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)

Second Year													
3rd Semester							4th Semester						
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	HS-203	Organization Behavior	3	0	0	3	1	MA-203	Engineering Mathematics-III	3	1	0	4
2	ME-211	Kinematics of Machines	3	1	0	4	2	ME-221	Dynamics of Machines	3	1	0	4
3	ME-212	Engineering Thermodynamics	3	1	0	4	3	ME-222	Heat and Mass Transfer	3	1	0	4
4	ME-213	Fluid Mechanics and Machinery	3	1	0	4	4	ME-223	Mechanics of Solids	3	1	0	4
5	ME-214	Metrology and Measurement	3	1	0	4	5	ME-224	Industrial Engineering	3	0	0	3
6	ME-215	Fluid Mechanics and Machinery Lab	0	0	2	1	6	ME-225	Material Testing Lab	0	0	2	1
7	ME-216	Metrology and Measurement Lab	0	0	2	1	7	ME-226	Heat and Mass Transfer Lab	0	0	2	1
8	ME-217	Machine Drawing Lab	0	0	2	1	8	ME-227	Kinematics and Dynamics of Machinery Lab	0	0	2	1
		Total Hours = 25				22			Total Hours = 25				22

Third Year													
5th Semester							6th Semester						
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	ME-311	Machine Design-I	3	1	0	4	1	ME-321	Machine Design-II	3	1	0	4
2	ME-312	Manufacturing Science and Technology-I	3	1	0	4	2	ME-322	Manufacturing Science and Technology-II	3	1	0	4
3	ME-313	Thermal Power Engineering-I	3	1	0	4	3	ME-323	Thermal Power Engineering-II	3	1	0	4
4	ME-314	Refrigeration and Air Conditioning	3	0	0	3	4	ME-324	Automobile Engineering	3	0	0	3
5	OET	Open Elective-I	3	0	0	3	5	OET	Open Elective-II	3	0	0	3
6	ME-315	Manufacturing Technology Lab-I	0	0	2	1	6	ME-325	Manufacturing Technology Lab-II	0	0	2	1
7	ME-316	Thermal Engineering Lab-I	0	0	2	1	7	ME-326	Thermal Engineering Lab-II / Automobile Engineering Lab	0	0	2	1
8	ME-317	Refrigeration and Air Conditioning Lab	0	0	2	1	8	ME-329	Seminar	0	0	2	1
		Total Hours = 24				21			Total Hours = 24				21

Fourth Year												
7th Semester							8th Semester					
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	ME-411	Operations Research	3	0	0	3	1	HS-404	Engineering Economics & Accountancy	3	0	0	3
2	ME-412	Computer Aided Design	2	0	2	3	2	ME-421	Computer Aided Manufacturing	2	0	2	3
3	DET	Professional Elective-I	3	0	0	3	3	DET	Professional Elective-III	3	0	0	3
4	DET	Professional Elective-II	3	0	0	3	4	DET	Professional Elective-IV	3	0	0	3
5	ME-418	Industrial Training Presentation	0	0	2	1	5	ME-428	General Proficiency	0	0	0	1
6	ME-419	Major Project (Stage-I)	0	0	12	6	6	ME-429	Major Project (Stage-II)	0	0	12	6
		Total Hours = 27				**19**			**Total Hours= 25**				**19**

Semester Wise Credits									
Semester	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Total**
Credits	24	24	22	22	21	21	19	19	**172**
Hours/week	28	28	25	25	24	24	27	25	**206**

Professional Elective Courses

Professional Elective-I

ME-430	Finite Elements in Engineering
ME-431	Optimization Methods in Engineering
ME-432	Artificial Intelligence in Engineering
ME-433	Design and Analysis of Experiments

Professional Elective-II

ME-450	Advanced Mechanics of Solids
ME-451	Product Design and Development
ME-452	Industrial and Engine Tribology
ME-453	Condition Monitoring and Diagnostics
ME-454	Mechanics of Composite Materials
ME-455	Mechatronics and Robotics

Professional Elective-III

ME-440	Computer Integrated Manufacturing Systems
ME-441	Maintenance Engineering
ME-442	Supply Chain Management
ME-443	Total Quality Management
ME-444	Manufacturing of Non-Metallic Products
ME-445	Additive Manufacturing Technology

Professional Elective-IV

ME-460	Alternative Fuels Technology
ME-461	Renewable Sources of Energy
ME-462	Exergy Analysis of Thermal Systems
ME-463	Computational Fluid Dynamics
ME-464	Design of Heat Exchangers
ME-465	Design of Air Conditioners

Open Elective Courses

Open Elective-I

ME-370	Computer Aided Design
ME-371	Product Design and Development

Open Elective-II

ME-380	Mechatronics and Robotics
ME-381	Total Quality Management

Course Name: **Organizational Behaviour**
Course Code: **HS-203**
Course Type: **Core**

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

Course Objectives

- To impart knowledge about the behavioural aspects related to professional organizations
- To introduce the fundamental concepts relevant to understanding of individual & group behavior in the organization
- To enable the students to understand the applied organizational themes like perception, motivation, interpersonal relationships, group dhynamics, leadership theories, role of power & politices in organizational context, conflict and negotiation, organizational diversity, dynamics of personality, attitude and job satisfaction, etc.

Unit Number	Course Content	Lectures
UNIT-01	**Organizational Behavior (OB):** Concept, nature, characteristics, conceptual foundations, determinants and importance, management functions, role & skills, disciplines that contribute to the field of OB, Challenges & Opportunities for OB, diversity in Organizations, attitudes & Job satisfaction.	**04L**
UNIT-02	**Perception**: Concept, nature, process, importance, management and behavioral applications of perception. Personality: concept, nature, types and theories of personality shaping. Learning; concept and theories of learning.	**08L**
UNIT-03	**Motivation:** concept, principles, theories-content, process & contemporary, Monetary and non-monetary motivation, applications of motivation. Leadership: Concept, functions, styles, and theories of leadership- trait, behavioural, and situational.	**06L**
UNIT-04	**Group and Interpersonal Relationship:** Analysis of Interpersonal Relationship, developing interpersonal relationship, Group Dynamic: Definition of Group, stages of Group Development, Punctuated Equilibrium Model, Group Structure, Group Decision Making, understanding work teams.	**05L**
UNIT-05	**Organizational Power and Politics:** concept of power, structure of power, classification of power, contrasting leadership & power, dependence a key to power, causes & consequences of political behaviour. Organizational conflict: view of conflict, conflict process, negotiation & bargaining strategies.	**06L**
UNIT-06	**Conflict and Negotiation:** conflict definition in conflict thought: Traditional view, the Human relation view, interactionist view. Functional versus dysfunctional conflict, conflict process. Negotiation Bargaining strategies, the negotiation process and issues in negotiation.	**07L**

Course Outcomes

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

CO1: Identify the challenges of the present organization

CO2: Describe the organizational system

CO3: Apply the principles of organizational behavior to inculcate the habit of team work and which is essential for the organization

CO4: Assess the role of psychological and social principal in improvement of efficiency as well as quality of empoyee life

Books and References

1. Organizational Behavior by Robbins, S.P., Prentice Hall of India.
2. Organizational Behavior by Luthans F., McGraw-Hill.
3. Human Behavior at Work: Organizational Behavior by Davis K., Tata McGraw-Hill.

Course Name: **Kinematics of Machines**
Course Code: **ME-211**
Course Type: **Core**

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

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	Lectures
UNIT-01	**Kinematic Analysis of Mechanisms** Kinematic Links , Kinematic Pairs , Constrained Motions, Degreeof Freedom Classification Of Kinematic Pairs , Kinematic Chain , Mechanism , Planar Mechanism , Grubler's Criteria For Plane Mechanisms, Inversion Of Mechanism , Position Analysis , Spatial Mechanism .	**06L**
UNIT-02	**Velocity And Acceleration In Mechanism** Relative Velocity Method, Kennedy's Theorem For Three Centers, Instantaneous Centre Method, Acceleration Diagram, Coriolis Component Of Acceleration, Klein's Construction, Computer aided analysis of mechanisms.	**09L**
UNIT-03	**Friction Devices(Clutch , Belt, Rope , Chain ,Brakes And Dynamometer)** Friction And Its Types (Pivot And Collar Friction, Uniform Wear And Uniform Pressure), Laws Of Friction, Introduction To Clutches, Belt Drives, Rope Drives, Chain Drives, Brakes And Dynamometer.	**06L**
UNIT-04	**Cams and Followers** Classification Of Cams And Followers, Nomenclature, Types Of Follower Motion, Generation Of Cam Profile With Uniform Velocity, SHM, Uniform Acceleration And Retardation, Cycloidal Motion Of The Follower, Cam Applications And Manufacturing.	**06L**
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, Overdrive. **Automotive Transmission** Introduction To Continuously Variable Transmission (CVT), Types Of CVT's.	**09L**

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 accelaration diagrams for diffferent mechanisms.
CO3: Understand the underlying theory and principles for various friction devices and their aplications.
CO4: Understand Cam profile generation and their applications
CO5: Learn the concept of gear and gear train and various automotive transmissions,

Books and References

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: **Engineering Thermodynamics**
Course Code: **ME-212**
Course Type: **Core**

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

Course Objectives

- To impart knowledge of basic concepts of thermodynamics and its laws and their applications for non-flow and flow processes.
- To introduce the concepts of steam table, Mollier diagrams to determine properties of pure substances and mixture of gases.
- To analyse working of different types of cycles and their performance

Unit Number	Course Content	Lectures
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.	**06L**
UNIT-02	**Pure Substances**: P-V-T- surfaces, Phase Transformations, Triple Point and Critical Point of Pure Substances, State Properties during Change of Phase, Dryness Fraction. Property Diagrams, Steam and Refrigerant 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.	**09L**
UNIT-03	**First and Second Law of Thermodynamics:** First Law of Thermodynamics for Flow and non-flow processes, Steady 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 of Second kind, Reversibility, Carnot Cycle, Thermodynamic temperature scale, Clausius Inequality, Entropy, Principle of Entropy Increase, Exergy analysis, Introduction to Third Law of Thermodynamics.	**12L**
UNIT-04	**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, Gibbs and Helmholtz Functions, Maxwell Relations, Clapeyron Equation	**06L**
UNIT-05	**Power Cycles:** Rankine Cycle, Otto, Diesel, Dual cycles, Thermal Efficiency, Mean Effective Pressures of Air Standard basis, Comparison of Cycles.	**03L**

Course Outcomes

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

CO1: Analyse 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
CO5: Determine the available energy and its loss during a process

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. An introduction to Thermodynamics by Y. V. C. Rao, Universities Press, Hyderabad.

Course Name: **Fluid Mechanics & Machinery**
Course Code: **ME-213**
Course Type: **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 impart method of determination of major and minor losses in pipes
- To enable understanding of performance of Hydraulic machines

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Fluid Mechanics**: Types of fluids, Continuum, Physical Properties of Fluids, Newton's Law of Viscosity, Rheology of fluids. Pressure variation in fluids, Manometers, Pressure Transducers, Forces on Plane and Curved Surfaces, Center of Pressure, Stability of floating objects, Fluid masses Subjected to Linear Acceleration and Uniform Rotation About an Axis.	**06L**
UNIT-02	**Fluid Kinematics and Dynamics:** Stream line, Path line, Streak line and Stream tube, Classification of Flows, Differential Equation, Velocity and Acceleration field, Derivation of Navier-Stokes equation and its application to simple flow cases. Euler's Equation of Motion along a Streamline and its integration, Bernoulli's Equation and its Applications, Flow measurement using Pitot tube, Orifice, Venturimeter, Rotameter, Notches and Weirs, Integral Momentum Equation and its Application to Pipe Bends etc. Dimensional Analysis, Buckingham's Pi Theorem, Dimensionless Numbers and their Physical Significance, Geometric, Kinematic and Dynamic Similarity, Similitude	**09L**
UNIT-03	**Laminar and Turbulent Flows:** Equation of Motion for Laminar Flow through Pipes, Hagen Poiseuille Flow, Stokes Law, Transition from Laminar to Turbulent Flow, Types of Turbulent Flow, Scale and Intensity of Turbulence, Eddy Viscosity, Prandtl's Mixing Length Theory, Velocity Distribution in Turbulent Flow, Major and Minor Losses, Moody's Diagram, Pipe in Series and Parallel, Pipe Network. Concept of boundary layer, Equations and Approximate Integral Analysis	**06L**
UNIT-04	**Hydraulic Machines:** Hydrodynamic Force of Jets on Stationary and Moving Flat, Inclined Vanes, Curved Vanes, Velocity Diagrams, Energy transfer, Degree of Reaction, Work Done and Efficiency, Classification of Turbines and Pumps, Similarity Laws and Specific Speed, Cavitation, Heads and Efficiencies, Impulse and Reaction Turbines, Pelton Wheel, Francis Turbine and Kaplan Turbine, Work done, Performance Characteristic Curves, Draft Tube Theory. **Centrifugal Machines:** Classification, Head Losses and Efficiencies, Specific Speed, Slip, Performance Characteristic Curves, NPSH. **Reciprocating Pumps:** Working, Discharge, Indicator Diagrams.	**15L**

Course Outcomes

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

CO1: Analyse forces on partially or fully submerged bodies
CO2: Analyse laminar and turbulent flow
CO3: Understand the Boundary Layer concepts and Flow through pipes
CO4: Evaluate performance and draw characteristic curves of hydraulic machines

Books and References

1. Fluid mechanics by Yunus A. Cengel and John M. Cimbala, McGraw Hill.
2. Fluid Mechanics and by F. M. White, McGraw Hill.
3. Fluid Mechanics and Fluid Power Engineering by D.S. Kumar, Kotaria & Sons.
4. A Text Book of Fluid Mechanics and Hydraulic Machines by K. Subramanya, McGraw Hill.

