MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT /CENTER: Department of Mechanical Engineering

Scheme for Master of Technology in Design Engineering

Semester. I

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MET503	Theory of Elasticity and Plasticity	Theory	Program Core	3	3	0	0
2	21MET501	Advanced Dynamics and Vibrations	Theory	Program Core	3	3	0	0
3	21MET502	Advanced Engineering Mathematics	Theory	Program Core	3	3	0	0
4	21MEP504	Vibration and Analysis Lab	Laboratory	Program Core	1	0	0	2
5		Program Elective- I	Theory	Program Elective	3	3	0	0
6		Program Elective- II	Theory	Program Elective	3	3	0	0
Total Semester Credits					16			

Semester. II

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MET505	Advanced Finite Element Methods	Theory	Program Core	3	3	0	0
2	21MET507	Modeling and Simulation of Dynamics Systems	Theory	Program Core	3	3	0	0
3	21MEP506	CAD/CAE Lab	Laboratory	Program Core	1	0	0	2
4	21MEP508	Modelling and Simulation of Dynamic Systems Lab	Laboratory	Program Core	1	0	0	2
5		Program Elective- III	Theory	Program Elective	3	3	0	0
6		Program Elective- IV	Theory	Program Elective	3	3	0	0
7		Program Elective- V	Theory	Program Elective	3	3	0	0
Total Semester Credits					17			

Semester. III

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MES602	Seminar	Seminar	Seminar	4	0	0	4
2	21MED601	Dissertation	Research	Dissertation	8	0	0	8

Total Semester Credits	12			

Semester. IV

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MED603	Dissertation	Research	Dissertation	12	0	0	12
Total Semester Credits					12			

Code	Code	Course Name	Credit (L-T-P)
List of Program Electives			
1.	21MET803	Design against Fracture and Fatigue	3 (3-0-0)
2.	21MET810	Robotics and Control	3 (3-0-0)
3.	21MET811	Rotor Dynamics	3 (3-0-0)
4.	21MET805	Dynamics of Multibody Systems and Applications	3 (3-0-0)
5.	21MET804	Design of Mechanisms	3 (3-0-0)
6.	21MET809	Mechanics of Composite Materials	3 (3-0-0)
7.	21MET806	Experimental Stress Analysis	3 (3-0-0)
8.	21MET808	Mechanical Behavior of Materials	3 (3-0-0)
9.	21MET807	Machinery Fault Diagnostics and Signal Processing	3 (3-0-0)
10.	21MET802	Data Acquisition and Control Lab	1 (0-0-2)
11.	21MET801	Computer Aided Fluid Dynamics	3 (3-0-0)

Credit Distribution among different types of courses is as under

Type of courses	Credits	Range as per scheme
Program core (PC)	18	18-21
Program elective (PE)	15	15-21
Open elective (OE)	0	0-6
Research project, seminar, dissertation	24	16-24
Total	57	54-60

Program coordinator

Syllabus of All Courses of M.Tech. (Design)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF MECHANICAL ENGINEERING

Course Code : 21MET503

Course Name : Theory of Elasticity and Plasticity

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Core

Prerequisites : The students are required to have basic knowledge of Solid Mechanics and Engineering Mathematics obtained at UG level.

COURSE CONTENTS

Unit I: Introduction to the mathematical theory of elasticity: Two-dimensional idealizations, plane stress and plane strain problems, equations of equilibrium, strain-displacement relations, constitutive relations, compatibility conditions, and displacement and traction boundary conditions.

(no. of lectures- 5)

Unit-II: Two-dimensional problems in rectangular coordinates: Airy Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever.

(no. of lectures- 7)

Unit-III: Two-dimensional problems in polar coordinates: General equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole, concentrated force on a straight boundary.

(no. of lectures- 7)

Unit-IV: Stress and strain problems in three dimensions: Principal stresses, principal strains, three-dimensional problems. Energy Theorems and Variational Principles of Elasticity, uniqueness of elasticity solution. - Torsion of straight bars, membrane analogy, narrow rectangular cross-section, torsion of rectangular bars, rolled profile sections, hollow shafts and thin tubes.

(no. of lectures- 7)

Unit-V: Introduction to plasticity: One-dimensional elastic-plastic relations, problems contained plastic deformation, True stress-strain curve, strain rate effects, idealization, plastic stress-strain relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elasto-plasticity.

(no. of lectures- 10)

RECOMMENDED READINGS

Text Books:

1. Timoshenko S. P. & Goodier J. N., *Theory of Elasticity*, 3rd Edition, Mc-Graw Hill, 1982.
2. J. Chakrabarty, *Theory of Plasticity*, Mc-Graw Hill Book Company, Singapore, 1987.

Reference Books:

1. M. Filonenko-Borodich, *Theory of Elasticity*, Foreign Language Publishing House, Moscow.
2. Advanced Mechanics of Solids, Srinath, L.S,, Second Edition, Tata McGraw Hill, India, 2003.
3. Arthur P. Boresi, Ken P. Chong and James D. Lee, Elasticity in Engineering Mechanics, Third Edition, John Wiley & Sons, 2011.
4. Alexander Mendelson Plasticity-Theory & application, The Macmillan Company, New York, 1968.

Online/E-Resources:-

1. An online course on Theory of Elasticity at NPTEL: https://nptel.ac.in/courses/105/105/105105177/

2. Unit 5 and 6 of the online course on Theory of Production Processes at NPTEL: https://nptel.ac.in/courses/112/107/112107239/

Course Code : 21MET501

Course Name : Advanced Dynamics and Vibrations

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Core

Prerequisites : Engineering Mechanics, Engineering Mathematics, Solid Mechanics, Theory of Machines

COURSE CONTENTS

(i) Newton-Euler mechanics Mathematical preliminaries: Coordinate systems, Vectors, Tensors, Outer product; Coordinate transformation. Rotating frames; Rotation tensor; Euler angles; Angular velocity. (5 Lectures)

(ii) Rigid-body kinematics; Five-term acceleration formula; Examples. Rigid-body kinetics: Linear Momentum; Angular momentum; Inertia tensor; Kinetic energy. Rigid-body kinetics: Balance laws; Governing equations; Euler‟s equations. Examples: Rigid body in free space; Gyroscopes.

