer, and slotter, and prepare the job as per drawing using a Shaper machine.
6.	To drill a hole of a given diameter using a radial drilling machine and make a hexagonal slot as per drawing in this hole using the Slotting machine.
7.	Study of Indexing mechanism for gear cutting and to cut gear on a gear blank using Indexing mechanism on a horizontal milling machine.
8.	To study Hobbing machines and cut a gear of a given number of teeth on Hobbing machines.
9.	To make a T-slot as per drawing using a Vertical milling machine.
10.	To make a job as per drawing using a Surface grinding machine.
11.	To make a job as per drawing using a cylindrical grinding machine.
12.	Demonstration and study of Electrical discharge machine.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Provide practically the different tool angles on a given cuboid piece to make a single point cutting tool.

CO2: Understand the measurement of cutting forces, tool wear and cutting temperature at various cutting conditions.

CO3: Understand the differences in motion mechanism and machining operations performed by shaper, planner and slotter.

CO4: Select suitable machining processes for the specific object manufacturing.
Recommended Books 1. Fundamentals of Modern Manufacturing: Materials Processes and Systems by M. P. Groover, John Wiley and Sons. 2. A Course in Workshop Technology Volume 2 Machine Tools by B S Raghuwanshi.

Course Name: **Advanced Machining Processes**
Course Code: **ME-241**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: **03** Course Credits: **03**

Course Objectives

- To impart knowledge about the various advanced machining processes.
- To introduce the fundamental concepts of mechanical, chemical, electrochemical, and thermal-based advanced machining processes.
- To enable the students to understand technology and mode of material removal in advanced machining processes.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Types of Advanced Manufacturing Processes; Evolution, Need, and Classification of Advanced Machining Processes (Amps).	**2**
UNIT-02	**Mechanical Type AMPs:** USM, AJM, WJM, AWJM Processes: Process Principle and Elements; Tool Design; Mechanism of Material Removal, Parametric Analysis; Shape and Material Applications; Operational Characteristics; Limitations.	**7**
UNIT-03	**Advanced Finishing Process:** Abrasive Flow Machining; Magnetic Abrasive Finishing; Magneto Rheological Finishing: Process Principle, Process Equipment, Analysis, and Modelling of Finishing Mechanism; Parametric Analysis; Applications.	**6**
UNIT-04	**Chemical Type AMPs:** Process Principle and Details of Chemical Machining, Photochemical Machining and Bio-Chemical Machining Processes.	**2**
UNIT-05	**Electrochemical Type AMPs:** ECM Process: Principle, Mechanism of Material Removal; Kinematics and Dynamics of ECM; Tooling Design; Choice and Analysis of Process Parameters; Surface Finish and Accuracy.	**3**
UNIT-06	**Thermal Type AMPs:** EDM, LBM and EBM Processes: Working Principle; Power Circuits; Mechanism of Material Removal; Process Parameters and Characteristics; Surface Finish and Accuracy: Shape and Materials Applications, Limitations.	**7**
UNIT-07	**Derived and Hybrid AMPs:** Introduction of Processes Like Rotary Ultrasonic Machining, Electro Stream Drilling, Shaped Tube Electrochemical Machining, Wire Electro Discharge Machining, Electrochemical Grinding, Electrochemical Honing, Electrochemical Deburring, and Electro-Chemical Spark Machining.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify the requirements and needs of the advanced machining process.
CO2: Select a suitable non-conventional machining process as per the requirement.

CO3: Describe the effects of various process parameters in respective non-conventional machining process.
CO4: Apply principles of advanced machining processes in machining of difficult-to-machine materials.

Recommended Books

1. Advanced Machining Processes by V.K. Jain, Allied Publishers.
2. Modern Machining Processes by P.C. Pandey, H.S. Shan,Tata McGra Hill.
3. Non-traditional Manufacturing Processes: G.F. Benedict, CRC Press Inc.
4. Nonconventional Machining: P.K. Mishra, Narosa Publishing House.
5. Advance Method of Machining: J.A. McGeough, Ch'apman and Hall.

Course Name: **Thermal Engineering**
Course Code: **ME-242**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To apply the Thermodynamics principles to analyse vapour power cycles and their components.
- To understand and evaluate the perform of the major components and systems and their applications.
- To understand working principles of air compressors and steam nozzles.

Unit Number	Course Content	Contact Hours
UNIT-01	**Vapour Power Cycles:** Vapor Power Cycles, Deviation of Actual Vapour Cycles from Ideal Cycles, Rankine Cycle with Reheat, Regeneration, Bleeding of Steam, Binary Vapor Cycles, Internal and Stage Efficiencies, Reheat Factor, Steam Power Plant, Introduction of Organic Rankine Cycle.	**8**
UNIT-02	**Steam Generators:** Types and Classification, Water Tubes and Fire Tube Boilers, High Pressure Boilers, Mounting and Accessories, Natural and Forced Circulation, Boiler Draught, Boiler Trial and Heat Balance.	**4**
UNIT-03	**Compressor:** Single and Multistage Reciprocating Compressor, Air Compressor Terminology, Isothermal Vs Isentropic Compression, Effect of Intercooling, Isothermal and Volumetric Efficiency.	**4**
UNIT-04	**Condenser:** Jet and Surface Condenser, Condenser Vacuum, Measurement of Vacuum, Corrected Vacuum, Condenser and Vacuum Efficiency, Cooling Towers.	**3**
UNIT-05	**Steam Nozzles:** Steady Flow Energy Equation and its Application to Steam Nozzles, Isentropic Expansion of Steam through Convergent and Divergent Nozzles, Critical Pressure, Condition for Maximum Discharge, Choking of Nozzles, Effect of Back Pressure, Super Saturated Flow through Nozzles, Flow with Friction, Nozzle Efficiency.	**6**
UNIT-06	**Steam Turbines:** Principle and Working of Impulse and Reaction Turbines, Pressure and Velocity Compounding; Velocity Triangles for Various Types, Efficiency, Diagram Efficiency, Steam Speed to Blade Speed Ratio for Optimum Performance, Losses in Steam Turbine, Performance and Governing of Steam Turbines.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Explain the working principle of various types of steam generator, components, and its performance.
CO2: Explain the working principle of steam nozzle problems.
CO3: Explain the working principles of steam turbines and their performance.

Books and References

1.Thermal Engineering by Nag. P.K, Tata McGraw Hill.
2.A Course in Thermal Engineering by A. Domkundwar, Dhanpat Rai & Co., New Delhi.

3.Thermal Engineering by R. K. Rajput, Laxmi Publications, New Delhi.
4.Steam and Gas Turbines and Power Plant Engineering by R. Yadav, Central Publishing House.

Course Name: **Material Science and Metallurgy**
Course Code: **ME-243**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the different engineering materials.
- To introduce the fundamental concepts of crystal structure, crystal imperfection and phase equilibrium.
- To know about the different heat treatment processes and their applications.
- To find the causes and prevention of metallic corrosion.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction of Engineering Materials:** Metallic Materials, Ceramic Materials, Polymers, Composites, Nanomaterials, Metallic glasses, Super Conducting Materials, Optic Fibers, Smart Materials, Dielectric Material, and Piezo-electric Materials.	**5**
UNIT-02	**Crystal Geometry and Crystal Imperfection:** Unit Cell, Crystal Structure, Bravise Lattice, Atomic Packing, Coordination Number, Crystal Structures of Metallic Elements, Crystal Directions and Planes, Miller Indices, Polymorphism or Allotropy. Crystal Structure and Correlated Properties. Diffusion Processes; Crystallization: Mechanism of Crystallization - Nucleation and Growth, Factors Influencing Nucleation and Growth, Imperfections in Crystals, and their Effect on Properties.	**9**
UNIT-03	**Phase Equilibrium and Iron-Iron Carbide Equilibrium System:** Solidification of Metals and An Alloy, Nucleation and Growth During Freezing of Pure Metal and Alloy, Phases and Phase Rule, Structural Constituents, Gibb's Free Energy for Thermodynamic Stability of Phases, Gibb's Phase Rule. Solid Solutions and Compounds, Hume-Rothery Rules; Cooling Curves, Lever-Arm Principle, Unary and Binary Equilibrium Phase Diagrams, Different Reactions Like Eutectic, Eutectoid, Peritectic and Peritectoid; Non-Equilibrium Cooling. Allotropy of Iron; Iron-Iron Carbide Equilibrium Diagram: Phases Present and their Properties, Different Reactions of the Iron-Iron Carbide Equilibrium System; Constituents, Microstructures and Properties of Plain Carbon Steels.	**7**
UNIT-04	**TTT diagram and Heat Treatment of Steel:** Time-Temperature-Transformation Diagram, Isothermal and Continuous Transformations, Study of Heat Treatment Processes Such as Annealing, Normalizing, Spherodizing, Hardening, Tempering, Carburizing, Nitriding, Cyaniding, Induction Hardening, Flame Hardening and Hardenability of Steel, Application of the Above Processes to Machine Components and Mechanical Equipment Such as Gears, Shaft Bearings, Turbine Blades, Crankshafts, Pistons etc.	**6**
UNIT-05	**Corrosion:** Types of Corrosion-Dry and Wet Corrosion, Electrochemical and Oxidation (Chemical) Corrosion, Corrosion Prevention-Anodic and Cathodic Protection and Coatings.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Judge the Scope and limitations of different materials.

CO2: Describe the effects of crystal imperfection on the quality of the product produced.

CO3: Understand the principles of solidification and application of heat treatment on the product quality.

CO4: Prevent corrosion using the coating.

Recommended Books

1. Callister's Material Science and Engineering by R. Balasubramaniam, Wiley India.
2. Elements of Material Science and Engineering by Lawrence H. Van Vlack, Pearson Education.
3.The Science and Engineering of Materials by Donald R. Askeland and Pradeep P. Phule, Cengage Learning.
4. Principles of Materials Science and Engineering by W F Smith, McGraw Hill.
5. Materials Science and Metallurgy by K. I. Parashivamurthy, Pearson Education.
6. Physical Metallurgy by Sydney H. Avner, Tata McGraw-Hill.
7. Practical Non-Destructive Testing by Baldev Raj, T. Jayakumar and M. Thavasimuthu, Narosa Pub. House.
8. Metallography and Microstructure by Ed. George F. Vander Voort, ASM International 2004.

Course Name: **Fundamentals of Acoustics**
Course Code: **ME-244**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

This course introduces the physics and applications of acoustics. Students should be able to express solutions to the wave equation in one dimension (linear and spherical), be able to solve basic reflection and refraction problems of wave incident on a planar interface, understand the function of the simple source as a method of describing the field produced by a dipole or finite source, and be able to analyze simple resonant acoustical systems. Students should appreciate the basic elements of psychological and architectural acoustics, and the role of musical instruments as acoustical sources.

Unit Number	Course Content	Contact Hours
UNIT-01	**Basics of Acoustics:** Speed of Sound, Wavelength, Frequency, and Wave Number, Acoustic Pressure and Particle Velocity, Acoustic Intensity and Acoustic Energy Density, Spherical Waves, Directivity Factor and Directivity Index, Levels and the Decibel, Combination of Sound Sources, Octave Bands.	**8**
UNIT-02	**Acoustic Measurements:** Sound Level Meters, Intensity Level Meters, Octave Band Filters, Acoustic Analyzers, Dosimeter, Measurement of Sound Power, Noise Measurement Procedures.	**5**
UNIT-03	**Transmission of Sound:** The Wave Equation, Complex Number Notation, Wave Equation Solution, Solution for Spherical Waves, Changes in Media with Normal Incidence, Changes in Media with Oblique Incidence, Sound Transmission through a Wall, Transmission Loss for Walls.	**6**
UNIT-04	**Acoustic Criteria:** The Human Ear, Hearing Loss, Industrial Noise Criteria, Speech Interference Level, Noise Criteria for interior spaces, Community Reaction to Environmental Noise.	**5**
UNIT-05	**Silencer Design:** Silencer Design Requirements, Lumped Parameter Analysis, the Helmholtz Resonator, Side Branch Mufflers, Expansion Chamber Mufflers, Dissipative Mufflers.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basics of Acoustics.
CO2: Learn various acoustic measurement techniques and equipment.
CO3: Derive the wave equation and Helmholtz equation.

Recommended Books

1. Fundamentals of Acoustics by Kinsler and Frey.
2. Industrial Noise Control and Acoustics by Randall F. Barron.

3. Fundamentals of Acoustics by wikibooks.org.
4. Fundamentals of Acoustics by Michel Bruneau.
5. Acoustics of Ducts and Mufflers by Munjal.

SEMESTER V

Course Name: **Machine Design-I**
Course Code: **ME-311**
Course Type: **Discipline Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart fundamental knowledge of design principles in context of Mechanical Engineering.
- To introduce procedures of machine design and develop an ability to apply it.
- To capacitate, so as to identify formulate and solve problems based on design and analysis.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Engineering Design, Phases of Design, Design Considerations, Theories of Failure, Factor of Safety, Design against Static Load, Design against Dynamic load.	**6**
UNIT-02	**Design of Shafts and Couplings:** Design of Solid and Hollow Shafts, Design of Shafts for Strength and Deflection, Combined Loading due to Torsion and Bending of Shafts, Equivalent Bending Moment and Twisting Moment, Types of Shaft Coupling, Design of Muff Coupling, Rigid Flange Coupling, Bushed Pin Flexible Coupling.	**8**
UNIT-03	**Design of Joints:** Keys, Splines, Knuckle Joint, Cotter Joint, Riveted Joints, Welded Joints.	**6**
UNIT-04	**Design of Springs:** Closed and Open Coiled Springs, Strength and Stiffness, Optimum Design of Helical Springs, Helical Torsion Springs, Multi-leaf Springs, and Helical Springs of Non-Circular Wires.	**7**
UNIT-05	**Design of I.C Engine Elements:** I.C Engine Parts: Cylinder, Piston, Connecting Rod and Crankshaft, Mechanism of Valve Gear, and its Design.	**7**

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Acquire expertise in designing various machine elements exposed to static, dynamic loads.
CO2: Acquire ability to design IC engine elements.
CO3: Develop skills for applying failure theories.

Recommended Books

1. Machine Design by Shigley, McGraw Hill.
2. Design of Machine Elements by V.B. Bhandari, McGraw Hill.
3. Machine Design by R.L Norton, Pearson Education.
4. Machine Design by Sharma & Aggarwal, Kataria and Sons.
5. Design data Book by Kalaikathir Achagam, PSG College Coimbatore.

Course Name: **Heat Transfer**
Course Code: **ME-312**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits:**03**

Course Objectives

- To introduce the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.
- To introduce the concept of convective, boiling, condensation and radiative heat transfer.
- To introduce the thermal analysis and sizing of heat exchangers.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Modes of Heat Transfer, Examples, Difference Between Thermodynamics and Heat Transfer, Fundamental Laws, Fourier's Law of Heat Conduction, Thermal Conductivity, Newton's Law of Cooling, Stefan – Boltzmann's Law, Combined Modes of Heat Transfer.	**04**
UNIT-02	**Heat Conduction:** General Heat Diffusion Equation Derivations, 1-D Steady State Heat Conduction Equation for A Slab, Composite Slab, Boundary Conditions, Thermal Resistance Concepts, Electrical Analogy, Overall Heat Transfer Coefficient, 1-D Heat Conduction Equation in Cylindrical and Spherical Coordinates, Composite Cylinders and Spheres, Critical Thickness of Insulation, Heat Generation Inside Slabs and Radial Systems, Heat Transfer from Extended Surfaces, Fin Performance, Unsteady Conduction: Introduction, Lumped Capacitance Model, Derivation and Solution of Lumped Capacitance Model, Biot and Fourier Numbers, Transient Heat Conduction in Infinite and Semi-Infinite Slabs, Heisler Charts.	**09**
UNIT-03	**Convection Heat Transfer** **Forced Convection:** Derivation of Energy Equation External Flow: Flow Over Flat Plate, Concept of Hydrodynamic Boundary Layer, Thermal Boundary Layer, Derivation of Boundary Layer Equations, Physical Significance of Dimensionless Numbers, Cylinder in Cross Flow, Flow Over Bank of Tubes Internal Flows: Laminar Flow through Duct, Concept of Hydrodynamic Boundary Layer, Entry Length, Mean Velocity, Mean Temperature, Fully Developed Conditions for Constant Temperature and Constant Heat Flux, Turbulent Flow in Pipes. **Natural Convection:** Concepts, Boundary Layer, Equations of Motion, Energy, Convection Over Different Configurations. Condensation and Boiling: Introduction to Boiling and Condensation, Dimensionless Parameters in Condensation, Regimes of Boiling Heat Transfer, Condensation Over Vertical Surfaces, Velocity and Temperature Profiles, Film Condensation of Radial Systems, Laminar Film Condensation Over a Vertical Plate and Horizontal Circular Tube.	**09**
UNIT-04	**Heat Exchangers:** Classification of Heat Exchangers, Overall Heat Transfer Coefficient, Concept of Fouling Factor, LMTD and NTU Methods of Analysis for a Heat Exchanger, Applications to Multitube, Multi-Pass Heat Exchangers.	**06**

UNIT-05	**Thermal Radiation:** Radiation Properties, Blackbody Radiation, Planck's Law, Stefan-Boltzman Law, Kirchoff's Law, Radiation Exchange Between Black Surfaces, Concept of View Factor, Radiation Exchange Between Non-Black Surfaces, Two-Surface Enclosure, Three Surface Enclosure, Concept of Radiation Shield.	**08**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To classify the heat transfer problems and apply the principles of steady state one dimensional heat transfer extended surface, and unsteady state conduction for commonly encountered Mechanical Engineering Problems.

