| | T | P | C |
|---|---|---|---|
| **III  Year – II SEMESTER** | **3+1*** | **0** | **3** |

**OPERATIONS RESEARCH**

**Course Objectives:**
To learn the importance of Operations Research in the design, planning, scheduling, manufacturing and business applications and to use the various techniques of Operations Research in solving such problems.

**UNIT – I**
Development – definition– characteristics and phases – types of operation research models – applications.
**ALLOCATION:** Linear programming problem formulation – graphical solution – simplex method – artificial variables techniques -two–phase method, big-M method – duality principle.

**UNIT – II**
**TRANSPORTATION PROBLEM:** Formulation – optimal solution, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution - variants of assignment problem- traveling salesman problem.
**SEQUENCING** – Introduction – flow –shop sequencing – *n* jobs through two machines – *n* jobs through three machines – job shop sequencing – two jobs through 'm' machines.

**UNIT – III**
**REPLACEMENT:** Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.

**UNIT – IV**
**THEORY OF GAMES:** Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 & 2 x n games -graphical method.
**WAITING LINES:** Introduction – single channel – poison arrivals – exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel poison arrivals.

**UNIT – V**

**INVENTORY :** Introduction – single item – deterministic models – purchase inventory models with one price break and multiple price breaks – shortages are not allowed – stochastic models – demand may be discrete variable or continuous variable – instantaneous production. Instantaneous demand and continuous demand and no set up cost.  ABC & VED Analysis.

**UNIT – VI**

**DYNAMIC PROGRAMMING:** Introduction – Bellman's principle of optimality – applications of dynamic programming- capital budgeting problem – shortest path problem – linear programming problem.

**SIMULATION:** Definition – types of simulation models – phases of simulation– applications of simulation – inventory and queuing problems – advantages and disadvantages – simulation languages.

**TEXT BOOKS:**
1.  Operations Research / S.D.Sharma-Kedarnath

**REFERENCES:**
1.  Introduction to O.R/Hiller & Libermann (TMH).
2.  Operations Research / A.M.Natarajan, P. Balasubramani, A. Tamilarasi / Pearson Education.
3.  Operations Research: Methods & Problems / Maurice Saseini, Arhur Yaspan & Lawrence Friedman.
4.  Operations Research / R.Pannerselvam,PHI Publications.
5.  Operations Research / Wagner/ PHI Publications.
6.  Operation Research /J.K.Sharma/MacMilan.
7.  Operations Research/ Pai/ Oxford Publications
8.  Operations Research/S Kalavathy / Vikas Publishers
9.  Operations Research / DS Cheema/University Science Press
10. Operations Research / Ravindran, Philips, Solberg / Wiley publishers.

**Course Outcomes:**

After completion of the course, the student will be able to:

To solve the LP and DP problems.

To solve the Transportation, assignment, game, inventory, replacement, sequencing, queuing problems.

| | T | P | C |
|---|---|---|---|
| **III Year – II SEMESTER** | **3+1\*** | **0** | **3** |

## INTERACTIVE COMPUTER GRAPHICS

**Course objectives:**

This course allows the students to:

1. Understand the fundamental concepts and theory of computer graphics.
2. Understand modeling, and interactive control of 3D computer graphics applications.
3. The underlying parametric surface concepts be understood.
4. Learn multimedia authoring tools.

## UNIT-I

**INTRODUCTION:** Application areas of computer graphics, overview of graphic system, video-display devices, raster-scan systems, random scan systems, graphics monitors and work stations and input devices.

## UNIT-II

**OUTPUT PRIMITIVES:** Points and lines, line drawing algorithms, mid-point circle algorithm,

Filled area primitives: scan-line polygon fill algorithm, boundary-fill and flood-fill algorithm.

**2-D GEOMETRICAL TRANSFORMATIONS:** Translation, scaling, rotation, reflection and shear transformation matrix representations and homogeneous co-ordinates, composite transformations, transformations between coordinates.