(7 Lectures)

(iii) Analytical mechanics Generalized coordinates; Constraints; Degrees of freedom. Principal of virtual work in statics: Virtual displacements; Virtual work; Constraint forces; Workless constraints; Principal of virtual work; Lagrange multipliers; (7 Lectures)

(iv) Equilibria and stability of conservative systems; Examples. Dynamics: d‟Alembert‟s principal; Lagrange‟s equations of motion for holonomic and nonholonomic systems; Examples: Rigid bodies; Čaplygin‟s sleigh. Conservative systems. Legendre transformation; Hamiltonian mechanics; Energy theorem; Examples (7 Lectures)

(v) Vibrations Single degree of freedom system: free, damped, forced. Convolution integral.

(6 Lectures)

(vi) Two-degree of freedom systems: Normal modes; Extension to multi-degree of freedom systems. (7 Lectures)

RECOMMENDED READINGS

Text Books-:

1. Principles of Engineering Mechanics: Part I, II; Beatty, M. F., 1986, Springer.
2. Elements of Vibration Analysis 2nd edition, Meirovitch, L., McGraw Hill Education (India), 1986.
3. Theory and Practice of Mechanical Vibrations, J.S. Rao and K. Gupta, Wiley Easterm, 1985
4. Methods of Analytical Mechanics, Meirovitch, L. Dover publications. 2010
5. The Variational Principles of Mechanics 4th edition; Lanczos, C.; Dover publications, 1986.

Reference books:-

1. Principles of Dynamics 2nd edition; Greenwood, D. T.; Pearson Education, 1987.
2. Mechanical Vibrations. Hartog, D. Dover publishers. 1985.
3. Variational Principles in Classical Mechanics, Papaerback; Douglas Cline, River Campus Libraries, 2017

Online/E resources:-

1. https://freevideolectures.com/course/2264/engineering-mechanics
2. https://nptel.ac.in/courses/112/108/112108201/
3. https://ocw.mit.edu/courses/mechanical-engineering/2-003sc-engineering-dynamics-fall-2011/mechanical-vibration/

Course Code : 21MET502

Course Name : Advanced Engineering Mathematics

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Core

Prerequisites : Basic Engineering Mathematics

COURSE CONTENTS

Unit I- Linear Algebra: Vector space and its basis; Matrices as coordinate-dependent linear transformation; null and range spaces; Solution of linear algebraic equations: Gauss elimination and Gauss-Jordon methods, LU Decomposition and Cholesky method, Gauss-Seidel/ Jacobi iterative methods; Condition number; Minimum norm and least square error solutions.

(no. of lectures- 08)

Unit II- Eigenvalues and eigenvectors of matrices and their properties; Similarity transformation; Jordon canonical form and orthogonal diagonalization; Mises power method for finding eigenvalues/eigenvectors of symmetric matrices.

(no. of lectures- 06)

Unit III- Tensor Algebra and Index Notation. Vector and Tensor Calculus: Curves and surfaces; Gradient, divergence and curl, Line, surface and volume integrals; Gauss (divergence), Stokes and Green's theorems. -

(no. of lectures- 06)

Unit IV- Topics in Numerical Methods: Solution of a non-linear algebraic equation and system of equations; Interpolation methods, Regression; Numerical Integration. -

(no. of lectures- 06)

Unit V- Ordinary Differential Equations (ODEs): Techniques of the separation of variable and the integrating factor for 1st order ODEs; Solutions of linear, 2nd order ODEs with constant coefficients and Euler-Cauchy ODEs; System of 1st order ODEs; Numerical methods for solving ODEs, Homogeneous, linear, 2nd order ODEs with variable coefficients: power series and Frobenius methods; Sturm-Louville problem; Laplace transform method for non-homogeneous, linear, 2nd order ODEs: discontinuous right-hand sides

(no. of lectures- 10)

RECOMMENDED READINGS

Text Books:-

1. Advanced Engineering Mathematics, E. Kreyszig, John Wiley and Sons

Reference books:-

1. Applied Mathematical Methods by B. Dasgupta, Pearson Education,
2. Numerical Methods for Engineering, Steven C. Chapra, Mc-Graw Hill Education.
3. Numerical Methods for Engineers and Scientists, Joe D Hoffman, Second Edition, Marcel Dekker.

Online/E resources:-

1. NPTEL: https://nptel.ac.in/courses/111/105/111105035/#:~:text=%20%20%20%20Sl.No%20%20%20,and%20M%20...%20%206%20more%20rows%20
2. Online videos at NPTEL: https://nptel.ac.in/courses/111/105/111105121/

Course Code : 21MEP504

Course Name : Vibration and Analysis Lab

Credits : 1 L - 0 T - 0 P - 2

Course Type : Program Core

Prerequisites : Engineering Mechanics; Mechanical Vibration, Hyperworks

COURSE CONTENTS

1. To study un-damped free vibrations of a simple pendulum by determining the natural frequency and time period of oscillation.
2. To study un-damped free vibrations of a spring mass system and determining the natural frequency of system and the stiffness of spring.
3. To study damped free vibrations of a spring mass system and determining the damping ratio.
4. To study un-damped forced vibrations of a spring mass system and determining the unbalance in system.
5. To study damped forced vibrations of a spring mass system and determining the damping ratio.
6. Modeling and simulation of lateral Vibrations of a flat beam supported on rigid ends
7. Whirling of shaft
8. Exercise on Modal Analysis
9. Exercise on Machine Fault simulator
10. Exercise on Vibration control
11. Exercise on condition monitoring

RECOMMENDED READINGS

Text Books:- (Title, Authors, Publisher & Year)

1.Mechanical Vibrations, S. S. Rao, Pearson, 2018

Reference books:

1.Virtual Experiments in Mechanical Vibrations: Structural Dynamics and Signal Processing. Michael J Brennan; Wiley-Blackwell; 2020

Online/E resources:-

1. https://mv-iitg.vlabs.ac.in/
2. https://www.researchgate.net/figure/Virtual-and-real-time-remote-vibration-laboratories_fig2_255653682

Course Code : 21MET505

Course Name : Advanced Finite Element Methods

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Core

Prerequisites : Solid Mechanics, Engineering Mathematics

COURSE CONTENTS

Unit I- Introduction, history and basic concepts of FEM, Integral Formulations and Variational Methods: Weighted integral forms. Boundary, initial and eigen value problems, integral relations Functional forms, Weak Formulation of Boundary value problems, Linear and Bilinear Forms, Variational Methods of Approximations.