CO2: To identify the type of convection problems and to apply concepts of natural and forced convection for related problems.

CO3: To practice LMTD and effectiveness-NTU method for simple heat exchange device.

Books and References

1.Fundamentals of Heat and Mass Transfer by Incropera and Dewitt, Wiley India.
2.Heat and Mass Transfer by Cengel, TMH.
3.Principles of Heat Transfer by Krieth and Bohn, Cengage Learning.
4.Heat Transfer by Holman, TMH A heat Transfer Text Book, Lienhard IV and Lienhard V, Dover Publishers.

Course Name: **Dynamics of Machines**
Course Code: **ME-313**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the fundamentals of force analysis in mechanisms.
- To impart knowledge on balancing of machines.
- To enable the students to understand the need of flywheels and governors.
- To acquaint the students with the role of frictional devices in various applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Inertia Forces in Reciprocating Masses:** D-Alembert's Principle, Velocity and Force Analysis, Analytical Method for Velocity and Acceleration of Piston, Forces on Reciprocating Parts of Engine, Equivalent Dynamical System.	**4**
UNIT-02	**Balancing of Masses:** Balancing of Rotating Masses in One Plane and in Different Parallel Planes, Graphical and Analytical Methods, Balancing of Reciprocating Masses, Balancing of Single Cylinder Engine, Tractive Force, Swaying Couple, Hammer Blow Balancing of Inline Engines, Radial Engines, Direct and Reverse Crack Method.	**8**
UNIT-03	**Flywheel and Turning Moment Diagrams:** Introduction to Turning Moment Diagrams, Diagrams for Single Cylinder Double Acting Steam Engine, Four Stroke IC Engine, Multicylinder Engine, Concept of Energy Fluctuation, Coefficient of Fluctuation of Energy and Speed, Energy Stored in Flywheel, Flywheel Design Consideration.	**6**
UNIT-04	**Governors:** Different Types of Governors, Characteristics, Gravity Controlled and Spring Controlled Governors, Watts, Porter, Proell Governors, Stability, Hunting of Governors, Isochronous Governor, Controlling Force Curves, Sensitivity, Coefficient of Insensitiveness.	**7**
UNIT-05	**Gyroscopic Motion:** Concept of Gyroscopes, Angular Velocity, Acceleration and Torque on Disc, Gyroscopic Forces and Couples, Gyroscopic Stabilization of Ship, Effect of Gyroscopic Couple in Aeroplane, Pitching, Rolling, Stability of Two Wheel Vehicles Moving on Curved Path.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the problems associated with unbalance in machines.
CO2: Realize the requirement of frictional devices.
CO3: Identify the type of governors most suited for various applications.

Recommended Books

1. Theory of Machines by Thomas Bevan, CBS Publishers & Distributors.

2. Theory of Machines by S. S. Rattan, TMH Publication.
3. Mechanism and Machine Theory by J. S. Rao and R. V. Dukipatti, New Age International.
4. Mechanical Vibrations and Noise Engineering by Ambekar, PHI.

Course Name: **Kinematics and Dynamics of Machines Lab**
Course Code: **ME-314**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge about kinematics of machine components.
- To acquire the operating skills and principles about different test setups.
- To learn the simulation methodology involved in virtual laboratory.

List of Experiments

1.	To study various types of Links, Pairs, Chains and Mechanisms.
2.	To study inversion of Four Bar Mechanism, Single Slider Crank Chain Mechanism and Double Slider Crank Chain Mechanism.
3.	To study various types of Cam and Follower arrangement.
4.	To plot follower displacement vs. cam rotation graph for various cam follower arrangement.
5.	To study various types of Gears – Spur, Helical, Worm and Bevel Gear.
6.	To analyze and verify experimentally the gear ratio of a gear box.
7.	To analyze and verify experimentally the motion of epicyclic gear trains.
8.	To determine performance characteristic curves of Porter and Hartnell governor and to find its stability and sensitivity.
9.	To determine gyroscopic couple and verify gyroscopic effect on motorized gyroscope.
10.	To study various types of Cams and Follower arrangement.
11.	Virtual Laboratory: Mechanism a. Quick Return Mechanism. b. Oldham Coupling Mechanism. c. Grashof's 4 bar Mechanism.
12.	Virtual Laboratory: Vibrations a. Simple Harmonic Oscillator. b. Damped Harmonic Oscillator. c. Moment of Inertia of Connecting Rod.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the methodology of measurements of various kinematic parameters of machine elements.
CO2: Understand, analyze and verify the principle involved in working of machine elements.
CO3: Develop skills on virtual lab for analysis of machine elements.

Course Name: **Heat Transfer Lab**
Course Code: **ME-315**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by conducting experiments to correlate with the theory.
- To enable the student to apply conduction, convection, and radiation heat transfer concepts to practical applications.

List of Experiments

1.	To determine the thermal conductivity of lagging material and plot the temperature distribution across the lagged pipe.
2.	To determine the thermal conductivity of guarded hot plate and verify the results.
3.	To determine the thermal conductivity of insulating powder and verify the results.
4.	To determine the convection heat transfer coefficient for a vertical tube losing heat by natural convection and verify the results.
5.	To determine the convection heat transfer coefficient for a pipe losing heat by forced convection to air and plot the graph between Re and Nu. Verify the results.
6.	To draw the temperature distribution plot along the length of a pin/fin in natural and forced convection and find heat transfer coefficient and verify the result.
7.	To determine the Stefan Boltzmann constant.
8.	To determine the overall heat transfer coefficient & effectiveness for a tube type heat exchanger for parallel & counter flow.
9.	To determine the heat transfer rate and effectiveness of Shell & tube heat exchanger in co-current mode.
10.	To determine the heat transfer rate and effectiveness of Shell & tube heat exchanger in counter current mode.
11.	To determine the heat transfer rate and effectiveness of double pipe heat exchanger in co-current mode.
12.	To determine the heat transfer rate and effectiveness of double pipe heat exchanger in counter current mode.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic laws of heat transfer.

CO2: Understand the fundamentals of convective heat transfer process.

CO3: Evaluate heat transfer coefficients for natural and forced convection.

CO4: Analyse heat exchanger performance by using the method of heat exchanger effectiveness.

Course Name: **Introduction to Product Development**
Course Code: M**E-301**
Course Type: **Institute Elective**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To make student confident in their own abilities to produce a new product.
- To provide awareness about the role of various functions, such as marketing, finance, industrial design, production, etc., in product development.
- To enable students to understand the basics of engineering and production in producing a new product.
- To enhance the ability to coordinate multiple, interdisciplinary tasks to achieve a common objective.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction and Significance of Product Development, Product Design and Development Process, Sequential Engineering Design Method, Challenges of Product Development, Concept Development, Product Development and AMF Development Process, AMF Organizations.	**6**
UNIT-02	**Product Planning and Identifying Customer Needs:** Product Planning Process, Interpret Raw Data in terms of Customers Need, Organize Needs in Hierarchy and Establish the Relative Importance of Needs: Assessing Needs & Impact of Industrial Design, Industrial Design Process and Management, Assessing Quality of Industrial design.	**8**
UNIT-03	**Concept Generation:** Activities of Concept Generation, Clarifying Problem, Concept Selection: Overview, Concept Screening and Concept Scoring, Methods of Selection, Concept Testing, Product Architecture, Industrial Design.	**6**
UNIT-04	**Embodiment Design and Detailed Design:** Design for Prototyping and Manufacturing, Robust Design, Design for Manufacturing, Detailed Drawings and Specifications, Life Cycle Assessment.	**7**
UNIT-05	**Intellectual Property and Environmental Guidelines:** Elements and Outline, Patenting Procedures, Claim Procedure, Design for Environment: Impact, Regulations from Government, ISO System.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Distinguish different product development processes.
CO2: Distinguish associated engineering information with the product development processes.
CO3: Think about the sustainable design of a product and processes for competitive market.
CO4: Manage, construct, and defend product data and its supporting technologies for its development to disposal.

Books and References

1. Product Design and Development by Karl Ulrich and Steven D. Eppinger, Tata McGraw-Hill Education.
2. Product Design by K. Otto and K. Wood, Pearson Education.
3. Handbook of Materials for Product Design by C. A. Harper, McGraw-Hill.
4. Product Design: Creativity, Concepts and Usability by Prashant Kumar, PHI.
5. Engineering Design, by George E. Dieter and Linda C. Schmidt, McGraw-Hill Education.

Course Name: **Introduction to Robotics**
Course Code: M**E-302**
Course Type: **Institute Elective**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge and use of types of sensors and actuators.
- To introduce the fundamentals of Kinematics and Dynamics of Industrial Robots.
- To impart the knowledge of robotics, robotic programming, and robot vision.
- To use the Robots for various Industrial applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Robotics**: Historical Background, Definitions, Laws of Robotics, Configurations of Manipulators**:** Components of Robots, Arm Configuration, Wrist Configurations; Classification of Robots, Specification of Robots, Precision of Movement in Robotics**:** Resolution, Accuracy and Repeatability, Economics of Robotization in Industries, Applications of Robots in Manufacturing, Automation and Services, Introduction to Mobile Robots.	**6**
UNIT-02	**Components of Robotic Systems and Analysis:** Introduction, Drive system: Hydraulic system, Pneumatic System, Electrical Actuators, other Actuating Systems, Sensors: Need for Sensing Systems, Classification of Sensors, Characteristics of Sensors, Various Types of Sensors, Smart Sensors, Robot Vision Systems and Robot Cell Design and Control, Robot Control System, Manipulator Control, Robot End Effectors.	**6**
UNIT-03	**Kinematics and Dynamics of Robotics**: Introduction, Coordinate Frames and Transformations, Homogenous Transformations Matrix, Composite Transformations, Inverse Homogenous Transformations, Forward and Inverse Kinematic Equations, Denavit Hardenberg(D-H) Representation, Forward Kinematic Solution of Various Manipulators, Inverse Kinematic Analysis: Solvability of Inverse Kinematics Problems, Multiple Solutions, Solution to Inverse Kinematics. Dynamic Analysis of Manipulator, Trajectory Planning.	**10**
UNIT-04	**Robot Programming Methods and Languages:** Introduction, Methods of Programming, Motions Programming, Robot Programming Languages -Textual Robot Languages, Generation of Robot Programming Languages, Robot Programming Language Structure.	**8**
UNIT-05	**Robotics Applications and Social issues:** Application of Robots in Day-to-Day Life; Industrial Applications, Material Handling, Processing Operations, Assembly and Inspection, Approach for Implementing Robotics, Safety, Training, Maintenance and Quality, Social Issues and Future of Robotics.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Could classify the various robot configurations to be used in various situations and be able to frame specifications.
CO2: Select appropriate sensors, actuators and devise a system for collecting information for robot controller.
CO3: Demonstrate the concepts of kinetics & dynamics of robot.
CO4: Identify applications of robots in manufacturing, Industries, and society.

Recommended Books

1. Robotics for Engineers -Yoram Koren, McGraw Hill International, 1st edition, 1985.
2. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007.
3. Introduction to Robotics: Mechanics and Control by John.J. Crag Pearson/PHI Publication.
4. Robots manufacturing and application -Paul Afonh, John Wiley.

Course Name: **Total Quality Management**
Course Code: **ME-303**
Course Type: **Institute Elective**

Contact Hours/Week: 3**L** Course Credits: **03**

Course Objectives

- To understand the concept of Quality in Manufacturing and Service units.
- To understand the Implication of Quality in Business.
- To have exposure to challenges in Quality Improvement Programs.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Evolution of Quality, Historical Perspectives, Relationship among Quality, Vision, Mission and Objectives of an Organization, Role of Quality in a Corporate Structure of an Organization, Attributes of Product and Service Quality, Quality Characteristics: Quality of Design, Quality of Performance and Quality of Conformance, Zero Defect and Continuous Improvement.	**7**
UNIT-02	**Conceptualization of TQM:** Introduction to Total Quality Management (TQM), Barriers to TQM, Benefits of TQM implementation, Basic Approaches of TQM, TQM Models, Quality Information System and Planning, Importance of TQM in Manufacturing and Service Industry.	**5**
UNIT-03	**Organization Structure in TQM:** Role of Top Management, Quality Council, Quality Circles, Organization Structure for Quality Circles, Quality Policies, Role of Middle and Lower Management, Problem Solving Techniques.	**4**
UNIT-04	**Tools and Systems for Quality Management:** Basic Tools: Cause & Effect Diagram, Flow Diagrams, Trend Charts, Histogram, Scatter Diagram, Control Chart, Advanced Tools: Affinity Diagram, Inter Relationship Diagram, Tree Diagram, Matrix Diagram, Process Decision Program Chart (PDPC) and Matrix Data Analysis, Fault Tree Analysis, Quality Function Deployment (QFD): Definition and Phases in QFD, Taguchi Approach to Quality System Design, Six-sigma: Definition & Implementation Steps, Just in Time Production System, Quality Production through JIT and Kanban, Failure Mode and Effect Analysis (FMEA): Scope, Mode, Illustrative Example and Applications.	**8**
UNIT-05	**Quality Assurance & Control:** Causes of Quality Failure, Quality Assurance: Need and various elements in Quality Assurance Programme, Quality Control- on-line and off-line, Statistical Concepts in Quality, Chance and Assignable Causes, Types and examples of Control Charts, Bench Making in Quality Management.	**5**
UNIT-06	**Implementation and need of ISO 9000:** ISO 9000–2000 Quality System: Elements, Registration, Documentation, Implemental Steps, Quality Audit, Product and Process Audit: Scope, Steps and Benefits.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the significance of quality in an organization.

CO2: Apply the tools of quality improvement programs in an organization.

CO3: Assess the benefits of implementing TQM Program in an organization.

Books and References

1. Total Quality Management by Dale H Besterfield, Pearson India.
2. Total Quality Management by N.V.R Naidu, G. Rajendra, New Age international Publication.
3. Total Quality management by L. Sugandhiand Samual Anand, PHI Publications.
4. Total Quality management by R.S Naagarazan, New Age international Publication.

Course Name: **Renewable Sources of Energy**
Course Code: **ME-304**
Course Type: **Institute Elective**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart the understanding of Renewable source of energies.
- To introduce others, form of energy.
- To enable the identification of technologies for effective utilization of renewable energy sources.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Principles of Renewable Energy; Energy and Sustainable Development, Fundamentals, and Social Implications, Worldwide Renewable Energy Availability, Renewable Energy Availability in India, Causes of Energy Scarcity, solution of Energy Scarcity, Brief Descriptions of different form of Renewable Energy.	**4**
UNIT-02	**Solar Energy:** Fundamentals; Solar Radiation; Estimation of Solar Radiation; Solar Radiation Measurements-Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal Systems: Flat Plate Collector; ETC & PTC; Solar Distillation; Solar Pond, Solar Photovoltaic Systems	**8**
UNIT-03	**Hydrogen Energy:** Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Advantages and Disadvantages of Hydrogen Energy, Problems Associated with Hydrogen Energy.	**5**
UNIT-04	**Wind Energy:** Properties of wind, Availability of Wind Energy in India, Windmills, Wind Turbines, Wind Resources. **Biomass Energy:** Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass Conversion Technologies; Urban Waste to Energy Conversion; Biomass Gasification. Applications of Biomass Gasifier, Advantages, and Disadvantages of Bioenergy.	**8**
UNIT-05	**Geothermal Energy:** Geothermal Systems, Classifications, Geothermal Resource Utilization, Resource Exploration, Geothermal Based Electric Power Generation, Associated Problems, Environmental Effects. **Tidal Energy:** Introduction, Tidal Energy Resource, Tidal Energy Availability, Tidal Power Generation in India, Energy Availability in Tides, Tidal Power Basin, Advantages and Disadvantages of Tidal Power.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the environmental aspects of renewable energy resources.
CO2: Identify the different form of Renewable sources of energies.
CO3: Understand the concept of solar, Wind, Hydrogen, Tidal, biomass energy resources.

Books and References

1. Non-Conventional Energy Sources by Rai. G.D, Khanna Publishers
2. Renewable Energy Sources by Twidell, J.W. & Weir, Spon Ltd., UK, 2006.
3. Wind Energy Theory and Practice by Siraj Ahmed, PHI Learning.

Course Name: **Finite Elements in Engineering**
Course Code: **ME-351**
Course Type: **Discipline Elective (II)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the concept and methodology of Finite element method.
- To apply general FEM Methodology for solving Solid Mechanics and Heat Transfer problems.
- To develop algorithms based on general FEM methodology.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction & Fundamental Concept:** Historical Background, Approximate Solution of Boundary Value Problems, Packages and applications; Approaches-Galerkin's and Raleigh-Ritz, Step by Step Procedure of FEM Applications.	**4**
UNIT-02	**Finite Element Formulation**: Generalized FE Formulation Based on Weighted Residual Method, Displacement-Based Formulation, Concept of Discretization, Interpolation, Formulation of Finite Element Characteristic Matrices and Vectors, Compatibility Conditions, Assembly and Boundary Considerations. Strong and Weak Forms For 1D And 2D Problems.	**6**
UNIT-03	**Elements and Shape Functions:** Global, Local and Natural Coordinates, Shape Functions and Their Properties, Lagrange Interpolation, One, Two and Three-Dimensional Elements, Serendipity Elements, H-P Elements, Isoperimetric Elements, Higher Order Elements.	**5**
UNIT-04	**Finite Element Analysis for One Dimensional Problems:** Structural Problems with One Dimensional Geometry, Bar Element: Formulation of Stiffness Matrix, Boundary Conditions and their Incorporation, Elimination Method, Penalty Method, Introduction to Higher Order Elements, Formulation for Truss Elements, Finite Element Solution for One Dimensional Heat Conduction with Convective Boundaries, Formulation of Element Characteristics and Simple Numerical Problems.	**8**
UNIT-05	**Finite element Analysis for Two Dimensional Problems:** Governing Equation and Boundary Conditions for Describing Steady State Problems of Heat Transfer, Governing Equation and Boundary Conditions for Describing Steady State Plane Elastic Stress Analysis Problems: Discretization and Polynomial Approximation Using Standard 2-D Elements, Development and Evaluation of Elemental Matrices, Assembly Rules, Imposition of Boundary Conditions, Nodal Solution, Post Computation.	**8**
UNIT-06	**Software Practice and Algorithm Development:** Algorithm Development for Various Steps Involved in FEM Solution Methodology, Introduction to FEM Based Analysis Software like ANSYS, Hypermesh etc.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Learn the basic concepts and methodology of Finite Element Method.

