ME- 501	**I.C. Engine**	**3L:1T: 2P (05 hrs)**	**Credits:04**

Course Objective's:

- To understand the operation of internal combustion engines.
- To perform theoretical calculations to obtain thermodynamic efficiencies and then assess operating losses.
- To calculate engine operating parameters.
- To understand the implications of a tradeoff between performance, efficiency, emissions.

Course Content:

Module 1 **(07 hrs)**

Introduction of IC Engine: Internal Combustion Engine: S.I. and C.I. engines of two and four stroke cycles, real cycle analysis of SI and CI engines, determination of engine dimensions, speed, fuel consumption, output, mean effective pressure, efficiency, factors effecting volumetric efficiency, heat balance, performance characteristics of SI and CI engines, cylinder arrangement, firing order, power balance for multi-cylinder engines.

Module 2 **(08 hrs)**

Combustion in SI engines: Flame development and propagation, Pressure-Crank Angle diagram, Stages of Combustion ignition lag, effect of air density, temperature, engine speed, turbulence and ignition timings, physical and chemical aspects, abnormal Combustion, effect of engine and fuel variables on abnormal combustion, pre-ignition, its causes and remedy, salient features of various type combustion chambers.

Module 3 **(07 hrs)**

Combustion in CI Engines: Various stages of combustion in CI Engines, delay period, diesel knock, knock inhibitors, salient features of various types of combustion chambers. Fuel injection in CI engine, Working Principle of fuel pump & fuel injectors, types of nozzles. Fuel injection in SI engine (MPFI, TBI, CRDI), Theory of carburetion, Solex Carburetor, simple problems on carburetion. Fuel metering in CI engines.

Module 4 **(07 hrs)**

Fuel & Combustion: Classification of IC Engine fuels, Desirable characteristics of SI & CI engine fuels, Rating of SI & CI engine fuels, Alternative fuels for SI and CI engine (liquid, gaseous, hydrogen, LPG, CNG, Biogas etc.), Air requirement, Analysis of combustion products, HHV and LHV of fuels. Actual and theoretical combustion process.

Module 5 **(07 hrs)**

Supercharging & Turbo charging: Methods of supercharging, & turbo charging effects of super charging and turbo charging. Engine Modifications for supercharging, supercharging of two stroke engines. microprocessor controlled supercharging. Cooling & Lubrication of SI & CI Engines.

Course Outcomes: Students will be able to

1. Discuss the knowledge of internal combustion engine components and fuel Air cycles, Actual and theoretical Cycle.
2. Evaluate the Normal and Abnormal combustion aspect of SI Engines.
3. Evaluate the Concept of Normal and Abnormal combustion aspect of CI Engines and design

of combustion chamber
4. Utilize the concept of carburetion and working of Auxiliary system ignition system, Lubrication system Fuel injector and nozzle.
5. Explain the method of supercharging and turbo charging and their Importance.

Text Book:

1. R.K. Rajput, Internal Combustion Engines, Laxmi Publication.
2. V. Ganeshan, Internal Combustion Engines, McGraw Hill Publication.
3. Mathur & Sharma internal combustion engines, Dhanpat rai & sons

References:

1. J.B. Heywood. Internal combustion Engines, Wiley
2. Ganeshan V; Internal Combustion engines; TMH
3. Mathur M L & Sharma RP; A. Course in IC engines; Dhanpat Rai
4. R Yadav, Internal Combustion Engines, Central Publishing House.
5. Halderman JD and Mitchell CD; Automotive Engines theory and servicing; Pearson
6. Dom Kundwar; Internal Combustion Engines; Dhanpat Rai Publications
7. Taylor GF; Internal Combustion Engines Theory & Practice; MIT Press
8. Richard Stone; Introduction to IC Engines; Society of Automotive Engineers (Palgrave Mc Millan)

List of Experiments:

1. To Study the construction details & working principal of 2-Stroke / 4- Stroke Petrol Engine.
2. To study the constructional details & working principles involved in a 2-Stroke & 4-Stroke Diesel Engines.
3. To Prepare Heat Balance Sheet for a Single Cylinder Two Stroke Petrol Engine Test Rig with Electrical Dynamometer.
4. To draw the heat balance sheet of a Four Stroke Single Cylinder Diesel Engine Test Rig.
5. To draw the heat balance sheet and conduct a performance test on the Four Stroke Single Cylinder petrol Engine.
6. To Study and Determine the effect of A/F Ratio on the performance of the Two-Stroke, Single-Cylinder Petrol Engine.
7. To study and draw the valve timings diagram Four-Stroke, Single-Cylinder Diesel Engine.
8. Study of the lubrication and cooling system in IC Engine.
9. Study of carburetor.
10. Study of ignition system.

ME-502	**Mechanical Vibrations**	**3L:1T: 2P (05 hrs)**	**Credits:04**

Course Content:

- Formulate mathematical models of problems in vibrations using Newton's second law or energy principles,
- Determine a complete solution to the modeled mechanical vibration problems.
- Correlate results from the mathematical model to physical characteristics of the actual system.

Course Content:

Module 1 **(08 Hrs)**

Fundamental Aspects of Vibrations: Vibration and its causes, advantages and disadvantages; engineering applications of vibration; vector method of representing harmonic motion; characteristics of vibration, harmonic analysis and beats phenomenon, work done by harmonic forces on harmonic motion; periodic non- harmonic functions- Fourier series analysis; evaluation of coefficients of Fourier series; elements of vibratory system; lumped and distributed parameter systems.

Undamped Free Vibrations: Derivation of differential equation of motion: Systems involving angular oscillations: the compound pendulum.

Module 2 **(08 Hrs)**

Damped Free Vibrations: Viscous damping: coefficient of damping; damping ratio; under damped, over damped and critically damped systems; logarithmic decrement; frequency of damped free vibration; Coulomb or dry friction damping; frequency, decay rate and comparison of viscous and Coulomb damping; solid and structural damping; slip or interfacial damping.

Module 3 **(10 Hrs)**

Harmonically excited Vibration: One degree of freedom- forced harmonic vibration; vector representation of forces; excitation due to rotating and reciprocating unbalance; vibration Isolation, force and motion transmissibility; absolute and relative motion of mass (Seismic Instruments).

Whirling Motion and Critical Speed : Definitions and significance. Critical speed of a vertical , light flexible shaft with single rotor : with and without damping . Critical speed of a shaft carrying multiple discs (without damping), Secondary critical speed.

Module 4 **(08 Hrs)**

Systems With Muti-Degrees of Freedom : Un-damped free vibration of 2 d.o.f and Principal modes of vibration; torsion vibrations; Forced, Un-damped vibrations with harmonic excitation ; Coordinate coupling; Dynamic vibration absorber; torsion Vibration Absorber; Pendulum type of dynamic vibration.

Module 5 **(06 Hrs)**

Noise Engineering: Frequency and sound dependent human response; the decibel scale; relationship between, sound pressure level (SPL), sound power level and sound intensity scale; relationship between addition, subtraction and averaging, sound spectra and Octave band analysis; loudness; weighting networks; equivalent sound level, auditory effects of noise; hazardous noise, exposure due to machines and equipments; hearing conservation and damage risk criteria, daily noise doze.

Noise Sources, Isolation and Control: Major sources of noise on road and in industries, noise due to construction equipments and domestic appliances, industrial noise control, strategies noise control at source (with or without sound enclosures), noise control along the path (with or without partitions and acoustic barriers); noise control at the receiver, ear defenders, earplugs, semi-insert protectors.

Course Outcomes: Students will be able to:

1. Find natural frequency of SDOF systems.
2. Categorise damped system as under damped or critically damped.
3. Deal with resonant condition.
4. Design and Solve real world applications with increased DOF.
5. Design acoustically better applications (Based on SPL, Decibel Scale, Human Comfort Level etc.)

Text Books:

1. Ambekar A.G.,' Mechanical Vibrations and Noise Engineering; PHI

Reference Books:

1. G.K. Grover, ' Mechanical Vibration , Nem chand and Bross , Roorkee
2. Thomson , W.T., Theory of Vibration with Applications , C.B.S Pub & distributors .

List of Experiment:

1. To verify the relation of Simple Pendulum.
2. To study the longitudinal vibration of helical spring and to determine the frequency and time period of oscillation theoretically and actually by experiment.
3. To find natural frequencies of an single degree of freedom system from its response to an initial displacement.
4. To determine the radius of gyration ' K' of a given Compound Pendulum.
5. To determine the MI of a bar by using Tri-Filer suspension.
6. To determine the Damping Coefficient of Damped Torsional Oscillator.
7. To find out the excitation frequency of continuous system.

ME-503 (A)	**Mechatronics**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

- Be able to model and analyze electrical and mechanical systems and their interconnection.
- To develop an ability to design a system, component, or process to meet desired needs within realistic constraints. mechatronics systems. Be proficient in the programming of microcontrollers.

Course Content:

Module 1 **(08 Hrs)**

Introduction: Definition of Mechatronics, Multi-disciplinary scenario, origins. Evaluation of Mechatronics, An over view of mechatronics, Design of mechatronics system. Measurements system and function of main elements of measurement systems. Need for mechatronics in industries. Objectives, advantages and disadvantages of mechatronics. Microprocessor based controllers. Principle and working of engine management system, automatic washing machine.

Module 2 **(09 Hrs)**

Review of Transducers and Sensors: Definition and classification of transducers. Definition and classification of sensors. Principle of working and applications of light sensors, proximity sensors and Hall effect sensors. **Microprocessor**: Introduction, Microprocessor based digital control. Digital member system, binary and hexadecimal number system, Logic functions, Data word representation, basic Elements of control systems.

Module 3 **(07 Hrs)**

Microprocessor Architecture: 8085A processor architecture Terminology-such as, CPU, memory and address, ALU, assembler, data, registers, Fetch cycle, write cycle, state, bus interrupts. Micro controllers – difference between microprocessor and micro controllers. Requirements for control and their implementation in micro controllers. Classification of micro controllers.

Module 4 **(10 Hrs)**

Electrical Actuators: Actuator and actuator system. Classifications of actuator system with examples. Mechanical switches. Concept of bouncing Methods of Preventing bouncing of mechanical switches. Solenoids, Relays. Solid state switches – Diodes, Thyristors, Transistors. Electrical actuator, Principle, construction and working of AC, DC motors, stepper motors, permanent motors, servomotors, Servo systems and control

Hydraulic Actuators: Valves – Classifications, Pressure Control Valves – Pressure relief valves, Pressure regulating/reducing valves, Pressure sequence valve. Flow control valves – Principle, needle valve, globe valve. Direction control valve –sliding spool valve, solenoid operated.

Module 5 **(07 Hrs)**

Signal Conditioning: Concept, necessity, op-amps, protection, filtering, wheat stone bridge – Digital Signals – Multiplexer. Data acquisition – Introduction to digital signal processing – Concepts and different methods.

Course Outcomes: Students will be able to

1. Explain the design of Mechatronics system and its applications.
2. Identify appropriate sensors and transducers for an engineering application.

3. Acquire knowledge about microprocessor architecture and classify the micro-controller.
4. Interpret different types of actuator and actuator system.
5. Explain the concept of digital signals and elements of data acquisition.

Text Books:

1. R. K Rajput, "Mechatronics," Laxmi Publications

Reference Books:

1. Mechatronics – Principles, Concepts and applications – Nitaigour and Premchand, Mahilik – Tata McGraw Hill -2003
2. Mechatronics – W. Bolton, Pearson Education Asia -3rd Edition
3. Introduction to mechatronics and measurement systems –David G. Alciatore & Michel BiHistand – Tata McGraw Hill –2000
4. Mechatronics – H.D. Ramachandra – Sudha Publication -2003 Mechatronics by HMT Ltd. – Tata McGrawHill -2000.
5. Mechatronics System design by Devadas Shetty and Richard A. Kark – Thomas Learining - 1997.
6. Mechatronics an Introduction by Robert H Bishop – CRC
7 Mechatronics systems Fundamentals by Rolf Isermann - Springer

ME-503 (B)	**Dynamics of Machine**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
To equip the student with fundamental knowledge of dynamics of machines so that student can appreciate problems of dynamic force balance, transmissibility of forces, isolation of systems, vibrations. Develop understanding of dynamic balancing, flywheel analysis, gyroscopic forces and moments. .

Course Content:

Module 1 **(09 Hrs)**

Dynamics of Engine Mechanisms: Displacement, velocity and acceleration of piston; turning moment on crankshaft, turning moment diagram; fluctuation of crankshaft speed, analysis of flywheel and Punching Press.

Module 2 **(07 Hrs)**

Governor Mechanisms: Types of governors, characteristics of centrifugal governors, gravity and spring controlled centrifugal governors, hunting of centrifugal governors, inertia governors.

Module 3 **(11 Hrs)**

Balancing of Inertia Forces and Moments in Machines: Balancing of rotating masses, two plane balancing, determination of balancing masses (graphical and analytical methods), balancing of rotors, balancing of internal combustion engines (single cylinder engines, in-line engines, V-twin engines, radial engines, Lanchester technique of engine balancing.

Module 4 **(07 Hrs)**

Friction: Frictional torque in pivots and collars by uniform pressure and uniform wear rate criteria. Boundary and fluid film lubrication, friction in journal and thrust bearings, concept of friction circle and axis, rolling friction.

Module 5 **(08 Hrs)**

Brakes: Band brake, block brakes, Internal and external shoe brakes, braking of vehicles. Dynamometer: Different types and their applications.

Dynamic Analysis of Cams: Response of un-damped cam mechanism (analytical method), follower response analysis by phase-plane method, jump and cross-over shock.

Course Outcomes: Students will be able to

1. Apply an understanding of analytical and graphical approach to engineering problems of turning moment.
2. Understanding the theoretical and practical concepts behind working of Governors and their application for various functions.
3. Analyzing the balancing of rotating masses that can be used in different machineries.
4. Understanding the working principle of pivots and frictional behavior of these pivots and collars.
5. Understand about different brakes and also function of different dynamometer.

Text Books:

1. Ambekar, AG; Mechanism and Machine Theory; PHI
2. Rattan SS; Theory of machines; TMH

3. Sharma and Purohit; Design of Machine elements; PHI
4. Bevan; Theory of Machines.

Reference Books:

1. Ghosh and Mallik; Theory of Mechanisms and Machines; Affiliated East-West Press, Delhi
2. Norton RL; kinematics and dynamics of machinery; TMH
3.Grover; Mechanical Vibrations
4. Balaney; Theory of Machines by
5.Theory of Vibrations by Thomson

IPS Academy, Institute of Engineering & Science

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Mechanical Engineering

ME-503 (C)	**Alternate Automotive Fuels & Emissions**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

- To present a problem oriented in depth knowledge of Alternate fuel and energy system.
- To address the underlying concepts and methods behind alternate fuel and energy system.

Course Content:

Module 1 **(08 hrs)**

Introduction Automobile Fuels: Classification of Automobile alternative fuels(liquid, gaseous, hydrogen, LPG, CNG, Biogas etc.), Desirable characteristics of SI & CI engine alternative fuels, Rating of SI & CI engine fuels, Introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars. merits and demerits of various alternate fuels.