(no. of lectures- 10)

Unit II- Mathematical and Numerical modelling in FEM through 1-D problems: Modeling of 1-D problems, discretization, Derivation of element equations, connectivity of elements, Imposition of boundary conditions, solution of equations, Applications-Heat Transfer, Applications-Fluid Mechanics, and Applications-Solid Mechanics.

FEM modeling of bending of Beams: Introduction, Euler-Bernoulli beam element, governing equations, Discretization, derivation of element equations, assembly,Solution, plane frame Elements, Governing equations, finite element solution, Numerical examples

(no. of lectures 10)

Unit III- Eigen Value and Time dependent problems: Eigen value problems, formulation, FEM models, Time dependent problems, Semidiscrete FEM models, Time approximation schemes, Applications, Natural coordinates, isoparametric formulations, Numerical integration, Computer Implementation.

Single Variable problems: Introduction, weak formulation, Interpolation functions, assembly, Axisymmetric problems, Discretization, formulation, Impositions of essential BCs, Applications: Heat transfer, Applications: Fluid mechanics, Applications: Solid mechanics

(no. of lectures 8)

Unit IV- Plane Elasticity: Plane elasticity, governing equations, weak formulation, FEM analysis, Examples, Finite element models, Weak formulation.

(no. of lectures 6)

Unit V Non-linear FEM: Non-linear problems in elasticity- some solution methods- plasticity: introduction, general formulation for small strains- formulation for von Mises theory- computational procedure- problems of gaps and contact- geometric non-linearity- modelling considerations

(no. of lectures- 6)

RECOMMENDED READINGS

Text Book

Introduction to Finite Element Method , J. N. Reddy, McGraw Hill India, Fourth Editions, 2020

Reference Books:

1. The Finite Element Method: Its Basis & Fundamentals, Zienkiewicz.O.C, Taylor.R.L,&Zhu,J.Z, , India published by Elsevier India Pvt. Ltd., New Delhi., Seventh Edition 2013
2. Textbook of Finite element Analysis, P. Seshu , PHI, Eighteenth Printing, 2019
2. Concepts and Applications of Finite Element Analysis, Cook, R.D., Malkus, D. S., Plesha,M.E., and Witt,R.J , Wiley Student Edition, , Authorized reprint by Wiley India(P) Ltd., New Delhi, Fourth Edition, First Reprint 2007
4. Introduction to Non-Linear Finite Element Analysis, Reddy, J.N. , Oxford Uniiversity Press, 2014
5. The Finite Element Method in Engineering, Rao,S.S., Butterworth- Heinemann(An imprint of Elsevier), , Published by Elsevier India Pvt. Ltd., New Delhi, Indian Reprint, Fifth Edition,2008

Online/E resources:-

1. Online videos at NPTEL: https://nptel.ac.in/courses/112/104/112104193/
2. 1.Online videos at NPTEL: https://nptel.ac.in/courses/112/106/112106130/

Course Code : 21MET507

Course Name : Modeling and Simulation of Dynamics Systems

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Core

Prerequisites : Engineering Mathematics

COURSE CONTENTS

Unit I- Basic System Models- Mechanical Systems- Introduction to Measuring Systems, Sensors and Transducers, Modelling and Simulation, Basic System Models Lumped-parameter inertia properties of basic compliant (flexible) members, Mechanical, Lumped-parameter inertia properties of basic compliant (flexible) members, Lumped-parameter dynamic modeling of simple compliant mechanical microsystems, Mass detection in MEMS by the resonance shift method **(6 Lectures)**

Unit II- Electrical Systems- Capacitive sensing and actuation in MEMS. **(5 Lectures)**

Unit III- Fluid and Thermal Systems- Comprehensive coverage of liquid, pneumatic, and thermal systems, Natural response of fluid systems. **(5 Lectures)**

Unit IV- Laplace Transform-Linear ordinary differential equations with time-varying coefficients, Laplace transformation of vector-matrix differential equations. Use of the convolution theorem to solve integral and integral-differential equations, Time-domain system identification **(6 Lectures)**

Unit V- Transfer Function Approach- Extension of the single-input, single-output (SISO) transfer function, approach to multiple-input, multiple-output (MIMO) systems by means of the transfer function matrix. Application of the transfer function approach. **(4 Lectures)**

Unit VI - State Space Approach- Treatment of the descriptor state equation. Application of the state space approach to solve the forced and free responses with nonzero initial conditions. **(5 Lectures)**

Unit VII- Coupled-Field Systems- Formulation of the coupled-field problem, Principles and applications of sensing and actuation, Strain gauge and Wheatstone bridge for measuring mechanical deformation. **(6 Lectures)**

Unit VIII - OPTIMIZATION-Parameter Estimation, System Identification and Optimization, search Based Techniques and Modern Methods of Optimization, Optimizations of Engineering Systems. **(5 Lectures)**

RECOMMENDED READINGS

Text Books:-

1. Nicolae Lobontiu, System Dynamics for Engineering Students: Concepts and Applications
2. Edward Layer and Krzysztof Tomczyk, Measurements, Modelling and Simulation of Dynamic SystemsGilat, Amos:

Reference books:-

1. MATLAB: An Introduction with Applications, 2nd edition, John Wiley & Sons. ISBN 0-471-69420-7.
2. Hildebrand, F. B.: Introduction to Numerical Analysis, 2nd edition, McGraw-Hill. ISBN 0-070-28761-9.
3. Leader, Jeffery J. (2004). Numerical Analysis and Scientific Computation. Addison Wesley. ISBN 0-201-73499-0
4. Arora, Jasbir Singh: Introduction to Optimum Design
5. Rao, S.S. Engineering Optimization

Online/E resources:-

1. MIT OCW – Modelling & Simulation of Dynamic Systems https://ocw.mit.edu/courses/mechanical-engineering/2-141-modeling-and-simulation-of-dynamic-systems-fall-2006/index.htm.
2. NPTEL Course on Modelling and Simulation of Dynamic Systems by Prof. P.M. Pathak https://nptel.ac.in/courses/112/107/112107214/

