PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):
Enable the students:

I. To develop an aptitude to use fundamental engineering principles to conceptualize, create, model, test and evaluate designs within the context of local and global needs.

II. To understand and explore the behaviour of existing and new materials suitable for the design needs.

III. To develop innovative technologies and find solutions to contemporary issues in Engineering Design using modern engineering tools and methods.

IV. To pursue advanced education, research and development and other creative/innovative efforts in their professional career.

PROGRAMME OUTCOMES (POs):
On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics, science and engineering.
2. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
3. Graduates will have the ability to use the computer aided design tools to design a component or system.
4. Graduate will demonstrate an ability to design and conduct experiments, analyze, interpret, and validate data in the area of design engineering.
5. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze multidisciplinary problems.
6. Graduate will have the knowledge of material behaviour under various circumstances exist which can be utilize for the material selection process.
7. Graduate will have the knowledge of mechanisms behaviour and its design by analytical method and using software tools.
8. Graduates will demonstrate knowledge of professional and ethical responsibilities in the field of mechanical design.
9. Graduate will communicate their technical knowledge.
10. Graduate will develop confidence for self-education and ability for life-long learning and research.
Mapping of PEOs with POs

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# LIST OF ELECTIVES FOR M.E. ENGINEERING DESIGN

## SEMESTER I (Elective I)

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<td>Plates and Shells</td>
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## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

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OBJECTIVES :
This course is designed to enrich the knowledge in various advanced mathematical techniques such as matrix theory, calculus of variations, probability and random variables, Laplace transforms and Fourier transforms. The fundamental concepts in these areas will be more useful for the students to model the engineering problems and solving them by applying these methods.

UNIT I MATRIX THEORY
The Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Least squares method - Singular value decomposition.

UNIT II CALCULUS OF VARIATIONS
Concept of variation and its properties – Euler’s equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.

UNIT III PROBABILITY AND RANDOM VARIABLES

UNIT IV LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS

UNIT V FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS

TOTAL : 60 PERIODS

OUTCOMES :
After completing this course, students should demonstrate competency in the following skills:

- Apply various methods in matrix theory to solve system of linear equations.
- Maximizing and minimizing the functional that occur in various branches of engineering disciplines.
- Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.

REFERENCES :
OBJECTIVE:
- To impart knowledge on mechanics of cracked components of different modes by which these components fail under static load conditions.
- To impart knowledge on mechanics of cracked components of different modes by which these components fail under fatigue load conditions.

UNIT I  ELEMENTS OF SOLID MECHANICS  9
The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation – limit analysis – Airy’s function – field equation for stress intensity factor.

UNIT II  STATIONARY CRACK UNDER STATIC LOADING  9

UNIT III  ENERGY BALANCE AND CRACK GROWTH  9

UNIT IV  FATIGUE CRACK GROWTH CURVE  9
Empirical relation describing crack growth law – life calculations for a given load amplitude – effects of changing the load spectrum -- rain flow method– external factors affecting the K1c values.- leak before break analysis.

UNIT V  APPLICATIONS OF FRACTURE MECHANICS  9
Crack Initiation under large scale yielding – thickness as a design parameter – mixed mode fractures - crack instability in thermal and residual stress fields - numerical methods

OUTCOME:
- It helps the engineers to get familiarized with the design of components that contain crack under static load condition.
- It helps the engineers to get familiarized with the design of components that contain crack and its growth under fatigue load condition.

REFERENCES:

TOTAL: 45 PERIODS
OBJECTIVE:
- To impart knowledge on computer graphics which are used routinely in diverse areas as science, engineering, medicine, etc.

UNIT I  INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS  9
Output primitives (points, lines, curves etc.), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation.

UNIT II  CURVES AND SURFACES MODELLING  9
Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations.

UNIT III  NURBS AND SOLID MODELING  9

UNIT IV  VISUAL REALISM  9
Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry based software’s and their principles creation of prismatic and lofted parts using these packages.

UNIT V  ASSEMBLY OF PARTS AND PRODUCT DATA EXCHANGE  9
Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation.

TOTAL : 45 PERIODS

OUTCOMES:
- It helps the students to get familiarized with the computer graphics application in design.
- This understanding reinforces the knowledge being learned and shortens the overall learning curve which is necessary to solve CAE problems that arise in engineering.

REFERENCES:
ED5152  QUALITY CONCEPTS IN DESIGN  L T P C
3 0 0 3

OBJECTIVE:

- To impart knowledge on various concepts in engineering design and principles of implementing quality in a product or service through tools such as quality houses, control charts, statistical process control method, failure mode effect analysis and various strategies of designing experiments, methods to uphold the status of six sigma and improve the reliability of a product.

UNIT I  DESIGN FUNDAMENTALS, METHODS AND MATERIAL SELECTION  9

UNIT II  DESIGN FOR QUALITY  9
Quality Function Deployment - House of Quality -Objectives and functions-Targets-Stakeholders-Measures and Matrices-Design of Experiments –design process-Identification of control factors, noise factors, and performance metrics - developing the experimental plan- experimental design – testing noise factors- Running the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating.