## UNIT -III

**2-D VIEWING :** The viewing pipe-line, viewing coordinat4 reference frame, window to view-port co-ordinate transformations, viewing function, Cohen-Sutherland and Cyrus-beck line clipping algorithms, Sutherland-Hodgeman polygon clipping algorithm.

## UNIT -IV

**3-D OBJECT REPRESENTATION:** spline representation, Hermite curve, Bezier curve and B-spline curve, Polygon surfaces, quadric surfaces, , Solid modeling Schalars – wire frame, CSG, B-rep. Bezier and B-spline surfaces, Basic illumination models, shading algorithms.

**UNIT -V**

**3-D GEOMETRIC TRANSFORMATIONS:** Translation, rotation, scaling, reflection and shear transformation and composite transformations. Visible surface detection methods: Classification, back-face detection, depth-buffer, scan-line, depth sorting.

**UNIT-VI**

**COMPUTER ANIMATION:** Design of animation sequence, general computer animation functions, raster animation, computer animation language, key frame system, motion specification.

**TEXT BOOKS:**

1. " Computer Graphics C version" Donald Hearn and M. Pauline Baker, Pearson/PHI
2. "Computer Graphics Principles & practice", second edition in C, Foley, VanDam, Feiner and Hughes, Pearson Education.

**REFERENCES:**

1. "Computer Graphics Second edition", Zhigand xiang, Roy Plastock, Schaum's outlines, Tata Mc-Graw hill edition.
2. Procedural elements for Computer Graphics, David F Rogers, Tata Mc Graw hill, 2nd edition.
3. "Principles of Interactive Computer Graphics", Neuman and Sproul, TMH.
4. Computer Graphics, Steven Harrington, TMH.

**Course outcomes:**

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

1. Use the principles and commonly used paradigms and techniques of computer graphics.
2. Write basic graphics application programs including animation.
3. Design programs to display graphic images to given specifications.
4. Possess in-depth knowledge of display systems, image synthesis, shape modeling, and interactive control of 3D computer graphics applications.

| | T | P | C |
|---|---|---|---|

**III Year – II SEMESTER**    T 3+1*    P 0    C 3

## DESIGN OF MACHINE MEMBERS– II

**Course Objectives:**
- This course gives the insight of slider and roller bearings and the life prediction.
- Learn to design I.C engine parts.
- Design the mechanical systems for power transmission elements such as gears,belts,ropes,chains, keys and levers.

**UNIT – I**
**BEARINGS:** Classification of bearings- applications, types of journal bearings – lubrication – bearing modulus – full and partial bearings – clearance ratio – heat dissipation of bearings, bearing materials – journal bearing design – ball and roller bearings – static loading of ball & roller bearings, bearing life.

**UNIT – II**
**ENGINE PARTS:** Connecting Rod: Thrust in connecting rod – stress due to whipping action on connecting rod ends – cranks and crank shafts, strength and proportions of over hung and center cranks – crank pins, crank shafts.

**UNIT –III**
Pistons, forces acting on piston – construction design and proportions of piston, cylinder, cylinder liners.

**UNIT – IV**
Design of curved beams: introduction, stresses in curved beams, expression for radius of neutral axis for rectangular, circular, trapezoidal and t-section, design of crane hooks, c –clamps**.**

**UNIT – V**
**POWER TRANSMISSIONS SYSTEMS, PULLEYS**: Transmission of power by belt and rope drives , transmission efficiencies, belts – flat and v types – ropes - pulleys for belt and rope drives, materials, chain drives
**DESIGN OF POWER SCREWS:** Design of screw, square ACME, buttress screws, design of nut, compound screw, differential screw, ball screw- possible failures.

**UNIT – VI**

**SPUR & HELICAL GEAR DRIVES:** Spur gears- helical gears – load concentration factor – dynamic load factor, surface compressive strength – bending strength – design analysis of spur gears – estimation of centre distance, module and face width, check for plastic deformation, check for dynamic and wear considerations.

**MACHINE TOOL ELEMENTS:** Levers and brackets: design of levers – hand levers-foot lever – cranked lever – lever of a lever loaded safety valve-rocker arm straight – angular- design of a crank pin – brackets- hangers- wall boxes.