Course Code : 21MEP506

Course Name : CAD/CAE Lab

Credits : 1 L - 0 T - 0 P - 2

Course Type : Program Core

Prerequisites : Engineering Drawing, Finite Element Method

COURSE CONTENTS

Experiments based on

CAD: Exercises in Modeling and drafting of Mechanical Components - Assembly using Parametric and Feature based Packages like Autodesk Inventor

1. CAD Introduction. **(no. of lab hours- 2)**
2. Sketcher **(no. of lab hours- 2)**
3. Solid modeling –Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc. **(no. of lab hours- 2)**
4. Surface modeling –Extrude, Sweep, Trim ..etc and Mesh of curves, Free form etc. **(no. of lab hours- 2)**
5. Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc. **(no. of lab hours- 2)**
6. Assembly-Constraints, Exploded Views, Interference check. **(no. of lab hours- 2)**
7. Drafting-Layouts, Standard & Sectional Views, Detailing & Plotting. **(no. of lab hours- 2)**

CAE: Analysis of Mechanical Components – Use of Software like Hyperworks etc., Exercises shall include analysis of

1. Analysis of machine elements under Static loads **(no. of lab hours- 2)**
2. Thermal Analysis of mechanical systems **(no. of lab hours- 2)**
3. Modal Analysis **(no. of lab hours- 2)**
4. Machine elements under Dynamic loads **(no. of lab hours- 2)**
5. Machine elements under Fatigue **(no. of lab hours- 2)**
6. Non-linear Analysis **(no. of lab hours- 2)**

RECOMMENDED READINGS

List of facilities required

1. Tools like Autodesk Inventor® / Solid Works® / HyperWorks® etc.
2. Computer Workstations installed with software packages

Online E Resource:
https://www.autodesk.com/education/home
https://www.altair.com/resourcelibrary/

Course Code	**:**	**21MEP508**
Course Name	**:**	**Modelling and Simulation of Dynamic Systems Lab**

Credits	**:**	1	**L -** 0	**T -** 0	**P -** 2
Course Type	**:**	Program Core			
Prerequisites	**:**	Nil			

COURSE CONTENTS

PART I : Measurement Systems (8 Lab hours)

1. Introduction to Lab View
2. Building Virtual Instrumentation in Labview
3. Data Acquisition using Accelerometer
4. Signal Processing

PARTII: Simulation of Mechanical Systems (8 Lab hours)

5. Simulation Using Simulink- Introduction
6. Simulation of Spring – Mass System in MATLAB Simulink. (Writing Matlab Functions: Damped spring system)
7. Simulation of Simple and Compound Pendulum
8. Simulation of Planar Mechanism

PARTIII: Optimization (8 Lab hours)

9. Using GA Toolbox in MATLAB
10. Optimization with Modelling of Engineering Problems and Solution using Fminunc, Fmincon,

List of facilities required

1. Tools like MATLAB / LABVIEW / etc.
2. Computer Workstations installed with software packages

Course Code	**:**	**21MET803**
Course Name	**:**	**Design against Fracture and Fatigue**

Credits	**:**	3 **L -** 3 **T -** 0 **P -** 0
Course Type	**:**	Program Elective
Prerequisites	**:**	Basic knowledge of Solid Mechanics and Engineering Mathematics

COURSE CONTENTS

Unit-I: Fatigue of Structures: S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves – Fatigue of composite materials.

(no. of lectures- 7)

Unit-II: Statistical 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.

(no. of lectures- 7)

Unit-III: Physical Aspects of Fatigue: Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.

(no. of lectures- 6)

Unit-IV: Fracture Mechanics: 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, Linear Elastic fracture Mechanics (LEFM), Elasto-plastic Fracture Mechanics (EPFM).

(no. of lectures- 8)

Unit-V: Fatigue Design and Testing: Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in engineering structures - Application to composite materials and structures.

(no. of lectures- 8)

RECOMMENDED READINGS

TEXT BOOKS:

1. Fatigue of Materials 2nd Ed., S. Suresh. Cambridge University Press, 1998/2012
2. Prasanth Kumar, "Elements of fracture mechanics", Wheeter publication, 1999.

REFERENCE BOOKS:

1. T .L . Anderson, FractureMechanics - Fundamental s and Applications, 3rd Edition, Taylor and Francis Group, 2005.
2. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic, Publishers, Dordrecht , 1986.

ONLINE/E-RESOURCES:-

1. Online video lectures on Engineering Fracture Mechanics at NPTEL: https://nptel.ac.in/courses/112/106/112106065/
2. Online Course material on Fracture and Fatigue is available at MIT Open Course Ware: https://ocw.mit.edu/courses/materials-science-and-engineering/3-35-fracture-and-fatigue-fall-2003/

Course Code : 21MET810

Course Name : Robotics and Control

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Elective

Prerequisites : Engineering Mechanics, Theory of Machines & Mechanisms

COURSE CONTENTS

Unit 1: Introduction, Review of Rigid Body Motion, Elements of robots – links, joints, actuators, and sensors **(5 Lectures)**

Unit II: Review of Manipulator Kinematics, Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms, different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor. **(8 Lectures)**

Unit III: Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, workspace of a serial robot, Inverse kinematics of constrained and redundant robots, Velocity and static analysis of serial and parallel manipulators. **(9 Lectures)**

Unit IV: Dynamics of serial and parallel manipulators, formulation of equations of motion.