UNIT III  FAILURE MODE EFFECTS ANALYSIS AND DESIGN FOR SIX SIGMA  9
Basic methods: Refining geometry and layout, general process of product embodiment - Embodiment checklist- Advanced methods: systems modeling, mechanical embodiment principles- MEA method - linking fault states to systems modeling - Basis of SIX SIGMA –Project selection for SIX SIGMA- SIx SIGMA problem solving- SIX SIGMA in service and small organizations - SIX SIGMA and lean production –Lean SIX SIGMA and services

UNIT IV  DESIGN OF EXPERIMENTS  9
Importance of Experiments, Experimental Strategies, Basic principles of Design, Terminology, ANOVA, Steps in Experimentation, Sample size, Single Factor experiments - Completely Randomized design, Randomized Block design, Statistical Analysis, Multifactor experiments - Two and three factor full Factorial experiments, 2K factorial Experiments, Confounding and Blocking designs, Fractional factorial design, Taguchi’s approach - Steps in experimentation, Design using Orthogonal Arrays, Data Analysis, Robust Design- Control and Noise factors, S/N ratios

UNIT V  STATISTICAL CONSIDERATION AND RELIABILITY  9
Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams-Cause and Effect diagrams-Box plots- Probability distribution-Statistical Process control–Scatter diagrams –Multivariable charts –Matrix plots and 3-D plots.-Reliability-Survival and Failure-Series and parallel systems-Mean time between failure-Weibull distribution

TOTAL: 45 PERIODS

OUTCOME:

- It helps the students to get familiarized with various concepts in design, quality and reliability principles in the design of an engineering product or a service.

REFERENCES:
OBJECTIVE:
- To develop a thorough understanding of the advanced finite element analysis techniques with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering design

UNIT I BENDING OF PLATES AND SHELLS 9
Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements – Degenerated shell elements- Application and Examples.

UNIT II NON-LINEAR PROBLEMS 9

UNIT III DYNAMIC PROBLEM 9

UNIT IV FLUID MECHANICS AND HEAT TRANSFER 9

UNIT V ERROR ESTIMATES AND ADAPTIVE REFINEMENT 9
Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.

OUTCOMES:
1. The students will understand the Finite Element Formulation of Plate and Shell Elements and its application.
2. The students will be able to gain knowledge in material & geometric non-and plasticity.
3. The students will be able to solve problems under dynamic conditions by applying various techniques.
4. The students can arrive at the solutions for fluid mechanics and heat transfer problems.
5. The students will acquire knowledge in error norms, convergence rates and refinement.
6. The students will solve the real world engineering problems using FEA.

REFERENCES:
ED5161  CAD LABORATORY

OBJECTIVE:
- To impart knowledge on how to prepare drawings for various mechanical components using any commercially available 3D modeling software’s
  - CAD Introduction.
  - Sketcher
  - Solid modeling – Extrude, Revolve, Sweep, etc and Variational sweep, Loft etc
  - Surface modeling – Extrude, Sweep, Trim ..etc and Mesh of curves, Free form etc
  - Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
  - Assembly – Constraints, Exploded Views, Interference check
  - CAD data Exchange formats - IGES, PDES, PARASOLID, DXF and STL

Exercises in Modeling and drafting of Mechanical Components - Assembly using Parametric and feature based Packages like PRO-E / SOLID WORKS /CATIA / NX etc

OUTCOME:
- With laboratory classes, it helps the students to get familiarized with the computer applications in design and preparing drawings for various mechanical components.

TOTAL: 60 PERIODS

ED5162  ADVANCED ANALYSIS AND SIMULATION LABORATORY

OBJECTIVES:
- To give exposure to software tools needed to analyze engineering problems.
- To expose the students to different applications of simulation and analysis tools.

A. SIMULATION
1. MATLAB basics, Dealing with matrices, Graphing-Functions of one variable and two variables
2. Use of Matlab to solve simple problems in vibration
3. Mechanism Simulation using Multibody Dynamic software

B. ANALYSIS
1. Force and Stress analysis using link elements in Trusses, cables etc.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates and simple shells.
5. Thermal stress and heat transfer analysis of plates.
7. Vibration analysis of spring-mass systems.
8. Model analysis of Beams.
9. Harmonic, transient and spectrum analysis of simple systems.

OUTCOME:
- Upon completion of this course, the Students can model, analyse and simulate experiments to meet real world system and evaluate the performance.

TOTAL: 60 PERIODS
OBJECTIVE:

- To develop a thorough understanding of the various mechanisms and its design and simulation with an ability to effectively use the various mechanisms in real life problems.

UNIT I  INTRODUCTION


UNIT II  KINEMATIC ANALYSIS


UNIT III  PATH CURVATURE THEORY, COUPLER CURVE

Fixed and moving centrodes, inflection points and inflection circle. Euler Savary equation, graphical constructions – cubic of stationary curvature. Four bar coupler curve-cuspcrunode coupler driven six-bar mechanisms-straight line mechanisms

UNIT IV  SYNTHESIS OF FOUR BAR MECHANISMS

Type synthesis – Number synthesis – Associated Linkage Concept. Dimensional synthesis – function generation, path generation, motion generation. Graphical methods-Pole technique, inversion technique-point position reduction-two, three and four position synthesis of four- bar mechanisms. Analytical methods- Freudenstein’s Equation-Bloch’s Synthesis.

