SYLLABUS OF
UNDERGRADUATE DEGREE COURSE

Mechanical Engineering

Effective for the students admitted in year 2021-22 and onwards.

Office: Bikaner Technical University, Bikaner
Karni Industrial Area, Pugal Road, Bikaner-334004
Website:https://btu.ac.in

B.Tech. : Mechanical Engineering
4th Year - VII Semester

SN	Category	Course Code	Course Title	Hours L	Hours T	Hours P	Marks IA	Marks ETE	Marks Total	Credit
THEORY										
1	DC	7ME4-01	Finite Element Methods	2	0	0	30	70	**100**	**2**
2	DE		**DE-IV(Any one)**	2	0	0	30	70	**100**	**2**
		7ME5-11	System Monitoring and Fault Diagnosis							
		7ME5-12	Plasticity and Metal Forming							
		7ME5-13	Fundamentals of Machine Learning							
		7ME5-14	Gas Dynamics and Jet propulsion							
		7ME5-15	Machine Tool Design							
		7ME5-16	Computer Oriented Numerical Methods							
		7ME5-17	Computational Fluid Dynamics							
3	UE		**University Elective I**	3	0	0	30	70	**100**	**3**
			SUB TOTAL	**7**	**0**	**0**	**90**	**210**	**300**	**7**
PRACTICAL & SESSIONAL										
4	DC	7ME4-20	Python Lab	0	0	2	60	40	**100**	**1**
5	DC	7ME4-21	Modeling and Simulation Lab	0	0	2	60	40	**100**	**1**
6	UI	7ME7-30	Industrial Training	0	0	2*	60	40	**100**	**3**
7	UI	7ME7-50	Project Stage-I	0	0	4*	60	40	**100**	**2**
8	CCA	7ME8-00	SODECA/NCC/NSS/ ANANDAM/IPR	-	-	-	-	100	**100**	**1**
				0	**0**	**10**	**240**	**260**	**500**	**8**
			TOTAL OF VII SEMESTER	**7**	**0**	**10**	**330**	**470**	**800**	**15**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA**=Internal Assessment, **ETE**=End Term Exam, **Cr**=Credits

*****for calculation of contact hours

B.Tech. : Mechanical Engineering
4th Year - VIII Semester

SN	Category	Course Code	Course Title	Hours L	Hours T	Hours P	Marks IA	Marks ETE	Marks Total	Credit
THEORY										
1	UE		**University Elective II**	3	0	0	30	70	**100**	**3**
			SUB TOTAL	**3**	**0**	**0**	**30**	**70**	**100**	**3**
PRACTICAL & SESSIONAL										
2	UI	8ME7-50	Project stage- II	0	0	4*	60	40	**100**	**4**
3	UI	8ME7-40	Seminar	0	0	2*	60	40	**100**	**2**
4	CCA	8ME8-00	SODECA/NCC/NSS/ ANANDAM/IPR	-	-	-	-	100	**100**	**2**
			SUB TOTAL	**0**	**0**	**6**	**120**	**180**	**300**	**8**
			TOTAL OF VIII SEMESTER	**3**	**0**	**6**	**150**	**250**	**400**	**11**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA**=Internal Assessment, **ETE**=End Term Exam, **Cr**=Credits

*****for calculation of contact hours

7ME4-01: Finite Element Methods

Credit: 2Max **Marks: 100(IA: 30, ETE: 70)**

2L+0T+0P **End Term Exam: 3 Hours**

Course Objectives

To provide comprehensive understanding of fundamental principles and techniques of finite element methods, and its practical applications in engineering problems.