(7 Lectures)

Unit V: Linear and nonlinear control systems with applications in industrial manipulators, Introduction to Linear Control, State Space Modeling and Multivariable Systems, Nonlinear Control, Stability, Trajectory Generation. **(9 Lectures)**

RECOMMENDED READINGS

Text Books:-

1. Saha, S.k "Introduction to Robotics,2nd Edition, McGraw-Hill Higher Education, New-Delhi, 2014.

Reference books:-

1. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008

2. Murray, R.M., Li, Z., and Sastry,S.S., A Mathematical Introduction to Robotic Manipulator, CRC Press, 1994.

3. Craig, J. J., Introduction to Robotics: Mechanics and Control, 2nd edition

4. Groover, M. P., et al., "Industrial Robotics", MGHISE, 1986.

5. Fu, K. S., et al., Robotic: Control, Sensing, Vision & Intelligence, MGHISE, 1987.

6. Robert J., Schilling, Fundamentals of Robotics: Analysis and Control, Prentice Hall, NJ, 2002.

Online/E resources:-

1. NPTEL Course on Robotics by Prof. Dilip Kumar Pratihar, IIT Kharagpur. https://nptel.ac.in/courses/112/105/112105249/# and https://onlinecourses.nptel.ac.in/noc19_me74/preview
2. NPTEL Course on Introduction to Robotics by Prof. Amarnath, IIT Bombay https://nptel.ac.in/courses/112/101/112101099/

Course Code	**:**	**21MET811**
Course Name	**:**	**Rotor Dynamics**
Credits	**:**	3 **L -** 3 **T -** 0 **P -** 0
Course Type	**:**	Program Elective
Prerequisites	**:**	Engineering Mechanics; Kinematics and Dynamics of Machines, Advanced Dynamics and Vibration

COURSE CONTENTS

1. Lateral Rotor Vibration Analysis: Simple linear 2 DOF model with only deflection motion, Inclination Vibration of an Elastic Shaft with A Disc at Its Center: Free Vibrations and Forced Vibrations,

2. Vibrations of a 4 DOF Jefcott Rotor (Deflection motion and Inclination Motions coupled together), Vibrations of a Rigid Rotor, Balancing of a Rigid Rotor, Approximate Formulas for Critical speeds of a Shaft with Several Discs: Rayleigh‟s Method, Dunkerley‟s Formula

3. Vibrations of a Continuous Rotor: Transfer Matrix Analysis, Finite Element Method, Free Vibrations and Critical Speeds, Forced Vibrations, Balancing of a Flexible Rotor: Model Balancing Method, Influence Coefficient Method. Torsional Vibrations in Rotating Machinery: Transfer Matrix Analysis for Free Vibrations, Transient Response in Torsional Vibrations, Branched Systems.

4. Rotors Mounted on Fluid Film Bearings: Mechanism of pressure development in the film, Reynold‟s equation, Journal Bearing, Steady state solution for a short bearing, A simple rotor in fluid film bearing, Transfer matrix analysis of rotors in fluid film bearings, Transfer matrix analysis of rotors by distributed elements, Optimum design of bearings for minimum unbalance response.

5. Shafts with Dissimilar Moments of Inertia: Whirling of shaft with dissimilar stiffness, Effect of disk unbalance, Effecty of gravity on a balanced disk, transient response by a time marching scheme.

6. Condition Monitoring Using Vibration Measurements: Vibration generating mechanisms, Condition monitoring, Noise Specturm, Real time analysis, Applications of FFT Rotor Vibrations.

RECOMMENDED READINGS

Text Books:- (Title, Authors, Publisher & Year)

1."Rotor Dynamics, J. S. Rao, New Age International Publishers.

2.Linear and Nonlinear Rotor Dynamics, Toshio Yamanoto, Yukio Ishida John Wiley and Sons, Inc.

Reference books:-

1. Handbook of Rotordynamics; Fredric F Ehrich, Wiley,1998

2. Machinery Vibration and Rotordynamics, John M. Vance, Fouad Y. Zeidan, Brian G. Murphy, Wiley, 17 June, 2010

Online/E resources:-

1. https://nptel.ac.in/courses/112/103/112103024/

2. https://www.cadfem.net/in/en/shop/professional-development/training-elearning/rotor-dynamics-dynamic-simulation-of-rotating-structures-13634.html

3. https://www.vi-institute.org/the-eshleman-foundation/practical-rotor-dynamics-modeling/

Course Code	**:**	**21MET805**
Course Name	**:**	**Dynamics of Multibody Systems and Applications**
Credits	**:**	3 **L -** 3 **T -** 0 **P -** 0
Course Type	**:**	Program Elective
Prerequisites	**:**	Engineering Mechanics; Kinematics and Dynamics of Machines

COURSE CONTENTS

Unit I- Introduction The method of constraints for planar kinematic analysis. Revolute, prismatic, gear and cam pairs are considered together with other 2 degrees-of-freedom types of constraints.

(no. of lectures- 5)

Unit II- Basic principles for analysis of multi-body systems The automatic assembly of the systems of equations for position, velocity and acceleration analysis. Iterative solution of systems of nonlinear equations. Geometry of masses. The principle of virtual work and Lagrange's equations

(no. of lectures- 7)

Unit II- Dynamics of Planar Systems Dynamics of planar systems. Systematic computation and assembly of mass matrix. Computation of planar generalized forces for external forces and for actuator-spring-damper element. Simple applications of inverse and forward dynamic analysis. Numerical integration of first-order initialvalue problems. The method of Baumgarte for the solution of mixed differential-algebraic equations of motion. The use of coordinates partitioning, QR and SVD decomposition for the orthogonalization of constraints.

(no. of lectures- 7)

Unit III Dynamics of Planar Systems Dynamics of planar systems. Systematic computation and assembly of mass matrix. Computation of planar generalized forces for external forces and for actuator-spring-damper element. Simple applications of inverse and forward dynamic analysis. Numerical integration of first-order initialvalue problems. The method of Baumgarte for the solution of mixed differential-algebraic equations of motion. The use of coordinates partitioning, QR and SVD decomposition for the orthogonalization of constraints.

(no. of lectures- 7)

Unit IV Kinematics of rigid bodies in space Reference frames for the location of a body in space. Euler angles and Euler parameters. The formula of Rodrigues. Screw motion in

space. Velocity, acceleration and angular velocity. Relationship between the angular velocity vector and the time derivatives of Euler parameters.

(no. of lectures- 7)

Unit V Kinematic analysis of spatial systems Basic kinematic constraints. Joint definition frames. The constraints required for the description in space of common kinematic pairs (revolute, prismatic, cylindrical, spherical). Equations of motion of constrained spatial systems.

(no. of lectures- 7)

Unit VI Computation of Forces Computation of spatial generalized forces for external forces and for actuator-spring-damper element. Computation of reaction forces from Lagrange's multi- pliers.