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

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

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 metrology and measurement.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Concept and Need of Measurements, Generalized measuring systems and instruments, Classification of methods of measurement, Standards, Units, Precision and Accuracy, Repeatability and Reproducibility, Sensitivity, and Readability, Sources of error in measurement, Statistical analysis of Error, Correction, Calibration and Interchangeability.	**06L**
UNIT-02	**Linear and Angular Measurement:** Standards of Linear Measurement, Line and End Standards, ***Linear Measuring Instruments****:* Vernier Caliper and Micrometers, Vernier Height Gauge and Depth Gauge, Interval Measurement: Slip Gauges, Optical Flats **Comparators:** Mechanical, Electrical, Optical, and Pneumatics, ***Angle Measuring Instruments****:* Sine Bar, Bevel Protractor, Clinometer, Autocollimator, Functions of Coordinate Measuring Machine.	**03L**
UNIT-03	**Measurements of Geometric Forms and Finish:** Form Measurement**:** Measurements of Straightness, Squareness, Flatness, Circularity and Cylindricity, Optical Projectors, Tool Maker's Microscope, Optical Measuring Microscope, Finish Measurement**:** Quantitative Evaluation of Surface Roughness, Methods of Measuring Surface Finish by Contact and Non-Contact Methods	**06L**
UNIT-04	**Measurement of Threads and Gears:** Threads Measurement: Standard Threads Profiles and Measurement of Minor Diameter, Major Diameter, Effective Diameter, Pitch, Angle and Form for Internal and External Threats, Threads Gauges, Gear Measurement: Standard Gear Profiles and Measurement of Tooth Thickness and Pitch, Checking Profile of Spur Gear, Parkinson Gear Tester, Problems on Gear Measurement	**03L**
UNIT-05	**Systems of Limits and Fits:** Concept of Tolerances, Limits and Fits, Allowances, Tolerance Analysis, Limits Gauges and Gauges Design.	**06L**
UNIT-06	**Measurement of Displacement, Speed, Force, And Torque:**Tachometers and Stroboscope, Accelerometer, Proving Ring, Load Cells: Hydraulic and Pneumatic, Torque Measurement on Rotating Shafts Dynamometers: Absorption, Transmission and Driving	**06L**
UNIT-07	**Measurement of Pressure, Flow, Temperature and Strain:** Bourdon Tube, Diaphragm and Bellows, Vacuum Measurement: Mcleodguage, Thermal Conductivity Gauge and Ionization Gauge, Dead Weight Gauge Tester, Electromagnetic Flux Meters, Ultra-Sonic Flow Meters and Hot Wire Anemometer, Flow Visualization Techniques, Temperature Measurement by Thermometers, Bimetallic, Thermocouples, Thermistors and Pyrometers, Measurement of Flow, Strain Measurement.	**06L**

Course Outcomes

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

CO1: Understand the role of different measurements techniques

CO2: To analyze and measure different physical parameters using modern measurement methods

Books and References

1. Engineering Metrology and Measurements by N.V. Raghavendra and L.Krishnamurthy, Oxford University Press.
2. Engineering Metrology by R.K. Jain, Khanna Publisher.
3. Mechanical Measurements by Backwith, Marangoni and Lienhard Pearson Education.
4. A text book of Measurement and Metrology by A.K. Sawhney, and M. Mahajan Dhanpat Rai & Co.

Course Name: **Fluid Mechanics & Machinery Lab**
Course Code: **ME-215**
Course Type: **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 pipe lines.
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: Able to explain the effect of fluid properties on a flow system.
CO2: Able to identify type of fluid flow patterns and describe continuity equation.
CO3: To analyze a variety of practical fluid flow and measuring devices.
CO4: To select and analyze an appropriate turbine with reference to given situation in power plants.
CO5: To estimate performance parameters of a given Centrifugal and Reciprocating pump.

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 the 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-nogo gauge, plug gauge, go-nogo snap gauge bourdon tube pressure gauge),
2. Calibrations of linear measuring instruments by using slip gauges and calculation of percentage error.
3. Measurement of 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 measuring parameters with precision
CO4: Develop basic concept of the various comparators and interference

Course Name:	**Machine Drawing Lab**
Course Code:	**ME-217**
Course Type:	**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 Foot Step 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 sheet related to Assembly of Crane Hook.
12. Preparation of drawing sheet related to Assembly of Lathe Tailstock.

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

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

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	Lectures
UNIT-01	**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 L**
UNIT-02	**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.	**06L**
UNIT-03	**Numerical Integration** 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.	**05L**
UNIT-04	**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.	**07L**
UNIT-05	**Numerical Solution of Linear and Non Linear Equations** Non Linear Equations: Bisection Method, Regula Falsi Method, Newton-Raphson Method, Iteration method. Linear Equations: Jacobi and Gauss Seidel Iteration methods, Relaxation method.	**06 L**
		36 L

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.

Books and References

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: **Dynamics of Machines**
Course Code: **ME-221**
Course Type: **Core**

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

Course Objectives

- To introducethe fundamentals of force analysis in mechanisms
- To impart knowledge on balancing of machines
- To enablethe students to understand the need of flywheels and governors
- To acquaint the students with the role of frictional devices in various applications
- To make the students conversant with fundamentals of vibration and noise

Unit Number	Course Content	Lectures
UNIT-01	**Dynamic Analysis of Mechanisms:** Force Analysis of Mechanisms, D-Alembert'sPrinciple, Dynamics of Rigid Link in Plane Motion, Dynamic Force Analysis of Planar Mechanisms, Velocity and Acceleration Analysis of Plane Mechanisms, Turning Moment diagram forEngine and Speed Fluctuation, Flywheel.	**06L**
UNIT-02	**Balancing of Bodies:** Balancing of Rotating Masses in One Plane and in Different Parallel Planes, Graphical and Analytical Methods, Balancing of Rotors, Balancing of Reciprocating Masses, Balancingof Single Cylinder Engine, Balancing of Multi Cylinder Inline Engines, Balancing of V-Engine, and Radial Engines, Firing Order.	**09L**
UNIT-03	**Flywheel and Governors:** Introduction to Turning Moment Diagrams, Flywheel, Coefficient of Fluctuation, Energy stored in Flywheel, Different Types of Governors,characteristics, Gravity Controlled and Spring Controlled Governors, Hunting of Governors, Controlling Force Curves, Sensitivity, Stability, Coefficient of Insensitiveness	**09L**
UNIT-04	**Gyroscopic Motion:** Gyroscopes, Angular Velocity, Acceleration and Torque on Disc, Gyroscopic Forces and Couples, Gyroscopic Stabilization of Ship, Plane Stabilization, Stability of Four Wheel and Two Wheel Vehicles Moving on Curved Path	**06L**
UNIT-05	**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,Basics of Vibrations in Two Degrees of Freedom System, Forced Vibrations with Harmonic Excitation, Resonance, Whirling of Shafts and Critical Speed. Vibration Measuring Instruments, Effects and Remedies of Vibration.	**06L**

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.
CO4: Understand the challenges posed by vibration.

Books and References

1. The 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: **Heat and Mass Transfer**
Course Code: **ME-222**
Course Type: **Core**

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

Course Objectives

- To introducethe fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.
- To introducethe thermal analysis and sizing of heat exchangers.
- To enable the basic concepts of mass transfer.

Unit Number	Course Content	Lectures
UNIT-01	**Conduction Heat Transfer:** One- Dimensional Steady State Heat Conduction Equation for Slab, Cylinder, Sphere and Composite Medium (With and Without Heat Generation), Critical Thickness of Insulation, Extended Surface Heat Transfer, 2-D Steady State Conduction, Fourier General Conduction Equation in 3-D, Unsteady Heat Conduction, Semi-infinite Wall with Convection Boundary Condition, Use of Heisler Charts.	**09L**
UNIT-02	**Convection Heat Transfer:** Application of Dimensional Analysis to Free and Forced Convection, Concept of Hydrodynamic and Thermal Boundary Layer, Similarity Conditions of Heat Transfer Processes, Equations of Motion and Energy, Laminar Boundary Analysis on Flat Plate, Fully Developed Heat Transfer Through Smooth Pipes, Laminar Free Convection on a Vertical Flat Plate, Empirical Correlations, Reynold`sAnalogy, Heat Transfer in Boiling and Condensation.	**09L**
UNIT-03	**Radiation Heat Transfer:** Nature of Thermal Radiation, RadiativeProperties, Stefan Boltzmann's Law, Kirchhoff's Law, Wien's Law, Plank's Law etc. Black, Grey and Real Surfaces, Radiation Heat Transfer Between Black/Grey Surfaces, Network Method of Solving Radiation Problems, Concept of View Factor and Shape Factor, Heat Transfer in the Presence of Reradiating Surface.	**09L**
UNIT-04	**Heat Exchangers:** Basic Types of Heat Exchanger, Fouling Factor, Overall Heat Transfer Co-efficient, LMTD, Effectiveness, NTU, Method of Design of Single and Multiple Pass Heat Exchangers.	**06L**
UNIT-05	**Mass Transfer:** Introduction to Mass Transfer Operations, Molecular Diffusion in Gases, Liquids and Solids, Eddy Diffusion, Concept of Mass Transfer Coefficients, Theories of Mass Transfer, Different Transport Analogies, Application of Correlations for Mass Transfer Coefficients, Inter Phase Mass Transfer, Relationship between Individual and Overall Mass Transfer Coefficients.	**03L**

Course Outcomes

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

CO1: Understand and solve conduction, convection and radiation problems.Formulate and solve complex AC and DC circuits

CO2: Design and analyze the performance of heat exchangers.

CO3: Relate the skill of mass transfer and its applications.

Books and References

1. Heat Transfer by J.P. Holman, Tata McGraw-Hill.
2. Fundamentals of Heat and Mass Transfer by F.P. Incropera, and D.P. Dewitt, John Wiley.
3. Heat Transfer - A Basic Approach by M.N. Ozisik, McGraw-Hill.
4. Heat Transfer - A Practical Approach by Y.A. Cengel, McGraw-Hill.

Course Name: **Mechanics of Solids**
Course Code: **ME-223**
Course Type: **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 cloumns,struts and pressure vessels.

Unit Number	Course Content	Lectures
Unit-01	**Analysis of Stress and Strain** State of Stress, Equality of Cross Shear, Stress Invariants, Principal Planes, Cauchy's Stress Quadric, Introduction to Strain and Rectangular Strain Components, State of Strain at Point, Cubical Dilatation, Compatibility Conditions, Relationship between Elastic Constants, Thermal Stress & Strain, Stress due to Uniaxial and Biaxial Loads, Stress Induced by State of Pure Shear, Mohr's Circle and its Construction.	**06L**
Unit-02	**Shear Force and Bending Moment Diagrams** Introduction, Types of Load, Concentrated, Uniformly Distributed, Uniformly Varying Load and Combination of Loads,Types of Beams, Cantilever Beam, Simply Supported Beam, Overhanging Beam, Shear Force and Bending Moment Diagrams for Combination of loads, Point of Inflexion.	**06L**
Unit-03	**Slope and Deflection of Beams** Review of Bending Theory, 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.	**09L**
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.	**06L**
Unit-05	**Theory of Thin and Thick Pressure Vessels** Thin cylinders subjected to Internal Pressures, Hoops Stress, Longitudinal Stress in a Cylinder, Stresses in Thick Shells, Longitudinal and Shear Stresses, Distribution of Stresses Across the Shell Thickness, Cylindrical Shell Subject to Both Internal and External Fluid Pressure, Compound Cylinders.	**06L**
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. Utility of factor of safety in design.	**03L**

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.

Books and References

1. Strength of Materials by Timoshenko, Mcgraw 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.

Course Name: **Industrial Engineering**
Course Code: **ME-224**
Course Type: **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 impartan 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	Lectures
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.	**03L**
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.	**06L**
UNIT 3	**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.	**06L**
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.	**06L**
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 in product design; product cost considerations, Design for manufacturing (DFM), Concurrent Engineering, Concept of Break-Even analysis, Calculations of Break-Even Points, Advantages, and Application of Break-Even analysis	**06L**
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.	**06L**
UNIT07	**Latest Tools of Industrial Engineering :** Material requirement planning, Enterprise resource planning, JIT Production System; TQM, Bench marking; ISO standards ; Supply chain Management, Business Process Reengineering, Industry 4.0	**03L**

Course Outcomes

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

CO1: Ability to design, develop, implement and improve integrated systems that include people, materials, information, equipment, and people

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

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

Books and References:

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: **Material Testing Lab**
Course Code: **ME-225**
Course Type: **Core**

Contact Hours/ Week: **2P** 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 Searl'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. To conduct torsion test of a given specimen for determination of Modulus of Rigidity using Torsion Testing Machine.
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: **Heat and Mass Transfer Lab**

Course Code: **ME-226**

Course Type: **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: Analyze heat exchanger performance by using the method of heat exchanger effectiveness.

