ACADEMIC REGULATIONS COURSE STRUCTURE AND DETAILED SYLLABUS

MECHANICAL ENGINEERING

For

M. Tech. (Engineering Design)

(Two Year **Full Time** Programme)

JNTUH COLLEGE OF ENGINEERING HYDERABAD
(Autonomous)
Kukatpally, Hyderabad – 500 085, Telangana, India.

2015

JNTUH COLLEGE OF ENGINEERING HYDERABAD
M.Tech. (Engineering Design) – Full Time w.e.f. 2015-16

I – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Advanced Mechanics of solids	4	0	0	4
2	Advanced Mechanics of Machinery	4	0	0	4
3	Elective – I	4	0	0	4
4	Elective – II	4	0	0	4
5	Elective – III	4	0	0	4
6	Elective – IV	4	0	0	4
7	Kinematics and Dynamics Lab	0	0	4	2
8	Soft Skills Lab	0	0	4	2
	Total Credits				**28**

II – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Advanced Machine Design	4	0	0	4
2	Finite Element and Boundary Element Methods	4	0	0	4
3	Elective – V	4	0	0	4
4	Elective – VI	4	0	0	4
5	Elective – VII	4	0	0	4
6	Elective – VIII	4	0	0	4
7	Advanced Computer Aided Design and Analysis Lab	0	0	4	2
8	Seminar	0	0	4	2
	Total Credits				**28**

III - SEMESTER

S.No.	Subject	L	T	P	Credits
1	Comprehensive Viva Voce				4
2	Project Phase-I				12
	Total Credits				**16**

IV – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Project Phase-II & Dissertation				18
	Total Credits				**18**

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Elective -I
1. Mechanical Behavior of Engineering Materials
2. Computational Methods
3. Computer Simulation of Machines.

Elective -II
1. Geometric Modeling.
2. Micro Controllers and Applications
3. Applied Tribology

Elective -III
1. Theory of Elasticity
2. Plastic Deformation of Metals.
3. Computer Aided Manufacturing

Elective -IV
1. Optimization Techniques & Applications
2. Instrumentation and Control systems
3. Design for Manufacturing and Assembly

Elective-V
1. Industrial Robotics
2. Neural Networks And Fuzzy Logics
3. Advanced Tool Design

Elective-VI
1. Vibration Analysis of Mechanical Systems
2. Random Vibrations
3. Vehicle Dynamics

Elective-VII
1. Experimental Stress Analysis
2. Fracture Mechanics
3. Advanced Finite Element and Mesh less Methods

Elective-VIII
1. Advanced Mechanics of Composite Materials
2. Nano Composites Design and Synthesis
3. Design For Process and Product Development

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M.Tech. I Year I-Sem (Engineering Design)

L	T	P	C
4	0	0	4

ADVANCED MECHANICS OF SOLIDS

Prerequisite: Applied Mechanics, mechanics of solids

Course Objectives: The course is intend

- To understand the concept of theory of elasticity equations for solving various engineering problems
- To analyse the internal stresses in curved beams and beams subjected to un-symmetrical bending.
- To Understand the deformations and stresses in non circular cross section members with torsional loading.
- To analyse the Hertz contact stresses

Course outcomes:

After completing this course, the student should be able to

- Determined the point of location of applied load to avoid twisting in thin sections used in aerospace applications.
- Understand the concept of distinguish between neutral and centroidal axes in curved beams.
- Understanding the analogy models developed for analyzing the non circular bars subjected to torsion, and also analyzing the stresses developed between rolling bodies and stress in three dimensional bodies.

Unit –I:

Shear center: Bending axis and shear center-shear center for axi-symmetric and unsymmetrical sections.

Unsymmetrical bending: Bending stresses in Beams subjected to Nonsymmetrical bending, Deflection of straight beams due to nonsymmetrical bending.

Unit –II:

Curved beam theory: Winkler Bach formula for circumferential stress – Limitations – Correction factors –Radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses in chain links.

Unit –III:

Torsion : Linear elastic solution Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section, Hollow thin wall torsion members, Multiply connected Cross Section.

Unit –IV:

Contact stresses: Introduction, problem of determining contact stresses, Assumptions on which a solution for contact stresses is based; Expressions for principal stresses; Method of computing contact stresses, Deflection of bodies in point contact; Stresses for two bodies in contact over narrow rectangular area (Line contact) Loads normal to area, Stresses for two bodies in line contact, Normal and Tangent to contact area.

Unit –V:

Introduction to Three Dimensional Problems: Uniform stress stretching of a prismatic bar by its own weight twist of circular shafts of constant cross section, pure bending of plates.

Textbook:

1. Advanced Mechanics of materials by Boresi & Sidebottom-Wiely International.
2. Theory of elasticity by Timoschenko S.P. and Goodier J.N. McGraw-Hill Publishers 3rd Edition

References:

1. Advanced strength of materials by Den Hortog J.P.
2. Theory of plates – Timoshenko.
3. Strength of materials & Theory of structures (Vol I & II) by B.C Punmia
4. Strength of materials by Sadhu singh

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ADVANCED MECHANICS OF MACHINERY

Prerequisite: Kinematics of machinery

Course Objectives: The course is intend to
- Fundamentals of plane and spatial mechanism
- Advanced kinematics of plane motion of mechanisms
- Synthesis of plane mechanisms- various methods
- Manipulator Kinematics for several types of robot arms: (a) Direct kinematics (b) Inverse kinematics

Course outcomes:
After completing this course, the student should be able to
- Understand the kinematic analysis of rolling bodies based on graphical, geometrical and analytical methods.
- Design of mechanisms by using graphically and analytically by involving function generator, rigid body guidance and path generation(Coupler curve) methods

Unit – I:
Advanced Kinematics of plane motion- I: Introduction to plane motion. Euler – Savary Equation, the Inflection circle, Analytical and graphical determination of d_i, Bobillier's Construction, Collineation axis, Hartmann's Construction, Inflection circle for the relative motion of two moving planes, Application of the Inflection circle to kinematic analysis.

Unit – II:
Advanced Kinematics of plane motion - II: Polode curvature, Hall's Equation, Polode curvature in the four bar mechanism, coupler motion, relative motion of the output and input links, Freudenstein's collineation – axis theorem, Carter –Hall circle.

Unit – III:
Introduction to Synthesis-Graphical Methods - I: The Four bar linkage, Guiding a body through Two distinct positions, Guiding a body through Three distinct positions, The Roto center triangle, Guiding a body through Four distinct positions: Burmester's curve.

Unit – IV:
Introduction to Synthesis-Graphical Methods - II: Function generation- General discussion, Function generation: Overlay's method, Function generation- Velocity – pole method, Path generation: Hrones's and Nelson's motion Atlas, Roberts's theorem.

Unit – V:
Introduction to Synthesis - Analytical Methods: Function Generation: Freudenstien's equation, Precision point approximation. Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition, Method of components, Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link, Method of components.

Text Books:

1. Jeremy Hirschhorn, Kinematics and Dynamics of plane mechanisms,McGraw-Hill,1962.
2. Amitabh Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines. E.W.P.Publishers.

Reference Books:

1. Allen S.Hall Jr., Kinematics and Linkage Design, PHI,1964.
2. J.E Shigley and J.J . Uicker Jr., Theory of Machines and Mechanisms , McGraw-Hill, 1995.
3. Mohsen Shahinpoor, A Robot Engineering Text book, Harper & Row Publishers, New York, 1987.
4. Joseph Duffy, Analysis of mechanisms and Robot manipulators, Edward Arnold,1980

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MECHANICAL BEHAVIOUR OF ENGINEERING MATERIALS
(Elective - I)

Prerequisite: Physical metallurgy

Course objectives: To know the concepts and principles of various failures in materials.

Course outcomes:
After completing this course, the student should be able to
- Understand the different modes of failures like fracture, fatigue and creep of ductile and brittle materials

UNIT-I:
Griffiths analysis: Concept of energy release rate, G and fracture energy, R. Modification for ductile materials, loading conditions. Concept of R curves.

UNIT-II:
Linear Elastic Fracture Mechanics (LEFM): Three loading modes and the state of stress ahead of the crack tip, stress concentration factor, stress intensity factor and the material parameter, the critical stress intensity factor.

UNIT-III:
Elastic-Plastic Fracture Mechanics (EPFM): The definition of alternative failure prediction parameters, Crack Tip Opening Displacement, and the J integral. Measurement of parameters and examples of use.

UNIT-IV:
Fatigue: definition of terms used to describe fatigue cycles, High Cycle Fatigue, Low Cycle Fatigue, mean stress R ratio, strain and load control. S-N curves. Goodman's rule and Miners rule. Micro mechanisms of fatigue damage, fatigue limits and initiation and propagation control leading to a consideration of factors enhancing fatigue resistance. Total life and damage tolerant approaches to life prediction.

UNIT-V:
Creep deformation: The evolution of creep damage, primary, secondary and tertiary creep, Micro mechanisms of creep in materials and the role of diffusion, Ashby creep deformation maps. Stress dependence of creep – power law dependence. Comparison of creep performance under different conditions – extrapolation and the use of Larson-Miller parameters, Creep-fatigue interactions, Examples.

Text Books
1. G. E. Dieter, Mechanical Metallurgy, McGraw Hill, (1988)
2. L.B. Freund and S. Suresh, Thin Film Materials, Cambridge University Press,(2003).

References:
1. T.L. Anderson, Fracture Mechanics Fundamentals and Applications, 2nd Ed. CRC press, (1995)
2. B. Lawn, Fracture of Brittle Solids, Cambridge Solid State Science Series 2nd ed1993.
3. J.F. Knott, Fundamentals of Fracture Mechanics, Butterworths (1973)

4. J.F. Knott, P Withey, Worked examples in Fracture Mechanics, Institute of Materials.
5. H.L.Ewald and R.J.H. Wanhill Fracture Mechanics, Edward Arnold, (1984).
6. S. Suresh, Fatigue of Materials, Cambridge University Press, (1998)
7. D.C. Stouffer and L.T. Dame, Inelastic Deformation of Metals, Wiley (1996)
8. F.R.N. Nabarro, H.L. deVilliers, The Physics of Creep, Taylor and Francis, (1995)

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COMPUTATIONAL METHODS
(Elective - I)

Prerequisites: Mathematics I & II

Course Objectives: The course is intend to teach students how to apply computational methodologies to solve engineering problems when no closed-form or analytical solution may not exist. Transformations between time and frequency domains Fourier transforms, FFT and Laplace transforms need to be taught. Because numerical methods cannot be solved by hand calculator (Except for simple cases) algorithms and computer programs to implement for some of the numerical methods will be taught.