Course Outcomes

Upon successful completion of the course the students will be able to;

1. Understand and explain fundamental FEM concepts and formulations.
2. Apply the direct approach to solve linear spring system problems.
3. Solve one-dimensional FEM problems in solid mechanics, heat transfer, and fluid mechanics.
4. Analyze and implement two-dimensional FEM using various element types.
5. Develop and assess computational solutions for complex FEM field problems

S. No	Contents	Hours
1	**Basic Concepts:** Introduction, Review of equations of equilibrium, Approximate method vs. Exact method, Direct approach, Weak formulations, Weighted residual methods, Variational formulations, Weighted residual, Collocation, Subdomain, Least square and Galerkin’s method, Principle of minimum potential energy, Finite difference methods, Convergence criteria of finite element method	7
2	**Direct Approach to Finite Element Method:** Linear Spring System, Calculation of Stiffness Matrix, Assembling Element Stiffness Matrices, Boundary Conditions, Solution of System of Equations	3
3	**One-Dimensional Analysis:** Basis steps, discretization, element equations, linear and quadratic shape functions, assembly, local and global stiffness matrix and its properties, boundary conditions, applications to solid mechanics, heat and fluid mechanics problems, axisymmetric problem. Plane truss element, Beam element, Plane Frame element, Problems for various loadings and boundary conditions.	8
4	**Two-Dimensional Analysis:** Triangular and rectangular elements, Constant strain triangle, Bilinear element, Isoparametric formulation, Higher order elements, Six node triangle, Nine node quadrilateral, Master elements, Numerical integration, Computer implementation, Numerical problems	7
5	**Field Problem and Methods of Solutions** Heat conduction through a wall, Heat transfer through a fin, 2-D heat Conduction in a Plate, Torsion problems. Bandwidth, Elimination method and method of factorization for solving simultaneous algebraic equations, Features of software packages, Sources of error.	5

TEXT BOOKS

1. Seshu P., “Text Book of Finite Element Analysis” PHI Learning Private Limited, tenth edition, 2003.
2. Reddy J.N., "An Introduction to Finite Element Method", McGraw Hill, third edition, 2005.

REFERENCE BOOKS

1. Bathe, K.J. and Wilson, E.L., "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.
2. Bhavikatti S.S., “Finite Element Analysis”, New Age International (P)Ltd, 2005
3. Tirupathi.R. Chandrapatha and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall India, Fourth edition, 2012
4. Narasaiah G.L., “Finite Element Analysis”, BS Publications, 2008
5. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2000.
6. Rao. S.S., "Finite Element Methods in Engineering," Butterworth and Heinemann, 2001
7. Daryl L Logan., “A First course in Finite Element Methods”,Thomson Canada Limited, 2007[4th Edition]

7ME5-11: System Monitoring and Fault Diagnosis

Credit: 2 Max **Marks: 100 (IA: 30, ETE: 70)**

2L+0T+0P **End Term Exam: 3 Hours**

Course Objective:

The course should enable the students to:

1. To provide an understanding of Condition Monitoring (CM) and its relevance to industry.
2. To study the fundamentals of CM and Vibrational CM, integrity assessment techniques, the instrumentation and their utilization and how they are applied.
3. To learn the vibration-based health monitoring as well analysis of faults and their detection.

Course Outcomes:

Student will be able to

1. Have an appreciation of fundamentals of condition monitoring approaches, methods, and techniques.
2. Understand and be able to apply main techniques and methods of vibration-based CM.
3. Have an awareness of intelligent condition monitoring and be able to understand and apply rule-based and cased-based reasoning approaches.
4. Have an appreciation of some basic faults in machinery, their manifestation, and methods for detection and recognition.

S. No.	Contents	Hours
1	Introduction, Maintenance Principles, Failure Modes Effects and Criticality Analysis (FMECA), Fault Diagnostics and Prognostics, Machine Learning in CBM	4
2	Digital Signal Processing- Classification of Signals, Time Domain Analysis, Frequency Domain Analysis, Fundamentals of Fast Fourier Transform, Non-Stationary Signal Analysis, Modulation and Beats, Orbit and Order Analysis	5
3	Computer aided data acquisition, Data Recording, Cepstrum Analysis, Hilbert Transform in Condition Monitoring; Signal Conditioning and Filtering	4
4	Basics of Instrumentation, Errors in Measurements, Dynamic Range and Frequency Response, Overview of Transducers For CBM, Accelerometers Basics of Noise, Noise Monitoring, Sound Intensity Measurements.	7
5	Introduction to Faults in Rotating Machines, Unbalance Detection, Field Balancing, Misalignment, Crack and Looseness, Journal and Anti-Friction Bearings, Gears, Pumps and Cavitation	7
6	Basic Wear Debris Analysis - Detection of Wear Particles, Oil Sampling Technique, Oil Analysis, Particle analysis techniques	3
	Total	30