Module 2 **(08 hrs)**

Liquid alternative fuels: Vegetable Oils: Various vegetable oils for automobile engines, esterification, performance in engines, performance and emission characteristics, bio diesel and its characteristics. Alcohols: Properties as engine fuel, alcohols and gasoline blends, performance in automobile engine, methanol and gasoline blends.

Module 3 **(07 hrs)**

Gaseous Fuels: Biogas: Introduction to Biogas system, Process during gas formation, Factors affecting biogas formation. Usage of Biogas in SI engine & CI engine., Properties of Natural gas, Hydrogen gas, LPG & CNG as engine fuels, storage and handling, performance and safety aspects to all gaseous fuel, fuel metering systems.

Module 4 **(09 hrs)**

Automobile emissions: Types of automobile emissions, emission characteristics, formation of automobile emissions, mechanism of HC , CO and NO in SI engine, exhaust emission and factors affecting the emission, evaporative emission, crankcase emission, lead emission CI engine emissions: formation of smoke, factors affecting the smoke formation, unburned hydrocarbons, carbon monoxide, oxides of nitrogen, smog and comparison of diesel and petrol emissions.

Module 5 **(08 hrs)**

Emissions Norms & Measurement: Emission norms as per Bharat Standard up to BS – IV and procedures for confirmation on production. Demerits of automobile emission to environment. Types Of Catalytic Conversion, Measurement Techniques Emission Standards and Test Procedure NDIR,FID, Chemiluminescent analyzers, Gas Chromatograph, smoke meters, emission standards.

Course Outcome's: Students will be able to

1. Classify the different types of fuel and their ratings.
2. Understand the properties of bio fuels and their properties
3. Identify the properties of gaseous fuels.
4. Compare the SI and CI Engine Emissions and their calculation.
5. Explain the concept of BS IV and Emission test Procedure.

Text Books:

1. Dom Kundwar; Internal Combustion Engines; Dhanpat Rai Publications

2. R Yadav, Internal Combustion Engines.

References Books:

1. J.B. Heywood. Internal combustion Engines, Wiley
2. Ganeshan V; Internal Combustion engines; TMH
3. Mathur M L & Sharma RP; A. Course in IC engines; DhanpatRai
4. Halderman JD and Mitchell CD; Automotive Engines theory and servicing; Pearson
5. Taylor GF; Internal Combustion Engines Theory & Practice; MIT Press
6. Richard Stone; Introduction to IC Engines; Society of Automotive Engr (Palgrave Mc Millan)

ME 504 (A)	Industrial Engineering & Ergonomics	3L: 1T: 0P (4 hrs.)	4 Credits

Course Objectives:

To provide basic understanding to the students about the concept and significance of work study and ergonomics. To impart thorough knowledge to the students about various techniques of work-study for improving the productivity of an organisation. To inculcate the skill among the students for analysing and improving existing methods of working on the shop floor of an organisation. To impart through knowledge and skills to students with respect to allowances, rating, calculation of basic and standard time for manual operations in an organization.

Module 1 **(10 Hrs)**

Method Study : Purpose of work study, its objectives, procedure and applications; method study definition and basic procedure, selection of job, various recording techniques like outline process charts, flow process charts, man machine charts, two handed process charts, string diagram, flow diagram, multiple activity chart, simo, cyclographs and chrono-cyclographs; critical examination, development, installation and maintenance of improved method; principles of motion economy and their application in work design; micro motion study, memo motion study and their use in methods study.

Module 2 **(10 Hrs)**

Work Measurement Technique: Introduction & definition, objectives and basic procedure of work measurement; application of work measurement in industries; time study: basic procedure, equipments needed, methods of measuring time, selection of jobs, breaking a job into elements; numbers of cycles to be timed; rating and methods of rating, allowances, calculation of standard time. Work sampling**:** Basic procedure, design of work sampling study conducting work sampling study and establishment of standard-time. Methods Time Measurement (MTM)

Module 3 **(08 Hrs)**

Job Evaluation and Merit Rating: Purpose, Various types of jobs evaluation system and their application of classification. Wage Cure, Designing salary structure and Grade, Merit Rating, Performance Appraisal.

Standard data system**;** elemental and non-elemental predetermined motion systems, work factors system;

Module 4 **(08 Hrs)**

Wage Incentives: Various types of wage Incentive schemes and their impact on productivity, Comparison of different incentive plans, design of incentive plans, Group system of Wage payment, Supervisory incentive plans. Starlight line, Tailor, Merrick and Gantt incentive plans.

Module 5 **(10 Hrs)**

Human Factor Engineering: Definition and history of development of human factors engineering, types & characteristics of man-machine-system, relative capabilities of human being and machines; development and use of human factor data; information input and processing: Introduction to information theory; factors effecting information reception and processing; coding and selecting of sensory inputs.

Course Outcomes:

After completion of the course student will be able to:

1. Understand the various work study techniques for productivity improvement
2. Understand the basic concepts of work measurement technique
3. Understand the various Job Evaluation techniques
4. Realization of the significance of wage Incentive schemes and their impact on productivity
5. Explain human factor engineering and its application.

Text Books:

1. ILO; work-study; International Labour Organization ,1992
2. Khan MI; Industrial Ergonomics; PHI Learning 1St 2010.
3. John R. Wilson, Evaluation of Human Work, 3rd Edition , NIGEL CORLETT – 2005.
4. M.I. Khan ,Industrial Engineering, New Age International (P) Limited, 2007.
5. Kumar Pravin,Industrial Engineering and Management, Pearson India, 2015.

Reference Books :

1. Sandera M and Mc Cormick E; Human Factors in Engg and design; MGHill,1993
2. Currie RM; Work study; BIM publications, 1964.
3. Mynard; Hand book of Industrial Engg, McGraw-Hill Education, 05-Jun-2001

ME- 504 (B)	**TQM and SQC**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objectives:
This Course is to introduce the applications to formulate new plans/procedures to be implemented to achieve the desired quality status by knowing about the various principles of quality management

Course Content:

Module 1 **(08 Hrs)**

Total Quality Management: Historical perspective, teamwork, TQM and ISO 9000; information technology and Business Process Re-engineering (BPR); TPM and quality awards; aids and barriers to quality mgt, creating vision and initiating transformation, establishing programs for education and self coordination, policy setting and review, flowchart of policy mgt and relation with daily mgt. improvements, measurement of key indicators; quality mgt leader; cross functional teams and coordination, policy setting and review, flowchart of policy mgt and relation with daily mgt.

Module 2 **(10 Hrs)**

TQM Process: Definition, variation and feedback, funnel-marble experiment- rules of adjustment and its effects, quality- definition, goalpost and kaizen view, quality of design, conformance and performance; Taguchi loss function, cost of quality, chain action of improving quality to productivity to motivation and low cost; Deming's theory of mgt, fourteen points and variance reduction; attributes enumerative and variables analytic studies.

Module 3 **(10 Hrs)**

Statistical Quality Control: Control charts**:** basic discrete and continuous distributions, measures of central tendency, variability and shapes, sampling, size and central value theorem, control chart structure, process plotting and stability, study of out-of-control evidences, defect detection and prevention, use of control charts in evaluating past, present and future trends; attribute control charts, count and classification charts, construction and interpretation of p , np , c and u charts, PDSA cycle(plan, do, study, act), and R charts, and s charts, individual and moving range chart, trial control limits and out of control points.

Module 4 **(08 Hrs)**

Process Diagnostics: Between and Within Group variations, periodic and persistent disturbances, control chart patterns-natural, level-shift, cycle, wild, multi-universe, relationship and other out of control patterns; diagnosing a process, brainstorming; cause-effect, Ishikava, interrelationship, systematic and matrix diagrams; change concepts and waste elimination.

Module 5 **(10 Hrs)**

Process Improvement: Performance and technical specifications, attribute-process and variable-process capability studies; unstable and stable process capability studies and examples; attribute and variable improvement studies; Inspection: acceptance sampling(AS)- lot formation, single, double and multiple/sequential sampling plans, operating characteristic (OC) curve, producer and consumer risk, theoretical invalidation of AS, kp rule for stable and chaotic processes.

Course Outcomes: Students will be able to:
1. Get knowledge about history and evolution of TQM.
2. Have knowledge about TQM Process.

3. Understanding the concept of Statistical Quality Control.
4. Understanding the concept of Process Diagnostics in SQC
5. Understanding the concept of Process Improvement in SQC

Text books:

1. Gitlow HS, Oppenheim et al; Quality Management; TMH
2. Gryna FM; Juran's Quality Planning and Analysis; TMH
3. Kulkarni VA and Bewoor AK; Quality Control; Wiley
4. Subburaj R; Total Qality Management; TMH
5. Barsterfield, "Total Quality Management", Pearson Publication

Reference Books:

1. Crosby Philips; Quality is still free; New Amer Library
2 . Jankiraman B and Gopal RK; Total Quality Management- Text and Cases; PHI Learning
3 . Sugandhi L and Samual A; Total Quality Management; PHI Learning

ME- 504 (C)	**Finite Element Method**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
To provide the fundamental concepts of the theory of the finite element method.

Course Content:

Module 1 **(08 Hrs)**

Introduction: Structural analysis, objectives, static, Dynamic and kinematics analyses, Skeletal and continuum structures, Modeling of infinite d.o.f. system into finite d.o.f. system, Basic steps in finite element problem formulation, General applicability of the method.

Module 2 **(08 Hrs)**

Element Types and Characteristics: Discretization of the domain, Basic element shapes, Aspect ratio, Shape functions, Generalized co-ordinates and nodal shape functions. ID spar and beam elements, 2D rectangular and triangular elements, Axisymmetirc elements.

Module 3 **(08 Hrs)**

Assembly of Elements and Matrices: Concept of element assembly, Global and local co-ordinate systems, Band width and its effects, Banded and skyline assembly, Boundary conditions, Solution of simultaneous equations, Gaussian elimination and Choleksy decomposition methods, Numerical integration, One and 2D applications.

Module 4 **(08 Hrs)**

Higher Order and Isoparametric Elements: One dimensional quadratic and cubic elements, Use of natural co-ordinate system, Area co-ordinate system continuity and convergence requirements, 2D rectangular and triangular requirement.

Module 5 **(08 Hrs)**

Static & Dynamic Analysis: Analysis of trusses and frames, Analysis of machine subassemblies, Use commercial software packages, Advantages and limitations Hamilton's principle, Derivation of equilibrium, Consistent and lumped mass matrices, Derivation of mass matrices for ID elements, Determination of natural frequencies and mode shapes, Use of commercial software packages.

Course Outcomes: Students will be able to:

1. Obtain an understanding of the fundamental theory of the FEA method.
2. Develop a basic understanding of the Different element types and shapes.
3. Develop the concept of element assembly and matrices.
4. Create models of quadratic and cubic elements.
5. Demonstrate the ability to create models for trusses, frames, plate structures, machine parts, and components using ANSYS general-purpose software.

References:

1. Rao, S.S., The Finite Element Method in Engineering, 2nd ed.., Peragamon Press, Oxford.
2. Robert, D. Cook., David, S. Malkins, and Michael E. Plesha, Concepts and Application of Finite Element Analysis 3rd ed., John Wiley.

3. Chandrupatla, T.R. an Belegundu, A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India Pvt. Ltd.
4. Zienkiewicz O C, The Finite Element Method, 3rd ed, Tata McGraw Hill.

ME- 505	**FEM/CFD Lab**	**0L:0T: 2P (04 hrs)**	**Credits:02**

List of Experiments (Please Expand it)

1. To study fundamentals of Computational Fluid Dynamics (CFD).
2. To perform CFD analysis of lid driven cavity in Open-Foam.
3. To perform CFD analysis of square tube in Open-Foam.
4. To perform CFD analysis of a 2D-plate in Open-Foam.
5. To perform CFD analysis of bifurcated blood vessel in FEM.
6. To study fundamentals of Finite element method and FEA.
7. To perform FEM analysis of deep drawing process in FEM.
8. To study fundamentals of Sci-Lab.
9. To perform matrix operations in Sci-lab
10. To plot 2D & 3D graphs in Sci-lab.

Course Outcomes: Students will be able to

1. Define fundamentals of Computational Fluid Dynamics and Finite Element methods.
2. Knowledge about Analytical, Experimental and Numerical methods for problem solving.
3. To perform CFD analysis in FEM.
4. Define fundamentals of Sci-lab.
5. Solve various problems on 2D & 3D graphs in Sci-lab.

References:

1. Versteeg H; An introduction to Computational Fluid Dynamics (The Finite Volume Method);Pearson
2. Jiyuan Tu; Computational Fluid Dynamics: A Practical Approach; ButterworthHeinemann.
3. Gokhale NS; Practical Finite Element Analysis; Finite to Infinite 4. Seshu P; Finite element analysis; PHI.
5. Reddy JN; Introduction to the Finite Element Method;McGraw Hill Inc.
6. Das VV; Programming in Scilab 4.1; New Age International Publishers.
7. Verma A K; Scilab : A Beginner's Approach; Cengage publishers.

ME- 506	Python	0L:0T: 2P (04 hrs)	Credits:02

List of Experiments (Please Expand it):

1. To write a Python program to find GCD of two numbers.
2. To write a Python Program to find the square root of a number by Newton's Method.
3. To write a Python program to find the exponentiation of a number.
4. To write a Python Program to find the maximum from a list of numbers.
5. To write a Python Program to perform Linear Search
6. To write a Python Program to perform binary search.
7. To write a Python Program to perform selection sort.
8. To write a Python Program to perform insertion sort.
9. To write a Python Program to perform Merge sort.
10. To write a Python program to find first n prime numbers.
11. To write a Python program to multiply matrices.
12. To write a Python program for command line arguments.
13. To write a Python program to find the most frequent words in a text read from a file.
14. To write a Python program to simulate elliptical orbits in Pygame.
15. To write a Python program to bouncing ball in Pygame.

Course Outcomes: Students will be able to:

1. Describe about simple computational problems using Python programs.
2. Use of Python lists, tuples and dictionaries for representing compound data.
3. Solve problems using conditionals and loops in Python.
4. Explain about Object oriented programming and uses of exception Handling.
5. Describe Python programs using files.

References:

1. Timothy A. Budd: Exploring python, McGraw-Hill Education.
2. R.Nageshwar Rao ,"Python Programming" ,Wiley India
3. Allen B. Downey; Think Python, O'Reilly Media, Inc.

ME- 601	Thermal Engineering & Gas Dynamics	3L:1T: 2P (05 hrs)	Credits:04

Course Objective's:

How to use fundamental principles of fluid mechanics to solve thermal problem. How to use basic principles of thermodynamics to solve thermal problem. How to use basic principles of heat transfer to solve thermal problem. How to use basic principles of mass transfer to solve thermal problem.