CO2: Solve problems of Solid Mechanics and Heat Transfer using FEM.

CO3: Develop algorithms based on FEM methodology for a typical FEM problem.

Recommended Books

1. Introduction to Finite Elements in Engineering by Chandrupatla and Belegundu, Pearson.
2. Introduction to Finite Element Method by J.N. Reddy, Tata McGraw Hill.
3. The Finite Element Method in Engineering by S.S Rao, Butterworth Hienemann.
4. Finite Element Method by O.C Zienkiewicz, Dover Publications.
5. The Finite Element Method Using MATLAB by Kwon & Bang, CRC Press.

Course Name: **Product Design and Development**
Course Code: **ME-352**
Course Type: **Discipline Elective (II)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To acquaint the learners/students with the knowledge regarding conceptualization, design, and development of a new product.
- The need for a new product, the product life cycle, the product design process, the application of Value Engineering principles in product design, and various product design tools such as CAD, DFM, DFA and DFMA with relevant and specific examples/ case studies.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Sources of New Ideas, Development Processes, Product Planning, Identification for Customer Needs and Technology Potentials, Innovation and Intellectual Property Rights, Product and Process Patents, Patents and Patenting Processes.	**5**
UNIT-02	**Product and Tolerance Specifications:** Taguchi Loss Factor Concepts, Quality Function Deployment, Functional Specifications of Products, Form and Function, Development of Alternatives, and Design for Manufacture.	**7**
UNIT-03	**Design for Assembly & Manufacturing:** Prototyping and Analytical Prototyping, The Stage-Gate Process of Product Development, Holistic Product Development Approaches, from Product Concept to Decommissioning.	**8**
UNIT-04	**Environment Requirements:** Life Cycle Design, Product Data Management and Product Life Cycle Management Systems, Dependency, and Concurrent Engineering in Development of Products.	**7**
UNIT-05	**Internet Based Approach:** Product Development Involving Users, Democratization of Innovation, Connecting Products to Services, Experience Innovation, Robust Design, Patents and Intellectual Properties, Product Developments.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Develop the product from ideas to reality.
CO2: Apply about the design for assembly and for economy, prototyping and analytical prototyping.
CO3: Use Internet for product development and product response.

Recommended Books

1. Production Design and Manufacturing by A.K. Chitale & A.K. Gupta, Prentice Hall of India.
2. Management Development by Alan Mumford, Jaico Publishing House.
3. Product design by Kevin Otto, Kristin Wood, Pearson.

Course Name: **Turbo Machines**
Course Code: **ME-353**
Course Type: **Discipline Elective (II)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To provide a framework to discuss different kinds of turbomachinery through a unified approach.
- To provide the Knowledge of Basic Principles, Governing Equations, and applications of Turbo Machines.
- To explain the working principle and evaluate the performance characteristics of Turbo Machines.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Definitions of Turbo Machines, Parts of Turbo Machines, Classifications of Various (Turbines, Axial, Radial and Mixed Flow) Turbomachines, Method of Energy Transfer in Axial, Radial and Mixed Flow Machines, Euler's Turbine Equation in Terms of Velocity and its Application to Different Turbomachine, Degree of Reaction, Efficiencies of Turbomachine, Stage Efficiency or Polytropic Efficiency.	**8**
UNIT-02	**Two-Dimensional Cascade:** Nomenclature of Blade and Cascade, Blade Arrangement in Compressor Cascade and Turbine Cascade, Flow angles, Flow deviation, Analysis of Cascade Forces, Losses in Cascades, Velocity diagrams, Degree of Reaction.	**6**
UNIT-03	**Axial Flow Compressors:** Construction and Working, Velocity Diagrams and Work Done of a Stage of Axial Flow Compressors, Degree of Reaction, Losses in Axial Flow Compressor Stage, Performance of Axial Flow Compressor.	**6**
UNIT-04	**Hydraulic Turbines:** Classification, Euler's Equation for Turbines, Velocity Triangle for Single Stage Axial and Radial Machines, Impulse and Reaction Turbines, Pelton, Francis & Kaplan Turbine, Power and Efficiency Calculations, Draft Tube, Cavitation, Water Turbine Governing.	**8**
UNIT-05	**Centrifugal Pumps & Compressors:** Classification and Parts of Centrifugal Pump, Different Heads and Efficiencies of Centrifugal Pump, Theoretical Head–Capacity Relationship, Minimum speed for Starting the flow, Maximum Suction Lift, Net Positive Suction Head, Cavitation, Need for Priming, Pumps in Series and Parallel, Stage Velocity Triangles, Slip Factor, Power Input Factor, Stage work, Pressure Developed, Stage Efficiency, Surging and Stalling.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the thermodynamics analysis of turbomachines.
CO2: Analyse the energy transfers in Turbo machine with degree of reaction and utilization factor.
CO3: understand various type of hydraulic turbines, pump and compressors.

Books and References

1. Turbo Machines by B. U. Pai Wiley India Pvt, Ltd 1st Edition.
2. Fundamentals of Turbo Machinery by B.K Venkanna PHI Publishers.
3. Turbo machines by M. S. Govindegowda and A. M. Nagaraj M. M. Publications 7Th Ed, 2012.
4. Turbines, Compressors & Fans by S. M. Yahya Tata McGraw Hill Co. Ltd 2nd edition, 2002.

SEMESTER VI

Course Name: **Internal Combustion Engines**
Course Code: **ME-321**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the S.I & C.I engines.
- To impart knowledge about combustion process in internal Combustion Engines.
- To introduce the fundamental concepts relevant to pollutant emissions.
- To enable the students to understand the factors that cause the emissions.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** IC Engines and their Components, Comparison of Two Stroke & Four Stroke Engines, Comparison Between SI & CI Engines, Valve, and Port Timing Diagram, Working Cycles-Otto, Diesel and Dual Cycle and Comparison, Fuel Air Cycles, Actual Cycles, Conventional Fuels & Alternative Fuels.	**8**
UNIT-02	**Combustion in SI Engine:** Homogeneous Mixture, Heterogeneous Mixture, Stages of Combustion in SI Engines, Flame Front Propagation, Factors Influencing the Flame Speed, Abnormal Combustion in SI engine, Phenomenon of Knock in SI Engines, Effect of Engine Variables on Knock, Combustion Chambers for SI engine.	**6**
UNIT-03	**Combustion in CI Engines:** Stages of Combustion in CI Engines, Ignition Delay Period, Factors Affecting the Delay Period, Direct and Indirect Injection Systems, Injection Timing, the Phenomenon of Knock in CI Engines, Comparison of Knock in SI and CI Engines, Combustion Chambers for CI Engines.	**6**
UNIT-04	**Different Components and Testing of IC Engines:** Introduction of Carburation, Limitation of Carburettors, Gasoline Injection, CI Injection Systems, Measurement of Indicated Power, Brake power, and Friction Power - Morse Test, Willan's Line Method, Motoring Test, Calculation of Brake Thermal Efficiency, Brake Power and Brake Specific Fuel Consumption of IC Engines, Heat Balance Sheet of IC Engines.	**8**
UNIT-05	**Emission of IC Engines:** Pollutants from SI and CI Engines, Generation and Controlling the Formation of NOx, HC, CO, CO_2, Smoke, Pollution Control Strategies, Emission Norms-EURO and Bharat Stage Norms, Introduction to Turbo Charging and Supercharging, Catalytic Converters-EGR.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the underlying principles of operation of different I.C engines, components.
CO2: Understand combustion process of SI and CI Engines.
CO3: Provide knowledge on pollutant formation.

Books and References

1.Internal Combustion Engine Fundamentals by J.B. Heywood, McGraw-Hill.
2. Internal Combustion Engines by Ganesan, V, Tata McGraw Hill Book Co.
3. Fundamental of Internal Combustion Engine by Z. Smith, Gill, Oxford & IBH Publishing Co. Pvt. Ltd.
4. Engineering Fundamentals of the Internal Combustion Engines by Willard W. Pulkrabek, Second Edition, Pearson Prentice Hall.

Course Name: **Machine Design-II**
Course Code: **ME-322**
Course Type: **Discipline Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge of design of transmission components.
- To introduce procedures for strength and wear-based design.
- To enable to identify, formulate and solve design engineering problems based on design and analysis.

Unit Number	Course Content	Contact Hours
UNIT-01	**Design of Spur Gears:** Nomenclature, Involute Gears, Lewis Equation and Lewis Form Factors, Working Stress in Gear Teeth, Dynamic Loads on Gear Teeth, Estimation of Module Based on Beam Strength and Wear Strength, Design of Spur Gears for wear.	**6**
UNIT-02	**Design of Helical Gears:** Nomenclature - Virtual Number of Teeth, Helix Angle, Free Width, Velocity Factors, Strength Design, Limiting Endurance, Beam Strength Load, Dynamic Loading, Wear Strength of Helical Gears.	**5**
UNIT-03	**Design of Bevel Gears:** Straight Bevel Gears, Nomenclature, Virtual Number of Teeth, Endurance Load, Dynamic Load, Wear Load, Tredgold's Approximation, Spiral Bevel Gears.	**5**
UNIT-04	**Design of Worm Gears:** Nomenclature, Lewis Equation for Strength Design, Design of Worm Gears-given Approximate Center to Center Distance, Dynamic Load, Endurance Load, Wear Load, AGMA- Power Reducing Equations, Efficiency of Worm Gears, Friction in Worm Gears and Heat Dissipation.	**5**
UNIT-05	**Design of Journal Bearings:** Introduction to Lubrication, Hydrodynamic Bearings, Somerfield Number, l/d Ratio, Clearance Ratio, Minimum Film Thickness, Bearing Design Procedure: Selection of Parameters, Bearing Materials.	**6**
UNIT-06	**Design of Ball and Roller Bearings:** Types, Static and Dynamic Load Capacity, Bearing Life, Selection of Bearings for Steady and Variable Loading.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Design various machine components involved in transmission.
CO2: Acquire ability to design and analysis of various types of gears.
CO3: Design of Journal and Ball Bearings

Recommended Books

1. Machine Design by Shigley, McGraw Hill.
2. Design of Machine Elements by V.B. Bhandari, McGraw Hill.
3. Machine Design by R.L Norton, Pearson Education.
4. Machine Design by Sharma & Aggarwal, Kataria and Sons.
5. Design data Book by Kalaikathir Achagam, PSG College Coimbatore.

Course Name: **Operations Research**

Course Code: **ME-323**

Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce students with the basic concepts, models and statements of the operations research theory.
- To impart capabilities in the students for analyzing different situations in the industrial/ business scenario involving limited resources.
- To enable them to formulate and solve optimization problems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Nature and Development of Operation Research (OR), Some Mathematical Preliminaries, General Methodology of Operation Research, Phases of OR, Models in OR, Characteristics of Good Model, Construction of Model, Role of Computers in OR, and Application of Operation Research to Industrial Problems, A Survey.	**5**
UNIT-02	**Linear Programming Problems:** Formulation of Linear Programming Deterministic Models; Graphical Solution; Simplex Algorithm, Computational Procedure in Simplex, Duality and Its Concept, Dual Linear Programming, Application of Simplex Technique to Industrial Problem. Assignment Models; Formulation of Assignment Problems, Methods for Solutions; Transportation Problems; Methods for Obtaining Optimal Solution; Degeneracy in Transportation Problems; Transshipment Problems.	**8**
UNIT-03	**Game Problems:** Introduction and Scope of Game Problems in Business and Industry; Definitions, Rules for Game Theory, Mini-Max Criterion and Optimal Strategy, N Person Zero Sum Games, Solution of Two-Person Zero Sum Game; Game Problem as a Special case of Simplex.	**5**
UNIT-04	**Network Problems:** Introduction to Project Planning and Project Scheduling, Tools and Techniques of Project Management, Basic Principles of Network Construction, Fulkerson Rule, Critical Path Method, Programme Evaluation and Review Technique (CPM/PERT) Crashing of Activities, and Solution of Simple problems.	**5**
UNIT-05	**Queuing Problems:** Queuing Systems and Concepts; Kendall's Notation for Representing Queing Models Operating Characteristics of Queuing Systems, Classification of Queuing Situations; Solution of Queuing Problems, Single Channel, Single Stage, Finite and Infinite Queues with Poisson Arrival and Exponential Service Time; Applications to Industrial Problems	**6**
UNIT-06	**Sequencing Problems:** Sequencing Problems, Assumptions in Sequencing Problems, Processing of 'N' Jobs through one Machine Processing of 'N' Jobs through Two Machines, Processing of 'N' Jobs Through Three Machines, Processing of 'N' Jobs Through 'M' Machines, Solution of Sequencing Problems.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To have the knowledge of the role of O.R. in solving industrial problems.

CO2: Formulate and solve mathematical model for physical situations like production and distribution of goods and economics.

CO3: Develop mathematical skills to analyze and solve network models arising from a wide range of applications.

CO4: Choose rational options in practical decision-making problems using standard OR models.

Books and References

1.Operation Research: An Introduction by H.A.Taha, Pearson.
2. Introduction to Operation Research by Hira and Gupta, S. Chand.
3. Linear Programming by Loomba, Mc Graw Hill.
4. Fundamentals of Operation & Research by Ackoff and Sasiene, John Wiley.

Course Name: **Internal Combustion Engines Lab**
Course Code: **ME-324**
Course Type: **Discipline Core**

Contact Hours/Week: **2P** Course Credits:**01**

Course Objectives

- To impart knowledge about the working of S.I & C.I engines.
- To impart knowledge about valve timing of internal Combustion Engines.
- To introduce the fundamental concepts of IC engine performance and Combustion.
- To enable the students to understand engine cooling & lubricating Systems in IC Engine.

List of Experiments

1.	To Study the construction details & working principal of 2-Stroke / 4- Stroke Petrol Engine.
2.	To study the I.C. Engine Valve / Port Timing Diagrams.
3.	To study the constructional details & working principles involved in a 2-Stroke & 4-Stroke Diesel Engines.
4.	To Study of Ignition Systems in I.C. Engine.
5.	To Study of Fuel Injection Systems in C. I. Engine.
6.	To conduct a performance test on four stroke four-cylinder diesel engine test rig and to draw the heat balance sheet.
7.	To conduct a performance test on four stroke four-cylinder petrol engine test rig and to draw the heat balance sheet.
8.	To calculate the IHP (Morse Test) and mechanical efficiency of the four stroke four-cylinder petrol engine test rig.
9.	To conduct a performance test on four stroke single cylinder VCR engine test rig at different load condition with eddy current dynamometer.
10.	To conduct a combustion performance test on four stroke single cylinder VCR engine test rig at different compression ratio.
11.	To Study of the engine cooling & lubricating Systems in IC Engine.

Course Outcomes

Upon successful completion of the course the students will be able to

CO1: Understand the underlying principles of operation of different I.C engines, components.
CO2: Understand performance and combustion process of SI and CI Engines.
CO3: Provide knowledge on engine cooling & lubricating Systems in IC Engine.

Course Name: **Design Lab**
Course Code: **ME-325**
Course Type: **Discipline Core**

Contact Hours/ Week: **2P**
Course Credits: **01**

Course Objectives

- To gain practical knowledge about the machine elements
- To acquire the knowledge and operating skills about different testing machines and setups.
- To learn the principles and methodology involved in machine design.

List of Experiments

1.	To study the pressure and temperature distribution of a journal bearing using a journal bearing apparatus.
2.	To determine the lubricant's anti-wear and extreme pressure properties using Four ball tester.
3.	To determine the viscosity of lubricant using Rotational Viscometer.
4.	To determine the morphology and topography of wear debris using Ferrography.
5.	To study the impact of unbalance on a shaft as SDoF system and to plot/monitor the vibration levels of the bearings.
6.	To study the impact of unbalance on a shaft as MDoF system and to plot/monitor the vibration levels of the bearings.
7.	To study the influence of increase/decrease of distance from the source on the sound level of a source (compressor/turbine/engine) and to plot the sound levels at 1/3 octave band frequencies.
8.	To understand the dynamic vibration absorber system and study its characteristics for different excitation frequency and amplitude using virtual lab.
9.	Virtual Lab (based on CAD Modelling): • To design and model helical spring for a particular application. • To design and model shaft coupling for a particular application.
10.	Virtual Lab (based on Computer Programming): • To estimate the factor of safety of the machine element subjected to static loading. • To estimate the factor of safety of the machine element subjected to dynamic loading. • To determine pressure profile of journal bearing.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the concept of machine elements.
CO2: Learn the design and CAD modelling of different machine elements.
CO3: Acquire the computer programming skills for design calculations.