Course Name:	**Kinematics and Dynamics of Machines Lab**
Course Code:	**ME-227**
Course Type:	**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. 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 determine the unbalanced couple and forces for rotating parts.
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: **Machine Design - I**
Course Code: **ME-311**
Course Type: **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	Lectures
UNIT-01	**Introduction:** Engineering Design, Phases of Design, Design Considerations, Theories of Failure, Factor of Safety, Design against Static Load, Design against dynamic load, Design for X: Manufacturing and Assembly,Quality and Reliability, Aesthetic and Ergonomics.	**09L**
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, Principal Stress and Maximum Stress, Equivalent Bending Moment and Twisting Moment, Design of Muff Coupling, Rigid Flange Coupling, Bushed Pin Flexible Coupling.	**06L**
UNIT-03	**Design of Joints** Pins, Keys, Splines, Knuckle Joint, Cotter Joint, Design of Threaded Joints, Initial Tension, Riveted Joints, Joints for Pressure Vessels, Welded Joints: Types.	**09L**
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.	**06L**
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.	**06L**

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.

Books and References

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: **Manufacturing Science and Technology-I**
Course Code: **ME-312**
Course Type: **Core**

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

Course Objectives:

- To impart knowledge about the different processes, materials and systems in manufacturing.
- To introduce the fundamental concepts of metal casting, powder metallurgy, metal forming and atomic joining.
- To enable the students to understand about the different types of defects in casting, rolling, forging, drawing extrusion and welding.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Concept of Manufacturing- Processes in Manufacturing, Materials in Manufacturing, Systems in Manufacturing.	**03L**
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, Expendable Precision Sand Mould Castings: Shell Mould, Vacuum Mould and CO_2 Mould, Investment Casting and Evaporative Casting, Expendable Plaster Mould and Ceramic Mould Casting, Permanent Metal Mould Casting: Gravity and Pressure Die Casting, Vacuum and Slush Casting, Special Metal Casting Processes: Centrifugal, Continuous, Squeeze and Chilled Casting, Casting Defects and Inspection of Casting.	**09L**
UNIT-03	**Powder Metallurgy Processes:** Production of Metal Powders, Blending and/or Mixing, Compacting and Sintering, Hot Isostatic Pressing (HIP), Powder Injection Moulding (PIM), and Electro-Spark Pressing (ESP).	**03L**
UNIT-04	**Metal Forming Processes:** *Bulk Metal Forming Processes:* Need and Classification, Yielding and Flowing of Metal, Temperature, Friction and Lubrication, 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 Processes:* Need and classification, Blank Preparation by Sheet Metal Cutting, Press Forming: Bending and Drawing- Process Geometry and Calculation for Force and Power, Impulse Forming: Explosive forming, Electro-hydraulic forming and Electro-magnetic forming, Laser forming.	**15L**
UNIT-05	**Atomic Joinig Processes:** Need and Classifications, Solid Welding: Diffusion, Friction, Forge and Roll Welding, Explosive and Ultrasonic Welding, Resistance Welding: Spot, Projection and Seam, Resistant Butt and Flash Butt, High Frequency Resistance and High Frequency Induction, Arc Welding: Non-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: Heavy Engineering, Oil and Gas Industries, Nuclear Power, Automotive Industries, Ship Building and Aerospace Industries, Brazing and Soldering Processes.	**06L**

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, 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.

Books and References

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. Principles of Metal Casting by Richard W. Heine, Tata Mc Graw Hill.
4. Fundamentals of Metal Forming Processes by Juneja, New Age International.
5. Welding Processes and Technology by R.S. Parmar, Khanna Publishers.

Course Name: **Thermal Power Engineering-I**
Course Code: **ME-313**
Course Type: **Core**

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

Course Objectives

- To understand working principles of Steam Turbine.
- To introduce principles of the conversion of fossil fuel energy to useful power.
- To understand various theoretical concepts related to compressible flow.

Unit Number	Course Content	Lectures
UNIT-01	**Vapour Power Cycles** Review of Vapour Power Cycles, Rankine Cycle with Reheat,Regeneration, Bleeding of Steam, Binary Vapour Cycles, Deviation of Actual Cycles from Ideal Cycles, Internal and Stage Efficiencies, Reheat factor, Combined Power and Heating cycle Cogeneration.	**06L**
UNIT-02	**Steam Generators and Condensers** Classifications, Water tubes and Fire tube Boilers, High Pressure Boilers, Fluidized Bed Boiler, Mounting and Accessories, Natural and Forced Circulation, Boiler Draught, Boiler Trail and Heat Balance Draught, Height and Diameter of Chimney, Draught losses, Steam Jet Draught, Types, Vacuum Measurement, Air Removal from the Condenser, Air Pump, Condenser Efficiency, Cooling Tower.	**06L**
UNIT-03	**Steam Nozzles** Introduction, Steady Flow Energy Equation and its Application to Steam Nozzles, Isentropic Expansion of Steam through Convergent and Divergent Nozzles, Critical Pressure Ratio, Condition for Maximum Discharge, Choking of Nozzles, Effect of Back Pressure, Super Saturated Flow through Nozzles, Flow with Friction Nozzle Efficiency.	**06L**
UNIT-04	**Steam Turbines** Principle and Working of Impulse and Reaction Turbines, Pressure and Velocity Compounding; Velocity Triangles for Impulse and Reaction Turbines, Efficiency, Diagram Efficiency, Steam Speed to Blade Speed Ratio for Optimum Performance, Losses in Steam Turbine, Performance and Governing of Steam Turbines.	**09L**
UNIT-05	**Compressible Flow** Governing Equations for Inviscid-Compressible Flows - Static and Stagnation Properties - Speed of Sound and Mach number, Isentropic Flow through Variable Area Passage Ducts - Choking of Flow.	**09L**

Course Outcomes

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

CO1: Identify and predict the behavior of Vapour Power Cycle.
CO2: Draw heat balance sheet of Steam Generator.
CO3: Determine the performance of Steam turbines

Books and References

1. Steam Turbine Theory and Practice by WJ Kearton, CBS.
2. Thermal Engineering by Sadhu Singh and Sukumar Pati, Pearson
3. Thermal Engineering by Ajoy Kumar and GN Sah, Narosa Publishing.
4. Fundamentals of Compressible Flow by SM Yahya, New Age International.

Course Name: **Refrigeration and Air Conditioning**
Course Code: **ME-314**
Course Type: **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 introduce the fundamental principles of cryogenics and the various thermodynamic cycle for liquefaction of gases.
- Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.

Unit Number	Course Content	Lectures
UNIT-01	**Refrigeration Cycles:** Review of Thermodynamic Principles of Refrigeration, Refrigeration Methods, Reverse Carnot Cycle, Bell Coleman Cycle, COP Comparison, Air Craft Refrigeration Cycles	**03L**
UNIT-02	**Vapor Compression Refrigeration Systems:** Theoretical and Actual Vapor Compression Cycle, Factors Affecting the Performance of Vapour Compression Cycle, Methods of Improving Vapor Compression Cycle, Pressure-enthalpy and Temperature- entropy Charts, Multi Evaporator System, Multi Expansion Valve System, Multi Stage Compression System, Cascade Refrigeration	**09L**
UNIT-03	**Refrigerants:** Classification and Designation of Refrigerants. Desirable Properties of an Ideal Refrigerant. Properties and Uses of Common Refrigerants like R-12, R22, R 134-A, NH_3. Comparison of Refrigerants, Non CFC Refrigerants, Green House Effect.	**03L**
UNIT-04	**Vapor Absorption Refrigeration Systems:** Introduction, Working of Simple Vapor Absorption System, Desirable Properties of Binary Mixture (Aqua-ammonia), Performance Evaluation of Simple Vapor Absorption System, Actual VAS, Li-Br and Ammonia Water Absorption System, Applications of VAS, Comparison between Vapor Compression and Vapor Absorption System	**03L**
UNIT-05	**Liquefaction of Gases:** Joule Thompson Coefficient, Thermodynamically Ideal Liquefaction System, Liquefaction Systems – Simple Linde Hampson Cycle, Precooled Liquid Hampson Cycle, Dual Pressure Linde Hampson Cycle, Claude Cycle, Engineering Application of Cryogenics	**06L**
UNIT-06	**Psychometric and Air Conditioning:** Introduction to Air Conditioning, Psychometric Properties and Terms, Psychometric Relations, Psychometric Processes and Its Representation on Psychometric Chart, BPF of Coil, ADP, Adiabatic Mixing of Two Air Streams, SHF, RSHF, GSHF, ESHF,Evaporative Cooling, Humidifier Efficiency, Cooling Towers and Their Performance,Thermodynamics of Human Body, Comfort and Comfort Chart, Factors Affecting Human Comfort, Concept of Infiltration and Ventilation, Indoor Air Quality Requirements, Factors Contributing to Cooling Load	**12L**

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: Obtain cooling capacity and coefficient of performance by conducting test on vapor compression refrigeration systems.
CO3: Calculate cooling load for air conditioning systems used for various applications.
CO4: Operate and analyze the refrigeration and air conditioning systems.

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 S. N. Sapali, PHI Publication
5. Cryogenics Systems by Randall F. Barron, Oxford University of Press

Course Name:	**Manufacturing Technology Lab-I**
Course Code:	**ME-315**
Course Type:	**Core**
Contact Hours/ Week: **2P**	Course Credits: **01**

Course Objectives

- To gain practical knowledge of pattern and mould making.
- To learn the utility of green sand to make a mould to perform the casting operations.
- To make the product from metal powder using powder metallurgy process.
- To develop the skills of using the different machines such as rolling machine, wire drawing machine, punching machine, hydraulic press and edge bending machine.
- Apply the welding techniques to make various types of joints.

List of Experiments

1. To prepare a pattern as per given drawing using conventional and power operated tools.
2. Study of Sieve Shaker and to find grain fineness number for a given sample of foundry sand.
3. To estimate the clay content & moisture content in the green sand using Clay Content Tester and Moisture Content Tester respectively.
4. To estimate the permeability of the green sand using Permeability Tester and estimation of compressive & Shear strength for the green sand using Sand Strength Tester.
5. To prepare green sand mould as per drawing and pouring with Aluminum metal for solidification.
6. To make a product of giving drawing using metal powder by the compacting and sintering operation.
7. Preparation of utility job (tong) as per drawing using forging operation and to demonstrate the strip rolling using Rolling Mills.
8. Demonstration of wire drawing operation using wire drawing machine and to extrude a cylindrical cup by backward Extrusion.
9. To perform Blanking & Punching operation on a given sheet and study of simple, compound and progressive press tool.
10. To prepare a bend using edge bending machine and deep drawing using Hydraulic Press.
11. To make joints on the given sheets using spot and seem welding.
12. Study of MIG and TIG welding machine and to prepare the T-joint using MIG/TIG welding machines.
13. To make joints as per given drawing using soldering & brazing experiment

Course Outcomes

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

CO1: Decide the different characteristics of green sand.
CO2: Understand the effect of different ingredients on the quality of green sand.
CO3: Experimentally perform the forging and sheet metal forming operations.
CO4: Make various types of joints using the welding techniques.

Course Name:**Thermal Engineering Lab-I**

Course Code: **ME-316**

Course Type: **Core**

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

Course Objectives

- To gain practical knowledge by demonstration of experiments to correlate with the theory.
- To study the working principle of various type of boilers and steam turbines.

List of Experiments

1. To study& determine the cooling tower efficiency.
2. To find the efficiency of air pumps.
3. To study and demonstrate the horizontal fire tube boiler.
4. To study and demonstrate the water tube boiler.
5. To study the working and function of mountings and accessories in boilers.
6. To prepare heat balance sheet for given boiler.
7. To find the condenser efficiencies.
8. To find power output & efficiency of a steam turbine.
9. To study the working of impulse and reaction steam turbines.
10. To find dryness fraction of steam by separating and throttling calorimeter.
11. To find calorific value of a sample of fuel using Bomb calorimeter.
12. To study flow characteristics through a convergent, and convergent-divergent nozzle with both subsonic and supersonic flow.

Course Outcomes

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

CO1: Understand the working principle of various types of boilers.

CO2: Understand the working principle of Impulse & Reaction steam turbines, condenser & nozzles.

Course Name: **Refrigeration and Air Conditioning Lab**
Course Code: **ME-317**
Course Type: **Core**

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

Course Objectives

- To help understand operating of various refrigeration and air conditioning apparatuses
- To gain practical knowledge by applying the experimental methods to correlate with the theory
- To learn the usage of temperature and flow instruments for various performance measurements
- 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 determine the theoretical and experimental COP of a heat pump.
3. To estimate the effect of sub-cooling and super-heating on the COP of VCR (Vapor Compression Refrigeration) system.
4. To determine the system capacity, capacity factor, apparatus dew point (ADP) and COP of Window Air Conditioner.
5. To determine and compare the theoretical and experimental COP of VCR system.
6. To calculate the mass flow rate of refrigerant, bypass factor, ADP and capacity (in humidifying condition) of an air conditioning test rig.
7. To calculate the mass flow rate of refrigerant, bypass factor, ADP and capacity (in dehumidifying condition) of an air conditioning test rig.
8. To study and determine the COP of Vapor Absorption Refrigeration System
9. To study and determine the COP of Cascade Refrigeration System
10. To find the COP of a Water Cooler
11. To study the hermetically sealed compressor and different types of cut-out /safety devices used in Vapor Compression Refrigeration System
12. To study the Ice making 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 analyze results
CO2: Experimentally realize the actual physical phenomenon occurs in Refrigeration and air conditioning systems
CO3: Use various measuring sensors and instruments with precision
CO4: Work in a group for performing laboratory experiments and interpreting the results

Course Name: **Machine Design – II**
Course Code: **ME-321**
Course Type: **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	Lectures
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.	**06L**
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, Special Helical Gears.	**06L**
UNIT-03	**Design of Bevel Gears** Straight Bevel Gears - Nomenclature, Virtual Number of Teeth, Endurance Load, Dynamic Load, Wear Load –AGMA Standards, Design of Gears whose Axis are Intersecting at Right Angle, Spiral Bevel Gears.	**06L**
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.	**06L**
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.	**06L**
UNIT-06	**Design of Ball and Roller Bearings** Types, Static and Dynamic Load Capacity, Bearing Life, Selection of Bearings for Steady and Variable Loading.	**03L**
UNIT-07	**Design of Multispeed Gear Box** Use of Preferred Numbers, Design with Speed Diagrams for Gear Boxes.	**03L**

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 bearings and multispeed gear box.