Course outcomes:
After doing this, student should be able to
- Have a Idea of accuracy & precision rounding off & truncation errors and their propagation
- Apply numerical techniques for solving linear algebraic equations, non-linear equations and differentiation and integration with due idea of above said concept
- Understand the interpolation methods, transformation techniques and regression Methods

Unit I:
Approximations and Errors: Accuracy and precision, definitions of round off and truncation errors, error propagation.
Linear Algebraic Equations: Formulations and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss-Jacobi and Gauss-Siedel), convergence of iteration methods
Eigen values and Eigenvectors: Geometric meaning of Eigen values and Eigenvectors, Characteristic equation and determination of Eigen values and Eigenvectors, Power Method, Inverse Power Method, Similarity Transformations, Givens rotation method, Householder Transformation

Unit II:
Solution of non-linear equations: Bisection meted, Fixed point iteration, Newton Raphson method, Solution of a set of non-linear equations
Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials

Unit III:
Differentiation and integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration
Transform techniques: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral transform, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)

Unit IV:

Regression methods: Linear and non-linear regression, multiple linear regression, general linear least squares

Statistical methods: Statistical representation of data, modeling and analysis of data, test of hypotheses

Unit V:

Ordinary Differential Equations: Initial and boundary value problems, Eigen value problems. Euler Method, Modfied Euler Method, Runge-Kutta Methods, Adams Bashforth Moulton Methods

Partial Differential Equations: Classification of PDEs, Solution to Elliptic and Parabolic equations

Text Books:

1. Steven C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, 3rd edition, Tata-Mcgraw Hill, New Delhi, 2012.
2. S. P. Venkatesan and P. Swaminathan, *Computational Methods in Engineering*, Ane Books India, New Delhi, 2014.

Reference Books:

1. Gilbert Strang, *Computational Science and Engineering*, Wellesley-Cambridge Press, Wellesley, 2007.
2. Joe D. Hoffman, *Numerical Methods for Engineers and Scientists*, 2nd edition, CRC Press, 2001

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COMPUTER SIMULATIONS OF MACHINES
(Elective- I)

Prerequisite: Kinematics of machinery

Course Objectives: The course is propose to
- Impart how to simulate the mechanisms in dynamic and kinematic mode.
- understand the numerical solutions of non linear algebraic equations.
- understand the kinematic simulations using simulink.
- Introduce the simulating the dynamics of slider on inclined plane
- Understand the mechanisms of two link planar robot

Course outcomes:
After completing this course, the student should be able to
- Understand and apply the simulation methodologies for different mechanical systems

UNIT I:
Introduction: Overview, Why Simulate Mechanisms, Kinematics Simulations, Dynamic Simulation of Mechanisms, Summary, Vector Loop and Vector Chain Equations – Introduction, The Planar Vector, Single Loop Equations, Derivatives of Vectors, Other Common Mechanisms, Vector Chains.

UNIT II:
Solutions of the Position Problem: Overview, Numerical Solutions of Nonlinear algebraic Equations, The Position Problem of a Four-Bar Linkage, Mat lab Solution of the position of a Four-Bar Linkage.

UNIT III:
Kinematic Simulations Using Simulink: What is a Kinematic Simulation, Velocity Solution via Kinematic Simulation, Acceleration Solution via Kinematic Simulation, The Consistency Check, Kinematic Simulation of a Four-Bar Mechanism.

UNIT IV:
Introducing Dynamics: Simulating the slider on inclined plane, Adding the Pendulum, Assembling the Matrix Equation, Creating a Dynamic Simulation, Setting Initial conditions and Running Simulation

UNIT V:
Two-Link Planar Robot: Overview, Vector Equations, Dynamic Equations, The Simultaneous Constraint matrix, Dynamic Simulation, Robot Coordinate Control.

Text Books:
1. Simulation Of Machines using Mat Lab and Simulink – John F.Gardner, India Edition (IE)
2. CAD/CAM – Ibrahim zeid, TMH.
3. Mat Lab – Raj Kumar Bansal etal , Pearson Education

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GEOMETRIC MODELING
(Elective - II)

Prerequisite: CAD/CAM

Course objectives: The course is intend to

- Making the student understand how graphics created in computer world is the main goal of this course.
- Learn modeling curves (B-spline and Bezier)
- Learn modeling Bezier and B-spline surfaces
- Learning how to rescale, transmit (shift), shear (skew), and rotate different graphical objects is another goal.
- Familiarity with advanced techniques such as subdivision and reconstruction
- Mastery of object construction and manipulation methods including lofting, surface of revolution, boundary representation, cell decomposition and tabularization.

Course outcomes:

After completing this course, the student should be able to

- Understand the background of mathematical equations used for development of modeling software modules to develop the various structural related applications.

Unit – I:

Introduction: Definition, Explicit and implicit equations, parametric equations.

Cubic Splines: Algebraic and geometric form of cubic spline, tangent vectors, parametric space of a curve, blending functions, four point form, reparametrization, truncating and subdividing of curves. Graphic construction and interpretation, composite pc curves.

Unit – II:

Bezier Curves: Bernstein basis, equations of Bezier curves, properties, derivatives.

B-Spline Curves: B-Spline basis, equations, knot vectors, properties and derivatives.

Unit – III:

Surfaces: Bicubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, Sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.

Unit – IV:

Transformations: 2-D and 3D

Solids: Tricubic solid, Algebraic and geometric form.

Unit – V:

Solid modeling concepts: Wire frames, Boundary representation, Half space modeling, spatial cell, cell decomposition, classification problem.

Text Books:

- CAD/CAM by Ibrahim Zeid, Tata McGraw Hill.
- CAD/CAM concepts and Applications, Alavala, PHI

References:

1. Geometric Modeling by Micheal E. Mortenson, McGraw Hill Publishers
2. Computer Aided Design and Manufacturing, K.Lalit Narayan, K.Mallikarjuna Rao, MMM Sarcar, PHI Publishers
3. Elements of Computer Graphics by Roger & Adams, Tata McGraw Hill.

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MICRO CONTROLLERS AND APLLICATIONS
(Elective - II)

Prerequisite: None

Course objectives: The main purpose of this course is

- To provide sufficient detailed knowledge of a microcontroller so that students can breadboard and program a microcontroller and demonstrate its function in a real-time application.

Course outcomes:

After completing this course, the student will be able to

- Comprehend the architecture and instruction set of microcontrollers.
- Outline the knowledge on real time control interrupts & timers.
- Design control peripherals and high power devices.
- Analyze real time operating system for MCUs & MCU based industrial applications.
- Comprehend the architecture of 16 bit (8096/80196) & ARM microcontrollers.

UNIT-I: Overview Of Architecture & Microcontroller Resources

Architecture of a microcontroller – Microcontroller resources – Resources in advanced and next generation microcontrollers – 8051 microcontroller – Internal and External memories – Counters and Timers – Synchronous serial-cum asynchronous serial communication - Interrupts.

UNIT-II : 8051-Microcontrollers Instruction Set

Basic assembly language programming – Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

UNIT-III: Real Time Control

INTERRUPTS: Interrupt handling structure of an MCU – Interrupt Latency and Interrupt deadline – Multiple sources of the interrupts – Non-maskable interrupt sources – Enabling or disabling of the sources – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel 8051.

TIMERS: Programmable Timers in the MCU's – Free running counter and real time control – Interrupt interval and density constraints.

UNIT-IV: Systems Design

Digital And Analog Interfacing Methods:

Switch, Keypad and Keyboard interfacings – LED and Array of LEDs – Keyboard-cum-Display controller (8279) – Alphanumeric Devices – Display Systems and its interfaces – Printer interfaces – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Interfaces – Interfacing to High Power Devices – Analog input interfacing – Analog output interfacing – Optical motor shaft encoders – Industrial control – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control – Digital Signal Processing and digital filters.

UNIT-V: Real Time Operating System For Microcontrollers:
Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers.16-BIT MICROCONTROLLERS: Hardware – Memory map in Intel 80196 family MCU system –IO ports – Programmable Timers and High-speed outputs and input captures – Interrupts –instructions.ARM 32 Bit MCUs: Introduction to 16/32 Bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

Text Books:
1. Raj Kamal," Microcontrollers Architecture, Programming, Interfacing and System Design"–Pearson Education, 2005.
2. Mazidi and Mazidi, "The 8051 Microcontroller and Embedded Systems" – PHI, 2000.

Reference Books:
1. A.V. Deshmuk, "Microcontrollers (Theory & Applications)" – WTMH, 2005.
2. John B. Peatman, "Design with PIC Microcontrollers" – Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.
5. Microprocessors and Microcontrollers, Architecture, Programming and System Design, Krishna Kant, PHI Learning PVT. Ltd.
6. Microprocessors, Nilesh B. Bahadure, PHI Learning PVT. Ltd.

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4	0	0	4

APPLIED TRIBOLOGY
(Elective - II)

Prerequisite: Applied mathematics and statistics, Fluid mechanics, Theoretical mechanics, Material Mechanics

Course objectives: The course is intend to

- Design of surfaces in contact is a critical problem for mechanical engineering.
- This is an interdisciplinary course which deals with fundamentals of surface contact, friction, wear and lubrication.
- The Topics in this course include description and modeling of engineering surfaces, popular surface contact theories, major modes of friction, wear, lubrication and adhesion.

Course outcomes:
After completing this course, the student should be able to

- Have a knowledge of surface topography and know how to model a rough engineering surface;
- Have a clear overall picture about the basics of tribology and related sciences, theoretical background about processes in tribological system, mechanisms and forms of interaction of friction surfaces;
- Have a mastery of the friction/lubrication mechanisms and know how to apply them to the practical engineering problem;
- Know the methods to reduce the friction for engineering surface and failure analysis.

Unit – I
Selection of rolling element bearings: Nominal life, static and dynamic capacity - Equivalent load, probabilities of survival - cubic mean load - bearing mounting details, pre loading of bearings, conditioning monitoring using shock pulse method.

Unit – II
Hydrodynamic bearings: Fundamentals of fluid formation – Reynold's equation; Hydrodynamic journal bearings – Sommerfield number - performance parameters – optimum bearing with maximum load capacity – Friction – Heat generated and Heat dissipated. Hydrodynamic thrust bearings; Raimondi and Boyd solution for hydrodynamic thrust bearings - fixed tilting pads, single and multiple pad bearings - optimum condition with largest minimum film thickness.