Course Name: **Logistics and Supply Chain**
Course Code: **ME-341**
Course Type: **Discipline Elective (III)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the maximization of overall value generated through the connected network of individuals, organizations, resources, activities, and technologies involved in manufacturing.
- To introduce cost reduction mechanisms while maintaining quality and timely management of different operational activities.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Concepts, Drivers and Obstacles, Planning Demand and Supply in a Supply Chain, Demand Forecasting.	**3**
UNIT-02	**Physical Distribution:** Participation in the Physical Distribution Functions, The Environment of Physical Distribution, Channel Design Strategies and Structure, Electing Channel Members, Setting Distribution Objectives and Tasks, Target markets and Channel Design Strategies.	**7**
UNIT-03	**Logistics Management:** Logistics as Part of SCM, Logistics Costs, Different Models, Logistics Subsystem, Inbound and Outbound Logistics, Bullwhip Effect in Logistics, Distribution and Warehousing Management.	**5**
UNIT-04	**Purchasing & Vendor Management:** Centralized and Decentralized Purchasing, Functions of Purchase Department and Purchase Policies, Use of Mathematical Model for Vendor Rating / Evaluation, Single Vendor Concept, Management of Stores, Accounting for Materials, Aggregate Planning, Management of Inventory in Global Supply Chain.	**8**
UNIT-05	**Supply Chain:** Building Blocks of Supply Chain Network, Performance Measures in Decisions in the Supply Chain World, Models for Supply Chain Decision Making, Supply Chain Inventory Management, Economic Order Quantity Models, Recorder Point Models, Multichannel Inventory Systems, Supply Chain Facilities Layout, Capacity Planning, Inventory Optimization, Dynamic Routing and Scheduling, Role of Information Technology in Supply Chain, E-Business and the Supply Chain, Factors Influencing Logistics and Decision, Bench Marking and Performance Measurement, Supply Chain Risk, Reverse Logistics, Green Supply Chain.	**10**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify ways to fulfil customer demand through efficient resources.

CO2: Describe the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption.

CO3: Apply principles of effective distribution and optimization of pre & post-inventory levels.

CO4: Assess the product demand by driving customer value, improving responsiveness, facilitating financial success, and building a good network.

Books and References

1. Supply Chain Management by John T. Mentzer, SAGE Publication, New Delhi.
2. Business Logistics/Supply Chain Management by Ballou & Srivastava, Pearson Education, New, Delhi.
3. Supply Chain Logistics Management by Bowersox, Closs and Cooper, Tata McGraw-Hill.
4. Logistics and Supply Chain Management by Martin Christopher, Financial Times Prentice New Delhi.
5. Supply Chain Management: Text and Cases by Janat Shah, Pearson Education, New Delhi.

Course Name: **Composite Materials**
Course Code: **ME-342**
Course Type: **Discipline Elective (III)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the classifications and unique characteristics of composite materials.
- To understand the role of reinforcement on mechanical properties of composite materials.
- To understand the manufacturing methods of composite.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction of Composites; Reinforcement: Flexibility Concept, Types of Reinforcements: Different Types of Fibers, Whiskers and Particulates, Matrix Materials: Polymer: Types, Glass Transition Temperature, Degree of Crystallinity, Common Polymer Matrix Materials, Metals and Ceramic Matrix Materials, Interface: Wettability, Crystallographic Nature of Interface, Types of Bonding at the Interface, Test for Measuring Interfacial Strength.	**8**
UNIT-02	**Various Types of Composites:** Classification Based on Matrix Material: Organic Matrix Composites, Polymer Matrix Composites (PMC), Carbon Matrix Composites or Carbon-Carbon Composites, Metal Matrix Composites (MMC), Ceramic Matrix Composites (CMC); Classification Based on Reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & Limitations of Composites.	**8**
UNIT-03	**Manufacturing Methods:** Hand and Spray Lay-Up, Injection Molding, Resin Injection, Filament Winding, Pultrusion, Centrifugal Casting and Prepregs, Fibre/Matrix Interface, Measurement of Interface Strength, Characterization of Systems; Carbon Fibre/Epoxy, Glass Fibre/Polyester, etc.	**5**
UNIT-04	**Mechanical Properties-Stiffness and Strength:** Geometrical Aspects–Volume and Weight Fraction. Unidirectional Continuous Fibre, Discontinuous Fibers, Short Fiber Systems, Woven Reinforcements-Mechanical Testing: Determination of Stiffness and Strengths of Unidirectional Composites; Tension, Compression, Flexure and Shear.	**6**
UNIT-05	**Analysis of Laminated Composite**: Plate Stiffness and Compliance, Assumptions, Strains, Stress Resultants, Plate Stiffness and Compliance, Computation of Stresses, Types of Laminates, Symmetric Laminates, Antisymmetric Laminate, Balanced Laminate, Quasi-isotropic Laminates, Cross-ply Laminate, Angle ply Laminate. Orthotropic Laminate, Laminate Moduli, Hygrothermal Stresses, Failure theories: Micromechanics of Failure of Unidirectional Lamina, Anisotropic Strength and Failure Theories, Importance of Shear Strength, Choice of Failure Criteria, Examples.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Knowledge of the crystal structures of a wide range of ceramic materials and glasses.

CO2: Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure.

CO3: Able to select matrices for composite materials in different applications.

CO4: Able to describe key processing methods for fabricating composites.

Recommended Books

1. Composites, Engineered Materials Handbook, Vol. 1, ASM International, Ohio, 1988.
2. Structure and Properties of Composites, Materials Science and Technology, Vol. 13, VCH, Weinheim, Germany, 1993.
3. Composite Materials: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman & Hall, London, 1994.

Course Name: **Principles of Combustion**

Course Code: **ME-343**

Course Type: **Discipline Elective (III)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To Provide the Knowledge of Basic Principles of Various Combustion Modes.
- To Evaluate the Performance Characteristics of Various Types of Flames.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Combustion Modes and Flame Types, Property Relations, First Law of Thermodynamics, Reactant and Product Mixtures, Adiabatic Flame Temperature, Chemical Equilibrium, Equilibrium Products of Combustion.	**6**
UNIT-02	**Laminar Premixed Flames**: Laminar Flame Propagation, Laminar Flame Speed Variation; Structure of Premixed Flames, Flammability Limit; Premixed Flame Theory, Estimation of Laminar Flame Velocity and Thickness, Ignition of Premixed Mixture (Semenov's Analysis), Piloted Ignition and Flame Quenching, Premixed Flame Stability.	**8**
UNIT-03	**Laminar Diffusion Flames**: Theory of Gas Jets, Analysis of Gas Jets & Jet Diffusion Flames, Diffusion Flame Characteristics & Flame Structure, Diffusion Flame Structure; Flame Regimes, Diffusion Flame Regimes; Flame Height Correlations, Control, Diffusion Flame Configurations (Co-flow, Crossflow; Opposed Flow Flames), Diffusion Flame Stability.	**8**
UNIT-04	**Turbulent Flames:** Characteristics of Turbulence, Turbulent Length Scales; Turbulent Stresses, Axisymmetric Turbulent Jet, Turbulent Premixed Flames; Flame Regimes, Turbulent Diffusion Flames.	**6**
UNIT-05	**Pollution Emissions:** Effects of Pollutants, Quantifications of Emissions; Emissions from Premixed Combustions, Emission from Non-premixed Combustion.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Analyze the Thermodynamic and Chemical Analysis of Premixed and Non-Premixed Flames.

CO2: Analyze the Characteristic of Various Laminar and Turbulent Flames.

CO3: Understand the effect of emission coming out from the Premixed and Non-Premixed flames.

Books and References

1. D. P. Mishra by Fundamentals of Combustion, PHI Publishers, 2008.
2. K. K. Kuo by Principles of Combustion, 2nd Ed, Wiley-Inderscience, 2005.
3. J. Warnatz by U. Mass and R. W. Dibble, Combustion, 3rd Ed, Springer, 2001.
4. F. A Wiiliams by Combustion Theory, 2nd Ed, Addison Wesley Publishing Company, 1985.
5. S. R. Turns by An Introduction to Combustion, 2nd Ed, McGraw Hill, 2000.

Course Name: **Design of Experiments**
Course Code: **ME-361**
Course Type: **Discipline Elective (IV)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart principles and methods of experimental designs and analysis
- To introduce different techniques for design of experiments
- To enable select an appropriate design, conduct the experiment, and interpret the result using appropriate analysis methods.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction to Experimental Design Principles, Simple Comparative Experiments, Applications of Experimental Design, Experimental Variable and Its Classification, Strategy of Experimentation, Difference Between Field Experiments and Laboratory Experiments	**6**
UNIT-02	**Experiments with a Single Factor:** Concepts of Random Variable, Probability, Density Function, Cumulative Distribution Function, Sample and Population, Measure of Central Tendency; Mean, Median and Mode, Measures of Variability, Concept of Confidence Level, Concept of Hypothesis Testing Type One and Type Two Error and Test Statistic, Correlation and Regression Analysis, Analysis of Variance (ANOVA).	**7**
UNIT-03	**Factorial Design:** Classical Experiments: Factorial Experiments: Terminology: Factors, Levels, Interactions, Treatment Combination, Randomization, Two-Level Experimental Designs for Two Factors and Three Factors. Three-Level Experimental Designs for Two Factors and Three Factors, Factor Effects, Factor Interactions, Fractional Factorial Design, Saturated Designs, Central Composite Designs.	**6**
UNIT-04	**Response Surface Methodology and Robust Parameter Design:** Response Surface Methodology, Parameter Optimization, Robust Parameter Design, Main Effects and Interaction, Taguchi's Quality Philosophy Types, Orthogonal Arrays, Selection of Standard Orthogonal Arrays, Evaluation of Sensitivity to Noise, Signal to Noise Ratios for Static Problems: Smaller-the-Better Type, Nominal-the Better-Type, Larger-the-Better Type.	**6**
UNIT-05	**Application of Experimental Design and Analysis:** Types of Validity, Uncertainty and Reliability of Data. Application of Experimental Design for Manufacturing Process, Industrial Problem, other Engineering Problems.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Establish basic concepts in experimental design.
CO2: Identify the suitable technique for design of experiments.
CO3: Improve the critical analysis and predict relation between parameters using statistical method.
CO4: Solve practical industrial problems using suitable design of experiments techniques.

Books and References

1. Design and Analysis of Experiments by Douglas C. Montgomery, John Wiley & Sons.
2. Design and Analysis of Experiments by Angela Dean Daniel Voss,Springer.
3. Experimental Design and Analysis by Howard J. Seltman, Carnegie Mello University
4. Design and Analysis of Experiments by Gary W. Oehlert, W.H Freeman Publisher.

Course Name: **Industrial Tribology**
Course Code: **ME-362**
Course Type: **Discipline Elective (IV)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the surfaces and their related terminologies.
- To introduce the fundamental concepts of friction and wear mechanisms for metals, polymers, and ceramics, including abrasive wear, erosive wear, wear of polymers and composites, and boundary lubrication and solid-film lubrication.
- To enable the students to understand the factors that causes the wear and friction.

Unit Number	Course Content	Contact Hours
UNIT-01	**Engineering Surfaces:** Nature of Surfaces, Surface roughness quantification, Statistical Methods of Surface Texture Assessment, Surface Modifications and Surface Coatings, Techniques of surface examination.	**5**
UNIT-02	**Friction**: Friction, Mechanism of friction, Laws of Friction and Friction theories, Measurement of Friction Merits and Demerits.	**5**
UNIT-03	**Wear**: Classification of Wear, Theories of Wear, Types of Wear and their Mechanisms, Factors Affecting Wear, Selection of Materials for Different Wear Situations, Measurement of Wear	**6**
UNIT-04	**Lubricants and Lubrication:** Role of Lubrication in Present Day Practice, Fundamentals of Viscosity and Viscous Flow, Viscosity Index, Type of Lubrication, Lubrication System, Lubricant Monitoring and Testing, Ferrography and Other Rapid Testing Methods for Lubricants, Contamination. Basic Concepts of Lubrication, Continuity Equation and Reynold's Equation.	**7**
UNIT-05	**Hydrodynamic and Hydrostatic Lubrication**: Load Carrying Capacity, Power Loss and Friction in Ideal Journal Bearings, Significance of Sommerfeld Number, Eccentricity Ratio, Hydrodynamic Journals Bearings: Short and Finite Bearings, Thrust Bearings, Non-Circular Bearings, Hydrostatic Bearing -Basic Concepts, Bearing Pads, Flat, Conical and Spherical Pad Thrust Bearing, Multi- Recess Journal and Thrust Bearings.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand different concepts related to friction, wear and lubrication.
CO2: Determine wear rate in different conditions.
CO3: Know about the various types of wear and their identification and estimation.
CO4: Understand the need and requirement of lubrication and mechanisms.
CO5: Understand various standard tribological tests.

Recommended Books

1. Engine Tribology by C M Taylor, Elsevier, 1993
2. Applied Tribology - Bearing Design and Lubrication by Michael M Khonsari, Wiley, 2001
3. Engineering Tribology by John William, Cambridge University Press, 2005.
4. Engineering Tribology by Stachowiak and Batchelor, Elsevier Limited, 1993

Course Name: **Gas Turbines**
Course Code: **ME-363**
Course Type: **Discipline Elective (IV)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the basic thermodynamics principles behind gas turbines.
- To analyse the basic operation of a gas turbine and its components.
- To understand the various classifications of gas turbine.
- To orient the students for understanding about the turbines and compressors.

Unit Number	Course Content	Contact Hours
UNIT-01	**General Considerations:** Classification, Euler's Equation for Turbomachinery; Velocity Triangle; Cascade Analysis, Shaft Power, and Aircraft Propulsion Cycles.	**6**
UNIT-02	**Gas Turbines:** Principle of Gas Turbine, Operational Parameters, Simple Open Gas Turbine Cycle, Ideal and Actual Theoretical Cycles, Regenerator, Reheater, Intercooler, Open Cycle Gas Turbine, Closed Cycle Gas Turbine.	**6**
UNIT-03	**Aerothermodynamics:** Subsonic and Supersonic Inlets, Gas Turbine Combustors, Afterburners and Ramjet Combustors, Supersonic Combustion, Exhaust Nozzles.	**6**
UNIT-04	**Axial Flow and Centrifugal Compressors**: Introduction, Stage Pressure Rise, Blockage in Compressor Annulus, Degree of Reaction, Stage Performance, H-S Diagram & Efficiency, Performance Characteristics; Combustion System. Work Done and Pressure Rise; Slip; Compressibility Effects; Compressor Characteristics, Centrifugal Compressor Stage Dynamics, Diffuser, Impeller.	**8**
UNIT-05	**Axial Flow Turbines:** Stage Performance, Degree of Reaction, H-S Diagram & Efficiency, Vortex Theory, Overall Turbine Performance, Performance Characteristics, Blade Cooling, Prediction of Performance of Simple Gas Turbines, Gas Turbine Blade Materials, Matching Procedure.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Discuss the basic energy equation and thermodynamics law behind the gas turbine.
CO2: Understand the improvements brought to gas turbine plants in terms of performance.
CO3: Explain the elementary theories for turbines and compressors.

Books and References

1. Gas Turbine Theory by Cohen, Longman.
2. Fluid Mechanics, Thermodynamics of Turbomachinery by Dixon, Pergamon Press.
3. Elements of Gas Turbine Propulsion by Mattingly, McGraw-Hill, Inc.
4. Mechanics and Thermodynamics of Propulsion by Hill and Peterson, Pearson.

Course Name: **Additive Manufacturing**
Course Code: **ME-381**
Course Type: **Stream Core-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart knowledge of different Additive Manufacturing Technologies and their applications.
- To introduce the concept of solid modelling, STL file generation and model slicing.
- To enable students to repair STL files, generate proper tool paths, and select the proper AM method.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** History and Types of Additive Manufacturing Technologies, Traditional vs Additive Manufacturing, Advantages and Applications of Additive Manufacturing, Materials for Additive Manufacturing, AM Technology in Product Development.	**5**
UNIT-02	**Data Processing for Additive Manufacturing:** CAD Model Preparation, Part Orientation and Support Generation, STL File Generation, Defects in STL Files and Repairing Algorithms, Model Slicing: Slicing and various Slicing Procedures. Tool Path Generation, Additive Manufacturing Process Chain, Software for Additive Manufacturing Technology: MIMICS, MAGICS.	**5**
UNIT-03	**Liquid-Based and Solid-Based Additive Manufacturing Technologies:** Classification, Liquid-based System, Stereolithography Apparatus (SLA): Principle, Process, Advantages and Applications. Solid Based System, Fused Deposition Modeling: Principle, Process, Advantages and Applications. Laminated Object Manufacturing.	**5**
UNIT-04	**Powder Based Additive Manufacturing Technologies:** Materials, Powder Fusion Mechanism, Process Parameters and Modelling, powder Handling, Selective Laser Sintering (SLS): Principle, Process, Advantages and Application of SLS, Three-Dimensional Printing: Principle, Process, Advantages and Applications of 3-D Printing, Laser Engineered Net Shaping (LENS), Electron Beam Melting.	**5**
UNIT-05	**Post-Processing in Additive Manufacturing**: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Property Enhancements Using Non-thermal and Thermal Techniques, Brief Information on Characterization Techniques used in Additive Manufacturing, Repairing and Coating.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Generate STL file from the solid model.
CO2: Select the areas where AM technologies can be implemented.
CO3: Identify the issues in additive manufacturing and rectify them.

Books and References

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by I. Gibson, D. Rosen and B. Stucker, Springer.
2. Rapid Prototyping: Principles and Applications in Manufacturing by Chua C. K. and L. K. Fai, World Scientific Publishing Co., Inc.

3. Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing by Andreas Gebhardt, Hanser Publishers.