(no. of lectures- 7)

RECOMMENDED READINGS

Text Books:- (Title, Authors, Publisher & Year)

1. Wittenburg, J., Dynamics of Systems of Rigid Bodies, B.G. Teubner, Stuttgart, 1977.
2. Kane, T.R, Levinson, D.A., Dynamics: Theory and Applications, McGraw-Hill Book Co., 1985.
3. Nikravesh, P.E., Computer Aided Analysis of Mechanical Systems, Prentice-Hall Inc., Englewood Cliffs, NJ, 1988.
4. Roberson, R.E., Schwertassek, R., Dynamics of Multibody Systems, Springer-Verlag, Berlin, 1988.
5. Haug, E.J., Computer-Aided Kinematics and Dynamics of Mechanical Systems-Basic Methods, Allyn and Bacon, 1989.
6. Huston, R.L., Multibody Dynamics, Butterworth-Heinemann, 1990.
7. Schielen, W. ed., Multibody Systems Handbook, Springer-Verlag, Berlin, 1990.
8. de Jalo n, J.C., Bayo, E., Kinematic and Dynamic Simulation of Multibody Systems, Springer- Verlag, 1994.
9. Shabana, A.A., Computational Dynamics, John Wiley and Sons, 1994.

Reference books:-

1. "Why Do Multi-Body System Simulation?" by Rajiv Rampalli, Gabriele Ferrarotti and Michael Hoffmann, Published NAFEMS Publications, January 12
2. "Principles of Dynamics" by Donald T. Greenwood, 2nd ed., Prentice Hall
3. Dynamics and Balancing of Multibody Systems, H. Chaudhary, S. K. Saha, Springer, 2008

Online/E resources:- Nil

Course Code	**:**	**21MET804**
Course Name	**:**	**Design of Mechanisms**

Credits	**:**	3 **L -** 3 **T -** 0 **P -** 0
Course Type	**:**	Program Elective
Prerequisites	**:**	Kinematics and Dynamics of Machines

COURSE CONTENTS

Unit I- Fundamentals of Mechanisms: Basic Kinematic concepts and definitions, Mechanism, Link, Kinematic Pair, Classification of kinematic pairs, Degrees of freedom, Kinematic chain, Binary Ternary and Quaternary joints and links, Degrees of freedom for plane mechanism, Gruebler's criterion, Inversion of mechanism, Four bar chains and their inversions, Single slider crank chain, Double slider crank chain and their inversion, Number Synthesis, Paradoxes. Study of existing mechanisms used in industry, machine tools, vehicles, high speed machinery.

(no. of lectures- 4)

Unit II- Graphical Linkage Synthesis: Introduction to Synthesis: Function, Path, and Motion Generation, Dimensional synthesis- Two, three position synthesis, Quick return mechanisms, Coupler Curves, Cognates, Straight line mechanisms, Dwell mechanisms.

(no. of lectures- 8)

Unit III- Kinematic Analysis: Algebraic Position (Vector Loop) analysis of linkages, pin jointed four bar mechanism, Crank slider mechanism, transmission angle and toggle positions, Circuits and Branches; Analytical velocity and acceleration analysis.

(no. of lectures- 8)

Unit IV- Analytical Linkage Synthesis: Two-, three-, four- and five- positions analytical synthesis for four-bar mechanism, Comparison of analytical and graphical synthesis, Center-point and Circle Point Circles, Synthesis of Multiloop Linkages, Optimization methods.

(no. of lectures- 8)

Unit V- Dynamic Force Analysis and Balancing: Single Link in Pure Rotation, Force Analysis of a Four-bar Linkage and Four-bar slider-crank mechanism, Shaking Forces and Shaking Torque, Force and moment balancing of linkages, Optimization of shaking force and shaking moment.

(no. of lectures- 8)

Unit VI- Cam Design: Cam Terminology, SVAJ Diagrams, Polynomials for cams, Cam sizing. Use of MTALAB for assignment and programs in each module.

(no. of lectures- 4)

RECOMMENDED READINGS

Text Books:-

1. Kinematics and Dynamics of Machinery, R.L. Norton, McGraw Hill , 2017

2. Mechanism Design: Analysis and Synthesis, Vol. I & II, A.G. Erdman and G.N. Sandor, Prentice-Hall, 1984

Reference books:-

1. Kinematic Synthesis of Linkages, R. S.Hartenberg, and J Denavit,., McGraw-Hill, 1965
2. Mechanism Design Visual and Programmable Approaches, Kevin Russell, Qiong Shen, Raj S. Sodhi , CRC Press,2013

Online/E resources:-

1. NPTEL: Theory of Mechanisms by Prof. Sujatha Srinivasan, IIT Madras
2. NPTEL: Kinematics of Mechanisms and Machines by, Prof. A. Dasgupta, IIT Kharagpur

Course Code : 21MET809

Course Name : Mechanics of Composite Materials

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Elective

Prerequisites : Basic knowledge of Solid Mechanics and Engineering Mathematics

COURSE CONTENTS

Unit-I Introduction: Introduction to Composite Materials Constituents, Material forms Processing, Applications Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.

(no. of lectures- 5)

Unit-II Micromechanics and Macromechanics of a Lamina: Lamina Constitutive Equations:Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.

(no. of lectures- 6)

Unit III Macromechanics of a Laminate: Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

(no. of lectures- 7)

Unit-IV: Failure Analysis and Design of a Laminate: Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure

(no. of lectures- 6)

Unit-V: Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies

(no. of lectures- 6)

Unit-VI Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations. Orthotropic Lamina - special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates - Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates

(no. of lectures- 6)

RECOMMENDED READINGS

TEXT BOOKS:

1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.

REFERENCE BOOKS:

1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
2. Hyer, M.W., "Stress Analysis of Fiber-Reinforced Composite Materials", McGraw-Hill, 1998.
3. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006
4.Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006.