TEXT BOOKS

1. Amiya R. Mohanty, "Machinery Condition Monitoring: Principles and Practices", 2014, CRC Press.
2. Cornelius Scheffer and Paresh Girdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", 2004, Newnes.

REFERENCE BOOKS

1. Hosameldin Ahmed and Asoke K. Nandi, "Condition Monitoring with Vibration Signals: Comprehensive Wavelet Analysis and Applications in the Mechanical Industry", 2011, John Wiley & Sons.
2. Heinz P. Bloch and Fred K. Geitner, "Machinery Failure Analysis and Troubleshooting: Practical Machinery Management for Process Plants, Volume 2", 4th Edition, 2012, Butterworth-Heinemann.
3. Robert Bond Randall, "Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications", 2011, John Wiley & Sons.

7ME5-12: Plasticity and Metal Forming

Credit: 2 Max Marks: 100 (IA: 30, ETE: 70)

2L+0T+0P End Term Exam: 3 Hours

Course Objective:

The course should enable the students to:

1. Explain the basic principles of metal forming theory
2. Demonstrate various types of forming processes

Course Outcomes:

Student will be able to

1. Evaluate the state of stress during yielding of ductile and brittle materials when forming a component
2. Estimate problems and defects during forming on the basis of materials, their workability and frictional analysis
3. Recommend appropriate metal forming processes when provided a set of functional requirements and product development constraints
4. Recommend cost effective material options based upon near net shape, predicting load, torque and power requirements
5. Integrate product and process quality levels through the use of precision forming techniques

S. No.	Contents	Hours
1	**Fundamentals of elasticity and plasticity and yield – criterion:** Octahedral stresses and strains, Generalized Hooke's law, strain-hardening, Theories of plastic flow, Tresca's yield criteria, Von-Mises-Hencky's yield criteria; Constitutive Equations for Elasto-Plastic Materials; Integration of Constitutive Relations Workability Tests, Hot Working, Cold working, and warm (semi-hot) working of metals, work of deformation	7
2	**Drawing and extrusion:** Stresses in wire and strips for drawing and extrusion (zero friction and with friction case), work consumption, power requirement	6
3	**Rolling:** Classification, rolling mills, rolling of bars & shapes, rolling forces, analysis of rolling, defects in rolling, theories of hot & cold rolling, torque power estimation, forces on the rolls	6
4	**Forging:** Classification, Drop forging die design, Calculation of forging loads and stresses in open and closed die forging (plane strain, with friction)	6
5	**Sheet Metal Forming Process:** Methods – shearing and blanking, bending, stretch forming – deep drawing, Drawing force (with and without friction cases)	4
	Total	29

TEXTBOOKS

1. George E Dieter, Mechanical Metallurgy, Third Edition Tata McGraw Hill Education PVT Ltd, 2014.

REFERENCE BOOKS

1. Juneja. B.L, Fundamentals of Metal forming processes, 2nd Edition, New Age International, India, 2010.
2. William F. Hosford and Robert M. Caddell, Metal Forming: Mechanics and Metallurgy, 4th edition,

Cambridge University Press, 2011.

3. Henry S. Valberg, Applied Metal Forming: Including FEM Analysis, Cambridge University Press, 2010.
4. Uday S. Dixit, Metal Forming, 1st edition, McGraw Hill Education, 2013.