UNIT V  SYNTHESIS OF COUPLER CURVE BASED MECHANISMS & CAM MECHANISMS


Study and use of Mechanism using Simulation Soft-ware packages. Students should design and fabricate a mechanism model as term project.

** a Term Project must be given for Assessment – 3 (Compulsory)

TOTAL : 45 PERIODS

OUTCOME:

- It helps the students to get familiarized with the advanced mechanisms which are necessary to design and simulate mechanisms.

REFERENCES:

OBJECTIVE:
- To know the mechanical behavior of both metallic and non-metallic materials under different loading and temperature conditions.

UNIT I BASIC CONCEPTS OF MATERIAL BEHAVIOR

UNIT II BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES
Stress intensity factor and fracture toughness – Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law.– Safe life, Stress life, strain-life and fail - safe design approaches -Effect of surface and metallurgical parameters on fatigue – Fracture of non metallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III SELECTION OF MATERIALS
Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications – Computer aided materials selection.

UNIT IV MODERN METALLIC MATERIALS

UNIT V NON METALLIC MATERIALS
Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers – Advanced structural ceramics, WC, TIC, TaC, Al2O3, SiC, Si3N4 CBN and diamond – properties, processing and applications.

TOTAL : 45 PERIODS

OUTCOME:
- To familiarize the researchers in the area of material behavior under different loading and selection of materials for the design of engineering structures.

REFERENCES:
OBJECTIVE:
- To know the integrated design procedure of different machine elements for mechanical applications.

UNIT I FUNDAMENTALS AND DESIGN OF SHAFTS 9

UNIT II DESIGN OF GEARS AND GEAR BOXES 9

UNIT III BRAKES & CLUTCHES 9
Dynamics and thermal aspects of brakes and clutches – Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipments.

UNIT IV INTEGRATED DESIGN 18
Integrated Design of systems consisting of shaft, bearings, springs, motor, gears, belt, rope, chain, pulleys, Cam & Follower, flywheel etc. Example - Design of Elevators, Escalators, Gear Box, Valve gear Mechanisms, Machine Tools

TOTAL: 45 PERIODS

The Pattern of Question Paper will consist of one Question from Unit – 4 for 50% of total marks.
** a Term Project must be given for Assessment – 3 (Compulsory)

OUTCOME:
- This will familiarize the students with the concepts of integration of design of machines and structures.

REFERENCES:

APPROVED DATA BOOKS
OBJECTIVE:

- To understand the Fundamentals of Vibration and its practical applications
- To understand the working principle and operations of various vibration measuring instruments
- To understand the various Vibration control strategies

UNIT I  FUNDAMENTALS OF VIBRATION  10

UNIT II  TWO DEGREE FREEDOM SYSTEM  7
Introduction-Free Vibration Of Undamped And Damped - Forced Vibration With Harmonic Excitation System –Coordinate Couplings And Principal Coordinates

UNIT III  MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM  9
Multi Degree Freedom System – Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors - Matrix Iteration Method – Approximate Methods: Dunkerley, Rayleigh’s, and Holzer Method - Geared Systems - Eigen values & Eigen vectors for large system of equations using sub space, Lanczos method - Continuous System: Vibration of String, Shafts and Beams

UNIT IV  VIBRATION CONTROL  9

UNIT V  EXPERIMENTAL METHODS IN VIBRATION ANALYSIS  10

OUTCOME:

- This course will help the students to understand the basics of vibration and its importance in engineering field.
- The students are equipped with the working operations of various vibration measuring instruments, vibration control and analysis techniques.

REFERENCES

OBJECTIVES

- Introduce basic aspects of vibrational analysis, considering both single and multi-degree-of-freedom systems. Discuss the use of exact and approximate methods in the analysis of complex systems.
  - To study the forced vibration of the beam for different damping.
  - To determine the radius of gyration 'k' of a given compound pendulum.
  - To determine the radius of gyration of trifilar suspension.
  - To determine the radius of gyration of given bar using bi-filler suspension.
  - To verify the dunker lay's rule viz.
  - To study the pressure profile of lubricating conditions of load and speed.
  - To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.
  - To determine the natural frequency of undamped torsional vibration of two rotor shaft system.
  - To determine the frequency of undamped free vibration of an equivalent spring mass system.
  - To determine the frequency of damped force vibration of a spring mass system.

TOTAL: 30 PERIODS

OUTCOMES

- Upon completion of the course students shall be able to: Derive the equations of motion for vibratory systems. Linearize nonlinear systems so as to allow a linear vibrational analysis. Compute the natural frequency (or frequencies) of vibratory systems and determine the system's modal response. Determine the overall response based upon the initial conditions and/or steady forcing input. Design a passive vibration absorber to ameliorate vibrations in a forced system.