Course Name: **Computational Fluid Dynamics**
Course Code: **ME-382**
Course Type: **Stream Core-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To understand the basic concept of Computational fluid dynamics.
- To develop skills in computational fluid dynamics to address engineering problems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** What is CFD, Governing Equations of Fluid Dynamics, Divergence of Velocity, Initial and Boundary Condition.	**5**
UNIT-02	**Mathematical Behaviour of PDE:** Classification of Linear PDEs, Behaviour of Different Classes of PDEs, Well Posed Problems.	**5**
UNIT-03	**Basics of Numeric:** Basic Aspects of Discretization, Introduction to Finite Difference Method (FDM), Implicit and Explicit Approaches, Errors, and Stability Analysis.	**5**
UNIT-04	**CFD Techniques:** The Lax-Wendroff Technique, Maccormack Technique, Crank-Nicholson Method, Semi Implicit Method for Pressure Linked Equations, Introduction to Grids.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand flow physics and mathematical model of governing equations.
CO2: Understand proper use of boundary conditions for the solution.
CO3: Analyze the CFD results. Compare with available data and discuss the findings.

Books and References

1. Computational Fluid Dynamics by J D Anderson, McGraw Hill.
2. Computational Fluid Flow and Heat Transfer by K. Muralidhar and T. Sundararajan, Narosa Publishing.
3. Fundamentals of Computational Fluid Dynamics by Tapan K Sengupta, University Press.
4. Computational Techniques for Fluid Dynamics Volume I & II by C.A.J. Fletcher, Springer.

Course Name: **Advanced Mechanics of Solids**
Course Code: **ME-383**
Course Type: **Stream Core-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart concept of state of stress, and Compatibility conditions.
- To introduce the concept of energy methods.
- Enable the students to learn bending of curved bars and unsymmetrical bending.

Unit Number	Course Content	Contact Hours
UNIT-01	**Analysis of Stress:** State of Stress, Equality of Cross Shear, Stress Invariants, Principal Planes, Cauchy's Stress Quadric, Octahedral Stresses Lame's Ellipsoid, Differential Equation of Equilibrium, Airy's Stress Function and Its Importance.	**5**
UNIT-02	**Analysis of Strain:** Strain Analysis: Deformations, Deformations in the Vicinity of a Point, Strain of a Line Element, Final Direction of a Linear Element, State of Strain at a Point, Shear Strain Components, Principal Axes of Strain and Principal Strains, Plane State of Strain, Plane Strains in Polar Coordinates, Compatibility Conditions, Strain Deviator, and its Invariants.	**5**
UNIT-03	**Energy Methods**: Principle of Stationary Potential Energy, Castigliano's Theorem of Deflection, Castigliano's Theorem on Deflection for Linear Load-Deflection, Strain Energy for axial loading, Strain Energies for beams, Strain Energy for Torsion, Fictitious Load Method, Statistically Indeterminate Structures.	**5**
UNIT-04	**Bending of Curved Bars**: Stresses in Curved Bars, Division of Curved Beams Based on Radius of Curvature, Bending of Beams with Initial Curvature, Beams with Large Radius of Curvature, Values of Link Radius for–Rectangular, Trapezoidal, Circular, T, I, and Triangular Section, Position of Neutral Axis, Stresses in a Crane Hook, Variation of Stresses Across the Section.	**5**
UNIT-05	**Unsymmetrical Bending and Shear Center**: Definitions, Product of Inertia, Parallel Axis Theorem of Product of Inertia, Unsymmetrical Bending, Stresses due to Unsymmetrical Bending, Combined and Axial Loads, Shear Center for Symmetrical Section, Equal Leg Angle Section and Channel Section.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the concept of state of stress, strain, and significance of compatibility conditions.
CO2: Understand The concept of energy methods for solving problems.
CO3: Understand the theory of bending curved bars for solving problems.
CO4: Learn the underlying theory of unsymmetrical bending and concept of shear center.

Recommended Books:

1. Advanced Mechanics of Solids by L.S Srinath, Mcgraw Hill.

2. Theory of Elasticity by Timoshenko and Goodier, Mcgraw Hill.
3. Mechanics of Materials by Beer & Johnston, Mcgraw Hill.
4. Strength of Materials by Crandal, Mcgraw Hill Publications.

Course Name: **Vibration and Noise Control**

Course Code: **ME-384**

Course Type: **Stream Core-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To understand the basic Mechanical Vibrations.
- To understand the sources noise and acoustic.
- To reduce the noise and improve the life of the components and reduce the noise pollution.

Unit Number	Course Content	Contact Hours
UNIT-01	**Basic Mechanical Vibration:** Vibrations in Mechanical Systems, Types, Free, Damped and Forced Vibrations of Single Degree of Freedom System, Transverse Vibration of Shafts, Critical Speed of Shaft, Damped, under damped, Critically Damped and Overdamped Systems, Vibration Transmission and Isolation, Determination of Natural Frequency, Forced Vibrations with Harmonic Excitation, Resonance, Whirling of Shafts and Critical Speed. Vibration Measuring Instruments.	**5**
UNIT-02	**Single Degree and Two Degree Freedom Systems**: Basics of Vibrations in Single and Two Degrees of Freedom System, Free and Forced Vibration with Non-Harmonic and Transient Excitation. Damped–Free Vibration, Undamped Forced Vibrations. Introduction to the Multi Degree Freedom System.	**5**
UNIT-03	**Basic Acoustic Principles:** Acoustic Terminology and Definitions, Plane and Spherical Wave Propagation–Theories of Monopole, Dipole and Quadra Pole Sound Sources, Sound Transmission and Absorption.	**5**
UNIT-04	**Basics of Noise:** Introduction, Amplitude, Frequency, Wavelength and Sound Pressure Level, Addition, Subtraction and Averaging Decibel Levels, Noise Dose Level, Legislation, Measurement and Analysis of Noise, Measurement Environment, Equipment, Frequency Analysis, Tracking Analysis, Sound Quality Analysis.	**5**
UNIT-05	**Source of Vibration & Noise and Control:** Various Sources of Vibration and Voice Generation, Passive and Active Vibration Control, Methods for Control of Engine Noise, Combustion Noise, Mechanical Noise, Predictive Analysis, Palliative Treatments and Enclosures, Automotive Noise Control Principles, Sound in Enclosures, Sound Energy Absorption, Sound Transmission through Barriers.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the basics of Mechanical Vibration

CO2: Define the Basics of Acoustic Principles.

CO3: Explain the Basics of Noise sources.

CO4: Explain the sources and control of Noise & Vibration

Reference Books

1. Rao S S, Mechanical Vibration. 5th Edition, Pearson Education, Inc., 2006

2. Grover. G.T., Mechanical Vibrations, Nem Chand, and Bros., 2009

3. Bernard Challen and Rodica Baranescu – Diesel Engine Reference Book, Second Edition, SAE International, 1999.

4. Balakumar Balachandran and Edward B. Magrab, Fundamentals of Vibrations, 1st Editon, Cengage Learning, 2009

SEMESTER VII

Course Name: **Computer-Aided Manufacturing**
Course Code**: ME-411**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge of different types of automation and the use of computers in manufacturing.
- To introduce the fundamentals of numerical control of machine tools and its CNC part programming.
- To impart knowledge of robotics and flexible manufacturing systems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Automation and Numerical Control**: Goals and Level of Automation, Hard vs Soft Automation, Principles of Numerical Control and Components, Control of NC systems: Point to Point, Straight Cut and Continuous Path, Open loop and Closed Loop, NC Interpolations- Linear, Circular, Helical, Parabolic and cubic Interpolation, Applications of Automation and NC systems; Construction Features and Classification of CNC Machine Tool, Elements of CNC Machines and Systems, Precision Measuring and Positioning of CNC.	**6**
UNIT-02	**CNC Machine Tools and Programming:** Basis and Need of CNC Machines: NC, CNC and DNC Systems, Constructional Details of CNC Machines, CNC Machining Centre, Tooling for CNC Machines: Tooling Requirements of CNC Machine, Pre-Set and Qualified Tools, Work and Tool Holding Devices in CNC Machines, Programming for 2 Axis Control Systems: Manual Part Programming for a CNC Lathe/Turning Centre, Using Tool Nose Radius Compensation, Do Loop, Subroutines and Fixed Cycles; Programming for 3 Axis Control System: Manual Part Programming for CNC Milling/CNC Machining Centre, Using Tool Radius Compensation, Tool Offsets, Do Loop, Subroutines and Fixed Cycles, Computer-Aided CNC Part Programming: Using APT Language, CAD/CAM Aided CNC Part Programming.	**9**
UNIT-03	**Group Technology and Cellular Manufacturing**: Part Family's Formation, Selection of Classifications and Coding Systems, Production Flow Analysis, Cellular Manufacturing, Application Considerations in Group Technology.	**5**
UNIT-04	**Flexible Manufacturing Systems**: Introduction to Manufacturing Systems, Flexibility and Automation, Different Types of Flexibilities in Manufacturing, Volume Variety Relationships, Flexible Manufacturing System (FMS), FMS Components, FMS Applications and Benefits, FMS Planning and Implementation Issues, Quantitative Analysis of Flexible Manufacturing Systems, FMS Control Systems, Material Handling Systems: Overview Of Material Handling Systems, Material Transport Systems, Automated Guided Vehicles, Automated Storage And Retrieval Systems	**6**

UNIT-05	**`Manufacturing Support Systems and FMS layout**: Robotics Technology; Computer Aided Quality Control; Computer Aided Process Planning, Advanced Manufacturing Planning. CAD/CAM in Production System, Production Planning and Control Systems, Just-In-Time and Lean Production, Layout Considerations for Flexible Manufacturing Systems, Future Developments in FMS.	**6**

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

CO1: Understand and do programming of CNC machines.
CO2: Implementing of GT philosophy in Industries.
CO3: Design and analyse different manufacturing systems for industries.
CO4: Understand the design and implementation of material handling systems.
CO5: Understand various systems used in automated manufacturing.

Recommended Books

1. Koren, Y., Computer Control of Manufacturing systems, McGraw Hill (2009).
2. Suh Suk-Hwan, Kang Seong-Kyoon, Chung Dae-Hyuk, Stroud Ian., Theory and Design of CNC Systems, 2008, Springer-
Verlag London Limited.
3. Smith Peter, CNC programming handbook, 2nd edition, 2003, Industrial Press Inc.
4. Groover, M. P. and Zimmers, E. W., CAD/CAM: Computer Aided Design & Manufacturing, 2006, Pearson Education India
5. Hood-Daniel P., and Kelly J.F., Build Your Own CNC Machine, 2009, Springer-Verlag New York.

Course Name: **Refrigeration and Air Conditioning**
Course Code: **ME-412**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the fundamental principles and different methods of refrigeration and air conditioning.
- To impart the knowledge of various refrigeration cycles and evaluate performance using refrigerant property tables.
- To understand the concept of psychrometry, psychrometric processes, thermal comfort, and their application in air conditioning.

Unit Number	Course Content	Contact Hours
UNIT-01	**Refrigeration Cycles:** Review of Thermodynamic Principles of Refrigeration, Refrigeration Methods, Reverse Carnot Cycle, Bell Coleman Cycle, Aircraft Refrigeration Cycles.	**4**
UNIT-02	**Vapor Compression Refrigeration Systems:** Vapor Compression Refrigeration Systems: Theoretical and Actual Vapor Compression Cycle, Methods of Improving Vapor Compression Cycle, Pressure-enthalpy, and Temperature- entropy Charts, Multistage systems. **Refrigerants:** Classification and Designation of Refrigerants, Desirable Properties of an Ideal Refrigerant, Properties and Uses of Common Refrigerants, New Refrigerants.	**9**
UNIT-03	**Vapor Absorption Refrigeration Systems:** Ammonia Water Vapor Absorption System, Properties of Binary Mixture (Aqua-ammonia), Li-Br Absorption System, Thermodynamic Analysis of Li-Br Absorption System, Comparison of Vapour Absorption and Compression System.	**5**
UNIT-04	**Liquefaction of Gases:** Principle of Gas Liquefaction**,** Liquefaction Systems-Simple Linde Hampson Cycles, Claude Cycle.	**3**
UNIT-05	**Psychrometry and Psychrometric Processes:** Introduction to Air Conditioning, Psychrometric Properties and Terms, Psychrometric Relations, Development of Psychrometric Chart, Psychrometric Processes, and its Representation on Psychrometric Chart, Cooling and Dehumidification by Cooling Coil, BPF of Coil, ADP, SHF, RSHF, GSHF, Introduction to Summer and Winter Air Conditioning.	**10**
UNIT-06	**Thermal Comfort:** Thermodynamics of Human Body, Indices of Thermal Comfort, Factors Affecting Human Comfort, Comfort Chart, Introduction to Load Calculations.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Illustrate the fundamental principles and applications of refrigeration and air conditioning system.
CO2: Analyze the performance of vapour compression and vapour absorption refrigeration systems.
CO3: Apply the concept of psychrometry in air conditioning.

Books and References

1. Refrigeration and Air Conditioning by C.P. Arora, TMH Publication.
2. Refrigeration and Air Conditioning by Stoecker, McGraw Hill.
3. Refrigeration and Air Conditioning by Manohar Prasad, New Age International Publisher.
4. Refrigeration and Air Conditioning by RC Arora, PHI.
5. Cryogenics Systems by Randall F. Barron, Oxford University of Press.

Course Name: **Computer Aided Design**
Course Code: **ME-413**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart the basic knowledge of the use of computers in product development and design.
- To introduce the students to mathematical and computational modelling of curves, surface, and solids.
- To enable the student to use computer for product modelling and analysis.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction to CAD/CAM/CAE and Historical Development of CAD, Product Development Cycle, Typical CAD System Architecture, Graphic Devices and Classification, Input/output Devices, Operating Systems and Environments, Applications, Advantages and Limitations of CAD, Concept of Coordinate Systems, Line Generation Algorithm: DDA, Bresenham's Algorithms. Graphics Exchange Standards and Database Management Systems.	**5**
UNIT-02	**Modelling of Curves and Surfaces**: Curve Representation: Parametric vs Non-parametric, Implicit vs Explicit vs Intrinsic, Advantages of Parametric Representation, Analytic Curves, Synthetic Curves: Concept and Types of Continuity, Cubic Spline: Equation, Bezier Curve, B-Splines and NURBS, Various Types of Surfaces along with Their Typical Applications, Properties, Blending of Curves/Surfaces.	**6**
UNIT-03	**Modelling of Solids:** Properties of Solid Model, Properties of Representation Schemes, Concept of Half-Spaces, Boolean Operations, Schemes: Boundary Representation (B-Rep), Constructive Solid Geometry (CSG), Sweep Representation, Analytical Solid Modelling (ASM), Primitive Instancing, Solid Manipulations.	**6**
UNIT-04	**Geometric Transformations:** Homogeneous Representation, Translation, Reflection, Rotation, Scaling, Shear in 2D and 3D, Combined Transformations, Modelling and Coordinate Transformations, Graphic Projections: Orthographic, Axonometric Oblique, and Perspective Projections.	**6**
UNIT-05	**Finite Element Analysis:** Review of Stress-Strain Relation and Generalized Hooke's Law, Plane Stress and Plane Strain Conditions; Concept of Total Potential Energy; Basic Procedure for Solving a Problem using Finite Element Analysis, 1-D Analysis: Concept of Shape Function and Natural Coordinates, 1-D Structural Problems with Elimination and Penalty Approaches.	**6**
UNIT-06	**Design Optimization:** Introduction, Gradient-based and Heuristic Methods, Johnson Method of Optimization Normal Specification Problem, Redundant Specification Problem.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To use computers in mechanical component design.

CO2: To use mathematical concepts of curve, surface, and solid formulations in CAD.

CO3: To use design and analysis techniques and softwares in CAD.

Reference Books

1. CAD/CAM Theory and Practice by I. Zeid, McGraw Hill.

2. Mathematical Elements for Computer Graphics by David Rogers and J Alan Adams, TMH Publication.

3. Introduction to Finite Elements in Engineering by Chandrupatla T A and Belegundu A D, PHI.

4. Principles of Optimum Design: Modeling and Computation by Paplambros P. Y., Wilde D. J., Cambridge University Press, UK.

Course Name: **Refrigeration and Air Conditioning Lab**
Course Code: **ME-414**
Course Type: **Discipline Core**

Contact Hours/Week: **2** Course Credits: **01**

Course Objectives

- To help understand the operation of various refrigeration and air conditioning apparatus.
- To gain practical knowledge by applying experimental methods to correlate with the theory.
- Learnt to apply the mathematical steps and graphical analysis to the experimental data.

List of Experiments

1.	To determine the theoretical and experimental Coefficient of Performance (COP) of a Domestic Refrigerator.
2.	To estimate the effect of sub-cooling and super-heating on the COP of VCR (Vapor Compression Refrigeration) system.
3.	To determine the theoretical and experimental COP of a heat pump.
4.	To study and determine the COP of Cascade Refrigeration System.
5.	To study the Ice making test rig.
6.	To find the COP of a Water Cooler.
7.	To study the hermetically sealed compressor and different types of cut-out /safety devices used in Vapor Compression Refrigeration System.
8.	To study and determine the COP of Vapor Absorption Refrigeration System.
9.	To study the window, split and centralized air conditioning system.
10.	To determine the system capacity, capacity factor, apparatus dew point (ADP) and COP of Window Air Conditioner.
11.	To calculate the mass flow rate of refrigerant, bypass factor, ADP, and capacity (in humidifying condition) of an air conditioning test rig.
12.	To calculate the mass flow rate of refrigerant, bypass factor, ADP, and capacity (in dehumidifying condition) of an air conditioning test rig.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Handle various refrigeration and air conditioning equipment and take measurements and analyse results.

CO2: Experimentally realize the actual physical phenomenon occurs in Refrigeration and air conditioning systems.

CO3: Use various measuring sensors and instruments with precision.