7ME5-13: Fundamentals of Machine Learning

(Common with ME and MX)

Credit: 2 Max **Marks: 100 (IA: 30, ETE: 70)**

2L+0T+0P **End Term Exam: 3 Hours**

Course Objective:

Provide a comprehensive understanding of machine learning techniques, including advanced algorithms and feature engineering, to effectively analyse and solve real-world problems

Course Outcomes:

Student will be able to

1. Understand the basic concept of machine learning techniques and their applications to real-life problems.
2. Explain the theories and principles underlying various machine learning algorithms.
3. Apply appropriate machine learning algorithm to solve problems of varying complexity.
4. Analyse and evaluate the performance of machine learning models, including their strength and limitations.
5. Optimize machine learning models learned and report on the expected accuracy and potential improvement for real-world problems.

S. No	Contents	Hours
1	**Introduction:** Introduction to Machine Learning, Applications of machine learning, Need of ML in Mechanical Engineering, Understanding ML vs. AI vs. DL, Types of ML: Supervised, Unsupervised, Reinforcement learning, Feature engineering and model selection.	4
2	**Classification:** Classification definition, Naive Bayes, Support vector machines (SVM), Ensemble methods (bagging, boosting), XGBoost (Extreme Gradient Boosting), CatBoost, LightGBM.	5
3	**Regression:** Linear regression, Logistic regression, Support vector machines, Decision trees, Random forests, K-Means, K-Nearest Neighbour (KNN).	5
4	**Unsupervised Learning:** K-Means, MeanShift, DBSCAN (Density-Based Spatial Clustering of Applications with Noise), Distribution-based Clustering (Gaussian Mixture Model), Hierarchical Clustering, BIRCH (Balanced Iterative Reducing and Clustering using Hierarchies).	6
5	**Feature Extraction and Selection** Feature extraction: Statistical features, Principal Component Analysis, Creating new features from domain knowledge. Feature selection: Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward.	6
6	**Reinforced learning:** Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning.	4

TEXT BOOKS

1. Bishop, C. M., “Pattern Recognition and Machine Learning”, New York: Springer, 2006.
2. Géron, A., “Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow”, O'Reilly Media, Inc., 2022.
3. James, G., Witten, D., Hastie, T., & Tibshirani, R., “An Introduction to Statistical Learning: With Applications in R”. New York: Springer, 2013.
4. Theobald O., “Machine Learning for Absolute Beginners: A Plain English Introduction”, The author, 2017.

REFERENCE BOOKS

1. Mitchell. T, “Machine Learning”, McGraw Hill, 1997.
2. Nilsson, Nils J. "Introduction to machine learning: An early draft of a proposed textbook", Robotics Laboratory, Department of Computer Science, Stanford University, Stanford, 1998.
3. Flach, P., “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, Cambridge University Press, 2012.
4. Zollanvari, A., “Machine Learning with Python: Theory and Implementation”, Springer Nature, 2023.

7ME5-14: Gas Dynamics and Jet propulsion

Credit: 2 Max **Marks: 100 (IA: 30, ETE: 70)**

2L+0T+0P **End Term Exam: 3 Hours**

Course Objective:

1. To provide a thorough understanding of the principles of gas dynamics and jet propulsion.
2. To equip students with the ability to analyze and solve problems related to compressible flow and shock waves.
3. To introduce students to various jet and rocket propulsion systems and their performance characteristics.
4. To prepare students for advanced studies and research in the field of gas dynamics and propulsion systems.

Course Outcomes:

Student will be able to

1. Student shall be able to understand and apply the fundamental concepts of gas dynamics in various engineering applications.
2. Student shall become proficient in analyzing the behavior of normal and oblique shock waves in compressible flows.
3. Student shall be able to evaluate the performance of different types of nozzles and diffusers in compressible flow systems.
4. Student shall have thorough understanding of the working principles and performance parameters of various jet and rocket propulsion systems.
5. Student shall be able to understand the concept of integrating the propulsion systems with aircraft and spacecraft for optimized performance.