Course Content:

Module 1 **(07 hrs)**

Steam generators and boilers: Classification, conventional boilers, high-pressure boilers-Lamont, Benson, Loeffler and Velox steam generators, performance and rating of boilers, equivalent evaporation, boiler efficiency, heat balance sheet, combustion in boilers, super critical boilers, fuel and ash handling, boiler draught, overview of boiler codes.

Module 2 **(08 hrs)**

Vapour Cycles Phase Change Cycles: Vapor Carnot cycle and its limitation, Rankin cycle, effect of boiler and Condenser pressure and superheat on end moisture and efficiency of ranking cycle, modified Rankin cycle, reheat cycle, perfect regenerative cycle, Ideal and actual regenerative cycle with single and multiple heaters, open and closed type of feed water heaters, regenerative-reheat cycle, supercritical pressure and binary-vapor cycle, work done and efficiency calculations.

Module 3 **(07 hrs)**

Gas Dynamics: Speed of sound, in a fluid mach number, mach cone, stagnation properties, one dimensional isentropic flow of ideal gases through variable area duct-mach number variation, area ratio as a function of mach number, mass flow rate and critical pressure ratio, effect of friction, velocity coefficient, coefficient of discharge, diffusers, normal shock.

Module 4 **(08 hrs)**

Air Compressors: Working of reciprocating compressor, work input for single stage compression different, compression processes, effect of clearance, volumetric efficiency real indicator diagram, isentropic & isothermal and mechanical efficiency, multi stage compression, inter - cooling, condition for minimum work done, classification and working of rotary compressors.

Module 5 **(07 hrs)**

Nozzles and Condensers: Steam nozzles: isentropic flow of vapors, flow of steam through nozzles, condition for maximum discharge, effect of friction, super-saturated flow. Steam condensers, cooling towers: introduction, types of condensers, back pressure and its effect on plant performance air leakage and its effect on performance of condensers, various types of cooling towers.

Course Outcomes: Students are able to

1. Demonstrate the knowledge of operating characteristics of steam generator and their working performance.
2. Recognize the Rankine cycles and their types on pressure - volume and Temperature – Entropy diagram and evaluate their efficiencies.

3. Utilize the concepts of compressible fluid flow, Mach number and Gas Dynamics.
4. Explain the working of various types of air Compressors and evaluate their performance.
5. Evaluate and Compare the Performance of steam condenser and Steam nozzles.

Text Books:

1. Mahesh M Rathore; Thermal Engineering; TMH
2. Nag PK; Basic and applied Thermo-dynamics; TMH
3. Nag PK; Power plant Engineering; TMH
4. R.Yadav Thermal Engg.
5. Kadambi & Manohar; An Introduction to Energy Conversion – Vol II. Energy conversion cycles

Reference Books:

1. Thermodynamics, Yunus A Cengels & Boles, TMH
2. Fundamentals of Thermodynamics, Richards E Sonntag, Willey

List of Experiments:

1. Study of boiler draught and their classification.
2. Study of Subcritical boiler with demonstrate model.
3. Study of Supercritical boiler with demonstrate model.
4. Numerical Problem Based on Heat balance sheet for a Boiler.
5. To Determine the Volumetric efficiency of a single acting, double stage reciprocating air compressor.
6. To Determine the Nozzle coefficient of the given Nozzle meter.
7. To Determination of efficiency of condenser.
8. Numerical Problem Based on Steam Power Plant (Rankine Cycle).
9. Determination of airflow in duct and pipes.
10. Industrial Visit of Thermal power plant.

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Mechanical Engineering

ME-602	**Machine Component and Design**	**3L:1T: 2P (05 hrs)**	**Credits:04**

Course Objective's:
To teach students how to apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.
To illustrate to students the variety of mechanical components available and emphasize the need to continue learning.

Course Content:

Module 1 **(10 Hrs)**

Introduction to stress in machine component: Stress concentration and fatigue: causes of stress concentration; stress concentration in tension, bending and torsion; reduction of stress concentration, theoretical stress concentration factor, notch sensitivity, fatigue stress concentration factor, cyclic loading, endurance limit, S-N Curve, loading factor, size factor, surface factor. Design consideration for fatigue, Goodman and modified Goodman's diagram, Soderberg equation, Gerber parabola, design for finite life, cumulative fatigue damage factor. .

Module 2 **(10 Hrs)**

Shafts: Design of shaft under combined bending, twisting and axial loading; shock and fatigue factors, design for rigidity; Design of shaft subjected to dynamic load; Design of keys and shaft couplings

Module 3 **(12 Hrs)**

Springs: Design of helical compression and tension springs, consideration of dimensional and functional constraints, leaf springs and torsion springs; fatigue loading of springs, surge in spring; special springs, Power Screws: design of power screw and power nut, differential and compound screw, design of simple screw jack.

Module 4 **(08 Hrs)**

Clutches: Materials for friction surface, uniform pressure and uniform wear theories, Design of friction clutches: Disk, plate clutches, cone & centrifugal clutches.

Module 5 **(12 Hrs)**

Journal Bearing: Types of lubrication, viscosity, hydrodynamic theory, design factors, temperature and viscosity considerations, Reynold's equation, stable and unstable operation, heat dissipation and thermal equilibrium, boundary lubrication, dimensionless numbers, Design of journal bearings, Rolling-element Bearings: Types of rolling contact bearing, bearing friction and power loss, bearing life; Radial, thrust & axial loads; Static & dynamic load capacities; Selection of ball and roller bearings; lubrication and sealing.

Course Outcomes: Students will be able to

1. Understand component behavior subjected to loads and identify the failure criteria.
2. Understand the basic concept of shaft.
3. Designs of springs subjected to loads and identify the failure criteria.
4. Understand the basic concepts of Clutches and their design.
5. Design of Journal Bearing with their life.

Text Books:

1. Khurmi: Machine Design, S.Chand Publication
2. Dr Sadhu Singh: Design of Machine Element

Reference Books:

1. Shingley J.E; Machine Design; TMH
2. Sharma and Purohit; Design of Machine elements; PHI
3. Wentzell Timothy H; Machine Design; Cengage learning
4. Mubeen; Machine Design; Khanna Publisher
5. Ganesh Babu K and Srithar k; Design of Machine Elements; TMH
6. Sharma & Agrawal; Machine Design; Kataria & sons
7. Maleev; Machine Design;

List of Experiment:

1. Design considerations for fatigue.
2. Design criteria and procedure for springs.
3. Design of shaft.
4. Design of keys.
5. Design of couplings.
6. Design of leaf spring for a given load.
7. Design of power screw and nut.
8. Design of Centrifugal clutch.
9. Design of disc brake.
10. Design considerations for roller bearings.

ME-603 (A)	**Turbo Machinery**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
Basic design of Centrifugal pumps, Pelton-, Francis-, Kaplan- and gas-turbines. - Flow conditions and geometrical description of the main components in Centrifugal pumps, Pelton-, Francis-, Kaplan- and gas-turbines.

Course Content:

Module 1 **(08 Hrs)**

Energy Transfer in Turbo Machines: Application of first and second laws of thermodynamics to turbo machines, moment of momentum equation and Euler turbine equation, principles of impulse and reaction machines, degree of reaction, energy equation for relative velocities, one dimensional analysis only.

Module 2 **(10 Hrs)**

Steam Turbines: Impulse staging, velocity and pressure compounding, utilization factor, analysis for optimum U.F Curtis stage, and Rateau stage, include qualitative analysis, effect of blade and nozzle losses on vane efficiency, stage efficiency, analysis for optimum efficiency, mass flow and blade height. Reactions staging: Parson's stages, degree of reaction, nozzle efficiency, velocity coefficient, stator efficiency, carry over efficiency, stage efficiency, vane efficiency, conditions for optimum efficiency, speed ratio, axial thrust, reheat factor in turbines, problem of radial equilibrium, free and forced vortex types of flow, flow with constant reaction, governing and performance characteristics of steam turbines.

Module 3 **(10 Hrs)**

Water Turbines: Classification, Pelton, Francis and Kaplan turbines, vector diagrams and work-done, draft tubes, governing of water turbines. Centrifugal Pumps: classification, advantage over reciprocating type, definition of mano-metric head, gross head, static head, vector diagram and work done. Performance and characteristics: Application of dimensional analysis and similarity to water turbines and centrifugal pumps, unit and specific quantities, selection of machines, Hydraulic, volumetric, mechanical and overall efficiencies, Main and operating characteristics of the machines, cavitations.

Module 4 **(08 Hrs)**

Rotary Fans, Blowers and Compressors: Classification based on pressure rise, centrifugal and axial flow machines. Centrifugal Blowers Vane shape, velocity triangle, degree of reactions, slip coefficient, size and speed of machine, vane shape and stresses, efficiency, characteristics, fan laws and characteristics. Centrifugal Compressor – Vector diagrams, work done, temp and pressure ratio, slip factor, work input factor, pressure coefficient, Dimensions of inlet eye, impeller and diffuser. Axial flow Compressors- Vector diagrams, work done factor, temp and pressure ratio, degree of reaction, Dimensional Analysis, Characteristics, surging, Polytrophic and isentropic efficiencies.

Module 5 **(08 Hrs)**

Power Transmitting Turbo Machines: Application and general theory, their torque ratio, speed ratio, slip and efficiency, velocity diagrams, fluid coupling and Torque converter, characteristics, Positive displacement machines and turbo machines, their distinction. Positive displacement

pumps with fixed and variable displacements, Hydrostatic systems hydraulic intensifier, accumulator, press and crane.

Course Outcomes: Students will be able to
1. Apply law of thermodynamics in Turbo Machinery.
2. Explain the working principle of steam turbine and their application in power plants.
3. Design different hydro turbines and centrifugal pumps and discuss thier performance reliability.
4. Evaluate the performance of different air compressors
5. Discuss working principle of various power transmitting turbo machines and their practical

References:
1. Venkanna BK; turbomachinery; PHI
2. Shepherd DG; Turbo machinery
3. Csanady; Turbo machines
4. Bansal R. K; Fluid Mechanics & Fluid Machines;
5. Rogers Cohen & Sarvan Multo Gas Turbine Theory
6. Kearton W. J; Steam Turbine: Theory &Practice

ME-603 (B)	**Computer Aided Engineering**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
The CAE course is a continuation of the computer design thread begun in ME-102 (Engineering Graphics) and ME-212 (Intro. to Solids Modeling.) The objective of the course is to enhance and fine tune the skills developed in the previous courses through the use of specific projects and open-ended problems. A student successfully completing this course will be able to: develop a sophisticated solid assembly of components, design open part models using surface generation tools, animate assemblies to determine clearances, interference and tolerances, generate free and mapped meshes for the analysis by finite elements, and other design techniques determined by the class composition.

Course Content:

Module 1 **(08 Hrs)**

Introduction to Computer Engineering Methods to solve engineering problems: analytical, numerical, experimental, their merits and comparison, discretization into smaller elements and effect of size/ shape on accuracy, importance of meshing, boundary conditions, Computer Aided Engineering (CAE) and design, chain-bumping-stages v/s concurrent-collaborative design cycles, computer as enabler for concurrent design and Finite Element Method (FEM), degree of freedom (DOF), mechanical systems with mass, damper and spring, stiffness constant K for tensile, bending and torsion; Practical applications of FEA in new design, optimization/ cost-cutting and failure analysis.

Module 2 **(08 Hrs)**

Types of Analysis: Types of analysis in CAE, static (linear/ non linear), dynamic, buckling, thermal, fatigue, crash NVH and CFD, review of normal, shear, torsion, stress-strain; types of forces and moments, tri-axial stresses, moment of inertia, how to do meshing, 1-2-3-d elements and length of elements; force stiffness and displacement matrix, RayleighRitz and Galerkin FEM; analytical and FEM solution for single rod element and two rod assembly.

Module 3 **(08 Hrs)**

2 D- Meshing: Two-dimension meshing and elements for sheet work and thin shells, effect of mesh density and biasing in critical region, comparison between tria and quad elements, quality checks, jacobian, distortion, stretch, free edge, duplicate node and shell normal.

Module 4 **(08 Hrs)**

3 D-Meshing: Three-dimension meshing and elements, only 3 DOF, algorithm for tria to tetra conversion, floating and fixed trias, quality checks for tetra meshing, brick meshing and quality checks, special elements and techniques, introduction to weld, bolt, bearing and shrink fit simulations, CAE and test data correlations, post processing techniques/.

Module 5 **(08 Hrs)**

Optimization: Review of linear optimization, process and product optimization, design for manufacturing (DFM) aspects in product development, use of morphing technique in FEA, classical design for infinite life and design for warranty life, warranty yard meetings and functional roles, climatic conditions and design abuses, case studies.

Course Outcomes: Students will be able to

1. Know about Analytical, Experimental and Numerical methods for problem solving.
2. Learn about different type of Finite Element Analysis.
3. Learn about one dimensional element (rod, bar), two dimensional elements (3 noded Tria, 4 noded Quad) and meshing.
4. Understand three dimensional elements (Tetra, Hexa, Brick) and meshing.
5. Develop idea about optimization.

References:

1. Gokhle Nitin; et al; Practical Finite Element Analysis; Finite to Infinite, 686 Budhwar Peth, Pune. 2. Krishnamoorthy; Finite Element Analysis, theory and programming; TMH
3. Buchanan; Finite Element Analysis; Schaum series; TMH
4. Seshu P; Textbook of Finite Element Analysis; PHI.
5. Desai Chandrakant S et al; Introduction to finite element Method .

ME-603 (C)	**Product Design**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
Confidence in your own abilities to create a new product. Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production). Ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective.

Course Content:

Module 1 **(07 Hrs)**
Introduction to product design: Product life-cycle, product policy of an organization. Selection of a profitable product, Product design process, Product analysis.

Module 2 **(08 Hrs)**
Value engineering in product design: Advantages, applications in product design, problem identification and selection, Analysis of functions, Anatomy of function. Primary versus secondary versus tertiary/unnecessary functions, functional analysis: Functional Analysis System Technique (FAST), Case studies.

Module 3 **(06 Hrs)**
Introduction to Product design tools: QFD, Computer Aided Design, Robust design, DFX, DFM. DFA, Ergonomics in product design.

Module 4 **(08 Hrs)**
DFMA guidelines: Product design for manual assembly, Design guidelines for metallic and non-metallic products to be manufactured by different processes such as casting, machining, injection molding etc.,

Module 5 **(07 Hrs)**
Rapid Prototyping: Needs of rapid prototyping, needs, advantages, working principles of SLA, LOM and SLS.

Course Outcomes: Students will be able to
1. Explain the introduction to product design.
2. Explain the concept of Value engineering in product design.
3. Describe the various Product design tools.
4. Explain DFMA guideline for product design.
5. Explain Basic concepts & Needs of rapid prototyping.

References:
1. Value Engineering: Concepts, Techniques and Applications by A.K. Mukhopadhaya.
2. Rapid Prototyping: Principles and Applications by C.K. Chua 3. Engineering Design by Linda D. Schmidt.

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Mechanical Engineering

ME-604 (A)	**Robotics**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

- To acquire the knowledge on advanced algebraic tools for the description of motion.
- Be able to use matrix algebra and Lie algebra for computing the kinematics of robots.
- To develop an ability to use software tools for analysis and design of robotic systems.