TOTAL: 30 PERIODS

OBJECTIVE:

- It is proposed to carry out detailed design calculations and analysis of any mechanical component or mechanical system. This helps the students to get familiar with respect to the design methodologies applied to any component or mechanical system subjected to static, dynamic and thermo-mechanical loads.

Each student is required to select any new component or an integrated mechanical system that involves various sub components which are to be designed as per design standards and further required to be analyzed for optimum dimensions with respect to the strength and stiffness.

OUTCOME:

- It helps the students to get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.

TOTAL: 60 PERIODS
OBJECTIVE:
To understand history, concepts and terminology of PLM
To understand functions and features of PLM/PDM
To understand different modules offered in commercial PLM/PDM tools
To understand PLM/PDM implementation approaches
To understand integration of PLM/PDM with other applications

UNIT I  HISTORY, CONCEPTS AND TERMINOLOGY OF PLM
Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDM), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

UNIT II  PLM/PDM FUNCTIONS AND FEATURES

UNIT III  DETAILS OF MODULES IN A PDM/PLM SOFTWARE
Case studies based on top few commercial PLM/PDM tools

UNIT IV  ROLE OF PLM IN INDUSTRIES
Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for – business, organisation, users, product or service, process performance.

UNIT V  BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE
PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

OUTCOMES:
The students will be able to
1. Understand history, concepts and terminology of PLM.
2. Apply the functions and features of PLM/PDM.
3. Understand different modules offered in commercial PLM/PDM tools.
4. Understand PLM/PDM implementation approaches.
5. Integrate PLM/PDM with other applications.
6. Analyse the case studies.

REFERENCES
ED5311  PROJECT WORK PHASE I  L T P C  0 0 12 6

OBJECTIVES:
- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.
- To train the students in preparing project reports and to face reviews and viva-voce examination.

SYLLABUS: The student individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of engineering design. The topic may be theoretical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 180 PERIODS

OUTCOME:
- At the end of the course the students will have a clear idea of their area of work and they will be in a position to carry out the remaining phase II work in a systematic way.

ED5411  PROJECT WORK PHASE II  L T P C  0 0 24 12

OBJECTIVES:
- To solve the identified problem based on the formulated methodology.
- To develop skills to analyze and discuss the test results, and make conclusions.

SYLLABUS:
The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

OUTCOME:
- On completion of the project work students will be in a position to take up any challenging practical problem in the field of engineering design and find better solutions to it.

ED5071  OPTIMIZATION TECHNIQUES IN DESIGN  L T P C  3 0 0 3

OBJECTIVE:
- To impart knowledge on various categories of existing engineering problems and solutions to such problems through different optimization techniques and approaches.

UNIT I  UNCONSTRAINED OPTIMIZATION TECHNIQUES  10
Introduction to optimum design - General principles of optimization – Problem formulation & their classifications - Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods.
UNIT II  CONSTRAINED OPTIMIZATION TECHNIQUES  10
Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions, Lagrange multipliers - Geometric programming

UNIT III ADVANCED OPTIMIZATION TECHNIQUES  10
Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization.

UNIT IV STATIC APPLICATIONS  8

UNIT V DYNAMIC APPLICATIONS  7
Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

TOTAL: 45 PERIODS

OUTCOME:
• It helps the students to get familiarized with the different approaches of optimizing (maximizing or minimizing) an engineering problem or a function.

REFERENCES:

ED5072 DESIGN OF PRESSURE VESSELS AND PIPING L T P C 3 0 0 3

OBJECTIVE
• The main objective is to present the industrial related problems, procedures and design principles for pressure vessels and enhance the understanding of design procedure of pressure vessel and Design of piping layout.

UNIT I INTRODUCTION 3

UNIT II STRESSES IN PRESSURE VESSELS 15

UNIT III DESIGN OF VESSELS 15
Design of Tall cylindrical self supporting process columns – Supports for short, vertical and horizontal vessels – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design. Introduction to ASME pressure vessel codes
UNIT IV  BUCKLING OF VESSELS  8
Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

UNIT V  PIPING  4

TOTAL: 45 PERIODS

OUTCOME

• It helps the student to get familiarized with the various theories and practice on pressure vessel and piping design and procedures which are necessary to solve the industrial practical problems that arise and also for the research in the field of pressure vessel design.

REFERENCES


ED5091  DESIGN OF MATERIAL HANDLING EQUIPMENTS  L T P C
(Use of Approved Data Book Is Permitted)  3 0 0 3

OBJECTIVES:

• To impart students on the need, use, application and design of different material handling techniques, equipments and machines used in common use and in industrial sector

UNIT I  MATERIALS HANDLING EQUIPMENT  5
Types, selection and applications

UNIT II  DESIGN OF HOISTS  10

UNIT III  DRIVES OF HOISTING GEAR  10
Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and monorail cranes - slewing, jib and luffing gear - cogwheel drive - selecting the motor ratings.

UNIT IV  CONVEYORS  10
Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

UNIT V  ELEVATORS  10
Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.

TOTAL: 45 PERIODS
OUTCOME:
- The course would familiarize the student on the technique to select suitable material handling equipment and design them based on the need.