S. No	Contents	Hours
1	**Fundamentals of Gas Dynamics** Review of basic concepts: Continuity, momentum, and energy equations, Thermodynamic properties of gases. Isentropic Flow: Mach number and its significance, Area-velocity relationship in isentropic flow, Stagnation properties. Prandtl-Meyer Expansion Waves: Prandtl-Meyer function, Expansion wave properties and applications	6
2	**Normal and Oblique Shock Waves** Normal Shock Waves: Fundamental equations and relationships, Rankine-Hugoniot equations, Normal shock tables and applications. Oblique Shock Waves: Shock polar diagram, Shock reflections and interactions, Applications in supersonic inlets and nozzles	6
3	**Compressible Flow in Ducts** Flow Through Nozzles and Diffusers: Convergent and convergent-divergent nozzles, Under-expanded, perfectly expanded, and over-expanded flows. Fanno and Rayleigh Flow: Fanno flow: Adiabatic flow with friction in a constant area duct, Rayleigh flow*:* Flow with heat transfer in a constant area duct	6

S. No	Contents	Hours
4	**Jet Propulsion Systems** Introduction to Jet Propulsion: Historical development and classifications of propulsion systems, Thrust equation, Thermodynamic analysis, Thrust calculations and efficiency concept. Turbojet, Turbofan, and Ramjet Engines: Working principles and performance parameters, Comparative analysis of different jet propulsion systems. Rocket Propulsion: Basic principles of rocket propulsion, Types of rocket engines and their applications	5
5	**Advanced Topics in Gas Dynamics and Propulsion** High-Temperature Gas Dynamics: Real gas effects and equilibrium thermodynamics Chemical reactions in high-temperature flows Introduction to Hypersonic Flow: Characteristics and challenges of hypersonic flight Applications in space vehicles and high-speed aircraft Propulsion System Integration: Integration of propulsion systems with aircraft and spacecraft Performance analysis and optimization of propulsion systems	6

TEXT BOOKS

1. S. Ramachandran, A. Anderson, K. Pandian, “Gas Dynamics and Jet Propulsion”, Edition: 2nd Edition (2013), Airwalk Publications, USA
2. S. M. Yahya, “Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion”, Third Edition, Publisher: New Age International Publishers.
3. E. Rathakrishnan. "Gas Dynamics", Edition: 6th Edition (2018), Publisher: Prentice Hall India Learning Private Limited (India)

REFERENCE BOOKS

1. John D. Anderson, Jr. "Modern Compressible Flow: With Historical Perspective" Edition: 4th Edition (2021), Publisher: McGraw-Hill Education (USA)
2. George P. Sutton and Oscar Biblarz, "Rocket Propulsion Elements" Edition: 9th Edition (2016), Publisher: Wiley (USA)
3. Robert D. Zucker and Oscar Biblarz. "Fundamentals of Gas Dynamics" by Edition: 2nd Edition (2019) Publisher: Wiley (USA).
4. Hans W. Liepmann and Anatol Roshko. "Elements of Gas Dynamics" Edition: Latest Edition (2013), Publisher: Dover Publications (USA)
5. Philip G. Hill and Carl R. Peterson. "Mechanics and Thermodynamics of Propulsion" Edition: 2nd Edition (2019), Publisher: Pearson (USA)

7ME5-15: Machine Tool Design

Credit: 2 Max Marks: 100 (IA: 30, ETE: 70)
2L+0T+0P End Term Exam: 3 Hours

Course Objective:

1. This course is intended to introduce Design of machine tool structures,
2. Design and analysis of systems for specified speeds and feeds and selection of subsystems for achieving high accuracy in machining.
3. To develop a solution oriented approach by in depth knowledge of Machine Tool Design.

Course Outcomes:

Student will be able to

1. A general requirement of machine tool design and drives.
2. Understand the design consideration of machine tool elements and their principles.
3. Design the gearbox for machine tool
4. Design structural element of machine tool
5. Understand electrical, mechanical and hydraulic drives for the operational movements.