Course Content:

Module 1 **(08 Hrs)**

Introduction: Need and importance, basic concepts, structure and classification of industrial robots, terminology of robot motion, motion characteristics, resolution, accuracy, repeatability, robot applications.

Module 2 **(08 Hrs)**

End Effectors and Drive systems: Drive systems for robots, salient features and comparison, different types of end effectors, design, applications.

Module 3 **(08 Hrs)**

Sensors: Sensor evaluation and selection, Piezoelectric sensors, linear position and displacement sensing, revolvers, encoders, velocity measurement, proximity, tactile, compliance and range sensing. Image Processing and object recognition.

Module 4 **(08 Hrs)**

Robot Programming: Teaching of robots, manual, walk through, teach pendant, off line programming concepts and languages, applications.

Module 5 **(08 Hrs)**

Safety and Economy of Robots: Work cycle time analysis, economics and effecttiveness of robots, safety systems and devices, concepts of testing methods and acceptance rule for industrial robots.

Course Outcomes: Students will be able to

1. Demonstrate the robot anatomy with joint notations and applications.
2. Identify different types of drives and end effectors required for specific applications.
3. Analyze the requirement of sensor, Principles and Applications of different types of sensors and Visual Serving and Navigation.
4. Determine the forward kinematics, inverse kinematics and to develop programming principles and languages for a robot control system.
5. Create various applications and implementation with economical analysis of industrial robot systems.

References:

1. Mittal RK, Nagrath IJ; Robotics and Control; TMH
2. Groover M.P,Weiss M, Nagel,OdreyNG; Industrial Robotics-The Apple; TMH
3. Groover M.P; CAM and Automation; PHI Learning
4. Spong Mark and Vidyasagar; Robot Modelling and control; Wiley India
5. Yoshikava ; Foundations of Robotics- analysis and Control; PHI Learning;
6. Murphy ; Introduction to AI Robotics; PHI Learning

7. FU KS, Gonzalez RC, Lee CSG; Robotics □Control, sensing; TMH
8. Shimon, K; Handbook of Industrial Robots; John Wiley & Sons.
9. Ghosal Ashitava; Robotics Fundamental concepts and analysis; Oxford
10. Saha S; Introduction to Robotics; TMH 11. Yu Kozyhev; Industrial Robots Handbook; MIR Pub.

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Mechanical Engineering

ME-604 (B)	**Optimization Techniques**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

Learn classical optimization techniques and numerical methods of optimization. Know the basics of different evolutionary algorithms. Explain Integer programming techniques and apply different optimization techniques to solve various models arising from engineering areas.

Course Content:

Module 1 **(08 Hrs)**

Introduction to Optimization: Engineering application of Optimization – Statement of an Optimization problem - Optimal Problem formulation - Classification of Optimization problem. Optimum design concepts, Definition of Global and Local optima – Optimality criteria - Review of basic calculus concepts – Global optimality.

Module 2 **(08 Hrs)**

Linear Programming methods for optimum design: Review of Linear programming methods for optimum design – Post optimality analysis - Application of LPP models in design and manufacturing.

Module 3 **(08 Hrs)**

Optimization algorithms for solving unconstrained optimization problems: Gradient based method: Cauchy's steepest descent method, Newton's method, Conjugate gradient method.

Module 4 **(08 Hrs)**

Optimization Algorithms for solving constrained optimization problems: Direct methods – penalty function methods – steepest descent method - Engineering applications of constrained and unconstrained algorithms.

Module 5 **(08 Hrs)**

Modern methods of Optimization: Genetic Algorithms - Simulated Annealing - Ant colony optimization - Tabu search – Neural-Network based Optimization – Fuzzy optimization techniques – Applications. Use of Matlab to solve optimization problems.

Course Outcomes: The students will be able to

1. Explain the basic concepts of Optimization.
2. Review of Linear programming methods for optimum design
3. Define the concepts of Optimization algorithms for solving unconstrained optimization problems.
4. Define the concepts of Optimization algorithms for solving constrained optimization problems.
5. Explain the Modern methods of Optimization

References:

1. Rao S. S. - 'Engineering Optimization, Theory and Practice' - New Age International Publishers - 2012 - 4 th Edition.
2. Deb K. - 'Optimization for Engineering Design Algorithms and Examples' – PHI - 2000
3. Arora J. - 'Introduction to Optimization Design' - Elsevier Academic Press, New Delhi - 2004

4. Saravanan R. - 'Manufacturing Optimization through Intelligent Techniques' - Taylor & Francis (CRC Press) – 2006
5. Hardley G. -'Linear Programming' - Narosa Book Distributors Private Ltd. - 2002

ME- 604 (C)	**Renewable Energy Technology**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
To understand the importance of renewable energy resources and its utilization for the thermal and electrical energy needs and also the environmental aspects of these resources.

Course Content:

Module 1 **(08 hrs)**

Solar Radiation: Extra-terrestrial and terrestrial, radiation measuring instrument, radiation measurement and predictions. Solar thermal conversion: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, solar cooling and refrigeration. Solar photovoltaic: Principle of photovoltaic conversion of solar energy; Technology for fabrication of photovoltaic devices; Applications of solar cells in PV generation systems; Organic PV cells.

Module 2 **(09 hrs)**

Wind Energy: Characteristics and measurement: Metrology of wind speed distribution, wind speed statistics, Weibull, Rayleigh and Normal distribution, Measurement of wind data, Energy estimation of wind regimes; Wind Energy Conversion: Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics; power curve of wind turbine, capacity factor, matching wind turbine with wind regimes; Application of wind energy.

Module 3 **(10 hrs)**

Production of biomass: Photosynthesis-C3 & C4 plants on biomass production; Biomass resources assessment; Co2 fixation potential of biomass; Classification of biomass; Physicochemical characteristics of biomass as fuel Biomass conversion routes: biochemical, chemical and thermo chemical Biochemical conversion of biomass to energy: anaerobic digestion, biogas production mechanism, technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants, biogas plant manure-utilization and manure values. Biomass Gasification: Different types, power generation from gasification, cost benefit analysis of power generation by gasification.

Module 4 **(08 hrs)**

Small Hydropower Systems: Overview of micro, mini and small hydro system; hydrology; Elements of turbine; Assessment of hydro power; selection and design criteria of turbines; site selection and civil works; speed and voltage regulation; Investment issue load management and tariff collection; Distribution and marketing issues. Ocean Energy: Ocean energy resources, ocean energy routs; Principle of ocean thermal energy conversion system, ocean thermal power plants. Principles of ocean wave energy and Tidal energy conversion.

Module 5 **(08 hrs)**

Geothermal Energy: Origin of geothermal resources, type of geothermal energy deposits, site selection geothermal power plants; Hydrogen Energy: Hydrogen as a source of energy, Hydrogen production and storage. Fuel Cells: Types of fuel cell, fuel cell system and sub-system, Principle of working, basic thermodynamics.

Course Outcomes: Students are able to:

1. Explain the field applications of solar energy and Solar Radiation
2. Identify Winds energy as alternate form of energy and to know how it can be tapped.
3. Explain bio gas generation and its impact on environment.
4. Differantiate different hydro electic power plants and understand the production of Ocean and Tidal Energy.
5. Understand the Geothermal, Hydrogen Energy & Fuel Cell, its mechanism of production.

Text Books:

1.Kothari, Singal & Rajan; Renewable Energy Sources and Emerging Technologies, PHI Learn
2.Sukhatme and Nayak, Solar Energy, Principles of Thermal Collection and Storage, TMH.

Reference Books:

1. Khan, B H, Non Conventional Energy, TMH.
2. Tiwari and Ghosal, Renewable Energy Resources: basic principle & application, Narosa Publ
3. Koteswara Rao, Energy Resources, Conventional & Non-Conventional, BSP Publication.
4. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, technologies and Application, PHI
5. Abbasi Tanseem and Abbasi SA; Renewable Energy Sources; PHI Learning
6. Ravindranath NH and Hall DO, Biomass, Energy and Environment, Oxford University Press.
7. Duffie and Beckman, Solar Engineering of Thermal Process, Wiley
8. Nikolai, Khartchenko; Green Power; Tech Book International
9. Tester, Sustainable Energy-Choosing Among Options, PHI Learning.
10. Godfrey Boyle, Renewable Energy: Power for a sustainable future, Oxford OUP.

ME-605	**CAD Lab**	**0L:0T: 4P (04 hrs)**	**Credits:04**

Lab List of Experiments:

1. Layout and sketching of different geometries
2. Drawing environment in AUTOCAD
3. Elements of drawing and draw commands
4. 3D functions in AUTOCAD
5. 2D: Figures for practice using AutoCAD
6. ISOMETRIC drawing for practice using AutoCAD
7. 3-D solid figures using AUTOCAD
8. Introduction to CREO 3.0 9. Learning different Operations like Threading, Sweep, Swept-blend.
10. Modeling & Assembling

Course Outcome's: Students will be able to-

1. Understand drawing environment in AutoCAD and will be able to make drawings (layout and sketching) in AutoCAD.
2. Create isometric drawings in AutoCAD.
3. Create 3D models in AutoCAD.
4. Perform various operations (sweep, blend, extrude etc.) on Solid Works.
5. Create assembly drawings.

References:

1. Engineering graphics with Auto CAD- R.B. Choudary/Anuradha Publishers.
2. Beginning AutoCAD 2019 Exercise Workbook by Cheryl R. Shrock, Steve Heather.
3. CAD Exercises by Sachidanand Jh

ME-606	**3D Printing and CNC**	**0L:0T: 4P (04 hrs)**	**Credits:04**

List of Experiment:

1. To study of 3D printing
2. To make 3D model using CAD software
3. To convert 3D model into printable format using software.
4. To perform 3D printing with PLA or ABS material.
5. To study of 3D printing materials.
6. To study of 4D printing technology.
7. To study of CNC machine.
8. To make program for simple turning job using G & M code.
9. To perform CNC turning as per turning job given in drawing.
10. To study CNC milling.

Course Outcomes: Students will be able to-

1. Understand 3D printing and its application.
2. Perform 3D printing with PLA & ABS materials.
3. Understand the basics of CNC machine and its programming.
4. Apply the knowledge of machining for reducing the cycle time and increase its productivity.
5. Apply the knowledge of 3D printing for various applications like medical, aerospace and industrial solutions.

References:

1. Gibson, Ian, Rosen, David, Stucker, Brent, "Additive Manufacturing Technologies, 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2013.
2. Ibrahim Zeid ,CAD/CAM Theory and Practice, , Tata McGraw-Hill Publishing Company Ltd., New Delhi,2012
3. Dacid F. Rogers, J Alan Adams, Mathematical Elements for Computer Graphics, McGraw-Hill publishing Company Ltd.,2001
4. Chougule N.K., CAD/CAM/CAE, Scitech Publications Ltd, 2017

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Mechanical Engineering

ME-701	**Heat & Mass Transfer**	**3L:1T: 2P (05 hrs)**	**Credits:04**

Course Objective's:
To introduce history, importance and components of chemical engineering, concepts of unit operations and unit processes, and current scenario of chemical & allied process industries.

Course Content:

Module 1 **(08 hrs)**

Basic Concepts: Modes of heat transfer, Fourier's law, Newton's law, Stefan Boltzman law; thermal resistance and conductance, analogy between flow of heat and electricity, combined heat transfer process; Conduction: Fourier heat conduction equation, its form in rectangular, cylindrical and spherical coordinates, thermal diffusivity, linear one dimensional steady state conduction through a slab, tubes, spherical shells and composite structures, electrical analogies, critical - insulation-thickness for pipes, effect of variable thermal conductivity.

Module 2 **(08 hrs)**

Extended Surfaces (fins): Heat transfer from a straight and annular fin (plate) for a uniform cross section; error in measurement of temperature in a thermometer well, fin efficiency, fin effectiveness, applications; Unsteady heat conduction: Transient and periodic conduction, heating and cooling of bodies with known temperatures distribution, systems with infinite thermal conductivity, response of thermocouples.

Module 3 **(09 hrs)**

Convection: Introduction, free and forced convection; principle of dimensional analysis, Buckingham 'pie' theorem, application of dimensional analysis of free and forced convection, empirical correlations for laminar and turbulent flow over flat plate and tubular geometry; calculation of convective heat transfer coefficient using data book.

Module 4 **(08 hrs)**

Heat Exchangers: Types- parallel flow, counter flow; evaporator and condensers, overall heat transfers coefficient, fouling factors, log-mean temperature difference (LMTD), method of heat exchanger analysis, effectiveness of heat exchanger, NTU method;
Mass transfer: Fick's law, equi-molar diffusion, diffusion coefficient, analogy with heat transfer, diffusion of vapour in a stationary medium.

Module 5 **(09 hrs)**

Thermal Radiation : Nature of radiation, emissive power, absorption, transmission, reflection and emission of radiation, Planck's distribution law, radiation from real surfaces; radiation heat exchange between black and gray surfaces, shape factor, analogical electrical network, radiation shields.
Boiling and condensation: Film wise and drop wise condensation; Nusselt theory for film wise condensation on a vertical plate and it s modification for horizontal tubes; boiling heat transfer phenomenon, regimes of boiling, boiling correlations.

Course Outcomes: Students will be able to-

1. Explain various modes of heat transfer and Determine thermal conductivity of different materials.
2. Analyse the phenomenon of heat transfer through extended surface and to describe unsteady

state conduction.

3. Evaluate heat transfer coefficient for free and forced convection & apply the concept of dimensional analysis.
4. Study different types of heat exchanger and evaluate their performance characteristics.
5. Explain the concept of thermal radiation and examine the phenomenon of boiling and condensation.

Text Books:

1.R K Rajput, Heat & Mass Transfer
2.D. S Kumar, Heat & Mass Transfer

References Books:

1. Sukhatme SP; Heat and mass transfer; University Press Hyderabad
2. Holman JP; Heat transfer; TMH
3. Nag PK; heat and Mass Transfer; TMH
4. Domkundwar, Heat and Mass Transfer, Dhanpat Rai & Co.
5. Sachdeva R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science
6. Dutta BK; Heat Transfer Principles And App; PHI Learning
7. Mills AF and Ganesan V; Heat transfer; Pearson
8. Cengel Yunus A; Heat and Mass transfer; TMH
9. Yadav R; Heat and Mass Transfer; Central India pub-Allahabad
10. Incropera FP and Dewitt DP; Heat and Mass transfer; Wiley

List of Experiments:

1. To determine the thermal conductivity of metal rod.
2. To determine the equivalent thermal conductivity of composite wall.
3. To determine the heat transfer coefficient in natural convection.
4. To determine the heat transfer coefficient in force convection.
5. To determine the heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. To determine the heat transfer coefficient in Finned Tube Heat Exchanger.
7. To demonstrate the film-wise and drop-wise condensation and determination of heat transfer coefficient.
8. To calculate emissivity of the test plate by emissivity measurement apparatus.
9. To determine the heat transfer characteristics of a concentric tube heat exchanger.
10. To observe pool boiling phenomena and to determine the critical heat flux at different bulk temperature.