Unit – III
Hydrostatic Bearings: Thrust bearings – pad coefficients - restriction - optimum film thickness - journal bearings – design procedure –Aerostatic bearings; Thrust bearings and Journal bearings – design procedure.

Unit – IV
Dry rubbing Bearings: porous metal bearings and oscillatory journal bearings – qualitative approach only.

Lubrication: Choice of lubricants, types of oil, Grease and solid lubricants - additives - lubrication systems and their selection – selection of pump, filters, piping design - oil changing and oil conservation.

Unit – V

Failure of Tribological components: Failure analysis of plain bearings, rolling bearings, gears and seals, wear analysis using soap and Ferro graphy.

Text Books:

1. Rowe WW& O' Dionoghue, "Hydrostatic and Hybrid bearing design" Butterworths & Co. Publishers Ltd,1983.
2. Collacott R.A," Mechanical Fault diagnosis and condition monitoring", Chapman and Hall, London 1977.
3. Bernard J.Hamrock, "Fundamentals of fluid film lubricant", Mc Graw-Hill Co.,1994.

References:

1. Neale MJ, (Editor) " Tribology hand Book"Neumann Butterworths, 1975.
2. Connor and Boyd JJO (Editors) " Standard hand book of lubrication engineers " ASLE,Mc Graw Hill Book & Co.,1968
3. Shigley J, E Charles," Mechanical Engineering Design", McGraw Hill Co., 1989

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4	0	0	4

THEORY OF ELASTICITY
(Elective - III)

Prerequisite: Mechanics of solids

Course Objectives: The course is intend to

- Introduce to students the concepts of stresses, strains and stress-strain relationships, as well as the basic theory of elasticity.
- Develop students with an understanding of how stresses and strains within engineering components are related to both loads and displacements imposed at their boundaries and to inertial loads.
- Prepare students for the use of different methods to analyze the stresses and strains within engineering components.
- Allow students become familiar with problem formulations and solutions in elasticity; and prepare students for future study in advanced engineering mechanics.

Course outcomes:
After completing this course, the student should be able

- To know the definition of stress and deformation and how to determine the components of the stress and strain tensors.
- To know how to apply the conditions of compatibility and equations of equilibrium.
- To use the equilibrium equations stated by the displacements (Lame equations) and compatibility conditions stated by stresses (Beltrami-Michell equations).
- To define state of plane stress, state of plane strain in Cartesian and cylindrical coordinate systems.
- To determine the boundary restrictions in calculations.
- To solve the basic problems of the theory of elasticity by using Airy function expressed as biharmonic function.
- A few examples in 3-D stress analysis will be provided.

UNIT-I
Introduction: Elasticity – notation for forces and stress components of stresses - components of strain - Hooks law. Plane Stress and plain strain analysis - plane stress - plane strain- differential equations of equilibrium - boundary conditions – compatibility equations –stress function - boundary condition.

UNIT-II
Two dimensional problems in rectangular co-ordinates-solution by polynomials - saint-vanant's principle-determination of displacements-bending of simple beams-application of corier series for two dimensional problems-gravity loading.

UNIT-III
Two dimensional problems in polar coordinates - stress distribution symmetrical about an axis - pure bending of curved bars - strain components in polar coordinates – displacements - displacement for symmetrical stress distribution - simple symmetric and asymmetric problems - general solution of two-dimensional problem in polar coordinates - application of general solution in polar coordinates.

UNIT-IV

Analysis of stress and strain in three dimensions - principal stress - stress ellipsoid - director surface - determination of principal stresses - max shear stresses - homogeneous deformation - principal axes of strain rotation. General Theorems. Differential equations of equilibrium - conditions of compatibility - determination of displacement - equations of equilibrium in terms of displacements - principle of super position - uniqueness of solutions - the reciprocal theorem.

UNIT- V

Torsion of Prismatic Bars - torsion of prismatic bars - bars with elliptical cross sections - other elementary solution - membrane analogy - torsion of rectangular bars-solution of torsional problems by energy method - use of soap films in solving torsion problem - hydro dynamical analogies - torsion of shafts, tubes, bars etc.

Text Books:

1. Theory of Elasticity by Timeshanko, McGrawhill Publications

References:

1. Theory of Elasticity by Y.C. Fung.
2. Theory of Elasticity by Sadhu Singh. Dhanpat Rai sons Private Limited, New Delhi

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L	T	P	C
4	0	0	4

PLASTIC DEFORMATION OF METALS
(Elective- III)

Prerequisite:
Successful completion of the course is conditional on the knowledge of applied mathematics and physics, materials science, elasticity, strength, and plasticity, and a grasp of metal-forming technologies.

Course objectives: The course is intend to
- Introduce students to the principles of metal shaping by pressure;
- discuss the equipment and sequence of technological operations involved in the various methods of metal shaping by pressure; and
- provide students with opportunities to practically appreciate the essence of the methods of pressure shaping of metals as industrial manufacturing processes.

Course outcomes:
After completing this course, the student should be able to
- Understand the different mechanisms of metal forming and related mathematical theories.
- Understanding different metal forming methods and related flow stress relations.

UNIT - I:
Fundamentals of Metal Forming: Classification of forming processes, mechanisms of metal forming: slab method, Upper and lower bound analysis, Deformation energy method and finite element method temperature of metal working, hot working, cold working, friction and lubricants.

UNIT - II:
Rolling of metals: Rolling processes, forces and geometrical relationship in rolling, simplified analysis, rolling load, rolling variables, theories of cold and hot rolling, problems and defects in rolling, torque and power calculations, Problems.

UNIT - III:
Forging: Classification of forging processes, forging of plate, forging of circular discs, open die and closed-die forging, forging defects, and powder metallurgy forging. problems on flow stress ,true strain and forging load.
Press tool design: Design of various press tools and dies like piercing dies, blanking dies, compound dies and progressive blanking dies, design of bending, forming and drawing dies.

UNIT - IV:
Extrusion: Classification, Hot Extrusion, Analysis of Extrusion process, defects in extrusion, extrusion of tubes, production of seamless pipes. Problems on extrusion load.
Drawing: Drawing of tubes, rods, and wires: Wire drawing dies, tube drawing process, analysis of wire, deep drawing and tube drawing.Problems on drawforce.

UNIT - V:
Sheet Metal forming: Forming methods, Bending, stretch forming, spinning and Advanced techniques of Sheet Metal Forming, Forming limit criteria, defect in formed parts.

Advanced Metal forming processes: HERF, Electromagnetic forming, residual stresses, in-process heat treatment and computer applications in metal forming. problems on Blanking force, Blank diagram in Cup Diagram, Maximum considering shear.

Text Books:

1. Mechanical Metallurgy / G.E. Dieter / Tata McGraw Hill, 1998. III Edition
2. Principles of Metal Working / Sunder Kumar

References:

1. Principles of Metal Working processes / G.W. Rowe
2. ASM Metal Forming Hand book.

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COMPUTER AIDED MANUFACTURING
(Elective - III)

Prerequisite: None

Course Objectives: The course is intend to

- To make the students familiar with computer aided programming, different tooling for CNC.
- To use computers in the area of manufacturing to reduce manual processing and linking computers to all the manufacturing machines and increase the productivity, reduce the unnecessary costs.
- To study about group technology, computer aided process planning, material requirement planning (MRP) Enterprise resource planning (ERP), Computer aided quality control and Flexible manufacturing systems.

Course outcomes:

After completing this course, the student should be able to

- To familiarize the components of computer aided manufacturing and to introduce CNC machines and computer aided process planning.
- CNC machines and its constructional features and part programming
- Basics of concepts of FMS GT, computer aided inspection, Automated material handling systems and Computer aided production planning.

Unit – I

Introduction: Fundamental concepts in Manufacturing and Automation, Automation Strategies, Economic analysis in production, fundamentals of CAD / CAM, product cycle and CAD/CAM, Automation and CAD/CAM, Scope of CIM, Automated flow lines, Transfer mechanisms, methods of Line balancing.

Unit – II

Numerical control machines: Introduction- basic components of an NC system - the NC procedure - NC coordinate system, NC motion control system - application of numerical control- Economics of Numerical control.

NC part programming: Introduction – NC coding system, manual part programming, part programming with APT, NC part programming using CAD/CAM, manual data input.

Unit – III

Computer controls in NC: NC controllers' technology - Computer Numerical Control (CNC), Direct Numerical control (DNC).

Unit – IV

Group Technology: Part families, parts classification and coding, production flow analysis, Composite part concept, Machine cell design, benefits of GT.

Flexible Manufacturing Systems: Components of FMS, FMS Work stations, Material Handling Systems, and Computer Control system, FMS layout configurations and benefits of FMS.

Unit – V

Computer aided planning systems: Approaches to Computer aided Process Planning (CAPP) - Generative and Retrieval CAPP systems, benefits of CAPP, Material Requirement Planning (MRP), mechanism of MRP, benefits, and Capacity Planning, Adaptive control machining systems, adaptive control optimization system, adaptive control constraint system, applications to machining processes, computer process monitoring, hierarchical structure of computers in manufacturing, and computer process control.

Text books:

1. Automation, Production systems and Computer Integrated Manufacturing Systems – Mikel P.Groover, PHI Publishers
2. CAD / CAM Concepts and Applications, Alavala, PHI.

References:

1. CAD/CAM - Mikell P. Groover, and Emory W. Zimmers. Jr. PHI Publishers
2. Computer Aided Design and Manufacturing, K.Lalit Narayan, K.Mallikarjuna Rao, MMM Sarcar, PHI Publishers
3. CAD/CAM/CIM, Radhakrishnan and Subramanian, New Age Publishers

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OPTIMIZATION TECHNIQUES & APPLICATIONS
(Elective- IV)

Prerequisite: Operations Research

Course Objectives: The course is intend to
- To introduce the advanced optimization techniques such as classical optimization techniques, numerical optimization techniques and genetic algorithms.
- Learn the knowledge to formulate optimization problems

Course outcomes:
After completing this course, the student should be able to
- Learn various optimization techniques
- Develop a optimization model for a given problem
- Solve the model using suitable optimization technique.
- Analyze the sensitivity of a solution to different variables.
- Use and develop optimization simulation software for variety of industrial problems

UNIT- I:
Single Variable Non-Linear Unconstrained Optimization: Elimination methods :Uni-Model function-its importance, Fibonacci method,& Golden section method. Interpolation methods : Quadratic & Cubic interpolation methods.

UNIT- II:
Multi variable non-linear unconstrained optimization: Direct search methods – Univariant method , Pattern search methods – Powell's, Hook -Jeeves, Rosenbrock search methods. Gradient methods: Gradient of function& its importance, Steepest descent method, Conjugate direction methods: Fletcher-Reeves method,& variable metric method.