REFERENCES

CC5292 ADDITIVE MANUFACTURING AND TOOLING

OBJECTIVE:
To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications

UNIT I INTRODUCTION: 9

UNIT II REVERSE ENGINEERING AND CAD MODELING: 9

UNIT III LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS 9

UNIT IV POWDER BASED ADDITIVE MANUFACTURING SYSTEMS 9

UNIT V TOOLING 9
Classification, Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling, Fabrication processes, Applications Case studies automotive, aerospace and electronics industries

TOTAL: 45 PERIODS
OUTCOMES:
The students will be able to
1. Understand history, concepts and terminology of additive manufacturing
2. Apply the reverse engineering concepts for design development
3. Understand the variety of additive manufacturing techniques
4. Design and develop newer tooling models
5. Analyse the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools

REFERENCES:

ED5073 INFORMATION ANALYTICS

OBJECTIVE:
- To expose the students with fundamental concepts and the tools needed to understand emerging role of information analytics in the organisation.

UNIT – I DATA ANALYTICS LIFE CYCLE
Introduction to Big data Business Analytics - State of the practice in analytics role of data scientists - Key roles for successful analytic project - Main phases of life cycle - Developing core deliverables for stakeholders.

UNIT – II STATISTICS
Sampling Techniques - Data classification, Tabulation, Frequency and Graphic representation - Measures of central value - Arithmetic mean, Geometric mean, Harmonic mean, Mode, Median, Quartiles, Deciles, Percentile - Measures of variation – Range, IQR, Quartile deviation, Mean deviation, standard deviation, coefficient variance, skewness, Moments & Kurtosis.

UNIT – III PROBABILITY AND HYPOTHESIS TESTING

UNIT – IV PREDICTIVE ANALYTICS
Predictive modeling and Analysis - Regression Analysis, Multicollinearity, Correlation analysis, Rank correlation coefficient, Multiple correlation, Least square, Curve fitting and good ness of fit.

UNIT – V TIME SERIES FORECASTING AND DESIGN OF EXPERIMENTS
Forecasting Models for Time series: MA, SES, TS with trend, season - Design of Experiments, one way classification, two way classification, ANOVA, Latin square, Factorial Design.

TOTAL: 45 PERIODS
OUTCOMES:
Upon completion of the course, the students will be able to
1. Understand the importance of data analysis in the design of new products.
2. Carry out statistical analysis.
3. Do probability analysis and hypothesis testing.
4. Perform predictive analysis.
5. Learn the effect of forecasting methods and to apply for business process.
6. Build a reliable, scalable, distributed information system.

REFERENCES:
UNIT V  ANALYSIS OF THIN ELASTIC SHELLS OF REVOLUTION 9
Classification of shell surfaces- geometric properties of shells of revolution- general strain
displacement relations for shells of revolution- stress resultants- equations of motion of thin shells
analytical solution for thin cylindrical shells- membrane theory- flexure under axisymmetric loads
shells with double curvature- geometric considerations- equations of equilibrium- bending of
spherical shells- vibration of cylindrical shells- finite element analysis(elementary treatment only;
discussion of various elements used and their capabilities- not for examination)

TOTAL: 45 PERIODS

OUTCOME:
- After undergoing this course, the students would be in a position to understand the
behavior of these commonly occurring structural elements in engineering design and would
have developed the capability to design and analyse them in their normal design practice.

REFERENCES:
1. Dr. N. Subramanian, Principles of Space Structures , Wheeler Publishing Co. 1999
Delhi, 2013
2nd Edition 2002

ED5002  MODAL ANALYSIS OF MECHANICAL SYSTEMS  L T P C
3 0 0 3

OBJECTIVE:
- To impart knowledge on modal testing and modal analysis of single and multi- degree of
freedom systems.

UNIT I  INTRODUCTION 6
Introduction to Modal Testing – Applications of Modal Testing – Philosophy of Modal Testing –
Summary of Theory – Summary of Measurement Methods – Summary of Analysis – Review of
Test Procedure.

UNIT II  VIBRATIONS 12
Introduction – Single Degree of Freedom (SDOF) System Theory – Presentation and Properties of
FRF Data for SDOF System – Undamped Multi-degree of freedom (MDOF) system – Proportional
Damping – Hysteretic Damping – General Case – Viscous Damping – General Case –
Characteristics and presentation of MDOF – FRF Data – Complete and incomplete models -
Nonsinusoidal vibration and FRF Properties – Analysis of Weakly Nonlinear Structures.

UNIT III  MOBILITY MEASUREMENT TECHNIQUES 10
Transducers and Amplifiers – Analyzers – Digital Signal Processing – Use of Different Excitation
types – Calibration – Mass Cancellation – Rotational Mobility Measurement – Measurement on
Non linear structures – Multi point excitation methods.

UNIT IV  MODAL PARAMETER EXTRACTION METHODS 11
Introduction – Preliminary checks of FRF Data – SDOF Modal Analysis-I – Peak-amplitude – DOF
Modal Analysis-II – Circle Fit Method – SDOF Modal Analysis III – Inverse Method –Residuals –
MDOF curve-fitting procedures – MDOF curve fitting in the Time Domain – Global or Multi- Curve
fitting – Non linear systems.
UNIT V MATHEMATICAL MODELS 6

OUTCOME:
- The students will become exposed to modal testing and techniques used for measurement of modal parameters.