ME- 702(A)	**Advance Machining Processes**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
The objective of the course is to provide the students the knowledge of modern manufacturing processes such as Ultrasonic machining, Abrasive machining processes, Electrochemical machining, Electro discharge machining & their modifications into hybrid processes.

Course Content:

Module 1 **(10 Hrs)**
Mechanical Processes: Process selection, mechanics of cutting, metal removal rate, cutting tool system design, ultrasonic machining, abrasive jet machining, water jet machining, , effect of parameters and variables, applications and limitations, recent developments in mechanical processes.

Module 2 **(08 Hrs)**
Electrochemical and Chemical Metal Removal Processes: Electrochemical machining[ECM], elements of ECM, power source and control system, electrolytes, tool work system, chemistry of the process, tool design and metal removal rate, process faults, material removal and surface finish, electrochemical grinding, electrochemical deburring, electrochemical honing, chemical machining,

Module 3 **(10 Hrs)**
Thermal Metal Removal Processes: Electric discharge machining[EDM], spark erosion, mechanism of metal removal, spark erosion generator, electrode feed control, vibrating electrode system, dielectric fluid, flushing, accuracy, plasma arc machining[PAM], non thermal generation of plasma, mechanisms and parameters, equipments, electron beam machining[EBM],generation and control of electron beam, theory and process capabilities, neutral particle etching, laser beam machining, hot machining, methods of local heating, tool lie and production rate.

Module 4 **(08 Hrs)**
Rapid Prototyping: Fundamentals, technologies, applications, principles and working of 3D printing, subtractive v/s additive manufacturing process, VAT photo polymerization, material and binder jetting, continuous liquid inter phase production, direct metal laser sintering.

Module 5 **(08 Hrs)**
Technologies of Micro Fabrication: Types of micro system devices, industrial applications, micro fabrication processes, LIGA process . Technologies of nano fabrication, importance of size, scanning probe microscope, carbon Buckyballs and nano tubes, nano fabrication processes,

Course Outcomes: Students will be able to
1. Understand the fundamentals and technologies used in different advance machining processes.
2. Understand the concept of Electrochemical and Chemical Metal Removal Processes
3. Understand the concept of Thermal Metal Removal Processes
4. Develop an ability to create automated solid model
5. Understand the fundamentals of Technologies of Micro Fabrication

Text Books:

1. Mikell P. Groover, Fundamentals of Modern Manufacturing, Wiley India
2. Pandey P.C, Shan H.S., Modern Machining Processes, Tata McGraw
3. Lal G.K,Gupta V, Reddy N.V., Narosa Publishing House
4. Chua C.K., Leong K.F. and LIM C.S," Rapid prototyping: Principles and Applications" - World Scientific publications

References Books:

1. Gibson, Ian, Rosen, David, Stucker, Brent, "Additive Manufacturing Technologies, 3D Printing, Rapid Prototyping, And Direct Digital Manufacturing
2. Jain V.K. Introduction To Micro Machining Process Narosa Publication
3. Jain V.K., Micro manufacturing Processes , Crc Press.

ME-702 (B)	**Internet of Things**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Content:
Students will be explored to the interconnection and integration of the physical world and the cyber space. They are also able to design & develop IOT Devices.

Course Content:

Module 1 **(08 Hrs)**

Internet of Things (IoT): Vision, Definition, Conceptual Framework, Architectural view, technology behind IoT, Sources of the IoT, M2M Communication, IoT Examples . Design Principles for Connected Devices: IoT/M2M systems layers and design standardization, communication technologies, data enrichment and consolidation, ease of designing and affordability.

Module 2 **(08 Hrs)**

Hardware for IoT: Sensors, digital sensors, actuators, radio frequency identification (RFID) technology, wireless sensor networks, participatory sensing technology. Embedded Platforms for IoT: Embedded computing basics, Overview of IOT supported Hardware platforms such as Arduino, Raspberry pi, Beagle Bone, Intel Galileo.

Module 3 **(08 Hrs)**

IoT PROTOCOLS: IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks, Zigbee – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT.

Module 4 **(08 Hrs)**

Security Understanding the risks, Modes of attack: Denial of Service Guessing the credentials , Getting access to stored credentials, Man in the middle , Sniffing network communication , Port scanning and web crawling ,Search features and wildcards ,Breaking ciphers , Tools for achieving security - Virtual Private Networks , X.509 certificates and encryption , Authentication of identities , Usernames and passwords , Using message brokers and provisioning servers ,Centralization versus decentralization .

Module 5 **(08 Hrs)**

IoT Applications Home Automation: Smart Appliances , Smoke/ Gas Detection, Cities – Smart Parking ,Smart Lighting , Smart Road , Health and Lifestyle- Health and fitness monitoring, Retail- Smart Payments. Case Studies: Smart city streetlights:- control and monitoring.

Course Outcomes: The student will be able:
1. Understand the vision of IoT from a global context.
2. Understand the application of IoT.
3. Determine the Market perspective of IoT.
4. Use of Devices, Gateways and Data Management in IoT.
5. Building state of the art architecture in IoT.
6. Application of IoT in Industrial and Commercial Building Automation and Real World Design Constraints.

References:

1.Raj Kamal "Internet of Things", McGraw-Hill, 1st Edition, 2016
2.Olivier Hersent,David Boswarthick, Omar Elloumi "The Internet of Things key applications and protocols", Wiley
3. Peter Waher, "Learning Internet of Things", Packt publishing
4.Arshdeep Bahga, Vijay Madisetti, "Internet of Things (A hands on approach)" University Press (India).
5.Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1 st Edition, Apress Publications, 2013 .
6. Cuno Pfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1-4493-9357-1

ME702(C)	**Power Plant Engineering**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Content

Module 1 **(07 hrs)**

Introduction: Introduction to methods of converting various energy sources to electric power, direct conversion methods renewable energy sources, solar, wind, tidal, geothermal, bio-thermal, biogas and hybrid energy systems, fuel cells, thermoelectric modules, MHD-Converter

Module 2 **(08 hrs)**

Fossil fuel steam stations: Basic principles of sitting and station design, effect of climatic factors on station and equipment design, choice of steam cycle and main equipment, recent trends in turbine and boiler sizes and steam conditions, plant design and layout, outdoor and indoor plant, system components, fuel handling, burning systems, element of feed water treatment plant, condensing plant and circulating water systems, cooling towers, turbine room and auxiliary plant equipment., instrumentation, testing and plant heat balance.

Module 3 (**08 hrs)**

Nuclear Power Station: Importance of nuclear power development in the world and Indian context, Review of atomic structure and radio activity, binding energy concept, fission and fusion reaction, fissionable and fertile materials, thermal neutron fission, important nuclear fuels, moderators and coolants, their relative merits, thermal and fast breeder reactors, principles of reactor control, safety and reliability features.

Module 4 **(07 hrs)**

Hydro-Power Station: Elements of Hydrological computations, rainfall run off, flow and power duration curves, mass curves, storage capacity, salient features of various types of hydro stations, component such as dams, spillways, intake systems, head works, pressure tunnels, penstocks, reservoir, balancing reservoirs, Micro and pico hydro machines, selection of hydraulic turbines for power stations, selection of site.

Module 5 **(08 hrs)**

Power Station Economics: Estimation and prediction of load. Maximum demand, load factor, diversity factor, plant factor and their influence on plant design, operation and economics; comparison of hydro and nuclear power plants typical cost structures, simple problems on cost analysis, economic performance and tariffs, interconnected system and their advantages, elements of load dispatch in interconnected systems.

Course Outcomes: Students will be able to

1. Understand the conversion of renewable energy system into electrical power.
2. Design & enhance the performance of fossil fuel based power plant.
3. Analyze the nuclear power plant and its safety
4. Design & enhance the performance of hydro based power plant.
5. Determine economics of the power plant of renewable and non renewable / nuclear power system

Text Books:

1. Rajput RK; A text book of Power plant Engg.; Laxmi Publications.

Reference Books:

1. Nag PK; Power plant Engg; TMH
2. Al-Wakil MM; Power plant Technology; TMH
3. Sharma PC; Power plant Engg; Kataria and sons, Delhi
4. Domkundwar; Power Plant Engg; Dhanpatrai & sons.

ME702(D)	**Advance Machine Design**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

- To design machine components which are subjected to fluctuating loads.
- To distinguish different design criterions and their procedure to carry out the required design steps for designing mechanical components.
- To design machine components/parts based on creep criterions.

Course Contents:

Module 1

Design of Belt, Rope and Chain Drives: Methods of power transmission, design of flat belt drive and V-belt drive; Design of chain drives, roller chain and its selection; Design of rope drives.

Module 2

Spur and Helical Gears: Force analysis of gear tooth, AGMA Bending stress equation and AGMA Contact stress equation, modes of failure, beam strength, Lewis equation, form factor, formative gear and virtual number of teeth; Gear materials; Surface strength and wear of teeth; strength against wear; Design of straight tooth spur and Helical Gears.

Module 3

Bevel Gears: Application of bevel, formative gear and virtual number of teeth; Force analysis; Lewis equation for bevel gears; Strength against wear; Design of bevel gear.

Module 4

Design of I.C. Engine Components: General design considerations in I C engines; design of cylinder; design of piston and piston-rings; design of connecting rod; design of crankshaft.

Module 5

Design of Miscellaneous Components: Design of Knuckle joint, Design of Cotter joint, Design of keys, Design of Flanged coupling; Rigid coupling and Flexible coupling ,Design of Pressure vessels subjected to internal pressure, Design of power screw.

Course Outcomes: Students will be able to

1. Apply concept of design process, standardization, uncertainty and reliability to component design.
2. Analyze the design based on theory of elasticity, theory of plasticity and failure theories.
3. Analyze design based on tribological aspects.
4. Simplify design of parts subjected to unsymmetrical bending.
5. Explain the concept of strain gauge, gauge factor, measuring circuits, application of strain gauge & stress analysis.

References:

1. Shigley J.E.; Machine Design; TMH
2. Bhandari VB; Design of Machine Elments; TMH
3. Abdul Mubeen; Machine Design; Khanna Publishers
4. Sharma & Agrawal; Machine Design; Katson
4. Sharma CS and Purohit K; Design of Machine Elements; PHI Learning.

5. Dwivedi and Pandey; Machine Drawing and Design, Dhanpat Rai & Co.
6. Wentzell TH; Machine Design; Cegage Learning
7. Hall and Somani; Machine Design; Schaum Series; TMH
8. Kulkarni SG; Machine Design; TMH
9. Norton R; Design Of Machinery; TMH.

ME- 703(A)	**Operation Research & Supply Chain**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

- To understand how Logistics, Supply Chain, Operations, Channels of Distribution fit in to various types of Business viz., Manufacturing, Service and Project.
- To understand how Managers, take decisions – strategic, tactical and operations - and how they are taken in Warehouse Management functional area.

Course Content:

Module 1 **(12 Hrs)**

Linear System and Distribution Models: Mathematical formulation of linear systems by LP, solution of LP for two variables, Simplex method, special cases of LP- transportation and assignment model and their graphical solution, Vogels Approximation Method (VAM) or penalty method, cell evaluation degeneracy, basics of SW Lindo, Tora, Excell.

Module 2 **(10 Hrs)**

Inventory Models: Necessity of inventory in process and safety stock, problem of excess inventory and cycle time, JIT/ Lean Mfg; basics of inventory models with deterministic demand, Classical EOQ Model, ABC, VED and other analysis based on shelf life, movement, size, MRP technique and calculations, lot sizing in MRP, linking MRP with JIT; evolution of MRP to ERP to SCM and e-business.

Module 3 **(10 Hrs)**

Queuing Theory and Game Theory: Waiting Line Models: Introduction, Input process, service mechanism, Queue discipline, single server (M/M/1), average length and average time calculations, optimum service rate; basic multiple server models (M/M/s)
Competitive strategy: concept and terminology, assumptions, pure and mixed strategies, two-person zero sum games, saddle point, dominance, graphical, algebraic and LP methods for solving game theory problems.

Module 4 **(10 Hrs)**

Network Analysis and Meta-Heuristics: Network Analysis: Project Planning, Scheduling and Controlling; Project management; Network Techniques and its role in project management, Network logics, Fulkerson's Law, Merits and Demerits of AON Diagrams; Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Determination of critical path, Float/Slack.
Meta-Heuristics: Definition of heuristic and meta-heuristic algorithms; introduction to Tabu search, Simulated Annealing and Genetic algorithms and solution of traveling salesman, non linear optimization problems.

Module 5 **(08 Hrs)**

Supply Chain Management: Definition, importance, expenditure and opportunities in SCM; integration of inbound, outbound logistics and manufacturing to SCM, flow of material money and information, difficulties in SCM due to local v/s system wide (global) optimization and uncertainties in demand and transportation; Bull-whip effect; customer value; IT, info-sharing and strategic partnerships; plant and warehouse-network configuration; supply contracts and revenue sharing; outsourcing; transportation, cross docking and distribution, forecasting models in SCM; coordination and leadership issues;

change of purchasing role and vendor rating, variability from multiple suppliers.

Course Outcomes: Student able to:

1. Understand the concept of operation research and optimization methods.
2. Understand the concept of various inventory control techniques.
3. Understand the concept of Queuing and Game Theory
4. Implement project management concepts, tools and techniques in order to achieve project success
5. Understand the role of logistics in the supply chain within a focal firm as well as between organizations linked within a given supply chain network.

Text Books:

1. Hillier FS and Liberman GJ; Introduction to Operations Research concept and cases; TMH
2. Simchi-Levi, Keminsky; Designing and managing the supply chain; TMH.
3. Heera and Gupta, Operation Research, S Chand Pub.
4. Sharma JK; Operations Research; Macmillan
5. Kantiswaroop, Operation Research, Sultan Chand

Reference Books:

1. Taha H; Operations research; PHI
2. Jain, Pandey & Shrivastava; Quantitative techniques for management, New Age publishers.
3. Srinivasan G; Quantitative Models In Operations and SCM; PHI Learning
4. Mohanty RP and Deshmukh SG; Supply Chain Management; Wiley India
5. Sen RP; Operations Research-Algorithms and Applications; PHI Learning
6. Bowersox DJ, Closs DJ, Cooper MB; Supply Chain Logistic Mgt; TMH
7. Bronson R ;Theory and problems of OR; Schaum Series; TMH

ME- 703(B)	**Artificial Intelligence Techniques**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:

Apply the basic principles, models, and algorithms of AI to recognize, model, and solve problems in the analysis and design of information systems. analyze the structures and algorithms of a selection of techniques related to searching, reasoning, machine learning, and language processing.

Course Content:

Module 1 **(08 Hrs)**

Introduction to Artificial Intelligence: Main components and characteristics of AI (Feature Engineering, ANN, Deep Learning),Applications of AI, Advantages and disadvantages of AI, Goals of AI, Comparision of Programming of a System with AI and without AI, Challenges in AI, Programming languges preferably used in AI, Techniques/Algorithms used in AI,AI Software platforms, Future of AI.