UNIT- III:
Linear Programming – Formulation, Simplex method &Artificial variable optimization techniques: Big M & Two phase methods. Sensitivity analysis: Changes in the objective coefficients, constants& coefficients of the constraints. Addition and deletion of variables, constraints.
Simulation – Introduction – Types- steps – applications: inventory & queuing – Advantages and disadvantages

UNIT- IV:
Integer Programming- Introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method
Stochastic Programming: Basic concepts of probability theory, random variables-distributions-mean, variance, correlation, co variance, joint probability distribution. Stochastic linear programming: Chance constrained algorithm.

UNIT- V:
Geometric Programming: Polynomials – Arithmetic - Geometric inequality – unconstrained G.P- constrained G.P(≤ type only)

Non Traditional Optimization Algorithms: Genetics Algorithm-Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing-Working Principle-Simple Problems. Introduction to Particle Swarm Optimization(PSO)(very brief)

TEXT BOOKS:

1. Optimization theory & Applications / S.S.Rao / New Age International.
2. Optimization for Engineering Design, Kalyanmoy Deb, PHI

REFERENCE BOOKS:

1. S.D.Sharma / Operations Research
2. Operation Research / H.A.Taha /TMH
3. Optimization in operations research / R.LRardin

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INSTRUMENTATION AND CONTROL SYSTEMS
(Elective - IV)

Prerequisite: None

Course objectives: The course is intend to

- provide knowledge on the fundamentals of measurement science and measuring instruments To provide a knowledge on the basics of control system theory

Course outcomes:

After completing this course, the student should be able to

- Know general configuration of instrument, static and dynamics characteristics, Calibration analysis
- Know various properties to be measured
- Know various instruments for measuring above said properties
- Do calibrate the instrument when use it for measuring the given property.

UNIT – I

Introduction: Generalized measurement system – basic methods of measurements - Errors in measurements–types of errors - Statistical analysis of measurement data – single sample test – multi-sample test.

Static and Dynamic Characteristics: Static characteristics of instruments – accuracy, precision, sensitivity, reproducibility, drift, uncertainity, hysteresis.

Dynamic characteristics – types of input signals- impulse, step, ramp and sinusoidal, first order system – step- harmonically – significance of time constant, second order system – undamped – underdamped – critically damped - overdamped systems

UNIT-II

Electrical transducers: Sliding contact resistive transducer, thermistors, variable self-inductance transducer, variable mutual-inductance transducer, linear variable differential transformer, rotational variable differential transformer, variable reluctance transformer.

Capacitive Transducers, Ionization transducer, electronic transducer, electromagnetic transducer, piezoelectric transducer, photoelectric transducer,

UNIT – III

Measurement of displacement: Comparators, optical flats, interferometer, autocollimator.

Measurement of Stress and Strain: Principle of strain gages, selection and installation of bonded metallic strain gages, circuitry for the metallic strain gages, temperature compensation.

Measurement of Force: Proving ring, strain gage load cell, piezoelectric load cell, hydraulic load cell, pneumatic load cell.

Measurement of Pressure: High pressure measurement, low pressure measurement.

UNIT – IV:

Measurement of Flow: Variable area flow meters, turbine flow meter, magnetic flow meter.

Measurement of liquid level: Capacitance level detector, radar and microwave level sensors, ultrasonic level gages, nuclear level sensors.

Measurement of temperature: Thermocouples, thermistors, optical pyrometer.

Measurement of acceleration and vibration: seismic displacement pickup, seismic velocity pickup, seismic acceleration pick up, piezoelectric accelerometer.

UNIT-V:

Control system and their classification: Introduction - Classification of control systems - Transfer function, block diagrams, system stability-Routh stability - Hurwitz stability.

Hydraulic and Pneumatic controls systems: Functional operation of - proportional control- Proportional plus integral control - Proportional plus derivative control- Proportional plus derivative plus integral control - Hydraulic control systems – Pneumatic control systems.

Text Books :

1. Principles of Industrial Instrumentation and control systems, Alavala, Cengage Learning
2. Mechanical Measurements and controls by D.S.Kumar

References:

1. John P. Bentley, Principles of Measurement Systems, Third edition, Addison Wesley Longman Ltd., UK, 2000.
2. Doebelin E.O, Measurement Systems - Application and Design, Fourth edition, McGraw-Hill, New York, 1992

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DESIGN FOR MANUFACTURING AND ASSEMBLY
(Elective - IV)

Prerequisite: Production technology

Course objectives: The course is intend to
- Understand the design rules and considerations with reference to various manufacturing processes
- To discusses capabilities and limitations of each manufacturing process in relation to part design and cost
- To examine DFM principles including how the design affects manufacturing cost, lean manufacturing, six sigma, etc.

Course outcomes:
After completing this course, the student should be able to
- Understand how a design can be made suitable for various manufacturing processes.
- To study the various factors influencing the manufacturability of components
- To study the use of tolerances in manufacturing
- Application of this study to machining, casting and joining processes

UNIT I:
Introduction: Design philosophy – Steps in Design process – General Design rules for Manufacturability – Basic principles of designing for economical production – Creativity in design.
Materials: Selection of Materials for design – Developments in Material Technology – Criteria for material selection – Material selection interrelationship with process selection – process selection charts.

UNIT II:
MACHINING PROCESS: Overview of various machining processes – general design rules for machining - Dimensional tolerance and surface roughness – Design for Machining ease – Redesigning of components for machining ease with suitable examples, General design recommendations for machined parts.
METAL CASTING: Appraisal of various casting processes, Selection of casting process, General design considerations for casting – casting tolerances – Use of Solidification Simulation in casting design – Product design rules for sand casting.

UNIT III
METAL JOINING: Appraisal of various welding processes, Factors in design of weldments – General design guidelines – pre and post treatment of welds – Effects of thermal stresses in weld joints – Design of brazed joints.
FORGING – Design factors for Forging – Closed die forging design – parting lines of dies – Drop forging die design – General design recommendations

UNIT IV:
EXTRUSION, SHEET METAL WORK & PLASTICS: Design guidelines for Extruded sections - Design principles for Punching, Blanking, Bending, Deep Drawing – Keeler Goodman Forming Limit Diagram – Component Design for Blanking.

PLASTICS: Viscoelastic and Creep behavior in plastics – Design guidelines for Plastic components – Design considerations for Injection Moulding.

UNIT V:

DESIGN FOR ASSEMBLY : General design guidelines for Manual Assembly - Development of Systematic DFA Methodology - Assembly Efficiency - Classification System for Manual handling- Classification System for Manual Insertion and Fastening - Effect of part symmetry on handling time - Effect of part thickness and size on handling time - Effect of weight on handling time - Effect of symmetry , Further design guidelines.

Text books:

1. Engineering design-Material & Processing Approach/ George E. Deiter, Mc. Graw Hill Intl. 2nd Ed.2000.
2. Product design for Manufacture and Assembly/ Geoffrey Boothroyd/Marcel Dekker Inc. NY, 1994.

Reference books:

1. Product design and Manufacturing / A.K Chitale and R.C Gupta / Prentice – Hall of India, New Delhi, 2003.
2. Design and Manufacturing / Surender Kumar & Goutham Sutradhar / Oxford & IBH Publishing Co. Pvt .Ltd., New Delhi, 1998.
3. Product Design/ Kevin Otto and Kristin Wood/ Pearson Education

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KINEMATICS AND DYNAMICS LABORATORY

Prerequisite: None

Course objectives: The course is intend to

- To perform experiments which are related to engineering mechanics subject (Statics and Dynamics) in order to understand the behaviour of different mechanical equipments studied in theory

Course Out comes:
The student will be able to:

- Calculate natural frequency, mode shapes and balancing (static dynamic) of mechanical systems
- Perform direct and inverse kinematic analysis of planar and spatial robot.

(A Minimum of 10 experiments are to be conducted)

1. Determination of damped natural frequency of vibration of the vibrating system with different viscous oils.
2. Determination of steady state amplitude of a forced vibratory system.
3. Static balancing using steel balls.
4. Determination of the magnitude and orientation of the balancing mass in dynamic balancing.
5. Field balancing of the thin rotors using vibration pickups.
6. Determination of the magnitude of gyroscopic couple, angular velocity of precession and representation of vectors.
7. Determination of natural frequency of given structure using FFT analyzer.
8. Diagnosis of a machine using FFT analyzer.
9. Direct Kinematic analysis of a robot.
10. Inverse Kinematic analysis of a robot.
11. Trajectory planning of a robot in joint space scheme.
12. Palletizing operation using Robot programming.

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SOFT SKILLS LAB
(Activity-based)

Prerequisite: Basic grammar

Course Objectives:

- To improve the fluency of students in English
- To facilitate learning through interaction
- To illustrate the role of skills in real-life situations with case studies, role plays etc.
- To train students in group dynamics, body language and various other activities which boost their confidence levels and help in their overall personality development
- To encourage students develop behavioral skills and personal management skills
- To impart training for empowerment, thereby preparing students to become successful professionals

Course Outcomes:

- Developed critical acumen and creative ability besides making them industry- ready.
- Appropriate use of English language while clearly articulating ideas.
- Developing insights into Language and enrich the professional competence of the students.
- Enable students to meet challenges in job and career advancement.

INTRODUCTION

Definition and Introduction to Soft Skills – Hard Skills vs Soft Skills – Significance of Soft/Life/Self Skills – Self and SWOT Analysis ***and***

1. **Exercises on Productivity Development**
   - Effective/ Assertive Communication Skills (Activity based)
   - Time Management (Case Study)
   - Creativity & Critical Thinking (Case Study)
   - Decision Making and Problem Solving (Case Study)
   - Stress Management (Case Study)
2. **Exercises on Personality Development Skills**
   - Self-esteem (Case Study)
   - Positive Thinking (Case Study)
   - Emotional Intelligence (Case Study)
   - Team building and Leadership Skills (Case Study)
   - Conflict Management (Case Study)
3. **Exercises on Presentation Skills**
   - Netiquette
   - Importance of Oral Presentation – Defining Purpose- Analyzing the audience- Planning Outline and Preparing the Presentation- Individual & Group Presentation- Graphical Organizers- Tools and Multi-media Visuals
   - One Minute Presentations (Warming up)
   - PPT on Project Work- Understanding the Nuances of Delivery- Body Language – Closing and Handling Questions – Rubrics for Individual Evaluation (Practice Sessions)
4. **Exercises on Professional Etiquette and Communication**
   - Role-Play and Simulation- Introducing oneself and others, Greetings, Apologies, Requests, Agreement & Disagreement….etc.