**TEXT BOOKS:**

1. Machine Design, V.Bandari, TMH Publishers
2. Machine Design PSG Data hand book
3. Machine Design, Pandya & Shaw, Charotar publishers

**REFERENCES:**

1. Machine Design / R.N. Norton
2. Data Books : (I) P.S.G. College of Technology (ii) Mahadevan
3. Mech. Engg. Design / JE Shigley

**Course outcomes:**

At the end of the course

1. The student will able to select the suitable bearing based on the application of the loads and predict the life of the bearing.
2. Design power transmission elements such as gears, belts, chains, pulleys, ropes, levers and power screws.
3. Design of IC Engines parts.

**III  Year – II SEMESTER**

| T | P | C |
|---|---|---|
| 3+1* | 0 | 3 |

## ROBOTICS

**Course Objectives:**
1. To give students practice in applying their knowledge of mathematics, science, and Engineering and to expand this knowledge into the vast area of robotics.
2. The students will be exposed to the concepts of robot kinematics, Dynamics, Trajectory planning.
3. Mathematical approach to explain how the robotic arm motion can be described.
4. The students will understand the functioning of sensors and actuators.

### UNIT-I
**INTRODUCTION:** Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system.

### UNIT – II
**COMPONENTS OF THE INDUSTRIAL ROBOTICS:** Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.

### UNIT – III
**MOTION ANALYSIS:** Homogeneous transformations as applicable to rotation and translation – problems.
**MANIPULATOR KINEMATICS:** Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems.

### UNIT – IV
Differential transformation and manipulators, Jacobians – problems
Dynamics: Lagrange – Euler and Newton – Euler formulations – Problems.

### UNIT V
General considerations in path description and generation. Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint

integrated motion –straight line motion – Robot programming, languages and software packages-description of paths with a robot programming language..

## UNIT VI
## ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors.

Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors.

**ROBOT APPLICATIONS IN MANUFACTURING:** Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection.

## TEXT BOOKS:

1. Industrial Robotics / Groover M P /Pearson Edu.
2. Robotics and Control / Mittal R K & Nagrath I J / TMH.

## REFERENCES:

1. Robotics / Fu K S/ McGraw Hill.
2. Robotic Engineering / Richard D. Klafter, Prentice Hall.
3. Robot Analysis and Intelligence / Asada and Slow time / Wiley Inter-Science.
4. Introduction to Robotics / John J Craig / Pearson Edu.

## Course outcomes:

Upon successful completion of this course you should be able to:

1. Identify various robot configuration and components.
2. Select appropriate actuators and sensors for a robot based on specific application.
3. Carry out kinematic and dynamic analysis for simple serial kinematic chains.
4. Perform trajectory planning for a manipulator by avoiding obstacles.

**III  Year – II SEMESTER**

| T | P | C |
|---|---|---|
| 3+1* | 0 | 3 |

## HEAT TRANSFER

### (Heat transfer data book allowed)

**Course Objectives:**

This course is intended to impart knowledge of principles of heat transfer and analyze the heat exchange process in various modes for the evaluation of rate of heat transfer and the temperature distribution in different configurations.

### UNIT – I

**INTRODUCTION:** Modes and mechanisms of heat transfer – basic laws of heat transfer –General discussion about applications of heat transfer.

**CONDUCTION HEAT TRANSFER:** Fourier rate equation – general heat conduction equation in cartesian, cylindrical and Spherical coordinates. Steady, unsteady and periodic heat transfer – initial and boundary conditions.

**ONE DIMENSIONAL STEADY STATE CONDUCTION HEAT TRANSFER:** Homogeneous slabs, hollow cylinders and spheres – overall heat transfer coefficient – electrical analogy – critical radius of insulation-Variable thermal conductivity – systems with heat sources or heat generation.

### UNIT – II

extended surface (fins) heat Transfer – long fin, fin with insulated tip and short fin, application to error measurement of temperature.

**ONE DIMENSIONAL TRANSIENT CONDUCTION HEAT TRANSFER:** Systems with negligible internal resistance – significance of biot and fourier numbers - chart solutions of transient conduction systems.