Books and References

1. Machine Design by Shigley, McGraw Hill.
2. Machine Design by R.L Norton, Pearson Education.
3. Machine Design by Pandya & Shah, Charotar Publishing House.
4. Machine Design by Sharma & Aggarwal, Kataria Sons.
5. Design data Book by **Kalaikathir Achagam, PSG College Coimbatore.**

Course Name: **Manufacturing Science and Technology-II**
Course Code: **ME-322**
Course Type: **Core**

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

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 technology and science of layer lamination and surface coating processes.

Unit	Course Content	Lectures
UNIT-01	**Introduction:** Need and Classification of Material Substractive Processes (Machining) and Material additive Processes (Layer Lamination & Coating).	**03L**
UNIT-02	**Cutting Machining Processes:** *Mechanism and Mechanics of Cutting 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 and Temperature in shear and friction plane. *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.	**12L**
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.	**06L**
UNIT-04	**Advanced Machining Processes:** Need and Classification of Erosion based Machining Processes, Process Principle, Equipment's 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 (USM) and Jet Machining Processes (AJM, WJM, AWJM).	**09L**
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 (FDM) and Laminated Object Manufacturing (LOM), *Layer Coating Processes*: Physical Vapour Deposition, Chemical Vapour Deposition, Electro-Chemical Deposition, Atmoshperic Plasma Spraying, Vaccum Plasma Spraying, Detonation Gun Spraying.	**06L**

Course Outcomes:

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

CO1: Identify the requirements of selection of different process parameters to perform any particular machining operation.
CO2: Describe the effects of various forceses acting during different machining processes.
CO3: Apply principles of advanced machining processes in machining of difficult-to-machine materials.
CO4: Assess the quality of surface produced after applying the layer additive processes.

Books and References

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. Fundamentals of Machining Processes by Hassan El-Hofy, Taylor and Francis.
5. Rapid Protyping: Principles and Applications by Rafiq Noorani, Wiley International.

Course Name: **Thermal Power Engineering-II**
Course Code: **ME-323**
Course Type: **Core**

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

Course Objectives

- To introduce the concepts of propulsion and thrust.
- To introduce the concepts of Internal Combustion Engines.
- To enable the students to understand the factors that causes abnormal combustion.

Unit Number	Course Content	Lectures
UNIT-01	**Gas Turbine** :Introduction, Brayton Cycle, Regeneration and Reheating, Open and Closed Cycle Gas Turbine, Gas Turbine Systems: **Air Compressors:** Positive Displacement and Non-Positive Displacement; Reciprocating, Centrifugal and Axial Flow Type; Characteristic Curves of Compressors.	**09L**
UNIT-02	**Jet Propulsion Systems:** Fundamentals of Jet Propulsion, Concept of Propulsion and Thrust, Propulsion Cycle, Power and Efficiency Calculations, Turbojet, Turbofan, and Turboprop Engines, Fundamentals of Rocket Propulsion.	**06L**
UNIT-03	**IC Engines:** Introduction, Review of Cycles, Actual Cycles and their Analysis, Classification of IC Engine, Two Stroke and Four Stroke Cycle Engines, Difference between CI and SI Engines, Engine Design and Operating Parameters, Fuels and their Properties, Stoichiometric and Actual Air Requirements.	**06L**
UNIT-04	**Combustion in IC Engines**: Combustion in SI Engines, Flame Front Propagation, Flame speed, Ignition delay, Abnormal Combustion, Combustion Chambers for SI Engines, Combustion in CI Engines, Ignition Delay, Combustion Knock, Combustion Chamber for CI Engines,	**06L**
UNIT-05	**Different Components and Testing of IC Engines:** Carburetors, Gasoline Injection, Friction and Lubrication, Types of Lubrication Systems, Engine Cooling, Magneto and Battery Ignition Systems, Ignition Timing, Engine Power, Engine Efficiencies, Type of Tests and Characteristic Curves, Variables Affecting Performance Characteristics, Methods of Improving Engine Performance.	**09L**

Course Outcomes

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

CO1: Identify and predict the behavior of Gas turbine Cycle.
CO2: Understand phenomenon of Combustion in IC Engines.
CO3: Determine the performance of IC Engines.

Books and References

1. Internal Combustion Engines by Ganesan, V, Tata McGraw Hill Book Co.,
2. Internal Combustion Engine Fundamentals by J.B. Heywood, McGraw-Hill.
3. Gas Turbine Theory by H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, Pearson Education Ltd.
4. Fundamental of Propulsion by V. Babu, ANE Books.

Course Name: **Automobile Engineering**
Course Code: **ME-324**
Course Type: **Core**

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	Lectures
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.	**06L**
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.	**06L**
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.	**06L**
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.	**03L**
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.	**03L**
UNIT-06	**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	**06L**
UNIT-07	**Introduction to Hybrid Electric Vehicles** History of Hybrid and Electric Vehicles,Concept of Hybrid Traction,VariousHybrid Drive-Train Topologies, Power Flow Control in Hybrid Drive-Train Topologies, Basic Concept of Electric Traction, Introduction to Various Electric Drive-Train Topologies, Power Flow Control in Electric Drive-Train Topologies, Introduction to Electric Components used in Hybrid andElectric Vehicles.	**06L**

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 Engineeing 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, SatyaPrakshan.
5. 5. Electric and Hybrid Vehicles Design Fundamentals by Iqbal Hussein, CRC Press.

Course Name:	**Manufacturing Technology Lab-II**
Course Code:	**ME-325**
Course Type:	**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. Also write the process sheet for the same.
2. To measure the different components of cutting forces at various cutting speed, feed and depth of cut. Write the process sheet for the same.
3. To study tool wear and tool life at various cutting speed, feed and depth of cut. Write the process sheet for the same.
4. To measure the cutting temperature at different cutting speed, feed and depth of cut. Write the process sheet for the same.
5. To study the construction and motion mechanism of shaper, planer and slotter, and prepare the job as per drawing using shaper machine. Write the process sheet and draw the sketches of the machine tool and tools used.
6. To drill a hole of given diameter using radial drilling machine and make a hexagonal slot as per drawing in this hole using slotting machine. Write the process sheet and draw the sketches of the machine tool and tools used.
7. Study of indexing mechanism for gear cutting and to cut gear on a gear blank using indexing mechanism on horizontal milling machine. Write the process sheet and draw the sketches of the machine tool and tools used.
8. To study of hobbing machines and cut a gear of given number of teeth on hobbing machines. Write the process sheet and draw the sketches of the machine tool and tools used.
9. To make a T- slot as per drawing using vertical milling machine. Write the process sheet and draw the sketches of the machine tool and tools used.
10. To make a job as per drawing using surface grinding machine. Write the process sheet and draw the sketches of the machine tool and tools used.
11. To make a job as per drawing using cylindrical grinding machine. Write the process sheet and draw the sketches of the machine tool and tools used.
12. Demonstration and study of Electrical Discharge Machining (EDM), 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.

Course Name:	**Thermal Engineering Lab-II / Automobile Engineering Lab**
Course Code:	**ME-326**
Course Type:	**Core**

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

Course Objectives

- To gain practical knowledge by conducting experiments to correlate with the theory.
- To study the working principle of Gas Turbine and Turbofan Engine.
- To conduct a load and performance test for single and multi-cylinder petrol engine.
- To learn the automobile systems for various constructional details, working principles and operation.

List of Experiments

1. To determine the volumetric efficiency & mass flow rate of the single stage Air Compressor.
2. To conduct a performance test on four stroke four-cylinder diesel engine test rig and to draw the heat balance sheet.
3. To conduct a performance test on four stroke four-cylinder petrol engine test rig and to draw the heat balance sheet.
4. To calculate the IHP (Morse Test) and mechanical efficiency of the four stroke four-cylinder petrol engine test rig.
5. To Study a Gas Turbine model.
6. To study a Turbofan engine model.
7. To study and prepare report on the constructional details, working principles and operation of the Automotive Clutches.
8. To study and prepare report on the constructional details, working principles and operation of the Automotive Transmission systems.
9. To study and prepare report on the constructional details, working principles and operation of the Automotive Suspension Systems.
10. To study and prepare report on the constructional details, working principles and operation of the Automotive Steering Systems.
11. To study and prepare report on the constructional details, working principles and operation of the Automotive Brake systems.
12. To study and prepare report on the constructional details, working principles and operation of the Engine cooling & lubricating Systems.

Course Outcomes

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

CO1: Learn the underlying working principle of Turbine and Turbofan Engine.

CO2: Apply the concept of Morse test on SI engine. (Multi cylinder).

CO3: Calculate the IP, BP, brake thermal efficiency.

Course Name: **Operations Research**
Course Code: **ME-411**
Course Type: **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	Lectures
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.	**03L**
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; transhipment problems.	**09L**
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.	**06L**
UNIT-04	**Network Problems** Intoduction to project planning and project scheduling,Tools and techniques of project management, Basic principles of network construction,Fulkersons rule, Critical path Method , Programme Evaluation and Review Technique (CPM/PERT) Crashing of activities, and solution of simple problems.	**06L**
UNIT-05	**Queing Problems** Queuing systems and concepts; Kendalls notation for representing queing models Opearting characteristics of queing 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	**06L**
UNIT 6	**Sequencing Problems** Sequencing problems, Assumptions in sequencing problems, Processing of 'n' jobs through one machines 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.	**06L**

Course Outcomes

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

CO1: To have the knowledge of role of O.R. in solving industrial problems.
CO2: Formulate and solve mathematical model for a physical situations like production and distribution of goods and economics.
CO3: Develop mathematical skills to analyse and solve network models arising from a wide range of applications
CO4: Be able to 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.
2. Linear Programming by Loomba, Mc Graw Hill.
4. Fundamentals of Operation & Research by Ackoff and Sasiene, John Wiley.

Course Name: **Computer Aided Design**
Course Code: **ME-412**
Course Type: **Core**

Contact Hours/Week: **2L + 2P** Course Credits: **03**

Course Objectives

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

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:**Introduction to CAD/CAM/CAE and Historical Developmentof CAD,Product Development Cycle,Typical CAD SystemArchitecture,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.	**03L**
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.	**06L**
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.	**03 L**
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.	**03 L**
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	**06 L**
UNIT-06	**Design Optimization:** Introduction, Gradient-based and Heuristic Methods, Johnson Method of Optimization Normal Specification Problem, Redundant Specification Problem,.	**03 L**

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.

Books and References

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: **Engineering Economics and Accountancy**
Course Code: **HS-404**
Course Type: **Core**

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

Course Objectives

- To impart knowledge about the Economics and its applicability to the Engineers
- To introduce the fundamental concepts of economics
- To enable the students to understand the factors that causes the changes in economic conditions of the entrepreneur

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Engineering Economics:** Definitions, Nature, Scope and application; Difference between Micro Economics and Macro Economics; Theory of Demand & Supply: Meaning, Determinants, Law of Demand, Elasticity of demand, Demand Forecasting, Law of Supply, Equilibrium between Demand & Supply.	**06L**
UNIT-02	**Production and Cost**: Production functions, Isoquant, Least Cost combination, Laws of Returns to Scale. Economics and Diseconomies of Scale of production, Cost and Cost curves, Revenue and Revenue curve, Break even analysis.	**06L**
UNIT-03	**Costing and Appraisal:** Cost elements, Economic cost, Accounting cost, Standard cost, Actual cost, Overhead cost, Cost control, Criteria of project appraisal, Social cost benefit analysis	**05L**
UNIT-04	**Markets**: Meaning, Types of Markets, Characteristics (Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly) Price and Output Determination; Product Differentiation; Selling Costs; Excess Capacity.	**05L**
UNIT-05	**Money**: Meaning, Functions, Types; Monetary Policy- Meaning, Objectives, Tools; Fiscal Policy:-Meaning, Objectives, Tools. **Banking:** Meaning, Types, Functions, Central Bank: its Functions, concepts CRR, Bank Rate, Repo Rate, Reverse Repo Rate, SLR.	**04L**
UNIT-06	**Depeciation:** Meaning of depreciation, causes, object of providing depreciation, factors affecting depreciation, Methods of Depreciation: Straight line method, Diminishing balance method, Annuity method and Sinking Fund method	**04L**
UNIT-07	**Financial Accounting:** Double entry system (concept only), Rules of Double entry system, Journal(Sub-division of Journal) , Ledger, Trial Balance Preparation of final accounts-Trading Account. Profit and Loss account, Balance Sheet.	**06L**

Course Outcomes

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

CO1: Identify the challenges of the economy as entrepreneur/manufacturer as well as consumer
CO2: Describe the economic system at the micro and macro level
CO3: Apply principles of economics and accountancy in the professional, personal and societal life
CO4: Assess the role of engineering economics and accounting in attaining economic efficiency

Books and References

1. Principles of Micro Economics by Mceachern & Kaur, Cengage Publication.
2. Managerial Economics by Craig Peterson & W Cris Lewis, PHI Publication.
3. Modern Microeconomics by A. Koutsoyiannis, Macmillan.
4. Managerial Economics Theory and Applications by D. M.Mithani. Himalaya Publication House.
5. Fundamental of Managerial Economics Mark Hirschey, South Western Educational Publishing.
6. Engineering Economics by Degramo, Prentice Hall.
7. Financial Accounting–A Managerial Perspective by R. Narayanaswamy, PHI.
8. Introduction to Accounting by J.R. Edwards & Marriot, Sage Publication.
9. Cost Accounting by Jawahar Lal, Tata McGraw Hill.
10. Project Planning Analysis, Selection, Implementation and Review by Prasanna Chandra, Tata McGraw Hill

Course Name: **Computer Aided Manufacturing**
Course Code: **ME-421**
Course Type: **Core**

Contact Hours/Week: **2L+ 2P** Course Credits: **03**

Course Objectives

- To impart knowledge of different typed of automations and use of computer in manufacturing.
- To introduce the fundamentals of numerical control of machine tools and its CNC part programming.
- To impart the knowledge of robotics and flexible manufacturing system.