- Telephone Etiquette
- Active Listening
- Group Discussions (Case study)- Group Discussion as a part of Selection Procedure- Checklist of GDs
- Analysis of Selected Interviews (Objectives of Interview)
- Mock-Interviews (Practice Sessions)
- Job Application and Preparing Resume
- Process Writing (Technical Vocabulary) – Writing a Project Report- Assignments

5. Exercises on Ethics and Values

Introduction –– Types of Values - Personal, Social and Cultural Values - Importance of Values in Various Contexts

- Significance of Modern and Professional Etiquette – Etiquette (Formal and Informal Situations with Examples)
- Attitude, Good Manners and Work Culture (Live Examples)
- Social Skills - Dealing with the Challenged (Live Examples)
- Professional Responsibility – Adaptability (Live Examples)
- Corporate Expectations

☞ Note: Hand-outs are to be prepared and given to students.

☞ Training plan will be integrated in the syllabus.

☞ Topics mentioned in the syllabus are activity-based.

SUGGESTED SOFTWARE:

☞ The following software from **'train2success.com'**

- Preparing for being Interviewed
- Positive Thinking
- Interviewing Skills
- Telephone Skills
- Time Management
- Team Building
- Decision making

SUGGESTED READING:

1. Alex, K. 2012. *Soft Skills.* S. Chand Publishers
2. *Management Shapers*. 2011. Collection of 28 Books by different Authors. Universities Press.
3. Sherfield, Robert M. *2005. et al Cornerstone: Developing Soft Skills*. Pearson
4. Suresh Kumar,E; Sreehari, P. & Savithri, J. 2011. *Communication Skills and Soft Skills- An Integrated Approach.* New Delhi: Pearson
5. The ACE of Soft Skills by Gopalaswamy Ramesh & Mahadevan Ramesh. 2013. Pearson Publishers. New Delhi.
6. Patnaik, P. 2011. *Group Discussion and Interview Skills.* New Delhi: Foundation
7. Sudhir Andrews. 2009. *How to Succeed at Interviews.* New Delhi: Tata McGraw Hill
8. **Sasikumar, V & Dhamija, P.V. 1993. *Spoken English - A Self-Learning Guide to Conversation Practice.* New Delhi: Tata McGraw-Hill**
9. *Dixson, Richard J. Everyday Dialogues in English. Prentice Hall India Pvt Ltd*
10. Mukhopadhyay. L *et al. 2012. Polyskills. New Delhi: CUP India Pvt Ltd*
11. Rizvi, M. A. 2005. *Effective Technical Communication.* New Delhi: Tata McGraw Hill
12. *The Hindu Speaks on Education* by the Hindu Newspaper
13. Naterop, B. Jean and Revell, Rod. 2004. *Telephoning in English*. Cambridge: CUP

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ADVANCED MACHINE DESIGN

Prerequisite: Design of machine elements
Course objectives: The course is intend to
- To design machine components which are subjected to fluctuating loads.
- To distinguish different design criterions and their procedure to carry out the required design steps for designing mechanical components.
- To design machine components/parts based on creep criterions.

Course outcomes:
After completing this course, the student should be able to
- Ability to analyze behaviour of mechanical elements under different loads
- Understand the design of different transmission elements of automobile
- Ability to analyze mechanical elements critically.

Unit- I : Shafts and Axles:
Introduction, Causes of failure in Shafts and Axles And Stresses in Shafts, Materials for Shafts and Axles, Methods of Manufacturing of Shafts, Designing of Straight Shafts, Pure Tensional Load, Designing for Rigidity and Stiffness, Design of Axles, Flexible Shafts.

Unit- II : Rope drive:
Fibre ropes, rope drives for power transmission, fibrous Ropes used in Hoisting Tackle, Wire Ropes, Materials, Wire Rope Construction, Applications of Ropes, properties of various types of Ropes, Approximate wire Diameters and Effective Cross- section of Ropes: Fiber cores for steel wire ropes, Working loads, Friction and Efficiency wire rope, sheaves and Drum, rope fasteners, Selection of wire rope, design procedure.

Unit- III : Chain drives:
Types of Chain drives, construction of Chains, Roller Chains, Silent Chains, selection of a chain, Design of the chain Drive, Good design practice.

Unit- IV : Gear drives:
Design calculations for helical gears, Definitions, double helical , Gear tooth proportions, Design calculations, forces acting in a Bevel gear, Worm gear drives, worm wheel, designation of a worm gear drive, Materials, efficiency of Drive, Heat Dissipation, Design of worm Gearing, Forces on worm gears, advantages and disadvantages of worm gear drives.

Unit- V : Power screws:
Function, Types of Power screws , Multiple threads, Comparison of square and trapezoidal threads, Power screw drive, Efficiency of screws, square threads, Trapezoidal Threads, stresses in screws design calculations, design procedure, other types of screws, differential and compounds screws , ball baring screws.

Text books:
1. Machine Design by Dr. P.C. Sharma- S.K.Kataria & sons
2. Machine Design by Maleev and Hartman-C.B.S Publishers

References:
1. Machine Design by Schaum series
2. Mechanical Engineering design by J.E. Shigley

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FINITE ELEMENT AND BOUNDARY ELEMENT METHODS

Prerequisite: None

Course objectives: The course is intend
- To equip the students with the Finite Element Analysis fundamentals.
- To enable the students to formulate the design problems into FEA.
- To introduce basic aspects of finite element technology, including domain discretization,
- polynomial interpolation, application of boundary conditions, assembly of global arrays,
- and solution of the resulting algebraic systems.
- To introduce basic concepts of framing dynamic problems in FEA
- To keep track of the moving boundary at different instants of time.

Course outcomes:
After completing this course, the student should be able to
- Understand the background of mathematical equations used for development of modeling software modules to develop the various structural related applications
- Identify mathematical model for solution of common engineering problems.
- Solve structural, thermal, fluid flow problems.
- Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.

UNIT - I
Introduction to FEM: basic concepts, application of FEM, general description, One Dimensional problems : Stiffness equations for a axial bar element in local co-ordinates using Potential Energy approach and Virtual energy principle - Stiffness equations for a truss bar element oriented in 2D plane - Finite Element Analysis of Trusses – Plane Truss elements – methods of assembly.
Analysis of beams: Hermite shape functions – Element stiffness matrix – Load vector – Problems.

UNIT -II
2-D problems: CST - Stiffness matrix and load vector - Isoparametric element representation – Shape functions – convergence requirements – Problems. Two dimensional four noded isoparametric elements - Numerical integration.
3-D problems : Stiffness Matrix - Tetrahedron element – Hexahedron Element.

UNIT - III
Scalar field problems: 1-D Heat conduction – 1D fin elements – 2D heat conduction - analysis of thin plates – Composite slabs - problems.
Dynamic Analysis: Dynamic equations – Lumped and consistent mass matrices – Eigen Values and Eigen Vectors – mode shapes – modal analysis for bars and beams.

UNIT - IV
Boundary Element Method: Potential Problems: Introduction, boundary Element Approach-Fundamental solution, Another form of boundary integral equation. Numerical Implementation - Determination of Ci, Final Relation, Consideration of internal heat

generation (body force term), Three-dimensional analysis, tackling kernel singularity, Axi-Symmetric kernel, Mixed boundary condition.

UNIT - V

Boundary Element Formulation for Electrostatic Problems: Introduction, Basic Relation-Boundary condition, other relations. Boundary Integral Relation, Fundamental solution, Discretizatin and Matrix Formulation – Determination of term C(p)m. Illustrative Examples – Loose - fit , loaded pin in hole, Cam- tappet contact problem.

Text Book:

1. Finite and Boundary Element Methods in Engineering by O.P.Gupta, Oxford & IBH Publishing Co. Pvt. Ltd
2. The finite element methods in Engineering – S.S. Rao – Elsevier – 4th edition

References:

1. Finite Element Methods, Alavala, PHI.
2. Introduction to finite elements in engineering – Tirupathi K. Chandrupatla and Ashok D. Belagundu.
3. An Introduction to Finite Element Methods – J. N. Reddy – Mc Grawhill
4. The Finite element method in engineering science – O.C. Zienkowitz, Mc Grawhill.
5. Concepts and applications of finite element analysis – Robert Cook - Wiley

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INDUSTRIAL ROBOTICS
(Elective - V)

Prerequisite: None

Course objectives: The course is intend
- To impart knowledge on robot configurations, components, sensors and actuators used in robotics.
- To develop programming techniques for industrial robots, kinematic and dynamic analysis for simple planner robots, robot cell design and applications.

Course outcomes:
After completing this course, the student should be able to
- Understand with the automation and brief history of robot and applications.
- To familiarized with the kinematic motions of robot and good knowledge about robot end effectors and their design concepts.
- Write Programming methods & various Languages of robots.

UNIT I:
Introduction: Automation and Robotics, Robot anatomy, robot configuration, motions joint notation work volume, robot drive system, control system and dynamic performance, precision of movement.
Control System And Components: basic concept and modals controllers control system analysis, robot actuators and feedback components (sensors): Internal & External Sensors, Positions sensors, velocity sensors - Desirable features, tactile, proximity and range sensors, uses sensors in robotics , Power Transmission Systems.

UNIT II:
Motion Analysis and Control: Manipulator kinematics, position representation Homogeneous transformation, D-H Notation, D-H Transformation Matrix, Forward & Inverse transformations, problems on planar & spatial manipulators, Differential Kinematics, Jacobian Formulation, problems, manipulator path control: Slew, Joint Interpolated & Straight line motions, trajectory planning: Joint space scheme, Cartesian space scheme, Cubic Polynomial fit without and with via point, blending.

UNIT III:
Robot Dynamics: Lagrange – Euler & Newton - Euler formulations, problems on two link planar manipulators, configuration of robot controller.
End Effectors: Grippers-types, operation, mechanism, force analysis, tools as end effectors consideration in gripper selection and design.
Machine Vision: Functions, Sensing and Digitizing-imaging, Devices, Lighting techniques, Analog to digital single conversion, Image storage, Image processing and Analysis-image data reduction, Segmentation feature extraction. Object recognition, training the vision system, Robotics application.

UNIT IV:

Robot Programming: Lead through programming, Robot programming as a path in space, Motion interpolation, WAIT, SINGNAL AND DELAY commands, Branching capabilities and Limitations.

Robot Languages: Textual robot languages, Generation, Robot language structures, Elements and functions.