### UNIT – III

**CONVECTIVE HEAT TRANSFER:** Classification of convective heat transfer – dimensional analysis as a tool for experimental investigation – Buckingham Pi Theorem for forced and free convection, application for developing semi – empirical non- dimensional correlation for convective heat transfer – Significance of non-dimensional numbers – concepts of continuity, momentum and Energy Equations.

### UNIT –IV
### FORCED CONVECTION

**EXTERNAL FLOWS:** Concepts about hydrodynamic and thermal

boundary layer and use of empirical correlations for convective heat transfer -flat plates and cylinders.

**INTERNAL FLOWS:** Concepts about hydrodynamic and thermal entry lengths – division of internal flow based on this –use of empirical relations for horizontal pipe flow and annulus flow.

**FREE CONVECTION:** Development of hydrodynamic and thermal boundary layer along a vertical plate – use of empirical relations for vertical plates and pipes.

## UNIT V
## HEAT TRANSFER WITH PHASE CHANGE

**BOILING:** Pool boiling – regimes- calculations on nucleate boiling, critical heat flux and film boiling.

**CONDENSATION:** Film wise and drop wise condensation –nusselt's theory of condensation on a vertical plate - film condensation on vertical and horizontal cylinders using empirical correlations.

## HEAT EXCHANGERS:

Classification of heat exchangers – overall heat transfer coefficient and fouling factor – concepts of LMTD and NTU methods – Problems.

## UNIT VI
## RADIATION HEAT TRANSFER:

Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks.

## TEXT BOOKS:

1. Heat Transfer -  HOLMAN/TMH
2. Heat Transfer – P.K.Nag/ TMH
3. Principles of Heat Transfer – Frank Kreith, RM Manglik & MS Bohn, Cengage learning publishers.

## REFERENCE BOOKS:

1. Heat and Mass Transfer – Arora and Domkundwar, Dhanpatrai & sons.
2. Fundamentals of Engg. Heat and Mass Transfer / R.C.SACHDEVA / New Age International.
3. Heat and Mass Transfer –Cengel- McGraw Hill.

4. Heat and Mass Transfer – D.S.Kumar / S.K.Kataria & Sons.

**Course outcomes:**

The student after undergoing this course is expected to know the principles of heat transfer and be able to apply to practical situations where in heat exchange takes place through various modes of heat transfer including phase change.

**III  Year – II SEMESTER**

| T | P | C |
|---|---|---|
| 3+1* | 0 | 3 |

## INDUSTRIAL ENGINEERING & MANAGEMENT

**Course Objectives:**

1. To impart fundamental knowledge and skill sets required in the Industrial Management and Engineering profession, which include the ability to apply basic knowledge of mathematics, probability and statistics, and the domain knowledge of Industrial Management and Engineering.

2. To produce graduates with the ability to adopt a system approach to design, develop, implement and innovate integrated systems that include people, materials, information, equipment and energy.

3. To enable students to understand the interactions between engineering, business, technological and environmental spheres in the modern society.

4. To enable students to understand their role as engineers and their impact to society  at the national and global context.

**Unit – I**

**INTRODUCTION:**  Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. concepts of management, importance, functions of management, scientific management, Taylor's principles, theory X and theory Y, Fayol's principles of management.

**Unit – II**

**PLANT LAYOUT:** Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and breakdown maintenance.

**Unit – III**

**OPERATIONS MANAGEMENT:** Importance, types of production, applications, workstudy, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

**Unit – IV**

**STATISTICAL QUALITY CONTROL:** Quality control, its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – $\overline{X}$ and R – charts $\overline{X}$ AND $S$ charts and their applications, numerical examples.

**TOTAL QUALITY MANAGEMENT**: zero defect concept, quality circles, implementation, applications, ISO quality systems. six sigma – definition, basic concepts

**Unit – V**

**RESOURCE MANAGEMENT:** Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, types.

**Unit - VI**

**VALUE ANALYSIS:** Value engineering, implementation procedure, enterprise resource planning and supply chain management.