REFERENCES:

ED5003 ADVANCED METAL FORMING TECHNIQUES L T P C
3 0 0 3

OBJECTIVES:
- To study the concepts of latest metal forming techniques and their applications in metal forming industry.
- To study the thermo mechanical regimes and its requirements of metal forming

UNIT I INTRODUCTION TO THEORY OF PLASTICITY AND FORMING
9

UNIT II THEORY AND PRACTICE OF BULK FORMING PROCESSES
9
Analysis of plastic deformation in Forging, Rolling, Extrusion, rod/wire drawing and tube drawing – Effect of friction – calculation of forces, work done – Process parameters, equipment used – Defects – applications – Recent advances in Forging, Rolling, Extrusion and Drawing processes – Design consideration in forming - Formability of laminated sheet - Overview of FEM applications in Metal Forming analysis.

UNIT III SHEET METAL FORMING
9
Formability studies – Conventional processes – H E R F techniques – Superplastic forming techniques – Hydro forming – Stretch forming – Water hammer forming – Principles and process parameters – Advantage, Limitations and application

UNIT IV POWDER METALLURGY AND SPECIAL FORMING PROCESSES
9

UNIT V ELECTROMAGNETIC FORMING AND ITS APPLICATIONS
9

TOTAL: 45 PERIODS

OUTCOME:
- The course would familiarize the students on the latest metal forming techniques and help them decide on the suitable method to form the metals for various industrial applications.
REFERENCES:
7. Proceedings of International Workshop on EMFT 2010, Anna University

ED5074 TRIBOLOGY IN DESIGN

OBJECTIVE:

- To impart knowledge in the friction, wear and lubrication aspects of machine components
- To understand the material properties which influence the tribological characteristics of surfaces.
- To understand the analytical behavior of different types bearings and design of bearings based on analytical/theoretical approach

UNIT I SURFACE INTERACTION AND FRICTION
Topography of Surfaces – Surface features-Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction –Rolling Friction-Friction properties of metallic and non-metallic materials – friction in extreme conditions –Thermal considerations in sliding contact

UNIT II WEAR AND SURFACE TREATMENT

UNIT III LUBRICANTS AND LUBRICATION REGIMES

UNIT IV THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION
Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation-Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing-Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings

UNIT V HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION
Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory-Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and
outside contact zones—Film thickness and friction calculation—Rolling bearings—Stresses and deflections—Traction drives

TOTAL: 45 PERIODS

OUTCOME:
- Ability to select material / surface properties based on the tribological requirements
- Methodology for deciding lubricants and lubrication regimes for different operating conditions
- Analysis ability of different types of bearings for given load / speed conditions.

REFERENCES:

ED5004 SURFACE ENGINEERING  L T P C
3 0 0 3

OBJECTIVE:
- To impart knowledge on surface engineering and surface modification methods that will come in handy to solve the industrial problems. This will also serve as a precursor for future research in the same field.

UNIT I FRICTION 7
Topography of Surfaces – Surface features – Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction – Rolling Friction – Friction properties of metallic and non metallic materials – Friction in extreme conditions – Thermal considerations in sliding contact

UNIT II WEAR 6

UNIT III CORROSION 10

UNIT IV SURFACE TREATMENTS 12
UNIT V  ENGINEERING MATERIALS

OUTCOME:
• It helps the students to get familiarized with the various theories and practice on surface engineering and surface modification methods which are necessary to solve the industrial practical problems that arise and also for the research.

REFERENCES

ED5092  ADVANCED MECHANICS OF MATERIALS

OBJECTIVE:
• To know the fundamentals of mechanics of materials under various loading conditions.

UNIT I  ELASTICITY

UNIT II  SHEAR CENTER AND UNSYMMETRICAL BENDING
Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section.

UNIT III  STRESSES IN FLAT PLATES AND CURVED MEMBERS
Circumference and radial stresses – deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates – pure bending of plates – deflection – uniformly distributed load – various end conditions

UNIT IV  TORSION OF NON-CIRCULAR SECTIONS
Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin walled tubes.

UNIT V  STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES
Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress-deflection of bodies in point and line contact applications.

OUTCOME:
• It helps the students to be familiarized with the stresses under different loading conditions.
REFERENCES:

ED5075 DESIGN FOR INTERNET OF THINGS
L T P C 3 0 0 3

OBJECTIVE:
• To impart knowledge on state of art IoT architecture, data and knowledge management and
  use of devices in IoT technology

UNIT-I INTRODUCTION 9
Machine to Machine (M2M) to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-
the global context, A use case example, Differing Characteristics.

UNIT-II IoT STRUCTURE 9
M2M to IoT – A Market Perspective– Introduction, Some Definitions, M2M Value Chains, IoT
Value Chains, An emerging industrial structure for IoT, The international driven global value chain
and global information monopolies. M2M to IoT-An Architectural Overview– Building an
architecture, Main design principles and needed capabilities, An IoT architecture outline, standards
considerations.