Unit Number	Course Content	Lectures
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.	**03L**
UNIT-02	**CNC Machine Technology:** Construction Features and Classification of CNC Machine Tool, Elements of CNC Machine and Systems, Precision Measuring and Positioning of CNC, CNC Machine Structural Details-Configuration and Design, Friction and Anti-friction LM Guide ways, Ball Screw, Torque Transmission Elements, Spindle Drives, Feed Drives, Positional Measuring Transducers- Gratings, Encoders, Induction, Laser Interferometer, Spindle, ATC, APC, Tooling-Qualified, Preset Tooling.	**03L**
Unit-03	**CNC Machine Programming:** Structure of CNC program, Coordinate System, Manual CNC Part Programming: Programming for Two Axis and Three Axis Control System, G and M Codes, Cutter Radius Compensation, Tool Nose Radius Compensation, Canned Cycles, Sub Routines, Do Loop, Mirroring Features, Manual Part Programming for CNC Turning and Milling Centres, Computer Aided CNC Part Programming: Automatically Programmed Tools (APT) Programming- APT Language, Structure and Geometry, APT motion and Post Processor Commands, Complications Control Commands. Macro Subroutines, Part Programming Preparation for Typical Example, Macros and Parametric Programming Techniques, CAD/CAM Based Part Programming.	**09L**
UNIT-04	**Robot Technology:** Robot anatomy and Related Attribute, Robot Control Systems- Limited Sequence, Playback with Point to Point , Playback with Continuous and Intelligent Control, End Effectors – Gripper, Tool. Sensors in Robot- Tactile Sensors, Proximity, Optical Sensors and Machine Vision, Robot Programming, Applications of Industrial Robots.	**06L**
UNIT-05	**Flexible Manufacturing System:** Component of FMS, Need and Objectives of FMS, Types of Flexibility and FMS, FMS Lay Out and Advantages. Automated Material Handling System: Types and Application, Automated Storage and Retrieval System (ASRS), Automated Guided Vehicles (AGVs), Tool Management, Tool Supply System, Tool Monitoring System, Flexible Fixturing, Flexible Assembly Systems.	**06L**

Course Outcomes

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

CO1: Identify the correct use and place of automation.
CO2: Generate CNC part program for different machining operations.
CO3: Use the concept of flexible manufacturing system.

Books and References

1. Numerical Control and Computer Aided Manufacturing by T.K. Kundra, P.N. Rao and N.K. Tiwari, TMH
2. Numerical Control of Machine Tools by S. Martin, London: Hodder & Stoughton
3. Computer Control of Manufacturing Systems by Yoram Koren, McGraw-Hill
4. Computer Numerical Control by Jon Stenerson and Kelly Curran, Printice-Hall of India Pvt.Ltd. New Delhi

Course Name: **Finite Elements in Engineering**
Course Code: **ME-430**
Course Type: **Professional Elective-I**

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	Lectures
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.	**03L**
UNIT-02	**FEA of 1-D Problems:** Governing equation and Boundary conditions for describing steady state problems of Heat Transfer and Solid Mechanics, Finite Element Formulation-Discretization and Polynomial Approximation using linear and quadratic elements, Development and Evaluation of Elemental Matrices; Assembly Rule, Imposition Procedure for boundary conditions, Nodal solution using Gauss elimination method, Post computation of the nodal solutions.	**12L**
UNIT-03	**FEA of 2-D Thermal Analysis Problems:** Governing equation and Boundary conditions for describing steady state problems of Heat Transfer, Finite Element Formulation-Descritization and Polynomial Approximation using Standard 2-D elements, Development and evaluation of elemental matrices, Assembly Rules, Imposition of Boundary conditions, Nodal solution, Post computation of nodal solutions.	**09L**
UNIT-04	**FEA of 2-D Stress Analysis Problems:** Governing Equation and Boundary Conditions for describing steady state Plane Elastic Stress Analysis Problems: Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 2-D elements, Development and Evaluation of Elemental Matrices, Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations, Post Computation of the Solutions.	**09L**
UNIT-05	**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.	**03L**

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: Learn about Finite element Method Formulation.
CO3: To solve problems of Solid Mechanics and Heat Transfer using FEM.
CO4: Develop algorithms based of FEM methodology for a typical FEM problem.

Books and References

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: **Optimization Methods in Engineering**
Course Code: **ME 431**
Course Type: **Professional Elective -I**

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

Course Objectives

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

Unit Number	Course Content	Lectures
UNIT-01	**Introduction** Introduction, Terminologies, Design Variables and Constraints, Objective Function, Variable Bounds, and Problem Formulation.	**06L**
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. Marquan Method, Conjugate Gradient Method, Variable-Metric (DFP) Method.	**09L**
UNIT-03	**Constrained Optimization Methods** Kuhn Tucker Conditions, Transformation Methods: Penn Function Method, Method of Multipliers (MOM), and Sensitivity Analysis.	**09L**
UNIT-04	**Specialized Algorithms Methods** Integer Programming: Penalty Function Method, Branch and Bo' Method, Geometric Programming.	**06L**
UNIT-05	**Non-Traditional Optimization Methods** Genetic Algorithms, Simulated Annealing, Tabu Search and Ant Colony Optimization, Particle Swarm Optimization; Applications to Engineering Optimization Problems.	**06L**

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 amount 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: **Artificial Intelligence in Engineering**
Course Code: **ME-432**
Course Type: **Professional Elective-I**

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

Course Objectives

- To introduce the concept and methodology Artificial Intelligence.
- To learn expert systems methodology for solving problems.
- To learn methodologies of decision making and reasoning.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction & Fundamental Concept:** Foundations, Scope, Problems, and Approaches of Artificial Intelligence. Intelligent agents: Reactive, Deliberative, Goal-Driven, Utility-Driven, and Learning Agents Artificial Intelligence programming techniques, Introduction to knowledge-based intelligent systems.	**06L**
UNIT-02	**Knowledge Representation and Reasoning**: Ontologies, Foundations of Knowledge Representation and Reasoning, Representing and Reasoning about Objects, Relations, Events, Actions, Time, and Space; Predicate Logic, Situation Calculus, Description Logics, Reasoning with Defaults, Reasoning about Knowledge, Sample Applications.	**09L**
UNIT-03	**Expert system:** Fuzzy Expert Systems: Fuzzy Sets, Fuzzy Relations, Fuzzy Implications, Construction of Data Base and Rule Base, Inference Mechanisms, Defuzzification Methods, Artificial neural networks: neurons and neural networks, single layer perceptrons, multi-layer neural networks, learning processes, radial basis function networks, recurrent neural networks, Hybrid intelligent systems.	**09L**
UNIT-04	**Representing and Reasoning with Uncertain Knowledge**: Probability, Connection to Logic, Independence, Baye's Rule, Bayesian Networks, Probabilistic Inference, Sample Applications.	**06L**
UNIT-05	**Decision-Making** Basics of Utility Theory, Decision Theory, Sequential Decision Problems, Elementary Game Theory, Sample Applications.	**06L**

Course Outcomes

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

CO1: Learn the basic concepts Artificial Intelligence in Engineering.
CO2: Learn the basics of Artificial Neural Networks.
CO3: To Apply reasoning and decision making methodology in Artificial Intelligence.

Books and References

1. Neural Networks: A comprehensive Foundation by S. Haykin, Pearson Education.
2. Artificial Intelligence: A Guide to Intelligent Systems by M. Negnevitsky, Addison-Wesley.
3. An Introduction to Fuzzy Logic for Practical Applications by K.Tanaka and T. Niimura, Springer.
4. Fuzzy logic with engineering applications by T. J. Ross, Wiley India Pvt. Ltd.
5. Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig, Prentice Hall, New Jersey..

Course Name: **Design & Analysis of Experiments**
Course Code: **ME-433**
Course Type: **Professional Elective-I**

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	Lectures
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	**06L**
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).	**06L**
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.	**09L**
UNIT-04	**Response Surface Methodology and Robust Parameter Design:** Response Surface Methodology, Parameter Optimization, Robust Parameter Design, Main Effects and Interaction Effects. Taguchi's Quality Philosophy, Types of 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.	**09L**
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	**06L**

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 methods
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 byAngela Dean Daniel Voss, Springer.
3.Experimental Design and Analysis by Howard J. Seltman, Carnegie Mellon University
4. Design and Analysis of Experiments by Gary W. Oehlert, W.H Freeman Publisher

Course Name: **Advanced Mechanics of Solids**
Course Code: **ME-450**
Course Type: **Professional Elective-II**

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

Course Objectives

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

Unit Number	Course Content	Lectures
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.	**06L**
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.	**06L**
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.	**09L**
Unit-04	**Bending of Curved Bars** Stresses in Curved Bars, Division of Curved Beams on the Basis of 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.	**09L**
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.	**06L**

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 of curved bars for solving problems.
CO4: Learn the underlying theory of unsymmetrical bending and concept of shear centre.

Books And References

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: **Product Design and Development**
Course Code: **ME-451**
Course Type: **Professional Elective - II**

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 in order to achieve a common objective

Unit Number	Course Content	Lectures
UNIT-01	**Introduction**: Introduction and Significance of Product Design, Product Design andDevelopment Process, Sequential Engineering Design Method, Challenges of Product Development, Concept Development, Product Development and AMF Development Process, AMF Organizations.	**06L**
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.	**09L**
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.	**06L**
UNIT-04	**Embodiment Designand Detailed Design**: Design for Prototyping& Manufacturing, Robust Design, Design for Manufacturing, Detailed Drawings and Specifications, Life Cycle Assessment.	**09L**
UNIT-05	**Intellectual Property and Environmental Guidelines**: Elements and Outline, Patenting Procedures, ClaimProcedure, Design for Environment: Impact, Regulations from Government, ISO System.	**06L**

Course Outcomes

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

CO6: Distinguish different product development processes.
CO1: Distinguish associated engineering information with the product developmentprocesses.
CO2: Think about the sustainable design of a product and processes for competitive market.
CO3: 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: **Industrial and Engine Tribology**
Course Code: **ME-452**
Course Type: **Professional Elective-II**

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

Course Objectives

- To impart knowledge about the surface topography, modification and its measurement
- To introduce the fundamental concepts of friction and wear of mechanical components
- To enable the students the types of lubrication
- To divulge to the students the factors that causes the wear and friction of engineering components

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:**Tribology Fundamentals, General Tribological Considerations in Design and Industry,General Tribological considerations in the design of Mechanical and Engine components Surface Topography and its Measurement, Quantifying Surface Roughness, Statistical Methods of Surface Texture Assessment, Surface Modifications and Surface Coatings, Measurement of Surface Roughness.	**06L**
UNIT-02	**Friction:**Theories of Friction, Sliding Friction, Rolling Friction, Friction Characteristics of Common Metals and Non-Metals, Friction under Different Environments, Friction Losses in Engines, Engine Design Parameters Based on Friction, Friction in Extreme Conditions	**06L**
UNIT-03	**Wear:**Wear theories, Types of wear and their mechanisms; Factors affecting wear; selection of materials for different wear situations; Measurement of wear; Wear models asperity contact, constant and variable wear rate; Geometrical influence in wear models; Wear damage; Tribometers and tribometry; Wear in various mechanical components; Engine wear mechanisms; Wear controlling techniques-wear resistant materials and coatings and failure mode analysis	**09L**
UNIT-04	**Lubrication and Lubricants:**.Lubrication regimes;Classification of Lubricants, Properties of Gear Oil and Engine Oil, Lubrication System, Lubricant Monitoring and Testing, Ferrography and Other Rapid Testing Methods for Lubricants, Contamination. Basic Concepts of Lubrication, Lubrication Regimes in IC Engine Micro and Nano tribology; Hydrodynamics, Generalized Reynolds equation; Slider, fixed & pivoted bearings; Hydrodynamic journals bearings; Short and finite bearings, Thrust bearings, sintered bearing, non-circular bearings and multi side surface bearings. Hydrostatic bearing -basic concepts, bearing pads, flat, conical and spherical pad thrust bearing, multi- recess journal and thrust bearings, air and gas lubricated bearings.	**09L**
UNIT-05	**Engine Tribology:** General Tribological Considerations in Engine Components Like Bearings, Gears, Cams, Followers, Reciprocating Parts etc., Engine Bearings, Engine Lubrication and Its Types, Lubrication of Cam-Follower and Valve Train Mechanism, Valve Wear, Failure of Cam and Follower, Friction and Wear of Cylinder Liner Piston Ring Arrangement.	**06L**