Module 2 **(08 Hrs)**

Various types of production systems and search techniques: Types of production systems, Characteristics of production systems, Study and comparison of breadth first search and depth first search. Techniques, other Search Techniques like hill Climbing, Best first Search. A* algorithm, AO* algorithms etc, and various types of control strategies.

Module 3 **(08 Hrs)**

Knowledge Representation and Probabilistic Reasoning: Problems in representing knowledge, knowledge representation using propositional and predicate logic, comparison of propositional and predicate logic, Resolution, refutation, deduction, theorem proving, inferencing, monotonic and non monotonic reasoning. Probabilistic reasoning, Baye's theorem, semantic networks, scripts, schemas, frames, conceptual dependency, fuzzy logic, forward and backward reasoning.

Module 4 **(06 Hrs)**

Game playing techniques: Minimax procedure, alpha-beta cut-offs etc, planning, Study of the block world problem in robotics, Introduction to understanding and natural languages processing.

Module 5 **(08 Hrs)**

Introduction to learning ANN: Various techniques used in learning, introduction to Artificial neural networks, common sense, reasoning, Convolution Neural Network, Feed forward Neural Network, Recurrent Neural Network, Multilayer perceptron, Architecture / Three Layers in Artificial Neural Networks, Implementation of ANN, Applications of ANN in images, signals and language some example of expert systems.

Course Outcomes: The Students will be able to

1. Learn about importance and adoption of Artificial Intelligence (AI) technologies in our society.
2. Know the Various types of production systems and search techniques used in the AI Techniques.
3. Understand the working of Modern AI based systems. It often involves Knowledge Representation and Probabilistic Reasoning.

4. Know about Game playing techniques and natural languages processing used in AI.
5. Apply Various techniques used in machine learning like Artificial neural networks

References:

1. Rich E and Knight K, "Artificial Intelligence", TMH, New Delhi.
2. Nelsson N.J., "Principles of Artificial Intelligence", Springer Verlag, Berlin.
3. Stuart Russell , Artificial Intelligence: A Modern Approach , 3rd Edition), Peter Norvig, PHI, ISBN13: 978-0136042594, ISBN-10: 0136042597
4. B. Yegnanarayana , Artificial Neural Networks ,PHI 5.Schalkoff, Artificial Neural Networks . Mc Graw HILL Education

ME- 703(C)	**System Engineering**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
Develop a systems engineering plan for a realistic project. ... Understand system engineers' role and responsibilities. Understand the role of organizations. Apply systems engineering tools (e.g., requirements development and management, robust design, Design Structure Matrix) to realistic problems.

Course Content:

Module 1 **(08 Hrs)**
Overview of Systems Engineering: Introduction, Origin, Examples of Systems requiring systems engineering, Systems Engineer Career Development Model, Perspectives of Systems Engineering, Systems Domains, Systems Engineering Fields, System Engineering Approaches.

Module 2 **(08 Hrs)**
Structure of Complex Systems: System Building Blocks and Interfaces, Hierarchy of Complex Systems, System Building Blocks, The System Environment, Interfaces and Interactions, Complexity in Modern Systems.

Module 3 **(08 Hrs)**
Concept Development and Exploration: Originating a New System, Operational Analysis, Functional Analysis, Feasibility, System Operational Requirements, Implementation of Concept Exploration. Exploration in system life cycle, Concept definition phase, Activities involved in concept definition phase.

Module 4 **(08 Hrs)**
Engineering Development: Reducing Program Risks, Requirements Analysis, Functional Analysis and Design, Prototype Development as a Risk Mitigation Technique, Development Testing, Risk Reduction. Place of engineering design phase in system life cycle, Various activities involved in engineering design phase.

Module 5 **(08 Hrs)**
Integration and Evaluation: Integrating, Testing, And Evaluating The Total System, Test Planning And Preparation, System Integration, Developmental System Testing, Operational Test And Evaluation, Engineering For Production, Transition From Development To Production, Production Operations. Operation and support phase.

Course Outcomes: The Students will be able to
1. Define the scope, field and different approaches of System Engineering.
2. Explain the structure of complex systems, System building blocks of engineering systems.
3. Evaluate Apply the principle of concept development and implementation of concept exploration.
4. Analyze system development, testing and risk reduction techniques during system development.
5. Develop a total system integration and evaluation plan from development to production phase.

Reference Books:

1. Alexander Kossiakoff, William N Sweet, "System Engineering Principles and Practice, Wiley India
2. Blanchard Fabrycky, Systems engineering and analysis, Pearson
3. Dwivedi Krishna K, Pandey M., Fundamentals of Systems Engineering , Wiley Precise Text book Series, Wiley India. ISBN: 978-265-6654-9
4. Dennis M. Buede, William D.Miller, "The Engineering Design of Systems: Models & Methods" Wiley India
5. JeffreyL Whitten, Lonnie D Bentley, "System Analysis and Design Methods"
6. Richard Stevens, Peter Brook," System Engineering – Coping with complexity, Prentice Hall of India.
7. Eisner, H. Essentials of Projects and Systems Engineering Management, 2nd edition. John Wiley & Sons, New Jersey, USA.
8. Buede, D. M.. The Engineering Design of Systems, Models and Methods. John Wiley & Sons, New Jersey, USA.

ME-703 (D)	**Reliability Engineering**	**3L:1T: 0P (04 hrs)**	**Credits:04**

Course Objective's:
Understand major concepts of reliability prediction. Analyze statistical experiments leading to reliability modeling. Identify reliability testing components. Apply reliability theory to assessment of reliability in engineering design.

Course Content:

Module 1 **(08 Hrs)**
Reliability: Definition, Importance, History, Reliability Vs. Quality, Failure pattern of complex product, Factor of safety and reliability, Reliability analysis procedure, Reliability management , Some examples of system failures., Reliability function-MTTF, Hazard rate function, Bath tub curve.

Module 2 **(08 Hrs)**
Basic Probability Theory: Set theory, Laws of probability, Probability theorem Random variables and probability distributions, Bay's Theorem, Central limit theorem.

Module 3 **(10 Hrs)**
Functions of Random Variables: Single , two and several random variables, Probability distribution functions, density functions for different types of discrete and continuous variables, mean, mode and median, Numerical solutions, Extremal distributions, derivation of the reliability function -constant failure rate model – time dependent failure models. Weibull distribution – normal distribution – the lognormal distribution.

Module 4 **(10 Hrs)**
Modeling of Geometry, Strength and Loads: Fatigue strength, Time dependent reliability of components, Failure rate versus time, reliability and hazard functions and different distributions, Estimation of failure rate, Expected residual life, Se ries, parallel and mixed systems, complex systems, Reliability enhancement.

Module 5 **(08 Hrs)**
Reliability Based Design: Optimization problems, Failure modes and effect analysis, Event tree and fault tree analysis, Reliability testing, Reliability data and analysis, measurement of reliability, Monte Carlo Simulati on, Computation of reliability, Optimization techniques for system reliability with redundancy – heuristic methods applied to optimal system reliability - redundancy allocation by dynamic programming – reliability optimization by non linear programming.

Course Outcomes: Students will be able to
1. Understand the basic concepts of reliability, various models of reliability.
2. Understand the basic Probability Theory
3. Understand the basic concepts of Functions of Random Variables
4. Estimation the failure rate and Expected residual life of the process
5. Understand the Reliability Based Design

Text Book :

1. Singiresu S. Rao, Reliability Engineering, Pearson
2. Grant E. L. & Leave Worth, Statistical Q. C., T.M.H.
3. Balagurusamy, Reliability Engg., T.M.H.
4. Mahajan , Statistical Q.C.
5. Juran and Grayan, Quality Planning Analysis, T.M.H

Reference Books:

1. Charles E. Ebling, "An introduction to Reliability and Maintainability Engg", Tata McGraw -Hill
2. Atrick D To'connor, "Practical Reliability Engineringt", John -Wiley and Sons inc
3. David J Smith, "Reliability, Maintainability and Risk: Practical Methods for Engineers", Butterworth

ME-704	**CAD/CAM/CIM Lab**	**0L:0T: 6P (06 hrs)**	**Credits:03**

Course Objective's:

The purpose of this laboratory is to provide the complete practical exposure of Computer aided design software tools such as Solid works, CATIA, Unigraphics etc., Computer assisted manufacturing processes such as CNC Turning, CNC Milling, CNC Drilling etc as well Computer integrated manufacturing (i.e. demonstrating remotely over the internet the operations of actual CIM cell established in the deptt. of Institute /industry) to the students so that they will become industry ready just after completing their graduation.

Suggested list Experiments; (Pl expand it)

1. 2D and 3D modeling on CAD software
2. Use of CAM software for writing CNC programs
3. Study of automatic and semi automatic control system and writing the electrical analogy.
4. Production & layout for GT for group of jobs to be manufactured
5. A case study / tutorial using CAPP Software
6. Writing M & G codes for given operations.
7. Robot and AGV programming
8. Modelling and simulation of computer integrated manufacturing system'
9. Modelling, offline manual part programming and simulation of the operation of 3 axis CNC milling machine
10. Programming and operation of a 5 axis robot Manipulator
11. Remote monitoring and operation of Computer integrated manufacturing system
12. To write the part program for any component (stepped cylindrical rod) . Assuming the work piece is Aluminum and the speed is 1200 rpm, feed 20 mm/min and maximum depth of cut is 1 mm.
    a. With Canned cycle
    b. Without Canned cycle.

ME-705	**MATLAB & R Programming**	**0L:0T: 6P (06 hrs)**	**Credits:03**

Course Objective's:

The purpose of this laboratory is to provide the knowledge of latest research tools/techniques such as MATLAB and R Programming which is being used in finding out the solution of most of the engineering problems. MATLAB is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

Following are the suggested list of experiments related to MATLAB (Pl expand)

1. Introduction to MATLAB
2. Working with matrices
3. Rational and logical operation of MATLAB
4. Creating a plot using Plot function
5. Complex and stastical functions (e.g.: Produce ten elements vector of random complex numbers and find the summation of this vector)
6. Numbers and strings

(1.Write a program in M-File to read 3 x 3 Matrix, then display the diagonal of matrix as shown below: The Diagonal of This Matrix = [ ] 2. Write a program to read a string, then replace each character in the string with its following character in ASCII code*.)

R Programming is a programming language and free software environment for statistical computing and graphics supported by the R Foundation for Statistical Computing. The R language is widely used among statisticians and data miners for developing statistical software and data analysis. In this lab, students are supposed to learn how to program in R and how to use R for effective data analysis. Students need to learn how to install and configure software necessary for a statistical programming environment and describe generic programming language concepts as they are implemented in a high-level statistical language. The lab should cover practical issues in statistical computing which includes programming in R, reading data into R, accessing R packages, writing R functions, debugging, profiling R code, and organizing and commenting R code.

Following are the suggested tutorials to be covered:

1. What is R Programming Language?
2. How to Download & Install R, R Studio, Anaconda on Mac or Windows
3. Write R Data Types, Arithmetic & Logical Operators with Example
4. Write about R Matrix : Create, Print, add Column, Slice
5. Explain Factor in R: Categorical & Continuous Variables
6. Explain about R Data Frame: Create, Append, Select, Subset.

Course Outcome's: Students will be able to

1) Aware of MATLAB software and perform basic programs.
2) Perform Real time application and know about basic key features of MATLAB software.
3) Perform program to develop image using image processing in MATLAB Software.
4) Knowledge about image processing programming and develop application of system.
5) Perform program on different image compression and restoration technique.

ME-706	**Major Project I**	**0L:0T: 8P (08 hrs)**	**Credits:04**

Objectives of the course Major Project I :

- To provide students with a comprehensive experience for applying the knowledge gained so far by studying various courses.
- To develop an inquiring aptitude and build confidence among students by working on solutions of small industrial problems.
- To give students an opportunity to do something creative and to assimilate real life work situation in institution.
- To adapt students for latest development and to handle independently new situations.
- To develop good expressions power and presentation abilities in students**.** The focus of the Major Project I is on preparing a working system or some design or understanding of a complex system using system analysis tools and submit it the same in the form of a write up i.e. detail project report.

The student should select some real life problems for their project and maintain proper documentation of different stages of project such as need analysis market analysis, concept evaluation, requirement specification, objectives, work plan, analysis, design, implementation and test plan. Each student is required to prepare a project report and present the same at the final examination with a demonstration of the working system (if any)

Working schedule:
The faculty and students should work according to following schedule:

Each student undertakes substantial and individual project in an approved area of the subject and supervised by a faculty of the department. In special case, if project is huge, then maximum 03 students may be permitted to work together as a team to do the same. The student must submit outline and action plan for the project execution (time schedule) and the same be approved by the concerned faculty and Head of department.

Project guide should motivate students to develop some Innovative working models in the area of Advanced Automotives, Aero modelling, Renewable Energy based systems, Mechatronics, Robotic systems, Advanced Manufacturing Technology based systems etc. which can contribute to the society.

Course Outcome's: Students will be able to

1. Identify a topic in areas of Mechanical Engineering.
2. Review literature to identify gaps and define objectives & scope of the work.
3. Generate and implement innovative ideas for social benefit.
4. Develop a prototypes/models, experimental set-up and software systems necessary to meet the objectives.
5. Prepare a report as per recommended format and defend the work.

ME-801	Refrigeration & Air Conditioning	3L:1T: 2P (05 hrs)	Credits:04

Course Objective's:

- Illustrate the fundamental principles and applications of refrigeration and air conditioning system.
- Obtain cooling capacity and coefficient of performance by conducting test on vapour compression refrigeration systems.
- Present the properties, applications and environmental issues of different.

Course Content:

Module 1 **(08 Hrs)**

Introduction: Principles and methods of refrigeration, freezing; mixture cooling by gas reversible expansion, throttling, evaporation, Joule Thomson effect and reverse Carnot cycle; unit of refrigeration, coefficient of performance, vortex tube & thermoelectric refrigeration, adiabatic demagnetization; air refrigeration cycles- Joule's cycle Boot-strap cycle, reduced ambient cycle and regenerative cooling cycles.

Module 2 **(09 Hrs)**

Vapour Compression System: Vapor compression cycle, p-h and t-s diagrams, deviations from theoretical cycle, sub-cooling and super heating, effects of condenser and evaporator pressure on cop; multi-pressure system: removal of flash gas, multiple expansion & compression with flash inter cooling; low temperature refrigeration: production of low temperatures, cascade system, dry ice, production of dry ice, air liquefaction system.