**PROJECT MANAGEMENT**: PERT, CPM – differences & applications, critical path, determination of floats, importance, project crashing, smoothing and numerical examples.

**TEXT BOOKS:**
1. Industrial Engineering and management by O.P Khanna, Khanna Publishers.
2. Industrial Engineering and Production Management, Martand Telsang, S.Chand & Company Ltd. New Delhi.

**Reference Books:**
1. Industrial Management by Bhattacharya DK, Vikas publishers.
2. Operations Management by J.G Monks, McGrawHill Publishers.
3. Industrial Engineering by Banga & Sharma.
4. Principles of Management by Koontz O' Donnel, McGraw Hill Publishers.
5. Statistical Quality Control by Gupta.
6. Industrial Engineering and Management by Raju, Cengage Publishers.

**Course outcome:**

Upon successful completion of this course you should be able to:

1. Design and conduct experiments, analyse, interpret data and synthesise valid conclusions.

2. Design a system, component, or process, and synthesise solutions to achieve desired needs.

3. Use the techniques, skills, and modern engineering tools necessary for engineering practice with appropriate considerations for public health and safety, cultural, societal, and environmental constraints.

4. Function effectively within multi-disciplinary teams and understand the fundamental precepts of effective project management.

**III  Year – II SEMESTER**

| T | P | C |
|---|---|---|
| 3+1* | 0 | 3 |

## DEPARTMENTAL ELECTIVE – I

## REFRIGERATION & AIR CONDITIONING
### (Refrigeration and Psychrometric tables and charts allowed)

**Course objectives:**
The course is to understand the basic cycles of various refrigerating systems, their performance evaluation along with details of system components and refrigerant properties. The course is also aimed at imparting knowledge of psychrometric properties, processes which are used in airconditioning systems for comfort and industrial applications.

## UNIT – I
**INTRODUCTION TO REFRIGERATION:** Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: bell coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

## UNIT – II
**VAPOUR COMPRESSION REFRIGERATION**: Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.

## UNIT III
**REFRIGERANTS** – Desirable properties – classification - refrigerants used – nomenclature – ozone depletion – global warming.
**VCR SYSTEM COMPONENTS:** Compressors – general classification – comparison – advantages and disadvantages. condensers – classification – working principles evaporators – classification – working principles expansion devices – types – working principles.

## UNIT IV
**VAPOR ABSORPTION SYSTEM**: Calculation of maximum COP – description and working of $NH_3$ – water system and Li Br –water ( Two shell & Four shell) System, principle of operation three fluid absorption system, salient features.

**STEAM JET REFRIGERATION SYSTEM**: Working Principle and basic components. principle and operation of (i) thermoelectric refrigerator (ii) vortex tube.

## UNIT – V

**INTRODUCTION TO AIR CONDITIONING:** Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF, GSHF-problems, concept of ESHF and ADP temperature.

Requirements of human comfort and concept of effective temperature-comfort chart –comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

## UNIT – VI

**AIR CONDITIONING SYSTEMS:** Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits.

**TEXT BOOKS:**
1. A Course in Refrigeration and Air conditioning / SC Arora & Domkundwar / Dhanpatrai.
2. Refrigeration and Air Conditioning / CP Arora / TMH.

**REFERENCES:**
1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration - Dossat / Pearson Education.
3. Basic Refrigeration and Air-Conditioning – Ananthanarayanan / TMH

**Course outcomes:** At the end of the course the students should be able to:
After undergoing the course the student should be in a position to analyze various refrigerating cycles and evaluate their performance. The student also should be able to perform cooling load calculations and select the appropriate process and equipment for the required comfort and industrial airconditioning.

## COMPUTATIONAL FLUID DYNAMICS
### (DEPARTMENTAL ELECTIVE – I)

**Course Objectives:**
The course aims at providing required numerical and software techniques for solving various engineering problems involving fluid flow.

### UNIT-I
**ELEMENTARY DETAILS IN NUMERICAL TECHNIQUES:** Number system and errors, representation of integers, fractions, floating point arithmetic, loss of significance and error propagation, condition and instability, computational methods for error estimation, convergence of sequences.