Course Outcomes

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

CO1: understand the concepts related to friction, wear and lubrication.
CO2: know about the types of wear and their identification and estimation.
CO4: understand the need and requirement of lubrication and mechanisms.
CO5: recognize the importance of various components of the engine

Books and References

1. Engine Tribology by C M Taylor, Elsevier
2. Applied Tribology - Bearing Design and Lubrication by Michael M Khonsari, Wiley
3. Engineering Tribology by John William, Cambridge University Press.
4. Friction and Lubrication by Bowden F.P. & Tabor D., Heinemann Edu. Books
5. Engineering Tribology by Stachowiak and Batchelor, Elsevier Limited

Course Name: **Condition Monitoring and Diagnostics**
Course Code: **ME-453**
Course Type: **Professional Elective II**

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

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	Lectures
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; Cost Effectiveness &Performance Monitoring. Different Condition Monitoring Techniques(On Line and Off-Line Techniques)	**06L**
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 etc, Application of NDT Techniques	**09L**
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	**09L**
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; Fault Detection Transducers and Instrumentation.	**06L**
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.	**06L**

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

Books and References

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: **Mechanics of Composite Materials**
Course Code: **ME-454**
Course Type: **Professional Elective -II**

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	Lectures
UNIT-01	**Introduction** Definition, Characteristics and Classification of Composites, Mechanical Behavior and Basic Terminology, Multi-axial Stress Components and Stress Transformation; Multi-Axial Strain Components and Strain Transformation, Stress-strain relation.	**06L**
UNIT-02	**Elastic Behaviour of Uni-Directional Composite Lamina**: Micro-mechanics: properties and geometric characteristics of fibre and matrix, relation to overall elastic property of lamina; Macro- mechanics: stress-strain relations for anisotropic materials; transformation of stress, strain and elastic parameters for lamina.	**09L**
UNIT-03	**Strength of Uni-Directional Composite Lamina:** Micro-mechanics: failure mechanism under longitudinal or transverse tension loading and shear loading; Macro-mechanics: failure theories for strength prediction.	**09L**
UNIT-04	**Elastic Behaviour of Multi-Directional Laminates:** Lamination theory: layup arrangements for laminates and implications for elastic property of the composite; Sandwich plates.	**06L**
UNIT-05	**Failure Analysis of Multi-Directional Laminates:** Stress analysis for first ply failure; Progressive and ultimate failure; Design considerations	**06L**

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 Voyiadjisand Peter Kattan, Springer.

Course Name: **Mechatronics and Robotics**
Course Code: **ME- 455**
Course Type: **Professional Elective-II**

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

Course Objectives

- To impart knowledge and use of mechatronic system and different types of sensors and actuators.
- To introduce the fundamentals of microprocessors, microcontrollers and PLCs and their architecture.
- To impart the knowledge of robotics, robotic programming and robot vision.

Unit Number	Course Content	Lectures
UNIT-01	**Fundamentals of Mechatronics:** Definition, Applications, Block Diagram of Mechatronic System, Functions of Mechatronics Systems, Benefits of Mechatronics in Manufacturing. Analog Devices, Signal Conditioning, Digital Electronics, Data Acquisition systems	**03L**
UNIT-02	**Sensors and Actuators:** Static characteristics of sensors and actuators, Position, Displacement and Proximity Sensors, Force and torque sensors, Pressure sensors, Flow sensors, Temperature sensors, Acceleration sensors, Level sensors, Light sensors, Smart material sensors, Micro and Nano sensors, Selection criteria for sensors, Actuators: Electrical Actuators (Solenoids, Relays, Diodes, Thyristors, Triacs, BJT, FET, DC motor, Servo motor, BLDC motor, AC motor, Stepper motors), Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.	**09L**
Unit-03	**Microprocessors, Microcontrollers and Programmable Logic Controllers:** Logic Concepts and Design, System Interfaces, Communication and Computer Networks, Fault Analysis in Mechatronic Systems, Synchronous and Asynchronous Sequential Systems, Microcontrollers, Programmable Logic Controllers (PLCs): Architecture, Basics of PLC Programming, Logics, Timers and Counters, PLC Applications	**09L**
UNIT-04	**Introduction of Robotics**: Definition of a robot, types of robotic joints and motions, classifications of robot based on: Physical configurations, actuators and motion control; Terminologies used for robotics specification and selection for industrial applications; Types of end effectors.	**03L**
UNIT-05	**Robot Kinematics and Dynamics:** Homogeneous co-ordinates and co-ordinate transformations, kinematic parameters, use of Denavit-Hartenberg representation for finding arm equation of robotic arms, forward and inverse kinematics for basic industrial robotic configurations, SCARA configurations, Basics of Robot Dynamics.	**06L**
UNIT-06	**Robot Vision and Programming:** Sensing and digitization of vision data, image processing: image data reduction, segmentation, feature extraction, object recognition, and training of vision system, Robot programing methods, Robot Programming Languages.	**06**

Course Outcomes

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

CO1: Generate conceptual design for mechatronics products based on potential customer requirements
CO2: Select appropriate sensors and actuators and devise a system for collecting information about processes
CO3: Demonstrate the concepts of kinetics & dynamics of robot, and Identify an application of robots in manufacturing.

Books and References

1. Mechatronics: Electronic control systems in Mechanical and Electrical Engineering by W. Bolton, Pearson Edu.
2. Introduction to Mechatronics & Measurement Systems by David G Alciatore and Michael B Histand, McGraw-Hill.
3. Industrial Robotics: Technology, Programming and Applications by M.P. Grover and N. G. Odrey, TMH Edu. India
4. Robotics: Control and Programming by J. Srinivas, Rao V. Dukkipati and K. Ramji, Alpha Science International.

Course Name: **Computer Integrated Manufacturing Systems**
Course Code: **ME-440**
Course Type: **Professional Elective-III**

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

Course Objectives

- To impart knowledge of different types of planning and controls and their computerized execution and monitoring.
- To introduce the concepts of flexible manufacturing system and automated guided vehicle system.
- To enablethe students to find how the system can be automated at low cost.

Unit Number	Course Content	Lectures
UNIT-01	**Fundamentals of Manufacturing Systems:** Manufacturing Systems: Concept Objectives, Types and Trends; Concepts of Mechanization, Automation and Integration **Functions and Components of CIM System:** Concept of CAD/CAM and CIMS	**03L**
UNIT-02	**Software Technology for CIM System:** Business Database System: File processing, Data Processing and Database Design, File Organization and Relational Analysis; Decision Support System, Personal/Distributed Computing and Local Area Network	**06L**
UNIT-03	**Planning and Scheduling Functions in CIM System:** Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP), Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRP-II), and Enterprise Resource Planning (ERP).	**06L**
UNIT-04	**Group Technology and Cellular Manufacturing:** Concept of Group Technology and its Application, classification and Coding Techniques; Clustering Techniques, Part Families, Parts Classification and Coding, Part Coding System, Production Flow Analysis, Composite Part Concept, Machine Cell Design and Layout, Quantitative Analysis in Cellular Manufacturing – Rank Order Clustering Method, Arranging Machines in a GT Cell, Hollier Method.	**12L**
UNIT-05	**Advanced Manufacturing Systems:** Just-In-time Production Systems, Lean Manufacturing systems, Agile Manufacturing systems, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems and Agent-Based Manufacturing Systems	**06L**

Course Outcomes

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

CO1: Do process planning, master scheduling and capacity planning for an organization and use computer for them.
CO2: Learn Group Technology and Cellular Manufacturing Concept.
CO3: Apply the concepts of flexibility in manufacturing systems.

Books and References

1. Automation, Production Systems & Computer Integrated Manufacturing by M. P. Groover, Prentice Hall India.
2. Principles of Computer Integrated Manufacturing by Kant Vajpayee, Prentice Hall India.
3. Computer Aided Manufacturing by P.N. Rao, N.K. Tewari & T.K. Kundra, Tata McGraw Hill Publishing Company.
4. CAD/CAM/CIM by P. Radhakrishnan, S. Subramanyan and V.Raju, New Age International Publisher.
5. Computer-Integrated Manufacturing by James A. Rehg and Henry W. Kraebber, Pearson Education

Course Name: **Maintenance Engineering**
Course Code: **ME-441**
Course Type: **Professional Elective –III**

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

Course Objectives

- To perceive the role and involvement of maintenance towards achieving competitive advantage in the industries.
- To understand the key concept sand issues of maintenance in both manufacturing and service organizations.
- To know about the inspection, testing and quality control in the field of maintenance.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Maintenance Concept, Need of Maintenance Management, Objectives and Characteristics of Maintenance Function, Organizational Set up of the Maintenance System, Maintenance function; Maintenance cycle; Planning, Execution, Recording and Evaluation, Benefits and Effects of Maintenance.	**03L**
UNIT-02	**Maintenance Organising and Control:** Present Material Policy for Maintenance, Classification of Spare, Spare Parts Provisioning, Reliability and Quality of spares,Inventory Control of Spare Parts,ABC Analysis, FSN Approach, XYZ Approach, VED Approach, Work Planning and Scheduling, Long-Range and Short Range Planning; Man Power Allocation; Estimation of Maintenance Work and Control.	**06L**
UNIT-03	**Reliability of Engineering Systems:** Reliability and Maintainability, Quantitative Estimation of Reliability of Parts, Maintainability, Failure, Availability, Reliability Structure and Optimum Design Configuration of Series& Parallel, Combinations, Redundancy Structure, Mean Time to Failure (MTTF), Mean Time between Failure (MTBF), Mean Time to Repair (MTTR), Statistical Estimation of Reliability Indices, Machine Failure Pattern: Breakdown Time Distribution,Preventive andPredictive Maintenance	**09L**
UNIT-04	**Maintenance in Service:** Maintenance Requirement: Mechanical, Electrical, Process and Service Equipment; Maintenance Aspect: Lubrication, Control of Corrosion, Condition Monitoring Techniques, Computerized Maintenance Information System,Methods andInstruments for Condition Monitoring,Condition Monitoring,Fault Detection, Vibration Monitoring,Noise Monitoring,Wear and Debris Analysis, Signature Analysis, NDT Techniques in Condition Monitoring. Maintenance Decision Making	**06L**
UNIT-05	**Inspection, Testing and Quality Control:** Inspection, Testing and Quality Control inMaintenance, Definitions, Importance ofInspection and Testing in Maintenance, Inspection Frequency, Destructive, Non-destructive andSemi-destructive Testing, Liquid Penetration Test, Magnetic Particle Test, Ultrasound Testing, Vibration Analysis, Definition and Importance of Quality Control in Maintenance, Statistical Quality Control Tools and Techniques.	**06L**
UNIT-06	**Economic Aspect of Maintenance:** Cost of Machine Breakdown, Estimation of Life Cycle Cost, Impact of Maintenance Cost, Application of Work Measurement in Maintenance, Selection of Manpower andTraining, Incentive Payment of Maintenance Workers, Cost Reduction Approach to Spares, Reliability and Quality of Spares, Inventory Control of Spare Parts.	**06L**

Course Outcomes

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

CO1: Get thoroughthe knowledge of the overall understandingof maintenance, reliability and planning.
CO2: Applysystematictools/techniques to the fault examining of various machines andequipment.
CO3: Apply engineering concepts for improvement of equipment and procedures in order to enhance their Maintainability, reliability and availability.

Books and References

1. Industrial Maintenance Management by S.K.Srivastava, S. Chand & Company Ltd.
2. Maintenance and Spare Parts Management by P. Gopal Krishnan and A. K. Banerji, PHI.
3. Principlesof Planned Maintenance byR. H. Clifton, Edward Arnold.
4. A text Book of Reliability and Maintenance Engineering by Alakesh Manna, I.K.International Publishing House.
5. Planning and Control of Maintenance Systems: Modelling and Analysis by S. O. Duffuaa and A. Raouf, Springer.

Course Name: **Supply Chain Management**
Course Code: **ME-442**
Course Type: **Professional Elective-III**

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

Course Objectives

- To introduce the major building blocks, major functions, major business processes, performance metrics, and major decisions (strategic, tactical, and operational) in supply chain networks.
- To enable the role of stochastic models (Markov chains, queuing networks); optimization models and simulation in supply chain planning and decision-making.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction** Logistics Management and Supply Chain management: Definition, Evolution, Importance, The Concepts of Logistics, Logistics Relationships, and Functional Applications, HR, Marketing, Operations, Finance. Logistics Organization, Logistics in Different Industries, Fundamentals of Supply Chain and Importance, Development of SCM concepts and Definitions Supply chain strategy, Strategic Supply Chain Management and Key Components. Drivers of Supply Chain Performance: Key Decision Areas: External Drivers of Change	**06L**
UNIT-02	**Logistics Activities** Functions, Objectives, Solution. Customer Service, Warehousing and Material Storage, Material Handling, Order Processing and Information handling .Transportation and Packaging. Thirdparty and Fourth Party Logistics, Reverse Logistics, Global Logistics, Modeling Logistics Systems, Simulation of Logistic Systems, Dimensions of Logistics & SCM, The Macro Perspective and the Macro Dimension, Logistic System Analysis Strategy, Logistical Operations Integration, Customer service, Supply Chain Relationships	**06L**
UNIT-03	**Procurement and Operations Planning** Forecasting Requirements and Techniques, Forecasting Accuracy, Collaborative Planning, Forecasting and Replenishment decisions, Procurement Strategies, E-commerce and Procurement, Dimensions of Product Quality, Quality Standards, Manufacturing Perspectives, Manufacturing Strategies, Total Cost of Manufacturing, Lean Systems, Six Sigma	**09L**
UNIT-04	**Supply Chain Framework and Network Design** Framework and Role of Supply Chain in e-business and b2b practices, Value of Information in Logistics & SCM - E-logistics, E-Supply Chains, International and Global Issues in Logistics, Role of Government in International Logistics, Principal Characteristics of Logistics in Various Countries and regions, Enterprise Facility Network and Location Decisions.	**09L**
UNIT-05	**Supply Chain Risk Management** Concept of Supply Chain Risk, Product Complexity, Regulatory, Environmental, Financial Resource Availability, Outsourcing, Security, Developing a secure supply chain, Rationale for Supply Chain Protection, Crossborder Operations.	**06L**

Course Outcomes

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

CO1: Will gain knowledge into the different supply chain functions, such as inventory management, finance, operations management, transport and logistics, etc.
CO2: Apply logistics and purchasing concepts to improve supply chain operations
CO3: Identify and Analyze Business Models, Business Strategies and, corresponding competitive advantage
CO4: Use critical thinking skills in business situations or cases.