Module 3 **(08 Hrs)**

(a) Vapour Absorption System: Theoretical and practical systems such as aqua ammonia, Electrolux & other systems;

(b) Steam Jet Refrigeration: Principles and working, simple cycle of operation, description and working of simple system,

(c) Refrigerants: nomenclature & classification, desirable properties, common refrigeration, comparative study, leak detection methods, environment friendly refrigerants and refrigerant mixtures, brine and its properties

Module 4 **(09 Hrs)**

Psychrometric: Calculation of psychrometric properties of air by table and charts; psychrometric processes: sensible heating and cooling, evaporative cooling, cooling and dehumidification, heating and humidification, mixing of air stream, sensible heat factor; principle of air conditioning, requirements of comfort air conditioning, ventilation standards, infiltrated air load, fresh air load human comfort, effective temperature & chart, heat production & regulation of human body

Module 5 **(09Hrs)**

Air Conditioning Loads: calculation of summer & winter air conditioning load, bypass factor of coil, calculation of supply air rate & its condition, room sensible heat factor, grand sensible heat factor, effective sensible heat factor, dehumidified air quantity. Problems on cooling load calculation. Air distribution and ventilation systems

Course Outcomes: Students will be able to

1. To make students familiar with the design and operating characteristics of Basic Refrigeration System.
2. To study the Vapour Compression Refrigeration system and their effect.
3. To study the Vapour Absorption Refrigeration system and their effect.
4. To introduce students to the Psychometric Chart & Table and Process.
5. To introduce about Air Conditioning System.

Text Books:

1. Arora CP; Refrigeration and Air Conditioning; TMH
2. Sapali SN; Refrigeration and Air Conditioning; PHI

Reference Books:

1. Ananthanarayan; Basic Refrigeration and Air conditioning; TMH
2. Manohar Prasad; Refrigeration and Air Conditioning; New Age Pub
3. Ameen; Refrigeration and Air Conditioning; PHI
4. Pita ; Air conditioning Principles and systems: an energy approach; PHI
5. Stoecker W.F, Jones J; Refrigeration and Air conditioning; McGH, Singapore
6. Jordan RC and Priester GB Refrigeration and Air Conditioning, PHI USA

List of Experiment:

1. To determine the COP of split air conditioning System.
2. To determine the COP of Cascade refrigeration system
3. To compare the performance of different heat pipe
4. To determine the COP of Vapour compression refrigeration system.
5. To determine the COP of Vapour absorption refrigeration system
6. To determine the COP of window air conditioning system.
7. To determine the COP of Mechanical Heat Pump
8. To determine the COP of Ice Plant
9. To determine the COP of Ejector Expansion Refrigeration System.
10. Visit at any HVAC Plant

ME-802 (A)	**Automobile Engineering**	**3L:1T: 2P (05 hrs)**	**Credits:04**

Course Objective's:

- The anatomy of the automobile in general and location and importance of each part
- The functioning of the engine and its accessories, gear box, clutch, brakes, steering, axles and wheels, Suspension, frame, springs and other connections

Course Content:

Module 1 **(07 Hrs)**

Chassis, Frame & Body Engg: Types, Technical details of commercial vehicles, types of chassis, lay out, types of frames, testing of frames for bending & torsion on unutilized body frame, vehicle body and their construction, drivers visibility and methods for improvement, safety aspects of vehicles, vehicle aerodynamics, optimization of body shape, drivers cab design, body materials, location of engine, front wheel and rear wheel drive, four wheel drive.

Module 2 **(08 Hrs)**

Steering and Front Axle: Front axle beam, stub axle, front wheel assembly, principles of types of wheel alignment, front wheel geometry viz. camber, Kingpin inclination, castor, toe-in and toe out, condition for true rolling motion, centre point steering, directional stability of vehicles, steering gear, power steering, slip angle, cornering power, over steer & under steer, gyroscopic effect on steering gears.

Module 3 **(09 Hrs)**

Transmission System: Function and types of clutches, single plate, multi-plate clutch, roller & spring clutch, clutch lining and bonding, double declutching, types of gear Boxes, synchronizer, gear materials, determination of gear ratio for vehicles, gear box performance at different vehicle speed, automatic transmission, torque converters, fluid coupling, principle of hydrostatic drive, propeller shaft, constant velocity universal joints, differential gear box, rear axle construction.

Module 4 **(10 Hrs)**

Suspension system and Brakes: Basic suspension movements, Independent front & rear suspension, shock absorber, type of springs: leaf spring, coil spring, air spring, torsion bar, location of shackles, power calculations, resistance to vehicle motion during acceleration and breaking, power & torque curve, torque & mechanical efficiency at different vehicle speeds, weight transfer, braking systems, disc theory, mechanical, hydraulic & pneumatic power brake systems, performance, self-energisation, air bleeding of hydraulic brakes, types of wheels and tyres, tyre specifications, construction and material properties of tyres & tubes.

Module 5 **(08 Hrs)**

Electrical and Control Systems: Storage battery, construction and operation of lead acid battery, testing of battery, principle of operation of starting mechanism, different drive systems, starter relay switch, regulator electric fuel gauge, fuel pump, horn, wiper, Lighting system, head light dazzling, signaling devices, battery operated vehicles, importance of maintenance, scheduled and unscheduled maintenance, wheel alignment, trouble Shooting probable causes & remedies of various systems, microprocessor based control system for automobile, intelligent automobile control systems.

Module 6 **(08 Hrs)**

Emission standards and Pollution control: Indian standards for automotive vehicles, Bharat & Euro norms, fuel quality standards, environmental management systems for automotive vehicles, catalytic converters, fuel additives, and modern trends in automotive engine efficiency and emission control

Course Outcomes: Students will be able to:

1. Define the vehicle body aesthetics and appropriate location of engine.
2. Apply & identify the geometry of steering system and the parameters on which its performance depends.
3. Define & Compare the different types of gearboxes and their applications.
4. Judge the importance of suspension system and brakes.,
5. Apply knowledge about electrical system of automobiles and proper handling of battery, emission standards and pollution control.
6. Explain various automotive vehicle environmental management norms and how to control emission.

Text Books:

1. Kripal Singh, Automotive Engineering Khanna Pub.
2. R.B Gupta, Automative Engineering Satya Prakashan
3. Gupta HN; Internal Combustion Engines; PHI

Reference Books:

1. David Crolla, Encyclopedia of Automotive Engineering Wiley
2. Crouse, Automotive Mechanics TMH.
3. Joseph Heitner, Automotive Mechanics, Principles and Practices, CBS Pub.
4. Newton & Steeds , Automotive Engineering
5. Emission standards from BIS and Euro Norms

List of Experiment:

Study of chassis, suspension, steering mechanisms, transmission, gear-box, differential systems, and electrical systems of various light and heavy automotive vehicles,recent technologies in Automobile Industry.

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ME-802 (B)	**Tribology & Maintenance Engineering**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objective's:
The objective of the course is to impart knowledge of maintenance engineering to students in order to help industries solve maintenance related problems.

Course Content:

Module 1 **(06 Hrs)**

Introduction: History of tribology, early scientific studies of - friction, Wear Lubrication. Tribo-Surface preparations and characteristics. Surface contacts, Hertz contact stresses, residual stress, surface fatigue, creep, stress relaxation, fracture mechanics, elastic, visco elastic and plastic behavior of materials. Choice of materials.

Module 2 **(08 Hrs)**

Friction: laws of friction, rolling/sliding friction, theory of adhesion and abrasion, different mechanisms of friction , stick slip characteristics, interface temperature, thermal analysis, Molecular mechanical theory of friction, operating conditions and system parameters, calculations of coefficient of friction, design of friction devices.

Module 3 **(08 Hrs)**

Wear: different types of wear mechanisms, adhesive, abrasive impact, percussion erosion, fretting wear calculations of wear rate, two body/ three body wear, wear prevention, wear of metal cutting and metal forming tools, wear mapping of materials, cavitation, surface fatigue, corrosion, performance levels classifications and specifications of lubricants.

Module 4 **(08 Hrs)**

Lubrication: lubricants and additives, composition and properties of lubricants, maintenance of oil and emulsions, industrial hygiene aspects, technical regulations for lubricants. boundary/ mixed and fluid film lubrication, industrial methods of lubrications, SAE,BIS, ASTM, IP, DIN Standards.oil testings, wear and chemistry of lubricants.

Module 5 **(08 Hrs)**

Nano Tribology: Instrumental tests,. Bearings, clutches and brakes, slide units, dynamic seals, Automobile applications, machine tools/ press machines applications. Other applications and case studies.

Course Outcomes: Students will be able to

1. Illustrate mechanical behavior of materials of contacting surfaces.
2. Evaluate coefficient of friction for different material with different boundary conditions.
3. Classify wear mechanisms and classifications and specifications of lubricants.
4. Explain different types of lubrication method, lubricating material and standards.
5. Analyze tribological case studies and tribological behaviors of different machines.

Reference Books:

1 Principles and applications of tribology, Bharat Bhushan, John Wiley& sons, ISBN 0 471 59407 5
2 Tribology,, - lubrication ,friction and wear, I V Kragelsky and V V Alisin, Mir publication, ISBN 1 86058 288 5

3. Applied Tribology,M M Khonsari and E. R. Booser, John Wiley, ISBN 0 471 28302 9

ME-802 (C)	**Machine Tool Design**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objective's: After studying this course, students will be able to:

- Understand the Kinematics of Machine Tools.
- Work with different drive systems
- Design Concepts of Metal working Tools.
- Do Design of Jigs, Fixtures and Gauges

Course Content:

Module 1 **(08 Hrs)**

Basic Features and Kinematics of Machine Tools: Features of basic machine tools; Construction and operation, types of machine tools, machine tools motions, transmission-rotation in to rotation, rotation in to translation, kinematic-structures of machine tools: elementary, complex and compound structure, kinematic-features of gear shapers and gear hobbing machine.

Module 2 **(08 Hrs)**

Regulation of Speed: Design of gear boxes- need for variation of speed, selection of speed range, laws of stepped regulation, standardization of speeds, speed diagram, analysis of productivity loss, kinematic advantage of GP, structural diagrams, ray diagram and speed chart.

Gear Drives: Belt and cone pulley, slip gear type, north gear drive, draw key gear drive, clutch type, mechanical step less drives, electrical drives; hydraulic drive.

Module 3: **(08 Hrs)**

Design of Metal working Tools: Design of press working tools, shearing, piercing, blanking, dies, compound die design principles for forging dies, bending, forming drawing dies, tooling for forging design principles for forging dies, drop forging, upset forging, design principles and practice for rolling, roll press design.

Module 4: **(08 Hrs)**

Design of Jigs and Fixtures: Principles of location, locating method and devices, principles of clamping, clamping devices, drilling jigs, types, drill bushes, fixture and economics, types of fixture, milling, grinding, broaching, assembly fixtures indexing jig and fixtures, indexing devices.

Module 5: **(08 Hrs)**

Design of Gauges and Inspection Features: Design of gauges for tolerance for dimensions and form inspection; dies and mould design for plastics& rubber parts: compression molding, transfer molding, blow molding.

Course Outcome's: Students will be able to:

1. Describe the features and kinematics of machine tools.
2. Design various gear drives and gear boxes.
3. Design various metal working tools.
4. Explain and design jigs and fixtures.
5. Design and inspect various gauges.

References:

1. Mehta N.K.; Machine Tool Design and Numerical Control; TMH
2. Sen G.C, Bhattacharya A; Principles of Machine Tools; New Central Book Agency.
3. Donaldson; Tool Design T.M.H.
4. Jain KC and Chitale AK; Text Book Of Production Engineering; PHI Learning
5. Juneja, Sekhon and Seth; Fundamentals of Metal Cutting and Machine Tools; New Age.
6. Krar SF, Gill AR, Smid P; Technology of Machine Tools;TMH
7. Sharma P.C; Production Engineering; Chand S
8. Wilson; Fundamentals of Tool Design; ASTME
9. Paqwin J.R; Die Design Handbook; The Industrial Press-NY
10. ASTME; Die Design Hand Book; McGraw Hill
11. Archinov; Metal Cutting & Cutting Tool Design; MIR Publishers
12. Moscow Kempster M.H.A; Introduction to Jig and Tool Design; FLBS

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ME-802 (D)	**Production Planning and Control**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objectives: After studying this course, students will be able to:

- To understand the various components and functions of production planning and control such as work study, product planning, process planning, production scheduling, Inventory Control.
- To know the recent trends like manufacturing requirement Planning (MRP II) and Enterprise Resource Planning (ERP).
- To learn work study, time study, work measurement.

Course Content:

Module 1 **(06 Hrs)**

Introduction: Types and characteristics of production systems Objective and functions of Production, Planning & Control, Place of production, Planning in Engineering, manufactures organization.

Preplanning: Forecasting & Market Analysis. Factory Location & Layout, Equipment policy and replacement. Preplanning production, capacity planning.

Module 2 **(08 Hrs)**

Work Study: Method study, basic procedure-Selection-Recording of process – Critical analysis, Development – Implementation – Micro motion and memo motion study – work measurement – Techniques of work measurement – Time study – Production study – Work sampling – Synthesis from standard data – Predetermined motion time standards.

Module 3 **(06 Hrs)**

Production Planning: Aggregate Planning, MPS, Material Resource Planning, Selection of material methods, machines & manpower. Routing, Scheduling and Dispatching and its sheets & charts, Production Line Balancing.

Module 4 **(08 Hrs)**

Production and Inventory Control: Progress control through records and charts. Types of inventories, Inventory Classification. Inventory Control under constraints Economic lot (batch) size. Trends in purchasing and store keeping, JIT production MRP II, comparison of Push & Pull systems, ERP, CAPPC.

Module 5 **(06 Hrs)**

Productivity: Importance, Productivity patterns, productivity measurements & ratios, improvement maintenance process. 3 Human Factors & Ergonomics: Human abilities, Training & motivation safety programs, work place design & working conditions.

Course Outcome's: Student will be able to

1. Recognize the objectives, functions, applications of PPC and forecasting techniques.
2. Understand various methods of work study, time study, work measurement.
3. Summarize various aggregate production planning techniques.
4. Understand Inventory control techniques and the recent trends in industries.
5. Understand various Ergonomic factors, Productivity patterns, productivity measurements and safety in working conditions.

Reference Books:

1. Elements of Production Planning & Control –Eilon
2. Production Planning & Control – Jain and Agarwal
3. Operations Management – Buffa and Sarin.
4. Project Management, S.C. Sharma, Khanna Publishing House
5. Production System – J.L. Riggs.
6. Industrial Engineering and Production Management : Martand Telsang, First edition, S. Chand and Company, 2000.
7. Theory and Problems in Production & Operations Management: Chary. S.N, Tata McGraw Hill, 1995

ME-803 (A)	**Data Analytics**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objective's:
Data Analytics is the science of analyzing data to convert information to useful knowledge. This knowledge could help us understand our world better, and in many contexts enable us to make better decisions. While this is broad and grand objective, the last 20 years has seen steeply decreasing costs to gather, store, and process data, creating an even stronger motivation for the use of empirical approaches to problem solving.
This course will enable you with a wide range of data analytic techniques and is structured around the broad contours of the different types of data analytics, namely, descriptive, inferential, predictive, and prescriptive analytics.

Pre-requisites:
This course requires that you are familiar with high-school level linear algebra, and calculus. Knowledge of probability theory, statistics, and programming is desirable

Course Content

Module 1: (06 Hrs)
Descriptive Statistics: Probability Distributions, Inferential Statistics, Inferential Statistics through hypothesis tests Regression & ANOVA ,Regression ANOVA(Analysis of Variance).