### UNIT – II
**APPLIED NUMERICAL METHODS:** Solution of a system of simultaneous linear algebraic equations, iterative schemes of matrix inversion, direct methods for matrix inversion, direct methods for banded matrices.

**REVIEW OF EQUATIONS GOVERNING FLUID FLOW AND HEAT TRANSFER:** Introduction, conservation of mass, Newton's second law of motion, expanded forms of navier-stokes equations, conservation of energy principle, special forms of the navier-stokes equations.

### UNIT - III
Steady flow, dimensionless form of momentum and energy equations, stokes equation, conservative body force fields, stream function - vorticity formulation.

Finite difference applications in heat conduction and convention – heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer, closure.

### UNIT - IV
Finite differences, discretization, consistency, stability, and fundamentals of fluid flow modeling: introduction, elementary finite difference quotients, implementation aspects of finite-difference equations, consistency, explicit and implicit methods.

### UNIT - V
Introduction to first order wave equation, stability of hyperbolic and elliptic equations, fundamentals of fluid flow modeling, conservative property, the upwind scheme.

## UNIT -VI

**FINITE VOLUME METHOD:** Approximation of surface integrals, volume integrals, interpolation and differentiation practices, upwind interpolation, linear interpolation and quadratic interpolation.

## TEXT BOOKS:

1. Numerical heat transfer and fluid flow / Suhas V. Patankar- Butter-worth Publishers.
2. Computational fluid dynamics - Basics with applications - John. D. Anderson / Mc Graw Hill.

## REFERENCES:

1. Computational Fluid Flow and Heat Transfer/ Niyogi, Pearson Publications.
2. Fundamentals of Computational Fluid Dynamics – Tapan K. Sengupta / Universities Press.
3. Computational fluid dynamics, 3$^{rd}$ edition/Wendt/Springer publishers

## Course Outcomes:

After undergoing the course the student shall be able to apply various numerical tools like finite volume, finite difference etc for solving the different fluid flow problems.

# CONDITION MONITORING
## (DEPARTMENTAL ELECTIVE – I)

**Course Objectives:**
- This course is designed to introduce the benefits and opportunities of health Monitoring and covers a range of techniques.
- The students will be exposed to a range of techniques from Vibration based methods, Thermography, Oil conditions, Debris and ultrasonic monitoring.
- Using overall vibration, vibration limit zones, broadband vibration bandwidth, alert levels, typical severity guidelines, recording overall vibration, using overall vibration for fault finding, trending overall vibration.

Identifying Resonance, Hammer Test, Self Excitation, Exciter Testing. Reducing Resonance - Effects of Frequency, Stiffness, Mass, Damping, Isolation.

## UNIT-I
**BASICS OF VIBRATION:** Basic motion: amplitudes, period, frequency, basic parameters: displacement, velocity, acceleration, units (including dB scales) and conversions, Mass, spring and damper concept, Introduction to SDOF and MDOF systems, Natural frequencies and resonance, Forced response.

## UNIT-II
**VIBRATION MEASUREMENTS AND ANALYSIS:** Transducers and mounting methods, data acquisition using instrumentation recorders/data loggers, time domain signal analysis, orbit analysis, Filters, Frequency domain analysis (Narrow band FFT analysis), Nyquist criteria, Sampling, aliasing, windowing and averaging.

**VIBRATION MEASUREMENT AND ANALYSIS:** Use of phase; bode, polar and water fall plots, constant percentage band width analysis (1/3 and 1/1 Octave analysis), envelope detection /spike energy analysis, cepstral analysis, advances in analysis (PC based and portable instruments for vibration analysis).

## UNIT-III
Fault Diagnosis, Interpreting vibration measurements for common machine faults, imbalance, misalignment, mechanical looseness, bearing and gearing faults, faults in induction motors, resonances, some case studies, static and

dynamic balancing, international standards for vibration condition monitoring.