Course Name: **CAD/CAM Lab**
Course Code: **ME-415**
Course Type: **Discipline Core**

Contact Hours/ Week: **2P** Course Credits: **01**

Course Objectives

- To gain practical knowledge by conducting experiments related to CAD/CAM theory.
- Exposure to CNC Programming.
- Hands-on practice on AutoCAD, CATIA Software.

List of Experiments

CAM:

1.	To study the CNC Lathe and CNC milling machine.
2.	To Study the six-axis robot and make a pick and place program using teaching mode method.
3.	To write the complete Program for turning and milling operation using CIM system.
4.	To study of flexible manufacturing system.
5.	Write a part program for the given billet, to be machined on the CNC turning center using manual and BOX cycle.
6.	Write a part program for the given billet, to be machined on the CNC Turning center using multiple turning cycle.

CAD:

1.	To introduce the interface of 2D Drafting CAD Software and practice the basic commands of AutoCAD Software.
2.	To perform 2D drafting of CAD Models using AutoCAD Software.
3.	To draw the Isometric views of CAD Models using AutoCAD Software.
4.	To introduce the interface of 3D Modelling CAD Software.
5.	To understand and practice the basic commands of CATIA Software.
6.	To perform 3D modelling of CAD models using CATIA Software.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Learn basics of CNC programming

CO2: Learn Basics of AutoCAD

CO3: Work on 3D modeling in CATIA software

Course Name: **Design of Heat Exchanger**
Course Code: **ME-431**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge on the basic design methodologies of heat exchanger.
- To understand the principles and design methodologies of double pipe, shell and tube and compact heat exchangers.
- To introduce heat transfer enhancement technique and performance evaluation of heat exchangers.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Basic Concepts, Classification of Heat Exchanger, Selection of Heat Exchanger, Basic Design Methodologies for Heat Exchanger, Overall Heat Transfer Coefficient.	**6**
UNIT-02	**Design Considerations**: LMTD Method for Heat Exchanger Analysis for Parallel, Counter, Multi-Pass and Cross Flow Heat Exchanger, Effectiveness-NTU Method for Heat Exchanger Analysis, Fouling, Rating and Sizing Problems, Heat Exchanger Design Methodology.	**6**
UNIT-03	**Design of Double Pipe Heat Exchangers:** Thermal and Hydraulic Design of Inner Tube and Annulus, Hairpin Heat Exchanger with Bare and Finned Inner Tube, Total Pressure Drop, Performance and Design Calculations.	**6**
UNIT-04	**Design of Shell & Tube Heat Exchangers:** Basic Components, Design Procedure of Heat Exchanger, J-Factors, Conventional Design Methods, Bell-Delaware Method.	**6**
UNIT-05	**Design of Compact Heat Exchangers:** Heat Transfer Enhancement, Plate Fin Heat Exchanger, Tube Fin Heat Exchanger, Heat Transfer and Pressure Drop, Introduction to Pinch Analysis.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic concept and design methodology of heat exchangers.
CO2: Determine general design requirements for different types of heat exchangers.
CO3: Able to apply the basic knowledge of fluid mechanics, heat transfer, and material properties in design calculations.

Books and References

1. Heat Exchangers – Selection Design and Construction by Saunders, Longmann Scientific and Technical, NY.
2. Compact Heat Exchangers by Kays and London, McGraw Hill.

3. Heat Exchangers by Martin, Hemisphere Publ. Corp., Washington.
4. Fundamentals of Heat Exchanger Design by Shah and Sekulic, Wiley.

Course Name: **Mechanics of Composite Materials**
Course Code: **ME-432**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart basic knowledge of composite materials and their mechanics.
- To introduce the concept of strength and failures of composites.
- To enable the students to have analytical solutions for the underlying classical lamination theory.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Definition, Characteristics and Classification of Composites, Mechanical Behaviour and Basic Terminology, Multi-axial Stress Components and Stress Transformation; Multi-Axial Strain Components and Strain Transformation, Stress-strain relation.	**8**
UNIT-02	**Macro Mechanical Behaviour of Lamina:** Stress Strain Relation for Anisotropic Materials, Orthotropic Materials, Lamina of Arbitrary Orientation, Invariant Properties of Orthotropic Lamina, Strength of Orthotropic Lamina, Failure Criteria.	**8**
UNIT-03	**Micro Mechanical Behaviour of Lamina:** Mechanics of Material Approach to Stiffness, Elasticity Approach, Determination of Elastic Constants, Halpin-Tsai Equation, Mechanics of Material Approach to Strength.	**5**
UNIT-04	**Macro Mechanical Behaviour of Laminate:** Classical Lamination Theory, Strength of Laminate, Layup Arrangements for Laminates and Implications for Elastic Property of the Composite, Interlaminar Stresses.	**5**
UNIT-05	**Failure Analysis of Multi-Directional Laminates:** Stress Analysis for First Ply Failure; Progressive and Ultimate Failure; Design Considerations.	**5**

Course Outcomes

Upon Successful Completion of The Course, The Students Will Be Able To

CO1: Understand the composite materials, their classification, and applications.
CO2: Learn the stress strain relations for anisotropic materials.
CO3: Understand the concept of strength of composites and associated failure criteria.
CO4: Understand classical lamination theory and elasticity approach to stiffness of composites.

Books And References

1. Mechanics of Composite Materials by Robert M. Jones, CRC Press.
2. Principles of Composite Material Mechanics by Ronald F. Gibson, CRC Press.
3. Mechanics of Composite Materials with MATLAB by George Voyiadjis and Peter Kattan, Springer.

Course Name: **Automobile Engineering**
Course Code: **ME-433**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the various systems of automobiles and their integration as a whole.
- To enable the students to learn the principle and working of various systems of Automobiles.
- To enable the students to learn the trouble shooting of various automotive components.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction and Chassis Construction:** Classification of Automobiles, Components of an Automobile, Basic Structure, Transmission System, Auxiliaries, Front Engine Rear Drive and Front Engine Front Drive Vehicles, Four Wheel Drive Vehicles, Conventional Construction, Underbody, Sub Frames, Defects in Frames, Frameless Construction, Industrial Vehicle Frames, Design & Structural Testing.	**8**
UNIT-02	**Clutches and Transmission System:** Necessity & Functions of Transmission, Types of Transmission, Requirements and Principle of Clutches, Dry Friction Clutches, Types of Clutches-Single Plate, Multi Plate, Clutch Operation, Gear Box, Sliding Mesh Gear Box, Constant Mesh Gear Box, Synchromesh Gear Box, Selector Mechanism, Transfer Box, Automatic Transmission, Principle of Automatic Transmission.	**8**
UNIT-03	**Suspension System and Propeller Shaft:** Basic Requirements and Coordinate Frames, Function of Suspension Springs, Types of Suspensions, Shock Absorbers, Stabilizer or Anti-Roll Device, Suspension Mechanics: Solid Axle Suspension, Independent Suspension, Roll Center and Roll Axis, Trouble Shooting, Propeller Shaft, Universal Joints, Differential, Rear Axle, Rear Axle Drives, Rear Axle Casing.	**5**
UNIT-04	**Front Axle and Steering:** Front Axle, Wheel Geometry, Factors of Wheel Alignment, Steering Geometry, Mechanisms, Cornering Force, Self- Righting Torque, Understeer and Oversteer, Steering Gears and Ratio, Reversibility, Power Steering, Steering Kinematics, Steering Trouble Shooting.	**6**
UNIT-05	**Cooling System and Lubrication:** Necessity and Methods of Cooling, Types of Cooling, Components of Cooling System Radiator, Coolant, Antifreeze Solutions, Requirements of Lubrication, Types of Lubricants, Testing of Lubricants, Oil Additives, Systems of Engine Lubrication, Oil Filter, Oil Pump, Oil Cooler. **Fuel Supply and Ignition Systems:** Fuel Supply Systems, Carburettor Types, Fuel Injection Pump, Supercharger, Fuel Filter, Types of Ignition Systems, Components, Spark Plug, Magneto Ignition System.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different systems of automobiles.

CO2: Understand the interaction and working of different automotive systems.

CO3: Understand the parameters and ways for trouble shooting of automotive components.

Books and References

1.Automobile Engineering by Kirpal Singh, Standard Publisher.
2.Automotive Mechanics by Joseph Heitner, East West Press.
3.Vehicle Dynamics by Reza N. Jazar, Springer.
4.Automobile Engineering by R.B Gupta, Satya Prakshan.
5.Electric and Hybrid Vehicles Design Fundamentals by Iqbal Hussein, CRC Press.

Course Name: **Industrial Robotics**
Course Code: **ME-434**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge and use of types of sensors and actuators.
- To introduce the fundamentals of Kinematics and Dynamics of Industrial Robots
- To impart knowledge of robotics, robotic programming, and robot vision.
- To use the Robots for various Industrial applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to robotics**: Historical Background, Definitions, Laws of Robotics, Configurations of Manipulators: Components of Robots, Arm Configuration, Wrist Configurations; Classification of Robots, Specification of Robots, Precision of Movement in Robotics: Resolution, Accuracy and Repeatability, Economics of Robotization in Industries, Applications of Robots in Manufacturing, Automation and Services, Introduction to Mobile Robots.	**5**
UNIT-02	**Components of Robotic Systems**: Introduction, Drive System: Hydraulic System. Pneumatic System, Electrical Actuators, Other Actuating Systems, Sensors: Need for Sensing Systems, Classification of Sensors, Characteristics of Sensors, Various Types of Sensors, Smart Sensors, Robot Vision Systems and Robot Cell Design and Control, Robot Control System, Manipulator Control, Robot End Effectors.	**7**
UNIT-03	**Manipulator Kinematics and Dynamics**: Introduction, Coordinate Frames and Transformations, Homogenous Transformations Matrix, Composite Transformations, Inverse Homogenous Transformations, Forward and Inverse Kinematic Equations, Denavit Hardenberg(D-H) Representation, Forward Kinematic Solution of Various Manipulators, Inverse Kinematic Analysis: Solvability of Inverse Kinematics Problems, Multiple Solutions, Solution to Inverse Kinematics. Dynamic Analysis of Manipulator, Trajectory Planning.	**8**
UNIT-04	**Robot Programming:** Introduction, Methods of Programming, Motions Programming, Robot Languages -Textual Robot Languages, Generation of Robot Programming Languages, Robot Programming Language Structure.	**9**
UNIT-05	**Robots Applications, Implementation Principles and Issues**: Introduction, Work Cell Layout, Work Cell Design, Industrial Applications Material Handling, Processing Operations, Assembly and Inspection, Approach for Implementing Robotics, Safety, Training, Maintenance and Quality, Social Issues and Future of Robotics.	**4**

Course Outcomes
Upon successful completion of the course, the students will be able to

CO1: Classify the various robot configurations to be used in various situations and able to frame specifications.
CO2: Select appropriate sensors, actuators and devise a system for collecting information for robot controller.
CO3: Demonstrate the concepts of kinetics & amp; dynamics of robot.
CO4: Identify applications of robots in manufacturing, Industries and society.

Recommended Books

1. Robotics-control and programming by J. Srinivas, Narosa Publication.
2. Industrial Robotics by M.P. Groover, Mc Graw Hill Publication.
3. Fundamental of Robotics: Analysis and Control by Robert J Schilling, Person Publication Education.
4. Industrial Robotics by Ganesh S. Hegde, Laxmi Publication.
5. Robotics for Engineers -YoramKoren, McGraw Hill International, 1st edition, 1985.
6. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007.
7. Introduction to Robotics: Mechanics and Control by John.J. Crag Pearson/PHI Publication.
8. Robots manufacturing and application -Paul Afonh, John Wiley.

Course Name: **Optimization Methods in Engineering**
Course Code: **ME-435**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3** Course Credits: **03**

Course Objectives

- To formulate design problems as mathematical programming problems.
- To determine the degree of attainment of the goals with the available resources.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction, Terminologies, Design Variables and Constraints, Objective Function, Variable Bounds, and Problem Formulation.	**4**
UNIT-02	**Gradient Based Methods**: Newton-Raphson Method, Bisection Method, Secant Method, Multi-variable Optimization Algorithms: Optimality Criteria, Unidirectional Search, Direct Search Methods: Box Method, Hooke-Jeeves Pattern Search Method, Powell's Conjugate Direction Method, Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's Method. Marquat Method, Conjugate Gradient Method, Variable-Metric (DFP) Method.	**8**
UNIT-03	**Constrained Optimization Methods:** Kuhn Tucker Conditions, Transformation Methods: Penn Function Method, Method of Multipliers (MOM), and Sensitivity Analysis.	**5**
UNIT-04	**Specialized Algorithms Methods**: Integer Programming: Penalty Function Method, Branch and Bo' Method, Geometric Programming.	**5**
UNIT-05	**Non-Traditional Optimization Methods:** Genetic Algorithms, Simulated Annealing, Tabu Search and Ant Colony Optimization, Particle Swarm Optimization; Applications to Engineering Optimization Problems.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the required techniques to achieve a desired set of objectives.
CO2: Describe the best satisfying solution under a varying number of resources and priorities of the goals.
CO3: Apply principles of resource optimization.
CO4: Assess the suitability of technique for optimizing the real-world problem.

Books and References

1.Optimization for Engineering Design: Algorithms and Examples by Kalyanmoy Deb, PHI Publication.
2. Engineering Optimization: Theory and Practice by S.S Rao, New International (P) Publication.
3. Engineering Optimization - Methods and Applications by Ravindran, Ragsdell and Rekla, John Wiley & Sons Publication.
4. Multi-Objective Optimization using Evolutionary Algorithms by Kalyanmoy Deb, Wiley Publication.

Course Name: **Solar Energy Utilization**
Course Code: **ME-436**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To discuss the aspects of solar radiation to enable learners to analysis and estimate solar radiation at different locations.
- To discuss theories and parameters for designing solar energy systems.
- To dissipate the knowledge for estimating different losses in solar energy systems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Basics of Solar Radiation**: Structure of Sun, Spectral Distribution of Extra-Terrestrial Radiation, Solar Constant, Concept of Zenith Angle and Air Mass, Definition of Declination, Hour Angle, Solar and Surface Azimuth Angles; Direct, Diffuse and Total Solar Radiation, Solar Intensity Measurement-Thermoelectric Pyranometer and Pyrheliometer.	**8**
UNIT-02	**Radiative Properties and Characteristics of Materials**: Reflection, Absorption and Transmission of Solar Radiation through Single and Multi Covers; Kirchoffís Law-Relation Between Absorptance, Emittance and Reflectance; Selective Surfaces-Preparation and Characterization, Types and Applications; Anti-Reflective Coating.	**6**
UNIT-03	**Flat Plate Collectors**: Description of Flat Plate Collector, Liquid Heating Type FPC, Energy Balance Equation, Efficiency, Temperature Distribution in FPC, Definitions of Fin Efficiency and Collector Efficiency, Evacuated Tubular Collectors.	**8**
UNIT-04	**Concentrating Collectors:** Classification, Design, and Performance Parameters; Definitions of Aperture, Rim-Angle, Concentration Ratio and Acceptance Angle; Tracking Systems; Parabolic Trough Concentrators; Concentrators with Point Focus.	**8**
UNIT-05	**Solar hot water system:** Types of SHWS, Standard Method of Testing the Efficiency of SHWS; Passive Space Heating and Cooling Concepts, Solar Desalination, and Drier, Solar Thermal Power Generation.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Calculate the terrestrial solar irradiance on an arbitrary tilted surface.
CO2: Identify and describe the basic instruments used to measure solar radiation.
CO3: Use a flat plate solar collector mathematical model to predict performance.
CO4: Understand the different types of solar hot water and space heating system.

Books and References

1. Solar Energy: Principles of Thermal Collection and Storage by S.P. Sukhatme, Tata McGraw-Hill.
2. Solar Engineering of Thermal Processes by J. A. Duffie and W. A. Beckman, Johnn Wiley.
3. Principles of Solar Engineering, Goswami D Y by Frank Kreith and J F Kreider, Taylor & Francis.
4. Solar Energy: Fundamental and Application by H.P. Garg and Prakash S, Tata McGraw-Hill.
5. Solar Energy- Fundamentals, Design, Modeling and Applications by G.N. Tiwari, Narosa Publications.

Course Name: **Exergy Analysis of Thermal System**
Course Code: **ME-437**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To educate students about exergy and its applications in real-world situations.
- To carry out an exergy-economic analysis on the existing thermal system.

Unit Number	Course Content	Contact Hours
UNIT-01	**Recapitulation of Exergy:** Entropy, Entropy Generation, Concept of Exergy, Non-Flow Exergy, Exergy Concepts for Control Volume Analysis, Mechanism of Exergy Destruction, Exergy Loss, Exergy Balance, Physical Exergy, Chemical Exergy, Gouy-Stodola Theorem, Rational Efficiency.	**8**
UNIT-02	**Exergy Analysis of Simple Processes:** Exergy Analysis of Expansion and Compression Process, Heat Transfer Process, Mixing Processes, Combustion Process, Exergy Analysis of Steam Power Plant, Gas Turbine, Combined Cycle Power Plant, Cogeneration System**.**	**10**
UNIT-03	**Exergy Analysis of Refrigeration & Air conditioning Systems:** Exergy Analysis of Vapour Compression System, Vapour Absorption Refrigeration Plant, Exergy Analysis of Psychrometric Process, Total Flow Exergy of Humid Air, Evaporative Cooling Process.	**10**
UNIT-04	**Exergy-Economic Analysis:** Exergy Analysis of Thermal Radiation, Exergy Analysis of Solar Thermal Systems, Fundamental of Exergy-economic, Exergy Costing of Thermal Components of Steam and Gas turbine, Boiler, Cogeneration System.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and apply concepts of Exergy to the different thermodynamic systems.