UNIT V:

Robot Cell Design and Control: Robot cell layouts-Robot centered cell, In-line robot cell, Considerations in work cell design, Work cell control, Inter locks, Error detection, Work cell controller.

Robot Applications: Material transfer, Machine loading/unloading. Processing operations, Assembly and Inspection, Future Applications.

TEXT BOOKS:

1. Introduction to Robotics Mechanics & Control/ John J.Craig/Pearson
2. Industrial robotics / Mikell P.Groover / McGraw Hill.

REFERENCE BOOKS:

1. Robotics / K.S.Fu / McGraw Hill.
2. Robot Analysis/Lung Wen Tsai/John Wiley & Sons
3. Robotics & control/RK Mittal & IJ Nagrath/ Tata McGrawHill

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NEURAL NETWORKS AND FUZZY LOGICS
(Elective-V)

Prerequisites: None

Course objectives: The course is intend

- To cater the knowledge of Neural Networks and Fuzzy Logic Control and use these for controlling real time systems.

Course outcomes:

After completion of this course, the student should be able to

- Learn concepts of neural networks and fuzzy logics
- Understand the topology of multi-layer perception, recurrent neural networks and Fuzzification & Defuzzification.
- Understand the basic structure and operation of Fuzzy logic control systems

UNIT-I: Evolution of neural networks; Artificial Neural Network: Basic model, Classification, Feed forward and Recurrent topologies, Activation functions; Learning algorithms: Supervised, Un-supervised and Reinforcement; Fundamentals of connectionist modeling: McCulloach – Pits model, Perceptron, Adaline, Madaline.

UNIT–II: Topology of Multi-layer perceptron, Back propagation learning algorithm, limitations of Multi-layer perceptron. Radial Basis Function networks: Topology, learning algorithm; Kohenen's self-organising network: Topology, learning algorithm; Bidirectional associative memory Topology, learning algorithm, Applications.

UNIT–III: Recurrent neural networks: Basic concepts, Dynamics, Architecture and training algorithms, Applications; Hopfield network: Topology, learning algorithm, Applications; Industrial and commercial applications of Neural networks: Semiconductor manufacturing processes, Communication, Process monitoring and optimal control, Robotics, Decision fusion and pattern recognition.

UNIT–IV: Classical and fuzzy sets: Introduction, Operations and Properties, Fuzzy Relations: Cardinality, Operations and Properties, Equivalence and tolerance relation, Value assignment: cosine amplitude and max-min method; Fuzzification: Membership value assignment- Inference, rank ordering, angular fuzzy sets. Defuzzification methods, Fuzzy measures, Fuzzy integrals, Fuzziness and fuzzy resolution; possibility theory and Fuzzy arithmetic; composition and inference; Considerations of fuzzy decision-making.

UNIT-V:

Basic structure and operation of Fuzzy logic control systems; Design methodology and stability analysis of fuzzy control systems; Applications of Fuzzy controllers. Applications of fuzzy theory.

Text Books:

1. Limin Fu, "Neural Networks in Computer Intelligence," McGraw Hill, 2003.
2. Fakhreddine O. Karray and Clarence De Silva., "Soft Computing and Intelligent Systems Design, Theory, Tools and Applications," Pearson Education, India, 2009.
3. Timothy J. Ross, "Fuzzy Logic with Engineering Applications," McGraw Hill,1995.
4. B.Yegnanarayana, "Artificial Neural Networks," PHI, India, 2006.

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ADVANCED TOOL DESIGN
(Elective - V)

Prerequisite: Production technology

Course objectives: The course is intend to

- Describe tool design methods and punch and die manufacturing techniques
- Select material for cutting tools and gages;
- classify various cutting tools and gages and identify their nomenclature
- Describe the principles of clamping, drill jigs and computer aided jig design
- Design fixtures for milling, boring, lathe, grinding, welding;
- identify fixtures and cutting tools for NC machine tools
- Explain the principles of dies and moulds design

Course Outcomes:

At the end of the course the students will be able to

- Develop the conceptual design, manufacturing framework and systematic analysis of design problems on the machine tools apply the design procedures for different types of design problems such as gear box design, guide way
- Design, shaft loading and its associated parts, rolling bearings, die design and jigs and fixtures and so on.

UNIT I:

Tool Materials: Properties of materials, Tool steels, Cast Iron, Mild or low carbon steels, Non-metallic and nonferrous materials, Heat treating.

Design of Cutting Tools: Single point cutting tools, Milling cutters, Drills, Selection of carbide steels.

UNIT II:

Determination of shank size for single point carbide tools, determining the insert thickness for carbide tools.

Design of Jigs and Fixtures: Basic principles of location and clamping; Locating methods and devices. Jigs – Definition, Types.

UNIT III:

General considerations in the design of Drill jigs, Drill bushing, Methods of Construction. Fixtures – Vice fixtures, Milling, Boring, Lathe Grinding fixtures.

Design of Sheet Metal Blanking and Piercing Dies: Fundamentals of Die cutting operations, Power press types, General press information, Material Handling equipment.

UNIT IV:

Cutting action in Punch and die operations. Die clearance, Types of Die construction. Die design fundamentals – Blanking and piercing die construction, pilots, stripper and pressure pads presswork material, Strip layout, Short run tooling for piercing.

UNIT V:

Design of Sheet Metal Bending, Forming and Drawing Dies: Bending dies, Drawing dies, Forming dies, Drawing operations, Variables that effect metal flow during drawing. Determination of blank size, Drawing force, single and double action draw dies.

Text Books:

1. Tool Design / Donaldson / Tata Mc Graw Hill.
2. Mechanical Metallurgy / George E Dieter / Tata McGraw Hill

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VIBRATION ANALYSIS OF MECHANICAL SYSTEMS
(Elective-VI)

Prerequisite: None

Course objectives: The course is intend

- To prepare the student to understand the fundamentals of vibrations of various physical models for single and multi degree freedom systems
- To make the student apply numerical methods to various physical systems and their response to vibrations.
- Exposure to vibration measurement of industrial equipment using instruments

Course Outcomes:

At the end of the course the students will be able to

- To study the vibrations in machine elements and how to control them.
- Ability to analyze the mathematical model of linear vibratory system to determine its response
- Obtain linear mathematical models of real life engineering systems
- Determine vibratory responses of single and multi degree of freedom systems to harmonic, periodic and non-periodic excitation

Unit-I

Free Vibration of Single Degree of Freedom Systems:

Introduction, Free Vibration of an Undamped Translational System, Equation of Motion using Newton's second law of motion, Equation of motion using other methods, Equation of motion of a spring, mass system in vertical position, solution, Harmonic Motion Free Vibration of an Undamped torsional System- Equation of motion. Free Vibration with Viscous Damping- Equation of motion.

Unit-II

Forced Vibration of Single Degree of Freedom Systems:

Introduction, Response of an Undamped system under harmonic force, Total response, Beating Phenomenon. Response of a Damped System under Harmonic Force- Total Response, Quality Factor and Bandwidth, Response of a Damped system under the Harmonic Motion of the base, Fore Transmitted, Relative Motion.

Unit- III

Two Degree of Freedom Systems: Introduction, Equations of Motion for forced Vibration, Free Vibration Analysis of and undamped system, Torsional system, Coordinate Coupling and Principal Coordinates, forded Vibration Analysis, Semi definite Systems, Self- Excitation and stability Analysis.

Unit-IV

Multi-degree of Freedom Systems: Introduction Modeling of Continuous systems as Multi-degree of Freedom systems, Using Newton's second law to derive equations of motion, Influence Coefficients. Potential and kinetic energy expressions in matrix form, Generalized coordinates and generalized forces, Using Lagrange's equations to derive equations of motion, Equations of motion of undamped systems in matrix form, Eigen value problem,

solution of the Eigen value problems – solution of the characteristic equation, orthogonality of normal modes, repeated Eigen values.

Unit-V

Determination of Natural Frequencies and Mode Shapes:

Introduction, Dunkerley's formula, Rayleigh's Method- Properties of Rayleigh's Quotient, Computation of the Fundamental Natural Frequency, Fundamental Frequency of Beams and Shafts. Holzer;s Method-Torsional systems, Spring Mass Systems. Jacobis method, Standard Eigen value Problems.

Text books:

1. Mechanical Vibrations by S.S.Rao, 4th Edition, Pearson Publications.
2. Elements of Vibration Analysis by Meirovitch.

References:

1. Mechanical Vibrations by G.K. Groover.
2. Vibrations by W.T. Thomson
3. Mechanical Vibrations – Schaum series.
4. Vibration problems in Engineering by S.P. Timoshenko.
5. Mechanical Viabrations – V.Ram Murthy.

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RANDOM VIBRATIONS
(Elective - VI)

Prerequisites: Probability & Statistics, Kinematic of machinery and Dynamics of machinery.

Course objectives: The course is intend

- To introduce the fundamental ideas of random vibrations.
- To deal in some depth with digital spectral analysis, which involves the measurement and analysis of random vibrations

Course outcomes:

After completing this course, students should be able to

- Apply tools from probabilistic modeling to analyze dynamic systems while accounting for variability and uncertainties that are inevitably present in real engineered systems.
- Classify random excitations as stationary or non-stationary
- Discuss important properties of random processes
- Define and compute power spectral density functions
- Compute auto-and cross-correlation functions, and relate them to power spectral
- Density functions Describe the dynamic response of a multi-degree-of-freedom system to a stochastic excitation
- Quantify the distributions of peak loads and peak responses from a system subject to stochastic excitation

UNIT I: PROBABILITY THEORY:

Random Vibrations - Probability distribution and density functions - Excreted values - Conditional probability - Characteristic and log characteristic functions - Chebycshev inequality - Functions of random variables.

UNIT – II : RANDOM PROCESSES - I:

Concept of stationary and ergodicity - Evolutionary nonostationary process - Auto and cross correlation and covariance Functions - Mean square limit, differentiability and inerrability - Spectral decomposition.

UNIT III: RANDOM PROCESSES - II:

Power spectral and cross spectral density Factions - Wiener - Khintchine relations - Properties of Gaussian. Poisson and Markov processes –Fokker - Planck Equation - Broad band and narrow band random processes - white noise.

UNIT IV : RANDOM VIBRATIONS - I:

Response of linear single and multi - degree of freedom systems to stationary excitation - Response of continuous systems - Normal mode method.

UNIT V : RANDOM VIBRATIONS - II:

Level crossing, peak and envelop statistics - First excursion and fatigue.