## UNIT-IV

**THERMOGRAPHY:** The basics of infrared thermography, differences in equipment and specific wave length limitations, application of ir to: electrical inspection, mechanical inspection, energy conservation, how to take good thermal images, hands-on demonstrations focusing on proper camera settings and image interpretation, analysis of thermal images and report generation, study of thermo graphy applications

## UNIT-V

**OIL AND WEAR DEBRIS ANALYSIS**: Basics of oil analysis, monitoring condition of oil, lubricant analysis, physio – chemical properties, moisture, tan tbn, wear debris analysis, particle counting, spectroscopy, uses & limitations, ferrography wear particle analysis, concept of ferrography, principle particle classification, size, shape, composition, concentration, analysis procedure, sampling & analytical ferrography equipments, severity rating.

## UNIT-VI

**ULTRASONIC MONITORING AND ANALYSIS:** Ultrasonic monitoring (leak, crack and thickness) basics of ultrasonic monitoring , ultrasonic theory, test taking philosophy, ultrasonic theory, mathematics of ultrasound, equipment and transducers, inspection parameters and calibration, immersion theory, equipment quality control, flaw origins and inspection methods, UT Procedure familiarization, and study recommendations, application of ultrasound to: air leaks, steam trap testing, bearing lubrication, electrical inspection, case studies.

## TEXT BOOKS:

1. The Vibration Analysis Handbook, J I Taylor (1994)
2. Machinery Vibration Condition Monitoring, Lynn, Butterworth(1989)

## REFERENCE BOOKS:

1. Machinery Vibration: Measurement and Analysis. Victor Wowk (1991).
2. Mechanical fault diagnosis and condition monitoring, RA Collacott (1977).
3. The Vibration Monitoring Handbook (Coxmoor's Machine & Systems Condition Monitoring) (1998).

**Course outcomes:**

- Gaining invaluable insights into the benefits of Condition Monitoring.
- Understanding the reasons for selecting particular maintenance strategies.
- Understanding effective methodologies for implementing Condition Monitoring Techniques.
- Identifying the optimum maintenance strategy for different types of equipment.
- Gaining practical approaches to minimise the risk of plant and machinery breakdowns.
- Awareness of International Standards covering asset manageme.

# RAPID PROTOTYPING
## (DEPARTMENTAL ELECTIVE – I)

**Course Objectives:**
The course aims at the importance of Rapid Prototyping, classifications, models, specifications of various Rapid Prototype Techniques. To learn the different tools, soft-wares required and the applications of Rapid Prototyping.

## UNIT – I
**INTRODUCTION**: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.
**LIQUID-BASED RAPID PROTOTYPING SYSTEMS**: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

## UNIT-II
**SOLID-BASED RAPID PROTOTYPING SYSTEMS**: Laminated object manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modeling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

## UNIT – III
**POWDER BASED RAPID PROTOTYPING SYSTEMS:** Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. three dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

## UNIT-IV
**RAPID TOOLING:** Introduction to rapid tooling (RT), conventional tooling Vs RT, Need for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting, 3D Keltool process. Direct rapid tooling: direct AIM, LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.

**UNIT – V**

**RAPID PROTOTYPING DATA FORMATS:** STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, Newly Proposed Formats.

**RAPID PROTOTYPING SOFTWARE'S:** Features of various RP software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor.

**UNIT –VI**

**RP APPLICATIONS: A**pplication in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, arts and architecture. RP medical and bioengineering applications: planning and simulation of complex surgery, customized implants & prosthesis, design and production of medical devices, forensic science and anthropology, visualization of bimolecular.

**TEXT BOOK:**

1. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific publications.

**REFERENCE BOOKS:**

1. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer.
2. Wholers Report 2000 – Terry Wohlers, Wohlers Associates.
3. Rapid Prototyping & Manufacturing – Paul F.Jacobs, ASME Press.

**Course Outcomes:**

The student shall be able to identify the use of Rapid Prototyping Techniques in the manufacturing of complex components that are otherwise very difficult to manufacture.