Books and References

1. Logistical Management by Bowersox, Mc-Graw Hill.
2. Supply Chain Management for Global Competitiveness by Sahay, Macmillan India.
3. Logistics and Supply Chain Management Cases and Concepts by Reguram, Macmillan India.
4. The Management of Business Logistics by Coyle, Bradi&Longby, West Publishing Co.
5. Operations and Supply Chain Management by Ravi Shankar, McGraw Hill Education.

Course Name: **Total Quality Management**
Course Code: **ME-443**
Course Type: **Professional Elective III**

Contact Hours/Week: **3L** 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	Lectures
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.	**06L**
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.	**06L**
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.	**06L**
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.	**09L**
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.	**06L**
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.	**03L**

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: **Manufacturing of Non-Metallic Products**
Course Code: **ME-444**
Course Type: **Professional Elective-III**

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

Course Objectives

- To impart knowledge of different non-metallic materials, properties & their applications.
- To introduce different processing techniques for various non-metals.
- To enable students to select proper processing method suitable for product's material and shape

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Classification of Engineering Materials and Processing Techniques, Structure and Properties of Non-Metals.	**03L**
UNIT-02	**Shaping and Forming of Glass and Ceramics Products:** Glass structure and properties, Glass Melting and Forming, Glass Annealing, Ceramic Powder Preparation, Synthesis of Ceramic Powders, Fabrication of Ceramic Products from Powders: Pressing, Casting, Vapour Phase Techniques, Sintering, Finishing, Machining,Ceramic Coatings,	**09L**
UNIT-03	**Shaping and Forming of Plastics and Rubber Products:** Introduction to Plastic, ***Structure and MechanicalProperties, Thermoplastics&Thermosets,***Plastic Processing Techniques: Extrusion, Injection Moulding, Thermoforming, Compression Moulding. Transfer Moulding, General behavior of Polymer melts, Machining of plastics. Types of Rubber and its Processing, Shaping and Forming Processes for Rubber.	**12L**
UNIT-04	**Shaping and Forming of Polymer Matrix Composites Products:** Classification of Composite Materials, Properties of Composites, ProcessingMethods:Hand lay-up, Autoclaving, Filament Winding, Pultrusion, Compression Molding, Pre-pegging, Sheet Molding Compounds etc., Process Capability and Application Areas of Various Techniques.	**06L**
UNIT-05	**Shaping and Forming of Ceramic Matrix Composites Products:** Mechanical Properties of Ceramic Matrix Composites, Different Processing Techniques for Ceramic Matrix Composites, Process Capability and Applications of Various Techniques.	**03L**
UNIT-06	**Secondary Processing of Composite Materials**: Need of Secondary Operations, Different Type of Secondary Operations, Machining and Drilling of Non-Metals, Machining Induced Damage, Different Methods of Reducing the Damage on Account of Secondary Processing.	**03L**

Course Outcomes

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

CO1: Identify different non-metals and their suitability for various applications.
CO2: Select proper processing technique for a particular type of product and material.
CO3: Understand the properties and application of various non-metallic composites.

Books and References

1. Manufacturing Processes for Engineering Materials by S.Kalpakjian, Addison – Wesley.
2. Composite Materials: Engineering&Sc. by F.L.Mathews and R.D. Rawlings, CRC press.
3. Polymer Science and Technology- Plastics, Rubber, Blends, and Composites by Ghosh, TMH
4. Glass Engineering Handbook by E. B. Shand, McGraw-Hill
5. Introduction to ceramics by Kingery, Bowen and Uhlmann, John Wiley & Sons publishers

Course Name: **Additive Manufacturing Technology**
Course Code: **ME-445**
Course Type: **Professional Elective-III**

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

Course Objectives

- To impart knowledge of different Additive Manufacturing Technologies& theirapplications.
- To introduce the concept of solid modeling, STL file generation and model slicing.
- To enable students to repair STL file, to generate proper tool path, to select proper AM method.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** History andTypes of Additive Manufacturing Technologies,Traditional vs Additive Manufacturing, Advantages and Applications of additive Manufacturing, Materials for Additive Manufacturing, AM Technology in Product Development.	**03L**
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.	**09L**
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.	**09L**
UNIT-04	**Powder Based Additive Manufacturing Technologies:** Materials, Powder Fusion Mechanism, Process Parameters and Modeling, 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.	**09L**
UNIT-05	**Problem Areas of Additive Manufacturing:**Accuracy and Strength Issues of AM Parts, Surface Roughness Problem in AM, Part Orientation and Other Issueslike build time, support structure, cost etc.,	**06L**

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: **Alternative Fuels Technology**
Course Code: **ME-460**
Course Type: **Professional Elective-IV**

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

Course Objectives

- To impart the search of alternative fuel for future
- To introducethe types of alternative fuels and energy sources for IC engines
- To enable the understanding of non-convention fuel

Unit Number	Course Content	Lectures
UNIT-01	**Need For Alternate Fuel :** Availability and Properties of Alternate Fuels, General Use of Alcohols, LPG, Hydrogen, Ammonia, CNG and LNG, Vegetable Oils and Biogas, Merits and Demerits of Various Alternate Fuels, Introduction to Alternate Energy Sources,like EV, Hybrid, Fuel Cell and Solar Cars.	**06L**
UNIT-02	**Vegetable Oils as Fuels:** Various Vegetable Oils and their Important Properties. Different Methods of Using Vegetable Oils, Blending, Preheating Transesterification and Emulsification of Vegetable Oils – Performance in Engines, Performance, Emission and Combustion Characteristics in Diesel Engines.	**09L**
UNIT-03	**Hydrogen as Engine Fuel:** Production Methods of Hydrogen. Combustive Properties of Hydrogen, Problems Associated with Hydrogen as Fuel and Solutions. Different Methods of Using Hydrogen in SI and CI Engines, Performance, Emission and Combustion Analysis in Engines, Hydrogen Storage,Safety Aspects of Hydrogen.	**06L**
UNIT-04	**Alcohols as Fuels:** Introduction to Alternative Fuels, Need for Alternative Fuels, Availability of Different Alternative Fuels for SI and CI Engines, Alcohols as Fuels. Production Methods of Alcohols, Properties of Alcohols as Fuels, Methods of using Alcohols in CI and SI Engines, Blending, Dual Fuel Operation, Surface Ignition and Oxygenated Additives, Performance Emission and Combustion Characteristics in CI and SI Engines.	**09L**
UNIT-05	**Natural Gas, LPG and Biogas:** Layout of an Electric Vehicle, Advantage and Limitations, Specifications, System Components, Electronic Control System, High Energy and Power Density Batteries, Hybrid Vehicle, Fuel Cell Vehicles, Solar Powered Vehicles.	**06L**

Course Outcomes

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

CO1: To understand the various alternative fuels available as alternative option
CO2: To know the extraction process of fuel from different sources
CO3: performance characteristics, combustion characteristics, emission characteristics, engine modifications required

Books and References

1. Alternate Fuels by S. S. Thipse, Jaico Publications.
2. Alternative Fuels Guide Book by Richard. L. Bechfold, SAE International Warrendale.
3. Energy Today & Tomorrow by Maheswar Dayal, I& B Ministry Publication India.
4. Power Plant Engineering by Nagpal, Khanna Publishers.

Course Name: **Renewable Sources of Energy**
Course Code: **ME-461**
Course Type: **Professional Elective-IV**

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

Course Objectives

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

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Environmental Aspects of Energy Utilization, Renewable Energy Scenario in India and around the World, Potentials, Achievements / Applications, Economics of renewable energy systems. Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification.	**03L**
UNIT-02	**Solar Thermal Energy Collectors:** Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish, Solar Collector Systems, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooing, Solar Cookers, Solar Pond, Components of Solar Cell System, Solar Cell materials, Practical Solar Cells, Characteristics of Solar Cells, Efficiency of Solar Cells, Photovoltaic Panels.	**09L**
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.	**06L**
UNIT-04	**Wind Energy:** Windmills, Wind Turbines, Wind Resources, Wind Turbine. **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, Turbines for Tidal Power, Advantages and Disadvantages of Tidal Power.	**09L**
UNIT-05	**Biomass Energy:** Biomass Production, Energy Plantation, Biomass Gasification, Theory of Gasification, Gasifier and Their Classifications, Updraft, Downdraft and Cross-draft Gasifiers, Fluidized Bed Gasification, Use of Biomass Gasifier, Gasifier Biomass Feed Characteristics, Applications of Biomass Gasifier, Cooling and Cleaning of Gasifiers. **Biogas Energy:** Introduction, Biogas and its Composition, Anaerobic Digestion, Biogas Production, Benefits of Biogas, Factors Affecting the Selection of a Particular Model of a Biogas Plant, Biogas Plant Feeds and their Characteristics.	**09L**

Course Outcomes

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

CO1: Identify the different form of alternative energies
CO2: To know the extraction process of fuel from different sources
CO3: Realize the importace of search for future fuel
CO4: Identify future fuel for nation

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: **Exergy Analysis of Thermal Systems**
Course Code: **ME-462**
Course Type: **Professional Elective- IV**

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

Course Objectives

- To impart knowledge to the students about the exergy analysis
- To provide the concept, applications, importance of energy
- To familiarize the students about the exergy, and its applications in real life situations

Unit Number	Course Content	Lectures
UNIT-01	**Basic Concepts of Exergy Analysis:** Review of Laws of Thermodynamics, Entropy, Thermodynamics Theorems-I and II,Exergy.	**06L**
UNIT-02	**Exergy Concepts:** Classification of Forms of Exergy, Physical Exergy, Chemical Exergy, Exergy Concepts for Closed System Analysis.	**06L**
UNIT-03	**Exergy Analysis:**Quality of Energy, Importance of Exergy Analysis, Available Energy Referred to a Cycle, Availability in a Finite Process, Available Energy From a Finite Energy Source, Demonstration of Quality of Energy Based on Exergy.	**09L**
UNIT-04	**Exergy Analysis of Processes:** Expansions Process, Compression Processes, Heat Transfer Process, Mixing & Separation Process, Chemical Process Including Combustion	**06L**
UNIT-05	**Energy Analysis of Thermal Systems:** Gas Turbine Plant, Thermal Power Plant, Refrigeration Unit, Heat Exchanger.	**09L**

Course Outcomes

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

CO1: Acquire an overview of exergy analysis of thermal components
CO2: Able to compute exergy analysis of different processes and power and refrigeration cycles
CO3: Calculate exergy-economics costing of thermal components

Books and References

1. The Exergy Method of Thermal Plant Analysis by J. J.Kotas, Krieger Publishing Corp. USA
2. Advanced Thermodynamics for Engineers by Kenneth Wark, McGraw Hill Publishing Co. Ltd.
3. Fundamentals of Engineering Thermodynamics by Michel J. Moran, Howard N. Shapiro, Daisie D.Boettner, Margaret B. Bailey, John Wiley & Sons, Inc.
4. Steam Power Engineering, Thermal and Hydraulic Design Principles by Seikan Ishigai, Cambridge Univ. Press.

Course Name: **Computational Fluid Dynamics**
Course Code: **ME-463**
Course Type: **Professional Elective- IV**

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

Course Objectives

- To impart knowledge to the students about fundamental of Computational fluid Dynamics
- To provide the concept, applications, importance of Computational fluid Dynamics
- To familiarize the students about the methodology of solving problem with CFD..