Text Books :

1. Lishakoff, I., " Probabilistic Methods in the Theory of Structures", John Wiley, New York, 1983.
2. Newland, D.E., " An Introduction to Random Vibrations and Spectral Analysis", Longman Inc., New York, Second Edition, 1984.

References:

1. Nigam, N.C., "Introduction to Random Vibrations". MIT Press, Cambridge, Massachusettes, 1983
2. Nigam, N.C. and Narayanan, S., "Applications of Random Vibrations", Narosa Publications,1995

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VEHICLE DYNAMICS
(Elective - VI)

Prerequisite: Automobile Engineering

Course objectives: The course is intend
- To understand the fundamentals of dynamics of different vehicle tyres ,
- To impart the design of suspension and mechanisms of steering

Course Outcomes:
At the end of the course the students will be able to
- The focus of Automotive System Dynamics is to introduce the fundamentals of vehicle dynamics and the performance indices and evaluation criteria of vehicles, to analyze the influence of vehicle configuration and design parameters on vehicle performance.

UNIT I:
Introduction: Fundamental Principles, Vehicle tires performance, cornering characteristics, Mechanics of Vehicle Terrain interaction. Vehicle Kinematics, Fundamental principles of velocity, acceleration. Two dimensional mechanisms, Forward Vehicle Dynamics.

UNIT II:
Three dimensional Mechanisms, Multi-Body Systems Design, Introduction to 3D vehicle design.

UNIT III:
Suspension Design: Computer models using Bond Graph Technology, Drive train dynamics, vehicle performance

UNIT IV:
Steering Mechanisms: Two and three dimensional analysis, Mechanics of Vehicle Terrain interaction. Vehicle Collations, Fundamental laws of motion, energy and momentum, Forces and Moments 2D and 3D. The Dynamics of vehicle rollovers.

UNIT V:
Wheeled Vehicle Handling – Handling control loop, vehicle transfer function, Kinematic behavior of vehicles with rigid wheels and with complaint tyres: Neutral steer point, static margin, over and under-steer. Solution with two degree of freedom in the steady state: Stability factor, characteristic and critical speeds. Tracked Vehicle Handling – Analysis of sprocket torques and speeds, required to skid steer a tracked vehicle. Extension of theory to include three degrees of freedom.

Text Books:
1. Vehicle Dynamics Theory and Application- Reza Jazar, Springer 2008
2. Theory of Ground Vehicles – J.Y.Wong, John Wiley.

References:
1. Vehicle stability – Dean Karnopp, Dekker Mechanical Engineering
2. Modeling & Simulation of Mechatronics Systems – Karnoop Margolis, Rosenberg, Wiley 2007.
3. Suspension and Tyres - Giles J.G. Steering, Illiffe Books Ltd., London.
4. Fundamental of Vehicle Dynamics- Gillespie T.D, SAE USA.

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EXPERIMENTAL STRESS ANALYSIS
(Elective - VII)

Prerequisite: None

Course objectives: The course is intend

- To Provides knowledge about different experimental stress analysis techniques. These are very much needed to validate the design outputs.

Course Outcomes:

At the end of the course the students will be able to

- Know the working principle of strain gauges and do the model analysis using different theorems.
- Know the concepts of photo elasticity and its applications.
- Use the various Non-destructive testing methods.

UNIT-I

Strain Gauges - Mechanical and optical strain gauges – Description and operation – Electrical resistance- Inductance and capacitance gauges – Detailed treatment on resistant gauges – Measurement of static and dynamic strains – Strain rosettes – Effect of transverse strains – Use of strain recorders and load cells.

UNIT-II

Model Analysis - Structural similitude – Use of models – Structural and dimensional analysis – Buckingham Pi Theorem – Muller Breslau's principle for indirect model analysis – Use of Begg's and Eney's deformeters – Moment indicators – Design of models for direct and indirect analysis.

Unit-III

Two dimensional photo elasticity - Stress optic law – Introduction to polariscope – Plane and circular polariscope – Compensators and model materials – Material and model fringe value – Calibration of photo elastic materials – Isochromatic and isoclinic fringes – Time edge effects.

Unit-IV

Three dimensional photo elasticity - Introduction – Stress freezing techniques – Stress separation techniques – Scattered light photo elasticity – Reflection polariscope.

Unit-V

Miscellaneous Methods - Brittle coating method – Birefringence techniques – Moire fringe method – Non-destructive testing – Ultrasonic pulse velocity technique – Rebound hammer method – X-ray method – Gamma-ray method.

Text books :

1. Experimental stress analysis by Dally and Riley, Mc Graw-Hill

References:

1. Experimental stress analysis by Sadhu singh, Danapathi rai publications
2. Heteny M; Handbook of Experimental Stress Analysis, John Wiley and Sons, New York.
3. Photoelasticity Vol. I & II., Frocht M.M.; John Wiley and Sons, New York.

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FRACTURE MECHANICS
(Elective - VII)

Prerequisite: None

Course objectives: The course is intend

- To provide an understanding of fundamental principles and assumptions, and to give a basis for analysis and evaluation of structures from a fracture mechanics point of view.
- Also students will be explored to fatigue, creep deformation,creep-fatigue interactions.

Course Outcomes:

At the end of the course the students will be able to

- Predict material failure for any combination of applied stresses.
- Estimate failure conditions of a structure
- Determine the stress intensity factor for simple components of simple geometry
- Predict the likelihood of failure of a structure containing a defect

UNIT I:

Introduction to fracture Mechanics: The Crack tip plastic Zone, Methods for Measuring Fracture Toughness.

UNIT II:

Strength of cracked bodies- potential energy and surface energy – Griffith's theory – Irwin – Orwin extension of Griffith's theory to ductile materials – Stress analysis of cracked bodies – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries.

UNIT III:

PHYSICAL ASPECTS OF FATIGUE:

Phase in fatigue life - Crack initiation – Crack growth - Final fracture - Dislocation – Fatigue fracture surfaces. Safe Life and Fail safe design philosophies Importance of Fracture Mechanics in Aerospace structure – Applications to composite materials and structures.

UNIT IV:

STATICAL ASPECTS OF FATIGUE BEHAVIOUR:

Low cycle and high cycle fatigue - Coffin- Manson's Relation –Transition Life – Cyclic strain hardening and softening – Analysis of load histories – Cycle counting techniques – Cumulative damage – Miner's theory, other theories.

UNIT V:

Dynamic Fracture, Stress Corrosion Cracking, Corrosion Fatigue, Fatigue - Crack Propagation under Variable - Amplitude Load Fluctuation, Fatigue - Crack Initiation, Fatigue - Crack Propagation under Constant - Amplitude Load Fluctuation.

Text Books:

1. Introduction to Fracture Mechanics - Hellan K, McGraw Hill
2. Fracture Vol II – Liebowitz, H.Editor, Academic Press
3. The Practical Use of Fracture Mechanics – Broek.D, Kluwer Academic Publisher.

4. Elementary Engineering Fracture Mechanics IV th Edition– Broek.D, Martinus Nijhoff.

References:

1. Barrpos. W., and Ripley, E.L., " Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983.
2. Sih, C.G., "Mechanics of Fracture", Vol. 1 Sijthoff and Noordhoff International Publishing Co., Netherlands, 1989.
3. Knott , J.F., " Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London. 1983

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ADVANCED FINITE ELEMENT AND MESH LESS METHODS
(Elective-VII)

Prerequisite: Solid State physics and FEM

Course objectives: The course is intend to systematically explores and establishes the theory, principles, and procedures that lead to mesh-free methods. Course in Mesh Free and Other Advanced finite element gives basic understanding and application of a class of emerging numerical methods.

Course Outcome:
- To perform complete FE formulations for engineering analysis
- To write codes for a finite element model
- To use commercial FEA software to solve engineering problems
- To apply finite element methods in design engineering components or systems
- To Learn mesh free method types, mesh free shape functions, weak form types
- Have the ability to be able to solve problems by using mesh free methods
- to solve a problem by writing a computer code containing mesh free method

Advanced Finite Element

Unit-I
Bending of Plates and Shells: Review of Elasticity Equations-Bending of Plates and Shells-Finite Element Formulation of Plate and Shell Elements-Conforming and Non Conforming Elements - Co and C1 Continuity Elements-Application and Examples.

Non-Linear Problems
Introduction-Iterative Techniques-Material non-Linearity-ElastoPlasticity-Plasticity- Visco plasticity-Geometric Non linearity-large displacement Formulation-Application in Metal Forming Process and contact problems

Unit-II
Dynamic Problem
Direct Formulation - Free, Transient and Forced Response - Solution Procedures-Subspace Iterative Technique -Houbolt, Wilson, New mark - Methods – Examples

Unit-III
Fluid Mechanics and Heat Transfer
Governing Equations of Fluid Mechanics-Inviscid and Incompressible Flow-Potential Formulations-Slow Non- Newtonian Flow-Metal and Polymer Forming-Navier Stokes Equation-Steady and Transient Solutions. Error Estimates And Adaptive Refinement Error norms and Covergence rates- high refinement with adaptivity-Adaptive refinement

MESHLESS METHODS
Unit-IV
Overview on Meshless Methods and Their Applications: Approximation Function, Numerical Implementation, Applications

Procedures of Meshless Methods: Construction of the Approximation, Choice of Weight Function, Formulation of Meshless Analysis, Evaluation of the Integral, Treatment of Discontinuity, Treatment of Mirror Symmetry, H- and P-Refinements, Meshless Analysis of

Elastic Problems: Background Theory for Applications of Elastostatics, Meshless Analysis of Elastostatic Problems , General Dynamic Problems, Meshless Analysis of Elastodynamic Problems, Meshless Analysis of Multiphase Materials.

Unit-V

Meshless Analysis of Nonlocal Continua : Introduction to Nonlocal theory, The Framework of Nonlocal Theory ,Material Instability and Intrinsic Length , Nonlocal Constitutive Relations, Formulation of Nonlocal Meshless Method, Numerical Examples by Nonlocal Meshless Method.

Meshless Analysis of Plasticity : Constitutive Relations, Return Mapping Algorithm,J2 Flow Theory. Meshless Analysis of High-Speed Impact/Contact Problem, Incremental Plasticity and Slow Crack Growth Problem.