**III Year – II SEMESTER**

| T | P | C |
|---|---|---|
| 0 | 3 | 2 |

## HEAT TRANSFER LAB

**Objectives:**

The laboratory course is aimed to provide the practical exposure to the students with regard to the determination of amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

1. Determination of overall heat transfer co-efficient of a composite slab.
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere.
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin.
6. Determination of heat transfer coefficient in forced convection.
7. Determination of heat transfer coefficient in natural convection.
8. Determination of effectiveness of parallel and counter flow heat exchangers.
9. Determination of emissivity of a given surface.
10. Determination of Stefan Boltzman constant.
11. Determination of heat transfer rate in drop and film wise condensation.
12. Determination of critical heat flux.
13. Demonstration of heat pipe.
14. Study of two – phase flow.

**Outcomes:** The student should be able to evaluate the amount of heat exchange for plane, cylindrical & spherical geometries and should be able to compare the performance of extended surfaces and heat exchangers.

**IV Year – I SEMESTER**

| T | P | C |
|---|---|---|
| 3+1* | 0 | 3 |

## AUTOMOBILE ENGINEERING

**Course Objectives:**
The course imparts the principles of automobile systems and provides the salient features of safety, emission and service of automobiles.

## UNIT – I
**INTRODUCTION:** Components of four wheeler automobile – chassis and body – power unit – power transmission – rear wheel drive, front wheel drive, 4 wheel drive – types of automobile engines, engine construction, turbo charging and super charging – engine lubrication, splash and pressure lubrication systems, oil filters, oil pumps – crank case ventilation – engine service, reboring, decarbonisation, Nitriding of crank shaft.

## UNIT – II
**TRANSMISSION SYSTEM:** Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid fly wheel – gear boxes, types, sliding mesh, construct mesh, synchro mesh gear boxes, epicyclic gear box, over drive torque converter. propeller shaft – Hotch – Kiss drive, Torque tube drive, universal joint, differential rear axles – types – wheels and tyres.

## UNIT – III
**STEERING SYSTEM:** Steering geometry – camber, castor, king pin rake, combined angle toein, center point steering. types of steering mechanism – Ackerman steering mechanism, Davis steering mechanism, steering gears – types, steering linkages.

## UNIT – IV
**SUSPENSION SYSTEM:** Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, Independent suspension system.
**BRAKING SYSTEM:** Mechanical brake system, hydraulic brake system, master cylinder, wheel cylinder tandem master cylinder requirement of brake fluid, pneumatic and vacuum brakes.
**ELECTRICAL SYSTEM:** Charging circuit, generator, current – voltage regulator – starting system, bendix drive mechanism solenoid switch, lighting

systems, horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator etc.

## UNIT – V

**ENGINE SPECIFICATION AND SAFETY SYSTEMS:** Introduction-engine specifications with regard to power, speed, torque, no. of cylinders and arrangement, lubrication and cooling etc.

Safety: Introduction, safety systems - seat belt, air bags, bumper, anti lock brake system (ABS), wind shield, suspension sensors, traction control, mirrors, central locking and electric windows, speed control.

## UNIT – VI

**ENGINE EMISSION CONTROL:** Introduction – types of pollutants, mechanism of formation, concentration measurement, methods of controlling-engine modification, exhaust gas treatment-thermal and catalytic converters-use of alternative fuels for emission control – National and International pollution standards

**ENGINE SERVICE:** Introduction, service details of engine cylinder head, valves and valve mechanism, piston-connecting rod assembly, cylinder block, crank shaft and main bearings, engine reassembly-precautions.

## TEXT BOOKS:

1. Automotive Mechanics – Vol. 1 & Vol. 2 / Kripal Sing, standard publishers.
2. Automobile Engineering / William Crouse, TMH Distributors .
3. Automobile Engineering- P.S Gill, S.K. Kataria & Sons, New Delhi.

## REFERENCES:

1. Automotive Engines Theory and Servicing, James D. Halderman and Chase D. Mitchell Jr., Pearson education inc.
2. Automotive Engineering / Newton Steeds & Garrett.
3. Automotive Mechanics / Heitner.

## Course Outcomes:

The student after undergoing the course, shall visualize the layout of an automobile and its systems like transmission, steering, suspension, braking, safety etc and should know the vehicle troubleshooting.