CO2: Apply the concepts of exergy analyses in specific applications e.g. power plant, refrigeration and Air Conditioning systems etc.

CO3: Carry out the exergy economic analysis different thermodynamics systems.

Books and References

1. Advanced Engineering Thermodynamics by Adrian Bejan, John Wiley & Sons.
2. The Exergy Method of Thermal Plant Analysis by T J Kotas, Krieger Publishing Company.
3. Advance Thermodynamics for Engineers by D E Winterbore, Ali Turan, Kidlington, Oxford.
4. Fundamentals of Engineering Thermodynamics by Michel J Moran, Howard N Shapiro, Daisie D Boettne, Argaret Bailey, Wiley.

Course Name: **Electric and Hybrid Vehicle**
Course Code: **ME-438**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the concept of electric vehicles.
- To study about the motors & drives for electric vehicles.
- To study about the Battery for electric vehicle
- To understand the concept of hybrid vehicles.
- To study about fuel cell for electric vehicles.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Electric Vehicle Need, Types, Cost and Emissions, End of life. Electric Vehicle Technology, layouts, Basics of EV Building Blocks, Types of Drive Train, Types of Power train. EV Charging–Methods and Standards. Alternate Charging Sources.	**5**
UNIT-02	**Electric Vehicle Motors:** Motors (DC, Induction)–Types, Principle, Construction, Control, Electric Drive Trains (EDT)–Series HEDT (Electrical Coupling)– Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling)–Torque Coupling and Speed Coupling, Switched Reluctance Motors (SRM) Drives-Basic structure, Drive Convertor.	**7**
UNIT-03	**Battery for electric vehicle:** Basics of Batteries: Battery Basics, Battery Parameters, Types of Battery, Technical Characteristics, Battery Charging and Chargers Techniques, Types of Chargers, Standards for Chargers Charging, Battery Handling and Battery Management.	**6**
UNIT-04	**Hybrid Vehicles:** Hybrid Electric Vehicles–Classification–Micro, Mild, Full, Plug-in, EV. Layout and Architecture–Series, Parallel and Series-Parallel Hybrid, Propulsion Systems and Components, Regenerative Braking, Economy, Vibration and Noise reduction. Hybrid Electric Vehicles System Types and Controls.	**6**
UNIT-05	**Fuel Cells for Electric vehicles:** Fuel Cell–Introduction, Technologies & Types, Obstacles, Operation Principles, Potential And I-V Curve, Fuel Cell Characteristics–Efficiency, Durability, Specific Power, Factors Affecting, Power Design of Fuel Cell Vehicle, Fuel Cell Vehicle–System, Components, Maintenance.	6

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Describe the working principle of electric vehicles.
CO2: Understand the different types and working principle of hybrid vehicles.
CO3: Impart the knowledge about Battery and fuel cell for electric Vehicle.

Books and References

1. Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.
3. Jack Erjavec and Jeff Arias, "Alternative Fuel Technology–Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi, 2007.

4. Mohammad S. Alam, Reji Pillai, Murugesan Navaneetha Krishnan, Developing Charging Infrastructure and Technologies for Electric Vehicles, IGI Global.
5. Prof. Sunil R. Parwar, Electrical Vehicle Technology.: The Future Towards Eco-Friendly Technology... Paperback–11 September 2021.
6. Iqbal Hussain, Electric and Hybrid Vehicles Design Fundamentals 2nd Edition 2010 by Iqbal Husain, Taylor & Francis Ltd.

Course Name: **Smart Manufacturing**
Course Code: **ME-451**
Course Type: **Stream Core-II**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart knowledge about manufacturing automation and smart manufacturing.
- To introduce the fundamental concepts of additive manufacturing technologies, industry 4.0 and industrial IoT.
- To introduce the concepts of smart sensing, machine learning, data preparation and augmented reality in manufacturing.

Unit Number	Course Content	Contact Hour
UNIT-01	**Introduction to Smart Manufacturing**: How to Start Smart Manufacturing, Economic Benefits of Smart Manufacturing, How Smart Manufacturing Solves Existing Manufacturing Problems. Key Elements of Smart Manufacturing, Smart Machines and Machine Subsystems.	**3**
UNIT-02	**Manufacturing Automation in Smart Factories**: Fluid Power- Pneumatic and Hydraulic, Basics of Pneumatic, Electro-Pneumatic Circuit Design, Various Types of Valves and their Applications, Introduction to PLCs, PLC-Based Control, Interfacing of I/O Devices with A PLC, Programming Languages and Instruction Sets, Ladder Logics, Structured Text, Functional Blocks and Applications.	**5**
UNIT-03	**Additive Manufacturing Technologies:** Traditional Manufacturing v/s Additive Manufacturing (AM); STL File Formats, Defects in STL Files and Repairing Algorithms, Support Structure in AM, Various Slicing Procedures, Materials in AM, AM Technologies: Liquid Based-Stereo Lithography and Solid Ground Curing; Powder Based-Selective Laser Sintering and Three-Dimensional Printing; Solid Based-Fused Deposition Modelling (FDM) and Laminated Object Manufacturing (LOM).	**5**
UNIT-04	**Industry 4.0 and Industrial IoT system:** Basics of Industry 4.0, Key Features and Elements of Industry 4.0, Introduction to the Industrial Internet of Things (Iot), Industrial Iot Implementation, Key Opportunities and Benefits, Iot Reference Architecture.	**4**
UNIT-05	**Smart Sensing for Industry 4.0:** Basic Principles of Sensing and Type of Industrial Sensors, Review of Smart Industrial Sensors, Identification System, Basics of Industrial Network and Communication, IO Links Technology.	**4**
UNIT-06	**Machine learning in manufacturing:** Basics of Machine Learning, Machine Learning Opportunities in Manufacturing, Supervised and Unsupervised Learning, Data Preparation for Machine Learning, Traditional Predictive Maintenance and Machine Learning Approach. Introduction to Augmented Reality and Its Role in Empowering Design, Marketing, and Service Industries.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the requirements and needs of smart manufacturing.

CO2: Select a suitable automation strategy as per the requirement.

CO3: Identify areas of knowledge of additive manufacturing that can be applied through the theoretical studies.

CO4: Apply the concept of machine learning and augmented reality in manufacturing.

Books and References

1. Fluid power with applications by Anthony Esposito, Pearson Education, 4th Edition.

2. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by I. Gibson, D. Rosen and B. Stucker, Springer.

3. Industry 4.0- The Industrial Internet of Things by Gilchrist, Apress.

4. Machine Learning in Production: Developing and Optimizing Data Science Workflows and Applications by Andrew Kelleher and Adam Kelleher, Addison-Wesley.

Course Name: **Condition Monitoring and Diagnostics**
Course Code: **ME-452**
Course Type: **Stream Core-II**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart knowledge about plant maintenance and faults diagnosis systems.
- To introduce various condition monitoring techniques for faults diagnosis to enable for the use of modern technological approach for monitoring the health of the machinery system.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Maintenance Objectives, Types, Concepts and Economic Benefits, Types of Maintenance; Preventive and Corrective Maintenance; Preventive Maintenance Time Based & Condition Based Condition Monitoring; Different Condition Monitoring Techniques (Online and Off-Line Techniques).	**5**
UNIT-02	**Fault Identification**: Various Techniques for Fault Detection; Visual Inspection; Crack Detection Techniques Like Magnetic Crack Detection, Radiography; Oil Analysis; Wear Particle Analysis; SOAP, Ferrography; Ultrasonic Crack Detection, Thermography. Non-Destructive Techniques Important Features, Types of Defects Detected by NDT Visual, Dye Penetration, Acoustic Emission and Its Applications, X-Ray, Radiographic, Magnetic Flux Test, Application of NDT Techniques.	**6**
UNIT-03	**Vibration Monitoring Methods**: Vibration Data Collection; Techniques; Instruments; Transducers; Vibration Analysis of Rotating Machines and Mechanical Systems. Faults Diagnosed by Vibration Analysis. Noise Monitoring. Temperature Monitoring, Pressure Monitoring.	**5**
UNIT-04	**Signal Processing:** Signature Analysis and their Significance, Signal Analysis, and Computer Aided Data Acquisition, Time Domain Signal Analysis, Frequency Domain Signal Analysis, Spectrum Analysis.	**5**
UNIT-05	**Applications:** Applications of Condition Monitoring in Mechanical Systems, Cutting Tools and Machine Tools Condition Monitoring, IC Engine Condition Monitoring, Power Plant Condition Monitoring, 3D Printing Condition Monitoring, Rotating Machines Condition Monitoring.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand and apply the maintenance scheme to various problems in the industrial sectors.

CO2: Analyze for faults and machine condition monitoring and faults diagnostics.

CO3: Emphasizes on case studies with the use of modern testing equipment and analyze to identify the faults in Machines.

Reference Books

1. Mechanical Faults Diagnostics and Condition Monitoring by R. A. Colacott, Springer.
2. Handbook of Condition Monitoring by B.K.N. Rao, Elsevier.
3. Engineering Condition Monitoring Practice, Methods and Applications by Barron, R., Addison, Weslay Longman.

4. Condition Monitoring for Engineering Services by Armstrong, J.H, Spon Press.
5. Machinery vibration analysis and predictive maintenance by P Girdhar, Elsevier.

Course Name: **Compressible Flow**
Course Code: **ME-453**
Course Type: **Stream Core-II**

Contact Hours/Week: 2**L** Course Credits: **02**

Course Objectives

- To understand the basic difference between incompressible and compressible flow.
- To study the phenomenon of shock waves and its effect on flow.
- To gain the Gas dynamics theory and their applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Fundamentals of Compressible Flow:** Ideal Gas Relationship, the Adiabatic Energy Equation, Mach Number and Its Significance, Mach Waves, Mach Cone, and Mach Angle, Static and Stagnation States, Relationship Between Stagnation Temperature, Pressure, Density and Enthalpy in Terms of Mach Number, Stagnation Velocity of Sound, Reference Speeds, Various Regions of Flow, Effect of Mach Number on Compressibility, Area Velocity Relationship.	**5**
UNIT-02	**One Dimensional Isentropic Flow**: General Features of Isentropic Flow, Performance Curve, Comparison of Adiabatic and Isentropic Process, One Dimensional Isentropic Flow in Ducts of Varying Cross-Section- Nozzles and Diffusers, Operation of Nozzles Under Varying Pressure Ratio, Mass Flow Rate in Nozzles, Critical Properties and Choking, Area Ratio as Function of Mach Number, Impulse Function, Non-Dimensional Mass Flow Rate in Terms of Pressure Ratio, Area Ratio and Mach Number, Working Charts and Gas Tables.	**8**
UNIT-03	**Normal Shock Waves:** Development of Shock Wave, Thickness of Shock Wave, Governing Equations, Strength of Shock Waves, Prandtl-Mayer Relation, Rankine-Hugoniot Relation, Mach Number in the Downstream of Normal Shock, Variation of Flow Parameters Across the Normal Shock, Normal Shock in Fanno and Rayleigh Flows.	**5**
UNIT-04	**Flow in Constant Area Duct with Heat Transfer (Rayleigh Flow):** Simple Heating Relation of a Perfect Gas, Rayleigh Curve and Rayleigh Flow Equations, Variations of Flow Properties, Maximum Heat Transfer, Tables and Charts for Rayleigh Flow.	**4**
UNIT-05	**Flow in Constant Area Duct with Friction (Fanno Flow):** Fanno Curve and Fanno Flow Equations, Solution of Fanno Flow Equations, Variation of Flow Properties, Variation of Mach No. with Duct Length, Isothermal Flow in Constant Area Duct with Friction, Tables and Charts for Fanno Flow.	**4**

Course Outcomes

Upon successful completion of the course, the students will

CO1: Understand and grasp of the basic principles of compressible flow have creative thinking and a deeper understanding and intuitive feel for compressible flows and compressible flow theory.

CO2: Have basic understanding of the underlying principles of the technology pertinent to the theory and design of devices with compressible flow.

CO3: The student will be aware of the basic principles and its application in aviation industry.

Books and References

1.Fundamental of Compressible flow by S. M. Yahya, New age international Publication, Delhi.
2. Fundamentals of compressible fluid dynamics by P. Balachandran, PHI Learning, New Delhi.
3. Gas Dynamics by E. Rathakrishnan, PHI Learning Pvt. Ltd.
4. Fundamentals of Gas Dynamics by V. Babu, Ane/Athena Books.

Course Name: **Total Quality Management**
Course Code: **ME-471**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To understand the concept of Quality in Manufacturing and Service units.
- To understand the Implication of Quality in Business.
- To have exposure to challenges in Quality Improvement Programs.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Evolution of Quality, Historical Perspectives, Relationship among Quality, Vision, Mission and Objectives of an Organization, Role of Quality in a Corporate Structure of an Organization, Attributes of Product and Service Quality, Quality Characteristics: Quality of Design, Quality of Performance and Quality of Conformance, Zero Defect and Continuous Improvement.	**5**
UNIT-02	**Conceptualization of TQM:** Introduction to Total Quality Management (TQM), Barriers to TQM, Benefits of TQM implementation, Basic Approaches of TQM, TQM Models, Quality Information System and Planning, Importance of TQM in Manufacturing and Service Industry.	**5**
UNIT-03	**Organization Structure in TQM:** Role of Top Management, Quality Council, Quality Circles, Organization Structure for Quality Circles, Quality Policies, Role of Middle and Lower Management, Problem Solving Techniques.	**4**
UNIT-04	**Tools and Systems for Quality Management:** Basic Tools: Cause & Effect Diagram, Flow Diagrams, Trend Charts, Histogram, Scatter Diagram, Control Chart, Advanced Tools: Affinity Diagram, Inter Relationship Diagram, Tree Diagram, Matrix Diagram, Process Decision Program Chart (PDPC) and Matrix Data Analysis, Fault Tree Analysis, Quality Function Deployment (QFD): Definition and Phases in QFD, Taguchi Approach To Quality System Design, Six-sigma: Definition & Implementation Steps, Just In Time Production System, Quality Production through JIT and Kanban, Failure Mode and Effect Analysis (FMEA): Scope, Mode, Illustrative Example and Applications.	**5**
UNIT-05	**Quality Assurance & Control:** Causes of Quality Failure, Quality Assurance: Need and Various Elements in Quality Assurance Programme, Quality Control-on-Line and off-Line, Statistical Concepts in Quality, Chance and Assignable Causes, Types and examples of Control Charts, Bench Making in Quality Management.	**3**

UNIT-06	**Implementation and need of ISO 9000:** ISO 9000–2000 Quality System: Elements, Registration, Documentation, Implemental Steps, Quality Audit, Product and Process Audit: Scope, Steps and Benefits.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the significance of quality in an organization.

CO2: Apply the tools of quality improvement programs in an organization.

CO3: Assess the benefits of implementing TQM Program in an organization.

Books and References

1. Total Quality Management by Dale H Besterfield, Pearson India.
2. Total Quality Management by N.V.R Naidu, G. Rajendra, New Age international Publication.
3. Total Quality management by L. Sugandhiand Samual Anand, PHI Publications.
4. Total Quality management by R.S Naagarazan, New Age international Publication.

Course Name: **Bearing and Lubrication**
Course Code: **ME-472**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart knowledge about the bearings and their selection.
- To introduce the concepts of lubrication.
- To enable the students to select the appropriate type of bearing for machine applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Types of Bearings, Bearing Concepts and Applications, Lubrication Types, Lubrication Regimes, Lubrication Fundamentals.	**3**
UNIT-02	**Fundamental Equations:** Continuity Momentum (N-S) Equations/ Reynolds Equation, Energy Equation, Solution Of N-S/Reynolds Equations, Mechanisms of Pressure Development in Fluid Film Bearings, Numerical Solution of Fluid Film Bearings Such as FDM.	**5**
UNIT-03	**Hydrodynamic Slider Bearings:** Infinite Width Slider Bearings, Rayleigh Step Bearing, Finite Slider Bearings, Analysis of Slider Bearings, Application of Slider Bearings in Machine Tools.	**5**
UNIT-04	**Hydrodynamic Journal Bearings:** Infinitely Long Journal Bearing, Finite Journal Bearing, Boundary Conditions, Analysis of Journal Bearings, Phenomenon of Cavitation, Types of Non-Circular Bearings and Its Analysis.	**5**
UNIT-05	**Electrohydrodynamic Lubrication:** Basic Concepts, Lubrication Between Two Contacting Bodies, Hertzian and Non-Hertzian Contact, Phenomenon of Starvation, Applications of Electrohydrodynamic Lubrication.	**4**
UNIT-06	**Lubricants:** Types of Lubricants, Selection of Lubricants, Properties and Tests on Lubricants, Analysis of Used Oils/Lubricants, Particle Counter, Spectroscopic Oil Analysis, Ferrography.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify the type of lubrication to be employed for a particular application.
CO2: Design the fluid film bearings and identify Bearing Materials.
CO3: Apply principles of design consideration for fluid film bearings.

Recommended Books

1. Fundamentals of Tribology, Basu, Sengupta, and Ahuja, 2005.
2. Principles and Application of Tribology, Bharat Bhushan, 2013.
3. Fundamentals of Fluid Film Lubrication, Hamrock, Schmid, and Jacobson, 2004.
4. Basic Lubrication Theory, A Cameron, 1982.