Text Books:

1. Zeinkiewicz,O.C and Taylor,R.L., "The Finite element Method", Fourth Edition,Volumes 1 & 2, McGraw Hill International Edition,Physics services,1991
2. Cook R.D. "Concepts and Applications of Finite Element Analysis", John Wiley and Sons Inc., NewYork,1989
3. Bathe K.J..,"Finite Element Procedures in Engineering Analysis", Prentice Hall,1990
4. G.R Liu, Meshfree Methods: Moving beyond the Finite element method, CRC press
5. Youping Chen, James D. Lee,and Azim Eskandarian, Meshless Methods in Solid Mechanics,Springer
6. Michael Griebel, Marc Alexander Schweitzer, Meshfree Methods for Partial Differential Equations, Springer

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ADVANCED MECHANICS OF COMPOSITE MATERIALS
(Elective - VIII)

Prerequisite: None

Course objectives: The course is intend to understand the mechanics of composite materials. This understanding will include concepts such as anisotropic material behavior strength theories, micro mechanics and the analysis of laminated composites. The students will undertake a design project involving application of fiber reinforced composites.

Course Outcomes:
At the end of the course the students will be able to

- understanding of types, manufacturing processes, and applications of composite materials.
- basic understanding of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.
- Ability to analyze problems on macro and micro mechanical behavior of lamina
- Ability to analyze problems on macro mechanical behavior of laminate
- An ability to predict the loads and moments that cause an individual composite layer and a composite laminate to fail and to compute hygro thermal loads in composites.
- An ability to compute the properties of a composite laminate with any stacking sequence.
- An ability to use the ideas developed in the analysis of composites towards using composites in aerospace design.

UNIT-I
Introduction to Composite Materials: Introduction ,Classification Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites, Fiber-Reinforced Composites and nature-made composites, and applications .

UNIT-II
Reinforcements: Fibers- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibers. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.
Manufacturing methods: Autoclave, tape production, moulding methods, filament winding, man layup, pultrusion, RTM.

UNIT-III
Macro mechanical Analysis of a Lamina: Introduction, Definitions Stress, Strain, Elastic Moduli, Strain Energy. Hooke's Law for Different Types of Materials, Hooke's Law for a Two-Dimensional Unidirectional Lamina, Plane Stress Assumption, Reduction of Hooke's Law in Three Dimensions to Two Dimensions, Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina.

UNIT-IV
Macro mechanical Analysis of Laminates: Introduction , Laminate Code , Stress–Strain Relations for a Laminate, In-Plane and Flexural Modulus of a Laminate , Hygrothermal Effects in a Laminate, Warpage of Laminates.

UNIT-V

Failure, Analysis, and Design of Laminates : Introduction , Special Cases of Laminates, Failure Criterion for a Laminate, Design of a Laminated Composite, Other Mechanical Design Issues.

Text Books:

1. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press, 1994.
2. B. D. Agarwal and L. J. Broutman, Analysis and performance of fibre Composites, Wiley-Interscience, New York, 1980.
3. Mechanics of Composite Materials, Second Edition (Mechanical Engineering), By Autar K. Kaw ,**Publisher:** CRC

References:

1. R. M. Jones, Mechanics of Composite Materials, Mc Graw Hill Company, New York, 1975.
2. L. R. Calcote, Analysis of Laminated Composite Structures, Van Nostrand Rainfold, New York, 1969.

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NANO COMPOSITES DESIGN AND SYNTHESIS
(Elective - VIII)

Prerequisite: None

Course objectives:

The course is intend to cover nano composites, reinforcing nanostructures dispersed in various matrix materials like polymers, ceramics, metals, etc,. The subject covers mainly the synthesis methods, modeling and evaluation of nano composites.

Course Outcomes:

At the end of the course the students will be able to

- To synthesize and evaluate nanostructure reinforce matrix material
- To understand the importance of various nano material matrix
- To discuss various application including aerospace applications

Unit-I :

Introduction to Nano composites, Composites Material, Mechanical properties of Nano composite material: stress-strain relationship, toughness, strength, plasticity.

Unit-II:

Ceramic-Metal Nano composites, ceramic based nano porous composite, metal mat nano composites, Polymer-based nano composites carbon nano tube based nano composites and Natural nano bicomposites, Biomimetic nano composites and Biologically inspired nanocomposites; Nano composites for hard coatings; DLC coatings; Thin film nanocomposite ; Modeling of nano composites.

Unit-III:

Synthesis methods for various nano composite materials : sputtering, mechanical alloying, sol-gel synthesis, thermal spray synthesis etc.

Unit-IV:

Nano Indentation, Types of indentation: OLIVER & Pharr, Joslin- Oliver, Vickers indenter process.

Unit-V:

Processing of polymer Nanocomposites, properties of nanocomposites, Salt infiltrator Powder mixing, Intrusion method, exfoliation & interaction, Gel-casting impregnation techniques: Hot melt impregnation, solution impregnation.

Text Books:

1. Nanocomposite Science & Technology by P.M.Ajayan, I.S.Schadler and P.V.Brun, Wiley- VCH GmbH Co.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank j.Owens, Wiley India Pvt Ltd.
3. Nanotechnology, A gentle introduction to the next big idea by Mark Tanter, Daniel Ranner Pearson education.

Reference Books

1. Encyclopedia of Nanotechnology by H.S. Nalwa
2. Encyclopedia of Nano Technology by M. Balakrishna rao and K. Krishna Reddy. Vol I to X Campus books.

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DESIGN FOR PROCESS AND PRODUCT DEVELOPMENT
(Elective - VIII)

Prerequisite: None

Course objectives: The course is at providing the basic concepts of product design, product features and its architecture so that student can have a basic knowledge in the common features a product has and how to incorporate them suitably in product.

Course Outcomes:

At the end of the course the students will be able to

- Should know types of customer needs, need gathering methods
- Establish the product function and constraints and modeling process
- Should know environmental objectives global issues, Regional and Local issues and DFE Methods
- Should develop physical models and know design of experiment principles
- Should design the product for robustness.

Unit- I

Introduction to Product Design, Thoughts For the Reader and Students of Product Design, Product Development Versus Design, Types of Design and Redesign, Customer Satisfaction- Voice of the Customer, Customer Populations , types of Customer Needs, Customer Need Models, Gathering Customer Needs Need Gathering Methods, Organizing and Prioritizing Customer Needs, Grouping Interpreted Needs, Grouping the Needs- Affinity Diagram Method.

Unit- II

Establishing Product Function - Why Functional Decomposition?, Motivation, Function Modeling Basics, Functions and Constraints, Modeling Process.

Unit- III

Generating Concepts, Concept Generating Process, Basic Methods; Information Gathering and Brainstorming, Information Gathering – Conventional Aids, Traditional Brainstorming, Advanced Methods, Directed search, systematic search with physical principles, systematic search with classifying schemes, theory of inventive problem solving, Morphological Analysis - Develop concepts for each product function, Combining Solution Principles - Digression - function sharing, Product Application fingernail clipper, Concept Selection - Introduction, Factors that determine effective decision making, design evaluations, information quality, estimating technical risibility, concept selection process.

Unit- IV

Environmental Objectives, global issues, Regional and Local issues. Basic DFE Methods; Design Guidelines, application. Life cycle assessment, weighted sum assessment methods. Life cycle assessment method. Techniques to reduce environmental impact - design to minimize material usage, design for disassembly design for recyclability and design for remanufacturing design for high - impact material reduction design for energy efficiency.

Unit- V

Physical Models and Experimentation: Design of experiments - basic of designed experiments, basic method - two factorial experiments , extended method – interactions, Design of experiments: Reduced tests and fractional experiments, full factorial inefficiencies, orthogonality, base design method, Higher dimensions fractional factorial designs. Stastical analysis of experiments - degrees of freedom, correlation coefficient.

Design for Robustness: Quality design theory, general robust design model, robust design model construction. Basic method: Taguchi's method, noise variable matrix, design variable matrix, experimental matrix, single to noise ratios, selection of a target design, parameter design and the Taguchi philosophy. Advantage analysis - Probability Theory Sizing the variation, general robust design Problem formulation.

Text Books:

1. Integrated product and process design and development by Edward B.Magrab, Satyandra K Gupta et al, CRC Press, 2nd Edition
2. Engineering Design by George E. Dieter, Linda C. Schmidt, McGraw- Hill, International Edition, 4th Edition

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ADVANCED COMPUTER AIDED DESIGN AND ANALYSIS LABORATORY

Prerequisite: None

Course objectives: The course is intend to

- Understand and draw part drawings with appropriate tolerances using CAD software package.
- Practice the students to generate 3D models, surface and assembly modeling using modeling software package
- Train the students in static and transient ,thermal analysis using FEA packages

Course Outcomes:

At the end of the course the students will be able to

- Students should be able to use CATIA and Pro-E and software for modeling, tolerance & GD&T analysis of a product.
- Students should be able to use CATIA software to model a consumer product and industrial robot.
- Students should be able to carry out structural, Harmonic and fracture analysis using FEA software.

Note : Conduct any Ten exercises from the list given below :

1. Two- dimensional drawing using CAD software.
2. Three-dimensional drawing using CAD software.
3. Various Dimensioning and tolerancing techniques on typical products using CAD software.
4. Assembly and animation of simple assemblies like screw jack, bolt-nut mechanism, etc.
5. Truss analysis using FEA software.
6. Beam analysis using FEA software.
7. Frame analysis using FEA software.
8. Buckling analysis of columns using FEA software.
9. Harmonic analysis using FEA software.
10. Fracture analysis using FEA software.
11. Analysis of laminated composites using FEA software.
12. Couple-field analysis using FEA software.
13. Modal Analysis
14. Transient dynamic analysis.
15. Spectrum analysis

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SEMINAR

Prerequisites: None

Course Objectives:

Course Outcomes:
At the end of the course, the student will be able to:

- Identify and compare technical and practical issues related to the area of course specialization.
- Outline annotated bibliography of research demonstrating scholarly skills.
- Prepare a well organized report employing elements of technical writing and critical thinking
- Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

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COMPREHENSIVE VIVA – VOCE

Prerequisites: None

Course Outcomes:
- Comprehend the knowledge gained in the course work
- Infer principles of working of mechanical components
- Demonstrate the ability in problem solving and to communicate effectively

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PROJECT PHASE - I

Prerequisites: None

Course Outcomes:
- Identify a topic in advanced areas of Engineering Design, materials
- Review literature to identify gaps and define objectives & scope of the work
- Employ the ideas from literature and develop research methodology
- Develop a model, experimental set-up and / or computational techniques necessary to meet the objectives.

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PROJECT PHASE - II

Prerequisites: None

Course Outcomes:
- Identify methods and materials to carry out experiments/develop code
- Reorganize the procedures with a concern for society, environment and ethics
- Analyze and discuss the results to draw valid conclusions
- Prepare a report as per the recommended format and defend the work.
- Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.