ONLINE/E-RESOURCES:-

1. Online video lectures on Introduction to Composites at NPTEL: https://nptel.ac.in/courses/112/104/112104229/

Course Code : 21MET806

Course Name : Experimental Stress Analysis

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Elective

Prerequisites : Solid Mechanics/Mechanics of Materials

COURSE CONTENTS

Unit I: Stress analysis: Analytical, numerical and experimental approaches, need for experimental stress analysis, advantages and disadvantages. **(no. of lectures- 04)**

Unit II: Electrical resistance strain gages: Gage sensitivity and gage factor, Wheatstone's bridges, strain gage construction, bonding of a strain gauge, surface preparation, adhesives, strain gauge installation, environmental effects, temperature compensation, strain gauge selection, strain gauge designation systems, various gauge patterns for different applications, two element, three element rectangular and delta rosettes, correction for transverse strain effects, single element strain gauge to evaluate stress intensity factor (SIF). **(no. of lectures- 09)**

Unit III: Photo-elasticity: Snell's laws, passage of light through crystalline media, quarter wave, half wave and full wave plates, Stress-optic law, reflection and transmission photoelasticity, plane polariscope, circular polariscope, isochromatics, isoclinics, dark and bright fields, fringe order determination, photoelastic materials, compensation techniques, Tardy's method of compensation, need for calibration of photoelastic materials, model to prototype relations, properties of photoelastic model materials, three dimensional photoelasticity, stress freezing, slicing, introduction to digital photoelasticity. **(no. of lectures- 09)**

Unit IV: Brittle coatings: Introduction to photoelastic coatings, optical arrangements, evaluation of coating and specimen stresses, methodology of brittle coatings, crack patterns produced by direct loading, uniaxial, biaxial and isotropic stress fields.

(no. of lectures- 08)

Unit V: Moire methods: Moiré Interferometry, moire fringes, holography, hologram interferometry, speckle method.
Digital Image Correlation (DIC): Basic principle of digital image correlation, components of experimental setup, specimen preparation, correlation function, displacement and strain measurement, three dimensional DIC. **(no. of lectures- 08)**

RECOMMENDED READINGS

Text Books:-

1. Experimental Stress Analysis, J.W. Dally and W.F. Riley, McGraw-Hill, 1991.

Reference books:-

1. Digital Photoelasticity – Advanced Techniques and Applications, K. Ramesh, Springer, 2000.
3. Experimental Solid Mechanics, W.N. Sharpe, Springer, 2008.
4. Experimental Stress Analysis, L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa,B. Pant, and K. Ramachandra, Tata Mc Graw Hill, 1984.
5. Image Correlation for Shape, Motion and Deformation Measurements, M. A. Sutton, J.J. Orteu, and H. Schreier, Springer, 2009.

Online/E resources:-

1. Online Video Lectures available at NPTEL: https://nptel.ac.in/courses/112/106/112106068/

Course Code : 21MET808

Course Name : Mechanical Behavior of Materials

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Elective

Prerequisites : Engineering Materials

COURSE CONTENTS

Unit-I Defects in Crystals: Vacancies and interstitials, edge, screw and mixed dislocations, Burgers vector, slip, cross-slip and climb, stress fields around edge and screw dislocations, strain energy of dislocations, dislocation-dislocation interaction: Peach-Koehler force on dislocation, image forces, and dislocations in different crystal structures

Twinning in Crystalline Solids: Deformation twinning, geometry of twin formation, twin shape, stress requirement for twinning, twinning in HCP, BCC, and FCC crystals
(no. of lectures- 10)

Unit II- Strain hardening: Strain hardening of metals, Strain rate and Temperature dependence, Hardening mechanisms in metals- strain hardening, solid solution is strengthening, dynamic strain ageing. **(no. of lectures 8)**

Unit III- Fracture and Toughening Mechanisms : Theoretical fracture strength of a material and Griffith's Law, modes of fracture, fracture toughness, G and R-curve, brittle and ductile fracture, toughening mechanisms in metals, ceramics, and polymers
(no. of lectures 8)

Unit-IV Fatigue and Creep: Introduction to fatigue, stress and strain-life approach, cyclic stress-strain curve, fatigue crack propagation, high temperature deformation, fatigue-creep interaction.
(no. of lectures 8)

Unit-V Mechanical behaviour of other materials: Mechanical behavior of ceramics, glasses, polymers and Composites: FRP and MMC, Material characterization using optical microscopy and SEM.
(no. of lectures- 8)

RECOMMENDED READINGS

Text Book

Mechanical Behaviour of Materials, Courtney, T. H., 2nd Edition, Waveland Pr. Inc., 2005

Reference Books:

1. Mechanical Metallurgy, Dieter, G. E., 3rd Edition, McGraw Hill Book Company, 2017.

2. Dislocations and Mechanical Behaviour of Materials, Shetty, M.N., Prentice Hall India Learning Private Limited, 2013.

Online/E resources:-

1. Online Lectures available at NPTEL: https://onlinecourses.nptel.ac.in/noc21_mm27/preview

Course Code : 21MET807

Course Name : Machinery Fault Diagnostics and Signal Processing

Credits : 3 L - 3 T - 0 P - 0

Course Type : Program Elective

Prerequisites : Mechanical Vibrations

COURSE CONTENTS

Unit I: Introduction to condition based monitoring, fault diagnosis and prognosis, machine learning in fault diagnosis.
Condition monitoring techniques: vibration and noise monitoring, wear debris and oil analysis, thermography, acoustic emission, ultrasonics, Eddy current.

(no. of lectures- 06)

Unit II: Vibration Analysis: basics of vibration, free and forced response, vibration control, random vibration, statistical parameters i.e. RMS value, peak value, crest factor, kurtosis, standard deviation of vibration signals. **(no. of lectures- 08)**

Unit III: Instrumentation: data recording, data acquisition, errors in measurements, transducers, accelerometer, sound level meter. **(no. of lectures- 06)**

Unit IV: Signal processing: sample rate and aliasing, filtering, time domain signal analysis, frequency domain signal analysis, non-stationery signal analysis, Fourier series, Fast Fourier Transform, wavelet transform, Hilbert transform, modulation and sidebands, orbit and order analysis, cepstrum analysis.

(no. of lectures- 10)

Unit V: Faults in rotating machines: unbalance, misalignment, crack, spalling, loosening, fault in electrical machines.
Failure analysis of rotating machines, bearings and gears, fans, blowers, pumps, IC Engines.