UNIT-III IoT NETWORKING 9
M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area
networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M
and IoT Analytics, Knowledge Management.

UNIT-IV IoT ARCHITECTURE 9
IoT Architecture-State of the Art – Introduction, State of the art, Architecture Reference

UNIT-V ARCHITECTURE MODELING 9
IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and
Operational View, Other Relevant architectural views. Real-World Design Constraints-
Introduction, Technical Design constraints-hardware is popular again, Data representation and
visualization, Interaction and remote control. Industrial Automation- Service-oriented
architecture-based device integration, SOCRADES: realizing the enterprise Integrated Web of
Things, IMC-AESOP: from the Web of Things to the Cloud of Things, Commercial Building
Automation- Introduction, Case study: phase one-commercial building automation today, Case
study: phase two- commercial building automation in the future.

TOTAL: 45 PERIODS

OUTCOMES:
At the end of the course the student will be able to:
1. Understand the vision of IoT from a global context.
2. Determine the Market perspective of IoT.
3. Use of Devices, Gateways and Data Management in IoT.
4. Build state of the art architecture in IoT.
5. Understand the design constraints in the real world.
6. Apply of IoT in Industrial and Commercial Building Automation and Real World Design
Constraints.
REFERENCES:

ED5005 DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS
L T P C 3 0 0 3

OBJECTIVE:
- To impart students on the science, use and application of hydraulics and pneumatics as fluid power in industry. Also to impart knowledge on the methodology of basic and advanced design of pneumatics and hydraulics systems.

UNIT I OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS
Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators – selection, specification and characteristics, Hydrostatic drives, types, selection.

UNIT II CONTROL AND REGULATION ELEMENTS
Pressure - direction and flow control valves - relief valves, non-return and safety valves – actuation systems, Proportional Electro hydraulic servo valves.

UNIT III HYDRAULIC CIRCUITS

UNIT IV PNEUMATIC SYSTEMS AND CIRCUITS
Pneumatic fundamentals - control elements, position and pressure sensing, Pneumatic equipments- selection of components - design calculations - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods – mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map.

UNIT V ELECTROMAGNETIC & ELECTRONIC CONTROL OF HYDRAULIC & PNEUMATIC CIRCUIT

TOTAL : 45 PERIODS

OUTCOME:
- It helps students to get knowledge on the need, use and application of fluid power and make them familiar to industrial design that lead to automation.

REFERENCES:
OBJECTIVE:
- To know about different types of bearings available for machine design and their operating principles
- To design hydrodynamic/hydrostatic/rolling bearing for given specifications and analyze the bearings for their performance
- To understand the bearing behavior under dynamic conditions

UNIT I CLASSIFICATION AND SELECTION OF BEARINGS

UNIT II DESIGN OF FLUID FILM BEARINGS

UNIT III SELECTION AND DESIGN OF ROLLING BEARINGS
Contact Stresses in Rolling bearings-Centrifugal stresses- Elasto hydrodynamic lubrication- Fatigue life calculations- Bearing operating temperature- Lubrication- Selection of lubricants- Internal clearance – Shaft and housing fit- Mounting arrangements-Materials for rolling bearings-Manufacturing methods- Ceramic bearings-Rolling bearing cages-bearing seals selection

UNIT IV DYNAMICS OF HYDRODYNAMIC BEARINGS
Hydrodynamic Lubrication equation for dynamic loadings-Squeeze film effects in journal bearings and thrust bearings -Rotating loads, alternating and impulse loads in journal bearings – Journal centre Trajectory- Analysis of short bearings under dynamic conditions- Finite difference solution for dynamic conditions

UNIT V ROTOR DYNAMICS
Rotor vibration and Rotor critical speeds- support stiffness on critical speeds- Stiffness and damping coefficients of journal bearings-computation and measurements of journal bearing coefficients-Mechanics of Hydro dynamic Instability- Half frequency whirl and Resonance whip-Design configurations of stable journal bearings

OUTCOME:
- Acquisition of knowledge in the analysis of all types of bearings.
- Ability to make specifications of all types of bearings
- Skill for conducting dynamic/vibration analysis and trouble shooting of bearings

REFERENCES:
OBJECTIVE:
- To understand the basic concepts of sustainability.
- To gain knowledge about the tools and techniques for sustainable design.
- To improve the design by assessing the customer needs.

UNIT-I BASIC CONCEPTS IN SUSTAINABILITY
Understanding the language of sustainable engineering design, construction and operation. Natural resources terminology. Carrying capacity. Sustainable development, corporate responsibility, biophysical constraints, environmental management.

UNIT-II TOOLS AND TECHNIQUES

UNIT-III FOUNDATIONAL CONCEPTS & PRINCIPLES FOR SUSTAINABLE BREAKTHROUGH DESIGN
Infrastructure for managing flows of materials, energy and activities; sustainable value creation approaches for all stakeholders, environmental design characteristics; design changes & continual improvement; inclusive sustainable design principles, crowd sourcing, multiple-objective designs; infrastructures that support system thinking; knowledge management for sustainable design, learning systems and experimentation; smart data systems, understanding variation.