5. Theory of Lubrication by Ghosh, Majumdar, Sarangi, McGraw Hill Education,2014.

Course Name: **Propulsion Systems**
Course Code: **ME-473**
Course Type: **Stream Core-III**

Contact Hours/Week: 2**L** Course Credits: **02**

Course Objectives

- Analyze thermodynamics of an aircraft jet engine and calculate the performance measures, such as thrust and specific fuel consumption in terms of design requirement.
- To estimate the best possible engine performance as a function of principal design parameters, such as maximum engine temperature, pressure ratio, and flight speed.
- Analyze the internal mechanisms of gas turbine engine components and understand the factors that limit the practical performance of inlets, combustion chambers, and nozzles.
- Understand the operating characteristics of compressors and turbines in terms of given blade shapes, angles, and direction of rotation.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Review of Thermodynamic Principles, Principles of Aircraft Propulsion, Types of Power Plants, Working Principles of Internal Combustion Engine, Two–Stroke and Four–Stroke Piston Engines, Gas-Turbine Engines, Cycle Analysis of Reciprocating Engines and Jet Engines, Advantages and Disadvantages.	**5**
UNIT-02	**Propeller Theories & Jet propulsion:** Types of Propellers, Propeller Thrust: Momentum Theory, Blade Element Theories, Propeller Blade Design, Propeller Selection, Illustration of Working of Gas Turbine Engine–The Thrust Equation–Factors Affecting Thrust – Effect of Pressure, Velocity and Temperature Changes of Air Entering Compressor–Methods of Thrust Augmentation–Characteristics of Turboprop, Turbofan and Turbojet–Performance Characteristics.	**5**
UNIT-03	**Inlets & Nozzles:** Internal Flow and Stall in Subsonic Inlets, Boundary Layer Separation, Major Features of External Flow Near A Subsonic Inlet, Relation Between Minimum Area Ratio and Eternal Deceleration Ratio, Diffuser Performance, Supersonic Inlets, Starting Problem in Supersonic Inlets, External Deceleration, Modes of Inlet Operation, Theory of Flow in Isentropic Nozzles, Convergent Nozzles and Nozzle Choking, Nozzle Throat Conditions, Nozzle Efficiency, Losses in Nozzle, Over Expanded and Under-Expanded Nozzles, Ejector and Variable Area Nozzles, Thrust Reversal.	**5**
UNIT-04	**Gas Turbine Engine Compressors**: Principle of Operation of Centrifugal Compressors, Work Done and Pressure Rise -Velocity Diagrams, Diffuser Vane Design Considerations, Performance Characteristics, Concept of Pre-Whirl, Rotating Stall, Elementary Theory of Axial Flow Compressor, Velocity Triangles, Axial Compressor Performance Characteristics.	**5**
UNIT-05	**Combustion chambers and Turbines:** Classification of Combustion Chambers,	**5**

	Important Factors Affecting Combustion Chamber Design, Combustion Process, Combustion Chamber Performance, Effect of Operating Variables on Performance–Flame Tube Cooling–Flame Stabilization–Use Of Flame Holders, Turbine Stage, Multi-Staging of Turbine, Exit Flow Conditions, Turbine Cooling, Heat Transfer in Turbine Cooling, Thermodynamics of Radial Turbines, Losses and Efficiency.	

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Calculate the thrust and specific fuel consumption in terms of design requirement.

CO2: Describe the fundamentals of combustion chamber, nozzle, ramjet and rocket propulsion.

CO3: Understand the broader context of aircraft propulsion technology, including the environmental and economic issues.

Books and References

1. Fundamentals of Compressible Flow with Aircraft and Rocket propulsion by S. M. Yahya New Age International Publications.
2. Gas Turbine Theory by Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H Longman.
3. Elements of Gas Turbine Propulsion by J. D. Mattingly McGraw Hill Publications.
4. Aircraft Propulsion by V. Babu, CRC Press.

Semester VIII

Course Name: **Material Selection in Engineering Design**
Course Code: **ME-461**
Course Type: **Stream Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives:

- To classify materials based on their properties, structure, and applications.
- To provide with a comprehensive understanding of materials and their role in mechanical design
- To analyse case studies of successful and unsuccessful material selection in real-world applications.

Unit Number	Course Content	Contact Hours
UNIT 1	**Classification of Engineering Materials** Historical evolution of engineering materials - Classification of materials - Families of engineering materials and their properties, Iron based materials, Aluminium based materials, Super alloys, Composite materials, Plastics and elastomers, Glass and ceramics, Shape memory alloys, Bio-compatible materials - Material designation systems	**6**
UNIT 2	**Behaviour of Engineering Materials** Elastic Behaviour -Hooks Law, Anisotropic Behaviour, Viscoelastic Behaviour-Plastic Behaviour-Cyclic stress strain behaviour- Failure behaviour, Yielding theories for metals, Failure theories of composites, Basics of fracture mechanics, Creep, Fatigue, High temperature behaviour, Miscellaneous properties-Vibration damping behaviours, Wear resistance, Corrosion resistance, Bio-compatibility	**6**
UNIT 3	**Selection of Materials for Design** Introduction to Ashby charts- Selection of materials, Derivation of material index, Selection of material based on single objective, Selection of material based on multiple objectives, Material selection with multiple objectives and multiple constraints, Material shape efficiency factor, 4 quadrant methodology for the selection of materials.	**6**
UNIT 4	**Material Selection: Design Requirements** Identification of design requirements, Performance requirements, Reliability requirements, Size, shape, and mass requirements, Cost requirements, Manufacturing requirements, Industry standards, Government regulations, Intellectual property requirements, Sustainability requirements.	**7**
UNIT 5	**Case Studies in Materials Selection** Materials for airframes, Materials for ship structures, Materials for engines and power generation, Materials for automobile structures.	**5**

Course Outcomes:
Upon successful completion of the course, the students will be able to
CO1: Familiarise different classes of material and their potential applications.
CO2: Familiarise mechanical behaviour of different materials.
CO3: Select the materials considering the expected material behaviour.
CO4: Select suitable materials for an application based on the objective.

Recommended Books:
1. Materials Selection in Mechanical Design by Ashby M. F.
2. Materials: Engineering, Science, Processing and Design by Ashby M. F., Shercliff H. and Cebon D.
3. Selection and Use of Engineering materials by Charles J. A.
4. Material Science and Engineering by Calister W. D. and Balasubramanian R.

Course Name: **Mechatronics**
Course Code: **ME-462**
Course Type: **Stream Elective-I**

Contact Hours/Week: 3**L** Course Credits: **03**

Course Objectives

- Understand key elements of the Mechatronics system and representation in the block diagram.
- Understand principles of sensors and signal conditioning, its characteristics, interfacing with DAQ microcontroller.
- To impart the knowledge of mechanical, pneumatic, and hydraulic actuators.

Unit Number	Course Content	Contact Hours
UNIT-01	**Fundamentals of Mechatronics**: Definition, Systems, Measurement systems, Control systems, Programmable logic controller, Block Diagram of Mechatronic System, Functions of Mechatronic Systems, Comparison between Traditional and Mechatronics approach, Examples of Mechatronic Systems.	**4**
UNIT-02	**Sensors and Signal Conditioning**: Sensors and Transducers, Micro and Nano-sensors, Signal conditioning, Digital Signal and Digital logic, Data Conversion Devices, Signal Processing Devices, Data Acquisition and Data Presentation, PID Controller, Microprocessors and Microcontrollers and PLCs.	**6**
UNIT-03	**Actuation Systems:** Mechanical Actuation Systems: Cams, Gears, Bearings, Belt and Chain Drives, Ratchet and Pawl, Mechanical Aspect of Motor Selection; Pneumatic and Hydraulic Actuation System: Directional Control Valves, Pressure Control Valves, Servo and Proportional Control Valves, Rotary Actuators; Electrical Actuation Systems: Mechanical and Solid Switches, Solenoids, D.C. Motors, Stepper Motors, Servomotors, Motor Selection.	**8**
UNIT-04	**System Models**: Mathematical Models, Modeling of Mechanical systems, Fluid systems, Thermal systems and Electrical Systems, Dynamic Response of Systems, System Transfer Function.	**8**
UNIT-05	**Mechatronics-Products and systems in manufacturing:** Application of Mechatronic Systems Computer Numerical Control (CNC) Machines, Tool Monitoring Systems, Advanced Manufacturing Systems: Flexible Manufacturing System (FMS), Computer Integrated Manufacturing (CIM); Automatic Inspection Systems: Machine Vision Systems, Automatic Packaging Systems, Industrial Robotics, Automobile Control Systems, Introduction to Artificial Intelligence.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the concept of Mechatronics systems in automation of various products.

CO2: Select appropriate sensors and actuators and devise a system for collecting information about processes.
CO3: Demonstrate the concepts of actuating systems to be used in Mechatronic systems products.
CO4: Develop mathematical model of the real-world problem in different industrial environments.
CO5: Generate conceptual design for Mechatronic products based on potential customer requirements

Books and References

1. Mechatronics: Electronic control systems in Mechanical and Electrical Engineering by W. Bolton, Pearson.
2. Introduction to Mechatronics & Measurement Systems by D. G Alciatore and M. B Histand, McGraw-Hill.
3. Robotics: Control and Programming by J. Srinivas, R.V. Dukkipati and K. Ramji, Alpha Science International
4. Mechatronic Systems: Fundamentals, R. Iserman, Springer.
5. Fundamentals of Mechatronics, Musa Jouaneh, Cengage Learning.

Course Name: **Power Plant Engineering**
Course Code: **ME-463**
Course Type: **Stream Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce students to different aspects of power plant engineering.
- To familiarize the students to the working of power plants based on different fuels.
- To expose the students to the principles of safety and environmental issues.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Energy Resources and their Availability, Types of Power Plants, Selection of the Plants, Flow Sheet and Working of Modern-Thermal Power Plants, Site Selection, Plant Efficiency, Steam Generators and their Accessories: High Pressure Boilers, Design of Accessories, Steam Generator Control, Draught System.	**8**
UNIT-02	**Combined Cycle Power Plants:** Gas Turbine Power Plants, Arrangements of Combined Plants (Steam & Gas Turbine Power Plants), Parameters Affecting Thermodynamic Efficiency of Combined Cycles, Integrated Gasification Combined Cycle, PFBC Based Combined Cycle, Re-Powering of Thermal Power Plant.	**6**
UNIT-03	**Nuclear Power Plants:** Basics Of Nuclear Engineering, Layout and Subsystems of Nuclear Power Plants, Working of Nuclear Reactors: Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Deuterium- Uranium Reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety Measures for Nuclear Power Plants.	**6**
UNIT-04	**Power from Renewable Energy:** Hydro Electric Power Plants–Classification, Typical Layout and Associated Components Including Turbines. Principle, Construction and Working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geothermal, Biogas and Fuel Cell Power Systems.	**6**
UNIT-05	**Energy, Economic and Environmental Issues of Power Plants:** Power Tariff Types, Load Distribution Parameters, Load Curve, Comparison of Site Selection Criteria, Relative Merits & Demerits, Capital & Operating Cost of Different Power Plants. Pollution Control Technologies Including Waste Disposal Options for Coal and Nuclear Power Plant.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the principles of thermodynamics to analyse the performance of steam, gas, combined and nuclear power plants.

CO2: Design and develop power plant components for optimum performance.

CO3: Select appropriate site and technology for power plants.

CO4: Evaluate economic and environmental implications on power plants.

Books and References

1. Power Plant Engineering by P. K. Nag, McGraw Hill Education.
2. Power Plant engineering by P. C. Sharma, S.K. Kataria & Sons, New Delhi.
3. Power Plant Technology by M. M. El. Wakil, McGraw Hill Education.

Course Name: **Design of Electro-Mechanical Systems**
Course Code: **ME-481**
Course Type: **Stream Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives:
- To impart knowledge about the electro-mechanical systems (EMS)
- To introduce the fundamental concepts relevant to fabrications process of EMS
- To enable the students to understand use of sensors, actuators, and controllers

Unit Number	Course Content	Contact Hours
UNIT 1	**Introduction to Electro-Mechanical Systems (EMS)** Mechatronics Vs EMS, elements of EMS, Physical systems, and their mathematical models: Mathematical models of mechanical, electrical, hydraulic, and pneumatic elements and systems; Transfer function approach, block diagram reduction, state space representation.	**6**
UNIT 2	**Behaviour of Engineering Materials** Sensors and Actuators: selection of actuators and sensors, position, force/torque, temperature vision sensors and sensors for micro level applications; permanent magnet, stepper, servo and ac motors, mechanical actuators, electro-mechanical actuators, Actuators for micro level applications: piezoelectric, SMA and magnetostrictive actuators.	**8**
UNIT 3	**Drives and basic solid-state components and devices** Various components and elements of electromechanical energy conversion, starting, inversion and control of electrical drives, motor drivers (h-bridge and PWM control), basics of digital signal processing data acquisition, types and applications op-amp circuits and filters.	**8**
UNIT 4	**Introduction to Control of Electromechanical Systems and PID Control Laws** Elements of telemetry and remote control of mechatronic systems, design and implementation of control strategies for mechanical system; Design of proportional, integral, derivative and PID controllers and their applications.	**7**

Course Outcomes
Upon successful completion of the course, the students will be able to
CO1: Model physical systems mathematically using transfer function method, block diagram reduction technique and state space method.
CO2: Identify actuators & sensors for an EMS through case studies.
CO3: Select electrical drives and understand methodology for signal conditioning and data acquisition.
CO4: Design control strategies such as Proportional, Integral, Derivative and PID controllers for an EMS.

Recommended Books:
1. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering by W. Bolton
2. Mechatronics by D.S. Necsulescu

3. Modern Control Systems by R.C. Dorf and R.H. Bishop
4. Computer-Based Industrial Control by K. Kant
5. Digital Integrated Electronics by H. Taub and D. Schilling
6. Electromechanical Systems and Devices by S.E. Lyshevski
7. Mechatronics: An Integrated Approach by Clarence W. de Silva

Course Name: **Industrial Automation**

Course Code: **ME-482**

Course Type: **Stream Elective-II**

Contact Hours/Week: 3**L** Course Credits: **03**

Course Objectives:

- To understand the need and differentiate between different types of automation systems.
- To understand various components of state-of-the-art automation technologies encountered in modern manufacturing industries.
- To introduce the design and practical aspects of automatic control of machines, processes, and systems.

Unit Number	Course Content	Contact Hours
UNIT-01	I**ntroduction**: Introduction of Automation Technologies, Applications in Manufacturing, Types of Automation Systems – Hydraulic, Pneumatic, Electrical, Electronic with Comparison. Role Of Energies in Automation-Fluid Power and Electrical. Different Types of Sensors, Actuators, And Controllers.	**7**
UNIT-02	**Pneumatic systems and circuits**: Introduction to Pneumatic Systems and their Components, Various Types of Valves, and their Applications, Pneumatic Circuit Design Approach and Examples, Pneumatic Circuit Sequencing, Limit Switches, Limitations of Pneumatic Systems.	**8**
UNIT-03	**Electro-pneumatic Systems and Circuits:** Basics of Electro-Pneumatic Systems, Electro-Pneumatic and Electrohydraulic Systems and Their Components, Circuit Design, Relay Control, Sequence Control Application with Example, Terminal Allocation.	**8**
UNIT-04	**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.	**10**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend and differentiate between various types of automation systems.

CO2: Analyse and solve an engineering problem using proper automation technology applicable.

CO3: Evaluate, i.e. test, detect, and monitor the working of different automation systems used in the industry.

CO4: Apply gathered knowledge to synthesize i.e. design and formulate an industrial automation system.

Reference Books

1. Introduction to Industrial Automation by Stamatios Manesis and George Nikolakopoulos, CRC press.
2. Industrial Automation: Hands-On by Frank Lamb, McGraw Hill publisher.
3. Fluid power with applications by Anthony Esposito, Pearson Education, 4th Edition.
4. Mechatronics. W. Bolton, Pearson publishers, 4th Edition.

Course Name: **Energy Conservation and Management**
Course Code: **ME-483**
Course Type: **Stream Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- It provides detailed understanding of energy conservation & management basically 3Es (Energy, Economics and Environment).
- It provides the concept of energy interaction, energy audit and financial management.

Unit Number	Course Content	Contact Hours
UNIT-01	**Energy Scenario:** Classification of Energy & Indian Power Scenario, Sectorial Energy Consumption (Domestic, Industrial, and Other Sectors) and Environmental Aspects Associated with Energy Utilization, Energy Conservation Act 2001, and Its Features, Notifications Under the Act, Schemes of Bureau of Energy Efficiency (BEE) Including Designated Consumers, Energy Needs of Growing Economy, Energy Conservation and Its Importance, Energy Strategy for the Future.	**8**
UNIT-02	**Energy Conservation in Industries:** Cogeneration, Combined Heating and Power Systems, Relevant International Standards, and Laws.	**5**
UNIT-03	**Energy Conservation Management:** General Principles of Energy Management and Planning, Application of Pareto's Model for Energy Management, Establishing Energy Data Base.	**5**
UNIT-04	**Financial Management:** Energy Economics- Payback Period, Discount Period, Net Present Value, Internal Rate of Return, Life Cycle Costing- ESCO Concept.	**5**
UNIT-05	**Energy Auditing:** Conducting Energy Audit; Identifying, Evaluating, and Implementing Feasible Energy Conservation Opportunities; Energy Audit Report, Energy Management Information Systems (EMIS)	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: To understand the basic knowledge of energy scenario, audit, and management.
CO2: To Evaluate the energy saving & conservation in different mechanical utilities.
CO3: To understand efficient energy utilization, saving and recovery in Industries.

Books and References

1. Energy Conservation Guidebook by Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press.
2. Energy Management Handbook by W.C. Turner, John Wiley and Sons, A Wiley Inderscience publication.
3. Handbook of Energy Audits by Albert Thumann, 6th Edition, The Fairmont Press.
4. Design and Management for Energy Conservation by P. W. Callaghan, Pergamum Press, Oxford.