Module 2: (08 Hrs)
Introduction to Big Data: Big Data and its Importance, Four V's of Big Data, Drivers for Big Data, Introduction to Big Data Analytics, Big Data Analytics applications.
Big Data Technologies: Hadoop's Parallel World, Data discovery, Open source technology for Big Data Analytics, cloud and Big Data, Predictive Analytics, Mobile Business Intelligence and Big Data, Crowd Sourcing Analytics, Inter- and Trans-Firewall Analytics, Information Management.

Module 3: (06 Hrs)
Processing Big Data: Integrating disparate data stores, Mapping data to the programming framework, Connecting and extracting data from storage, Transforming data for processing, subdividing data in preparation for Hadoop Map Reduce.

Module 4: (08 Hrs)
Hadoop Mapreduce: Employing Hadoop Map Reduce, Creating the components of Hadoop Map Reduce jobs, Distributing data processing across server farms, Executing Hadoop Map Reduce jobs, monitoring the progress of job flows, The Building Blocks of Hadoop Map Reduce Distinguishing Hadoop daemons, Investigating the Hadoop Distributed File System Selecting appropriate execution modes: local, pseudo-distributed, fully distributed.

Module 5: (08 Hrs)
Big Data Tools and Techniques: Installing and Running Pig, Comparison with Databases, Pig Latin, User- Define Functions, Data Processing Operators, Installing and Running Hive, Hive QL, Querying Data, User-Defined Functions, Oracle Big Data.

Course Outcome's: Students will be able to:
1. Describe the concepts of statistics.

2. Aware about the concept of big data technologies.
3. Apply the concepts of big data processing.
4. Explain about the hadoop Mapreduce.
5. Conceptualize the big data tools and techniques.

Reference Books and Study Materials:

1. Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
2. Montgomery, Douglas C., and George C. Runger. Applied statistics and probability for engineers. John Wiley & Sons, 2010
3. NPTEL Video Course: Introduction to Data Analytics by Dr. Balaraman Ravindran Department of Computer Science and Engineering IIT Madras and Dr. Nandan Sudarsanam Department of Management Studies IIT Madras.

ME-803 (B)	**Energy Conservation, Management & Audit**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objective's:

- After studying this course, students will be able to;
- Understand the concepts of energy management and conservation.
- Able to conduct energy audit and report.
- Able to do Electrical Energy Management in different electrical systems

Course Content:

Module 1: **(06 Hrs)**

Energy Management: Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers. Energy Conservation: Basic concept, energy conservation in Household, Transportation, Agricultural, service and Industrial sectors, Lighting, HAVC.

Module 2: **(08 Hrs)**

Energy Audit: Definition, need and types of energy audit; Energy management (Audit) approach: Understanding energy cost, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirement; Fuel & energy substitution; Energy audit instruments; Energy conservation Act; Duties and responsibilities of energy manager and auditors.

Module 3: **(06 Hrs)**

Material Energy Balance: Facility as an energy system; Method for preparing process flow; material and energy balance diagrams. Energy Action Planning: Key elements, force field analysis; Energy policy purpose, perspective, content, formulation, rectification.

Module 4: **(08 Hrs)**

Monitoring and Targeting: Definition monitoring & targeting; Data and information analysis. Electrical Energy Management: energy conservation in motors, pumps and fan systems; energy efficient motors.

Module 5: **(08 Hrs)**

Thermal Energy Management: Energy conservation in boilers, steam turbine and industrial heating system; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pump; Building Energy Management.

Course Outcome's: Students will be able to:

1. Understand principles of energy management and its influence on environment.
2. Use the energy audit methods learnt to identify the areas deserving tighter control to save energy expenditure.
3. Understand the concepts of Material energy balance and energy action plan.
4. Design suitable energy monitoring system to analyze and optimize the energy consumption in an organization
5. Improves the thermal efficiency by designing suitable systems for heat recovery and co-generation

References:

1. Murphy & Mckay, Energy Management, BSP Books Pvt. Ltd.
2. Smith CB; Energy Management Principle, Pergamon Press, New York.
3. Rajan GG, Optimising Energy Efficiency in Industry, TMH.
4. Callaghan P O, Energy Management, McGraw-Hill Book Company.
5. Amit Kumar Tyagi, Handbook on Energy Audit and Management, Tata Energy Research Institute. 6.
Bureau of Energy Efficiency, Study material for energy Managers and Auditors: Paper I to V.
7. Hamies; Energy Auditing and Conservation: Method, Measurement, Hemisphere, Washington.
8. Witty, Larry C, Industrial Enegy Management Utilisation, Hemisphere Publishers, Washington
9.Kreith & Goswami, Energy Management and Conservation Handbook, CRC Press.

ME-803 (C)	**Entrepreneurship and Management Concepts**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objective's:
To familiarize the students with the concepts and applications of Management, Marketing, Productivity & Entrepreneurship in competitive world.

Course Content:

Module 1: **(08 Hrs)**
System Concepts: Types, definition & characteristics; supra & subsystems, key component; boundary & interface complexity; feedback (pull) & feed forward (push) controls, open flexible-adaptive system, computer as closed system, law of requisite variety; system coupling, stresses and entropy; functional & cross functional system; Steven Alter's nine element work system model and its comparison with IPO (input-processing-output) model, structure and performance of work systems leading to customer delight.

Module 2: **(08 Hrs)**
Management: Importance, definition and functions; schools of theories, knowledge driven learning organization and e-business; environment, uncertainty and adaptability; corporate culture, difficulties and levels of planning, BCG matrix, SWOT analysis, steps in decision making, structured and unstructured decision; dimensions of organizations, size/specialization, behavior formalization, authority centralization, departmentalization, spam and line of control, technology and Minzberg organization typology, line, staff & matrix organization, coordination by task force, business process reengineering and process of change management, HR planning placement and training, MIS; attitudes and personality trait, overlap and differences between leader & manager, leadership grid, motivation, Maslow's need hierarchy and Herzberg two factor theory, expectation theory, learning process, team work and stress management.

Module 3: **(08 Hrs)**
Marketing: Importance, definition, core concepts of need want and demand, exchange & relationships, product value, cost and satisfaction (goods and services) marketing environment; selling, marketing and societal marketing concepts; four P's, product, price, placement, promotion; consumer, business and industrial market, market targeting, advertising, publicity, CRM and market research. Finance: Nature and scope, forms of business ownerships, balance sheet, profit and loss account, fund flow and cash flow statements, breakeven point (BEP) and financial ratio analysis, pay-back period, NPV and capital budgeting.

Module 4: **(08 Hrs)**
Productivity and Operations: Productivity, standard of living and happiness, types of productivity, operations (goods and services) Vs project management, production processes and layouts, steps in method improvement, time measurement, rating and various allowances; standard time and its utility, predetermined motion and time method, product and process specification, TQM, cost of quality, introduction to lean manufacturing (JIT), QFD, TPM & six sigma quality.

Module 5: **(08 Hrs)**
Entrepreneurship : Definition and concepts, characteristics, comparison with manager, classification, theories of entrepreneur, socio, economic, cultural and psychological; entrepreneur traits and behavior, roles in economic growth, employment, social stability, export promotion and

indigenization, creating a venture, opportunity analysis competitive and technical factors, sources of funds, entrepreneur development program.

Course Outcome's: Students will be able to:
1. Describe concepts of system and understand structure and performance of systems
2. Explain the basic concept, principles and processes of management.
3. Explain the concepts of Finance & Marketing.
4. Explain the concept of productivity and operations management.
5. Explain about entrepreneurship, its classification, traits, behaviors, roles, opportunities.

References:
1. Daft R; The new era of management; Cengage.
2. Bhat Anil, Arya kumar; Management: Principles,Processes and Practices; Oxford higheredu.
3. Mukharji R.S.,Agrawal N.K.; Entrepreneurship and Management Concepts,Technocrats Publication
4. Davis & Olson; Management Information System; TMH.
5. Steven Alter; Information systems, Pearson, www.stevenalter.com
6. Kotler P; Marketing management; 6- Khan, Jain; Financial Management; 7- ILO; Work study;ILO.
7. Mohanty SK; Fundamental of Entrepreneurship; PHI.

ME-803 (D)	**Management Information System**	**3L:0T: 0P (03 hrs)**	**Credits:03**

Course Objective's:
After studying the course, students will be able to;

- Know about MIS, MIS Theory, Systems Approach
- Understand the concept of decision making and MIS
- Learn about conceptual system design, detailed system design
- Understand implementation, evaluation and maintenance of MIS

Course Content:

Module 1: **(06 Hrs)**

Introduction of MIS: What is MIS, Decision support systems, systems approach, The systems view of business, MIS organization within the Company. Management organizational theory and the systems approach: Development of organizational theory, Management and organizational behavior, Management information and the systems approach.

Module 2: **(08 Hrs)**

Information systems for decision-making: Evolution of an information system, Basic information systems, Decision making and MIS, MIS as technique for making programmed decisions, design assisting information systems. Strategic and project planning for MIS General business planning, appropriate MIS response, MIS planning-general, MIS planning-details.

Module 3: **(08 Hrs)**

Conceptual System Design: Define the problems, Systems objectives, Establish system constraints, Determine information needs, Determine information sources, Develop alternative conceptual designs and select one, Document the system concept, Prepare the conceptual design report.

Detailed System Design: Information and involve the organization, arm of detailed design, Project management of MIS detailed design. Identify dominant and trade off criteria define the subsystems, Sketch the detailed operating MIS systems and information flows, Determine the degree of automation of each operation, inform and involve the organization again, Inputs, Outputs and processing, early system testing, Software, Hardware and tools, propose an organization to operate the system, Document the detailed design., Revisit the manager user.

Module 4: **(06 Hrs)**

Implementation, Evaluation and Maintenance of the MIS: Plan the implementation, Acquire floor space and plan space layouts organized for implementation, Develop procedures for implementation, Train the operating personnel, Computer related acquisitions, Develop forms for data collection and information dissemination, Develop the files, Test the system, Cut over, Document the system, Evaluate the MIS, Control and maintain the system.

Module 5: **(06 Hrs)**

Pitfalls in MIS Development: Fundamental weaknesses, Soft spots in planning, Design problem, Implementation the TAR PITF.

Course Outcome's: Students will be able to:

6. Introduce about management information system.
7. Conceptualize the information system for decision making.

8. Explain about system design.
9. Implement and Evaluate about Management Information System.
10. Explain the drawbacks of Management Information System.

References:

1. Murdick R.G., Russ J.B., Clagget J.R., Information Systems for modem management
2. Effy OZ, Management Information Systems, 3rd edition, Thomson.
3. Jawadekar W.S., Management Information System.
4. Brien J.A.O., Irwin, Management Information Systems, McGraw Hill
5. Dour's G.B., Olson M.H., Management Information Systems, 2nd edition, McGraw Hill
6. Thireramp R.J., Decision Support Systems for Effective Planning and Control, PHI.
7. Sadagopan S., Management Information Systems, 4thedition, Prentice-Hall of India
8. Kanter J., Managing with Information, 4th edition, Prentice-Hall of India.
9. Ladon K.C., Landon, J.P., Management Information Systems, 4th edition, Prentice-Hall of India.

ME-804	**Simulation And Modeling**	**0L:0T: 6P (6 hrs)**	**Credits:03**

Course Objective's:
Introduction to Modeling Software Packages like Solid Works, CATIA, ANSYS, Assembly of Sleeve and Cotter joint, Gib and Cotter joint/ Knuckle Joint/ Flanged Coupling, Assembly of Connecting Rod.
Introduction to Simulation software Packages like ANSYS, Fluent, and etc. Various types of analysis. Structure analysis, Thermal analysis, Stress analysis, CFD analysis, FEM analysis, and their problem solving in actual situations.

List of Experiments (Expandable)
1. Introduction to CATIA software.
2. Introduction to ANSYS software.
3. Assembly of Sleeve and Cotter joint/ Gib and Cotter joint/ Knuckle Joint/ Flanged Coupling using CATIA.
4. Assembly of Connecting Rod using CATIA.
5. Stress analysis using ANSYS (examples: plate with a circular hole, rectangular L bracket, Axis-symmetric components, various types of beams, etc.)
6. Thermal stress analysis of a 2D component.
7. Conductive and convective heat transfer analysis of a 2D component.
8. CFD Simulation of various situations (example: Laminar pipe flow, Flat plate boundary layer, steady flow past a cylinder, Compressible flow in a Nozzle, Flow over an airfoil.)
Evaluation will be continuous an integral part of the laboratory class followed by the final external viva/voce examination.

Course Outcome's: Students will be able to
1. Perform 3d modeling of any mechanical components.
2. Create assembly of components.
3. Understand and perform stress analysis using Ansys.
4. Understand thermal and heat transfer analysis of 2d component.
5. Understand CFD Simulation and its steps.

References:
1. User manual of CATIA software.
2. User manual of ANSYS and Fluent software.
3. Chandrupatla, T.R. and Belegundu, A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India Pvt. Ltd.
4. Zienkiewicz O C, The Finite Element Method, 3rd ed, Tata McGraw Hill.

ME-805	**Major Project- II**	**0L:0T: 8P (8 hrs)**	**Credits:08**

Course Objective's: The objectives of the course 'Major Project -II' are

- To provide students with a comprehensive experience for applying the knowledge gained so far by studying various courses.
- To develop an inquiring aptitude and build confidence among students by working on solutions of
- small industrial problems.
- To give students an opportunity to do something creative and to assimilate real life work
- situation in institution.
- To adapt students for latest developments and to handle independently new situations.
- To develop good expressions power and presentation abilities in students.

The focus of the Major Project-II is on preparing a working system or some design or understanding of a complex system using system analysis tools and submit it the same in the form of a write-up i.e. detail project report. The student should select some real life problems for their project and maintain proper documentation of different stages of project such as need analysis, market analysis, concept evaluation, requirement specification, objectives, work plan, analysis, design, implementation and test plan. Student may carry his /her topic of major project –I for major project –II provided that supervisor of the student is agree for the same on the basis of feasibilitity and scope of work of the selected topic. Each student is required to prepare a project report and present the same at the time of final examination with a demonstration of the working system (if any).

The faculty and student should work according to following schedule:

i) Each student undertakes substantial and individual project in an approved area of the subject and supervised by a member of staff.
ii) The student must submit outline and action plan for the project execution (time schedule) and the same be approved by the concerned faculty.
iii) At all the steps of the project, students must submit a written report of the same.

Course Outcome's: After completion of this course, students will be able to:

1) Identify a topic in areas of Mechanical Engineering.
2) Review literature to identify gaps and define objectives & scope of the work.
3) Generate and implement innovative ideas for social benefit.
4) Develop a prototypes/models, experimental set-up and software systems necessary to meet the objectives.
5) Prepare a report as per recommended format and defend the work.

Evaluation

Evaluation will be continuous an integral part of the project work done by student on regular basis by the supervisor followed by the final external viva/voce examination.