(no. of lectures- 06)

RECOMMENDED READINGS

Text Books:-

1. Machinery Condition Monitoring: Principles and Practices, Mohanty A.R., CRC Press, 2014.

Reference books:-

1. Vibration Condition Monitoring, Rao J. S., Narosa Publishing House, 2000.
3. Hand book of Condition Monitoring, Allan Davis, Chapman and Hall, 2000.
4. Instrumentation, Measurement and Analysis, Choudary K K., Tata McGraw Hill, 2012

5. Vibration Based Condition Monitoring, Randall R. B., Wiley
6. Fault Diagnosis Application, Isermann R., Springer-Verlag Berlin, 2011.
7. Handbook of Condition Monitoring, Rao. R. B.K. N., Elsevier Advanced Technology

Online/E resources:-

1. Online Videos Lectures available at NPTEL: https://nptel.ac.in/courses/112/105/112105232/

Course Code : 21MEP802

Course Name : Data Acquisition and Control Lab

Credits : 1 L - 0 T - 0 P - 2

Course Type : Program Elective

Prerequisites : No

COURSE CONTENTS

1.	DAQ hardware and software.	**(no. of lectures- 04)**
2.	Interfacing of sensors and transducers using DAQ cards	**(no. of lectures- 02)**
3.	Analog to digital conversion.	**(no. of lectures- 02)**
4.	Instrument control: digital to analog conversion.	**(no. of lectures- 04)**
5.	LabVIEW basics.	**(no. of lectures- 02)**
6.	DAQ Program in LabView	**(no. of lectures- 04)**
7.	Data Visualization	**(no. of lectures- 02)**
8.	Signal processing and analysis in MATLAB	**(no. of lectures- 04)**

RECOMMENDED READINGS

Text Books:-

1. Microprocessor PC Hardware and Interfacing, Mathivanan, N., Prentice Hall of India Private Limited (2007).

Reference books:-

1. Transducers and Instrumentation, Murthy, D.V.S., Prentice Hall of India pvt. (2006).
2. Introduction to Data Acquisition with LabVIEW, Robert H. King, McGrawHill, 2012.

Course Code	**:**	**21MET801**
Course Name	**:**	**Computer Aided Fluid Dynamics**
Credits	**:**	3 **L -** 3 **T -** 0 **P -** 0
Course Type	**:**	Program Elective
Prerequisites	**:**	Basic knowledge of Fluid Mechanics and Engineering Mathematics and basic programming skills

COURSE CONTENTS

Unit-I Introduction to CFD: Methods of prediction, potential and limitation of CFD; Review of numerical techniques: Solution of IVP and BVP, Euler method, Runge-Kutta method, accuracy and errors, solution of linear algebraic equations, convergence;

(no. of lectures- 6)

Unit-II Mathematics of physical model: conservation laws, classification of PDE's, initial and boundary conditions, coordinate systems; Discretization methods: Method of weighted residuals, finite difference method (FDM), finite volume method (FVM), implicit and explicit schemes, consistency, stability and convergence;

(no. of lectures- 6)

Unit-III Modelling of diffusion problems: Numerical solution of one dimensional steady state heat conduction, unsteady heat conduction, Crank-Nicolson scheme, ADI scheme, heat conduction in multidimensional cases;

(no. of lectures- 6)

Unit-IV Modelling of convection diffusion problems: One dimensional convection-diffusion using central difference scheme, upwind scheme, transportive property, numerical diffusion (artificial viscosity), higher order schemes;

(no. of lectures- 6)

Unit-V Modelling fluid flow: Discretization of incompressible Navier Stokes equations, vorticity and pressure based methods, staggered and collocated grid;

(no. of lectures- 6)

Unit-VI Modelling multiphase problems: Fixed grid and moving grid methods, enthalpy based method for melting and solidification, VOF method for two phase flows

(no. of lectures- 6)

RECOMMENDED READINGS

TEXT BOOKS:

1. W Malalasekera. *An introduction to computational fluid dynamics: the finite volume method*. Pearson Prentice Hall, 2007
2. Suhas Patankar. *Numerical heat transfer and fluid flow*. CRC press, 1980

REFERENCE BOOKS:

1. Bengt Andersson, Ronnie Andersson, Love H˚akansson, Mikael Mortensen, Rahman Sudiyo, and Berend Van Wachem. Computational fluid dynamics for engineers. Cambridge University Press, 2011
2. Keith W Morton and David Francis Mayers. Numerical solution of partial differential equations: an introduction. Cambridge university press, 2005
3. Dale Anderson, John C Tannehill, and Richard H Pletcher. Computational fluid mechanics and heat transfer. CRC Press, 2016

ONLINE/E-RESOURCES:-

1. Online video lectures on Computational Fluid Dynamics at NPTEL: https://nptel.ac.in/courses/112/105/112105045/

Course Code : 21MES602

Course Name : Seminar

Credits : 4 L - 0 T - 0 P - 4

Course Type : Seminar

Prerequisites : Nil

COURSE CONTENTS

1. Identify and compare technical and practical issues related to design engineering
2. Outline annotated bibliography of research demonstrating scholarly skills.
3. Search the existing literature and evaluate the literature for identification of research problem
4. Prepare a well-organized report employing elements of critical thinking and technical writing.
5. Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Course Code	**:**	**21MED601**
Course Name	**:**	**Dissertation**
Credits	**:**	8 **L -** 0 **T -** 0 **P -** 8
Course Type	**:**	Dissertation
Prerequisites	**:**	The students should have studied the basic and advanced courses of design engineering taught at UG level as well as the courses prescribed in Semester 1 and Semester 2 of M.Tech. (Design).

COURSE CONTENTS:

The student are required to:

1. Identify a research area in the field of design engineering or allied areas
2. Search relevant literature and identify research gap.
3. Formulate a research problem.

Course Code	**:**	**21MED603**
Course Name	**:**	**Dissertation**
Credits	**:**	12 **L -** 0 **T -** 0 **P -** 12
Course Type	**:**	Dissertation
Prerequisites	**:**	The student must have identified the research gaps, and defined a research problem in the field of design engineering or allied areas after a detailed literature survey in the course MED742 Dissertation prescribed in 3rd Semester of M.Tech. (Design).

COURSE CONTENTS:

The students are required to:

1. Identify a problem in area of design engineering or allied areas.
2. Review literature to identify research gaps and research methodology
3. Develop a model, experimental set-up and/or computational tools and techniques necessary to investigate the research problem and obtain results.
4. Prepare a report as per the recommended format and defend the work.
5. Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.