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to CFD:** Role of Computational Fluid Dynamics (CFD) and its Application, FDM and FVM, Governing equations (GE's) of Fluid Dynamics, Modeling of Flow, Control Volume Concept, Substantial Derivative, Physical Meaning of the Divergence of Velocity, Continuity Equation, Momentum Equation, Energy Equation and its Conservation Form, Equation for Viscous Flow (Navier-Stokes equation), Equation for Inviscid fFlow (Euler equation), Different Forms of GE's, Initial and Boundary Condition.	**06L**
UNIT-02	**Finite Difference Method**: Discretization of Derivatives by Taylor Series , Forward, Backward and Central Difference Quotients of First and Higher Order Derivatives, Difference Equations, Explicit and Implicit Methods, Consistency and Stability of Finite Difference Equations. Application of Different Boundary Conditions. Pressure Correction Method, Simple Algorithm.	**03L**
UNIT-03	**Applications of FDM**: Motion of a Sphere Falling in a Fluid Medium, Solution of One and Two Dimensional Unsteady Heat Equations by Explicit and Implicit Method, Thomas Algorithm, Solution of Steady Two Dimensional Heat Equation by Iterative Procedure, Alternating Direction Implicit Method, Solution of Steady Two Dimensional Steady Boundary Layer Equation Using Similarity Solution, Couette Flow Solution.	**09L**
UNIT-04	**FVM for Diffusion Problems**: FVM for 1D Steady State Diffusion, 2D Steady State Diffusion, Solution of Discretized Equation-TDMA Scheme.	**06L**
UNIT-05	**FVM for Convection-Diffusion Problems**: FVM for 1D Steady State Convection-Diffusion, Central Differencing Scheme, Conservativeness, Boundedness, Transportiveness, Upward Differencing Scheme, Hybrid Differencing Scheme for 2D and 3D Convection-Diffusion, Power Law Scheme, QUICK Scheme.	**06L**
UNIT-06	**FVM for Unsteady Flows**: 1D Unsteady Heat Equation (Explicit, Crank-Nicolson, Fully implicit schemes), Implicit Methods for 2D and 3D Problems, Discretization of Transient Convection-Diffusion Problems, Solution Procedure for Transient Unsteady Flow Calculations (Transient SIMPLE, Transient PISO Algorithms).	**06L**

Course Outcomes

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

CO1: Acquire an overview of CFD and its methodology.
CO2: Able to formulate and solve problems with CFD.
CO3: Generate algorithms for typical CFD problem.

Books and References

1. Computaional Fluid Dynamics by Anderson Jr, McGraw Hill.
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H.K. Versteeg and W. Malalasekara, Pearson Education.
3. Computational Fluid Flow and Heat Transfer by K. Muralidhar and T. Sundararajan, Narosa Publishing.
4. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, McGraw-Hill.
5. Computational Techniques for Fluid Dynamics Volume I & II by C.A.J. Fletcher, Springer.

Course Name: **Design of Heat Exchangers**
Course Code: **ME-464**
Course Type: **Professional Elective-IV**

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	Lectures
UNIT-01	**Different Classification and Basic Design Methodologies for Heat Exchanger:** Classification of Heat Exchanger, Selection of Heat Exchanger, Overall Heat Transfer Coefficient, LMTD Method for Heat Exchanger Analysis of Parallel, Counter, Multi-pass and Cross Flow Heat Exchanger, e-NTU Method for Heat Exchanger Analysis, Fouling, Cleanness Factor, Percent Over Surface, Technique to Control Fouling, Additives, Rating and Sizing Problems, Heat Exchanger Design Methodology.	**09L**
UNIT-02	**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	**06L**
UNIT-03	**Design of Shell and Tube Heat Exchangers:** Basic components, Basic Design Procedure of Heat Exchanger, TEMA Code, J-factors, Conventional Design Methods, Bell-Delaware Method.	**09L**
UNIT-04	**Design of Compact Heat Exchangers:** Heat Transfer Enhancement, Plate Fin Heat Exchanger, Tube Fin Heat Exchanger, Heat Transfer and Pressure Drop	**06L**
UNIT-05	**Heat Transfer Enhancement and Performance Evaluation:** Enhancement of Heat Transfer, Performance Evaluation of Heat Transfer Enhancement Technique. Introduction to Pinch Analysis.	**06L**

Course Outcomes

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

CO1: Understand the basic design methodologies of heat exchangers
CO2: Understand the design methodologies of double pipe, shell and tube and compact type heat exchangers
CO3: Analyze the performance of heat exchangers with different heat transfer enhancement techniques

Books and References

1. Heat Exchanger Selection, Rating and Thermal Design by Sadik, Kakac, CRC Press
2. Fundamentals of Heat Exchanger Design by Ramesh K Shah, Wiley Publication
3. Compact Heat Exchangers by Kays, V.A. and London, A.L., McGraw Hill
4. Heat Exchanger Design Handbook by Kuppan, T, Macel Dekker, CRC Press
5. Process Heat transfer by Donald Q Kern, McGraw Hill

Course Name: **Design of Air Conditioners**
Course Code: **ME-465**
Course Type: **Professional Elective-IV**

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

Course Objectives

- To introduce the advanced Psychrometric processes and study of comfort and design condition of air conditioners.
- To impart knowledge about load calculations for the designing of air conditioners.
- To impart knowledge for the design of air conditioning apparatus.
- To understand the design principles of transmission and air distribution system

Unit Number	Course Content	Lectures
UNIT-01	**Recapitulation of Psychrometric and Air Conditioning:** Recapitulation of Psychrometric Processes, Air Washer, Method of production of Dry Air, Chemical Dehumidification, Summer Air Conditioning System, Winter Air Conditioning System, Solar Assisted Desiccant Air Conditioning System **Comfort-Physiological Principles, IAQ and Design Conditions:** Introduction, Mechanical Efficiency of Humans, Metabolic Heat, Energy Balance and Models, Energy Exchange with Environment, Thermoregulatory Mechanisms, Heat Transfer Coefficients, Environmental Parameters, Application of Physiological Principles to Comfort Air Conditioning Problems, Prediction of Thermal Comfort and Thermal Sensation, Standard Effective Temperature and Modified Comfort Chart, Effect of Other Variables on Comfort, Indoor Air Quality, Inside Design Conditions, Outside Design Conditions, Choice of Supply Design Conditions, Critical Loading Conditions	**09L**
UNIT-02	**Solar Radiation:** Introduction to Irradiation Geometry and Various Related basic and Derived Angle, Direct Solar Radiation on a Surface, Diffuse Sky Radiation on a Surface, Heat Gain through Glass, Shading From Reveals, Overhangs and Fins, Effect of Shading Device **Heat Transfer through Building Structures:** Fabric Heat Gain, Overall Heat-Transmission Coefficient, Periodic Heat Transfer through Walls and Roofs, Methods to Evaluate Heat Transfer through Walls and Roofs, Natural Ventilation through Infiltration, Passive Heating and Cooling of Buildings.	**09L**
UNIT-03	**Load Calculations and Applied Psychrometrics:** Preliminary Considerations, Internal Heat Gains, System Heat Gains, Break-up of Ventilation Load and Effective Sensible Heat Factor, Cooling Load Estimate, Heating Load Estimate, Psychrometrc Calculations for Cooling, Selection of Air Conditioning Apparatus for Cooling and Dehumidification, Evaporative Cooling, Building Requirements and Energy Conservation in Air Conditioned Buildings.	**06L**
UNIT-04	**Design of Air Conditioning Apparatus:** Air Conditioning Apparatus, Heat and Moisture Transfer in Air Conditioning Apparatus, Coil Equipment-Design of Cooling and Dehumidifying Coils, Optimal Design of Cooling and Dehumidifying Coils, Spray Equipment-Design of Air washers and Cooling Towers	**06L**
UNIT-05	**Transmission and Distribution of Air:** Room Air Distribution, Total, Static and Velocity Pressures, Friction Loss in Ducts, Dynamic Losses in Ducts, Air Flow through a Simple Duct System, Air-Duct Design, Processing, Transmission and Distribution of Air in Clean Rooms, Air Locks, Air Curtains and Air Showers	**06L**

Course Outcomes

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

CO1: Understand the principle of comfort Physiology, IAQ and design conditions of the air conditioners
CO2: Understand the calculation of heat transfer through building structures
CO3: Calculate the cooling and heating load of the air conditioners
CO4: Design the dehumidifying coil, air washer and cooling tower

Books and References

1. Refrigeration and Air Conditioning by C.P. Arora, TMH Publication
2. Refrigeration and Air Conditioning by R.C. Arora, PHI Publication
3. Refrigeration & Air Conditioning by W.F. Stoecker, TMH Publication
4. Air Conditioning System Design by Roger Legg, Butterworth-Heinemann 2017
5. Handbook of air conditioning and Refrigeration by Shan K. Wang, Tata McGraw Hill.

Course Name: **Computer Aided Design**
Course Code: **ME-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **2L+2P** Course Credits: **03**

Course Objectives

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

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:**Introduction to CAD/CAM/CAE and Historical Developmentof CAD,Product Development Cycle,Typical CAD SystemArchitecture,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.	**03L**
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.	**06L**
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.	**03 L**
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.	**03 L**
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	**06 L**
UNIT-06	**Design Optimization:** Introduction, Gradient-based and Heuristic Methods, Johnson Method of Optimization Normal Specification Problem, Redundant Specification Problem,.	**03 L**

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.

Books and References

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: **Product Design and Development**
Course Code: **ME-371**
Course Type: **Open Elective- I**

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 in order to achieve a common objective

Unit Number	Course Content	Lectures
UNIT-01	**Introduction**: Introduction and Significance of Product Design, Product Design and Development Process, Sequential Engineering Design Method, Challenges of Product Development, Concept Development, Product Development and AMF Development Process, AMF Organizations.	**06L**
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.	**09L**
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.	**06L**
UNIT-04	**Embodiment Designand Detailed Design**: Design for Prototyping& Manufacturing, Robust Design, Design for Manufacturing, Detailed Drawings and Specifications, Life Cycle Assessment.	**09L**
UNIT-05	**Intellectual Property and Environmental Guidelines**: Elements and Outline, Patenting Procedures, Claim Procedure, Design for Environment: Impact, Regulations from Government ,ISO System.	**06L**

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 developmentprocesses.
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. Product Design: Creativity, Concepts and Usability by Prashant Kumar, PHI.
4. Making It: Manufacturing Techniques for Product Design by Chris Lefteri, McGraw-Hill Education.
5. Engineering Design, by George E. Dieter and Linda C. Schmidt, McGraw-Hill Education.

Course Name: **Mechatronics and Robotics**
Course Code: **ME- 380**
Course Type: **Open Elective-II**

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

Course Objectives

- To impart knowledge and use of mechatronic system and different types of sensors and actuators.
- To introduce the fundamentals of microprocessors, microcontrollers and PLCs and their architecture.
- To impart the knowledge of robotics, robotic programming and robot vision.

Unit Number	Course Content	Lectures
UNIT-01	**Fundamentals of Mechatronics:** Definition, Applications, Block Diagram of Mechatronic System, Functions of Mechatronics Systems, Benefits of Mechatronics in Manufacturing. Analog Devices, Signal Conditioning, Digital Electronics, Data Acquisition systems	**03L**
UNIT-02	**Sensors and Actuators:** Static characteristics of sensors and actuators, Position, Displacement and Proximity Sensors, Force and torque sensors, Pressure sensors, Flow sensors, Temperature sensors, Acceleration sensors, Level sensors, Light sensors, Smart material sensors, Micro and Nano sensors, Selection criteria for sensors, Actuators: Electrical Actuators (Solenoids, Relays, Diodes, Thyristors, Triacs, BJT, FET, DC motor, Servo motor, BLDC motor, AC motor, Stepper motors), Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.	**09L**
Unit-03	**Microprocessors, Microcontrollers and Programmable Logic Controllers:** Logic Concepts and Design, System Interfaces, Communication and Computer Networks, Fault Analysis in Mechatronic Systems, Synchronous and Asynchronous Sequential Systems, Microcontrollers, Programmable Logic Controllers (PLCs): Architecture, Basics of PLC Programming, Logics, Timers and Counters, PLC Applications	**09L**
UNIT-04	**Introduction of Robotics**: Definition of a robot, types of robotic joints and motions, classifications of robot based on: Physical configurations, actuators and motion control; Terminologies used for robotics specification and selection for industrial applications; Types of end effectors.	**03L**
UNIT-05	**Robot Kinematics and Dynamics:** Homogeneous co-ordinates and co-ordinate transformations, kinematic parameters, use of Denavit-Hartenberg representation for finding arm equation of robotic arms, forward and inverse kinematics for basic industrial robotic configurations, SCARA configurations, Basics of Robot Dynamics.	**06L**
UNIT-06	**Robot Vision and Programming:** Sensing and digitization of vision data, image processing: image data reduction, segmentation, feature extraction, object recognition, and training of vision system, Robot programing methods, Robot Programming Languages.	**06**

Course Outcomes

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

CO1: Generate conceptual design for mechatronics products based on potential customer requirements

CO2: Select appropriate sensors and actuators and devise a system for collecting information about processes

CO3: Demonstrate the concepts of kinetics & dynamics of robot, and Identify an application of robots in manufacturing.

Books and References

1. Mechatronics: Electronic control systems in Mechanical and Electrical Engineering by W. Bolton, Pearson Edu.
2. Introduction to Mechatronics & Measurement Systems by David G Alciatore and Michael B Histand, McGraw-Hill.
3. Industrial Robotics: Technology, Programming and Applications by M.P. Grover and N. G. Odrey, TMH Edu. India
4. Robotics: Control and Programming by J. Srinivas, Rao V. Dukkipati and K. Ramji, Alpha Science International.

Course Name: **Total Quality Management**
Course Code: **ME-381**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** 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 understand how to implement Quality Programs in an Organization
- To have exposure to challenges in Quality Improvement Programs

Unit Number	Course Content	Lectures
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.	**06L**
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.	**06L**
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.	**03L**
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.	**09L**
UNIT-05	**Quality Assurance** : 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, Bench Making in Quality Management.	**06L**
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.	**06L**

Course Outcomes

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

CO1: Identify the significance of quality in an organization

CO2: Describe how to manage quality improvement teams

CO3: Apply the tools of quality improvement programs in an organization

CO4: Assess the benefits of implementing TQM Program in an organization

Books and References

1. Total Quality Management by Dale H Bersterfilled, PHI Publication.
2. Total Quality Management by N.V.R Naidu, G. Rajendra, New Age international Publication.
3. Total Quality Management by L. Sugandhi and Samuel Anand, PHI Publication.
4. Total Quality Management by R.S Naagarazan, New Age International Publication.