UNIT-IV SUSTAINABLE DESIGN
Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, etc.

UNIT-V CUSTOMER AND USER NEEDS ASSESSMENT
Identification & breakdown structures that describe customers & stakeholders, green marketing, socially conscious consumerism, sources of customer information, collecting information, analyzing customer behavior, translating the voice of the customer, use analysis, structuring customer needs, service gap analysis, prioritizing customer needs, strategic design, Kano technique.

OUTCOMES
The student will
1. Understand the concept of sustainability in terms of design, construction and development.
2. Gain knowledge in engineering design tools and life cycle assessment.
3. Be able to apply sustainable value creation approaches, design changes & continual improvement.
4. Carry out sustainable design, green engineering, flexible design etc.
5. Able to design according to the customer needs.
6. Design the products that are environmentally friendly.

REFERENCES

ED5093 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

OBJECTIVES
- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Strokes Equations.

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 8

UNIT II DIFFUSION PROCESSES : FINITE VOLUME METHOD 10

UNIT III CONVECTION - DIFFUSION PROCESSES : FINITE VOLUME METHOD 9
One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

UNIT IV FLOW PROCESSES : FINITE VOLUME METHOD 8
Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

UNIT V MODELLING OF COMBUSTION AND TURBULENCE 10
Mechanisms of combustion and Chemical Kinetics, Overall reactions and intermediate reactions, Reaction rate, Governing equations for combusting flows. Simple Chemical Reacting System (SCRS), Turbulence - Algebraic Models, One equation model & k – ε, k – ω models - Standard and High and Low Reynolds number models.

TOTAL: 45 PERIODS

OUTCOME:
- On successful completion of this course the student will be able to apply the concepts of CFD to analyse the fluid flow and heat transfer in thermal systems.

REFERENCES:
OBJECTIVES:

- To know the concept of design for manufacturing, assembly and environment.
- To know the computer application in design for manufacturing and assembly.

UNIT I INTRODUCTION

General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances Geometric tolerances - Assembly limits - Datum features - Tolerance stacks.

UNIT II FACTORS INFLUENCING FORM DESIGN

Working principle, Material, Manufacture, Design - Possible solutions - Materials choice – Influence of materials on form design - Form design of welded members, forgings and castings.

UNIT III COMPONENT DESIGN - MACHINING CONSIDERATION


UNIT IV COMPONENT DESIGN – CASTING CONSIDERATION

Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design - Modifying the design - Group technology - Computer Applications for DFMA.

UNIT V DESIGN FOR THE ENVIRONMENT


TOTAL: 45 PERIODS

OUTCOME:

- To make the students get acquainted with the design for manufacturing, assembly and environment.

REFERENCES:

ED5077 BIOMECHANICS

OBJECTIVES:
- The student should be made to:
- Be exposed to principles of mechanics.
- Learn the mechanics of physiological systems.
- Be familiar with the mathematical models used in the analysis of biomechanical systems.

UNIT I INTRODUCTION TO MECHANICS

UNIT II BIOFLUID MECHANICS
Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow. Cardiovascular system - biological and mechanical valves development, artificial heart valves testing of valves, Structure, functions, material properties and modeling of Blood vessels.

UNIT III BIOSOLID MECHANICS

UNIT IV BIOMECHANICS OF JOINTS AND IMPLANTS
Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle. Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.

UNIT V MODELING AND ERGONOMICS

TOTAL: 45 PERIODS

OUTCOMES:
- At the end of the course, the student should be able to:
  - Explain the mechanics of physiological systems.
  - Analyze the biomechanical systems.
  - Design orthopaedic applications.
REFERENCES:

ED5078 COMPOSITE MATERIALS AND MECHANICS

OBJECTIVE
- To understand the fundamentals of composite material strength and its mechanical behavior.
- Understanding the analysis of fiber reinforced Laminate design for different combinations of plies with different orientations of the fiber.
- Thermo-mechanical behavior and study of residual stresses in Laminates during processing.
- Implementation of Classical Laminate Theory (CLT) to study and analysis for residual stresses in an isotropic layered structure such as electronic chips.

UNIT I INTRODUCTION TO COMPOSITE MATERIALS

UNIT II MANUFACTURING OF COMPOSITES
Manufacturing of Polymer Matrix Composites (PMCs)-handlay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM)-, bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) – Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) –hot pressing-reaction bonding process-infiltration technique, direct oxidation- interfaces

UNIT III INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS

UNIT IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES
UNIT V  THERMAL ANALYSIS  
Assumption of Constant Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke’s Law.  
Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E’s. C.T.E’s for special  
Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E.  
laminates, Thermally Quasi-Isotropic Laminates

TOTAL: 45 PERIODS

OUTCOME
• At the end of the course the students will be in position to understand the mechanics and  
design related to layered components such as fiber reinforced polymer composites,  
isotropic layered structures (example electronic chips) etc and its manufacturing  
methodologies.

REFERENCES:
   Ltd./Springer, New Delhi, 1st Indian Reprint, 2009
   - CRC press in progress.
   (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)