S. No	Contents	Hours
1	**Introduction to Machine Tool Design**: General requirements of Machine tool Design, Type of motion in Machine Tools, Parameter Defining for working motion of machine tool, Machine Tool Drives, **General Requirements of the Machine Tool:** Accuracy of Shape, Dimensional accuracy and surface finish of the components produced. High Productivity. High Technical and Economic Efficiency. Vibration.	6
2	**Design Principles:** Stiffness and Rigidity of the Separate Constructional Elements and their Combined behavior Under Load, Static Rigidity, Dynamic Rigidity, Natural frequencies, Damping, Mode of. Principles of design of structural components, namely, head stock, tail stock, carriage, table, knee, column and over arms to achieve desired static & fatigue strength, stiffness, dynamic characteristics and other requirements.	6
3	**Standardization of Spindle Speeds and Feed Rates:** Layout of Speed Change Gears. Saw Diagrams for Arithmetic Progression, Geometric Progression, Harmonic Progression and Logarithmic Progression of spindle speeds for Mechanical Stepped Drives for Machine Tools. Establishment of Gear Ratios, Layout of the Intermediate Reduction Gears, Calculation of Transmission Ratios, Pulley Diameter, Gear Wheel Diameters and Number of Teeth. Ray Diagram. Speed Diagram. Estimation of power requirements and selection of motor for metal cutting machine tool spindles.	8
4	**Design Of Guide Ways and Power Screws:** Function and types of guide ways – Design and lubrication of slide ways - aerostatic slide ways - antifriction guide ways, combination guide ways - protecting devices, design of power screws.	4
5	**Electrical, Mechanical and Hydraulic Drives for the Operational Movements:** Electric Drive and Control Equipment. Mechanical and Hydraulic Drives. Drives for Producing Rotational Movements, Stepped Drives, Step less Drives.	4

TEXT BOOKS

1. Design of Machine Tools, S.K. Basu, D K Pal, Oxford and IBH Publishing.
2. Principles of Machine Tools, G C Sen, A Bhattacharya, New Central Book Agency.

REFERENCE BOOKS

1. Machine Tool Design and Numerical Control, N K Mehta, McGraw-Hill.
2. Machine Tool Design Handbook, Central Machine Tool Institute, McGraw-Hill

7ME5-16: Computer Oriented Numerical Methods

Credit: 2 Max **Marks: 100 (IA: 30, ETE: 70)**

2L+0T+0P **End Term Exam: 3 Hours**

Course Objective:

1. Enable students to understand and analyze the principles of numerical methods and error analysis, including the impact of different types of errors on calculations.
2. Enable students to implement direct and iterative methods for solving linear systems and use interpolation techniques for data estimation.
3. Enable students to perform numerical differentiation and integration using various methods, such as finite differences and Simpson's rule.
4. Enable students to develop and implement numerical algorithms in programming languages, enhancing problem-solving skills for real-world engineering applications.

Course Outcomes:

Student will be able to

1. Master Numerical Techniques: Students will be able to understand and apply various numerical methods for solving complex engineering problems, enhancing their computational problem-solving skills.
2. Analyze and Minimize Errors: Students will develop the ability to analyze different types of numerical errors, understand their sources, and implement strategies to minimize these errors in engineering computations.
3. Solve Differential Equations: Students will acquire the skills to numerically solve ordinary differential equations (ODEs) and apply these techniques to real-world mechanical engineering problems, including initial and boundary value problems.

S. No	Contents	Hours
1	**Introduction to Numerical Methods and Error Analysis** (a) Overview of Numerical Methods: Importance and application in engineering problems, comparison with analytical methods (b) Error Analysis: Types of errors: Absolute, relative, and percentage errors, Error propagation and stability, Truncation and round-off errors, significant digits and precision	5
2	**Linear Systems of Equations** (a) Direct methods for solving linear systems: Gaussian elimination and pivoting strategies, lower–upper decomposition (b) Iterative methods for solving linear systems: Jacobi method, Gauss-Seidel method and Convergence criteria	5
3	**Interpolation and Curve Fitting** (a) Interpolation: Polynomial interpolation: Newton forward and backward difference interpolations, Lagrange and Newton's divided differences, Piecewise interpolation: Linear and spline interpolation (b) Curve Fitting:	5

S. No	Contents	Hours
	Least squares regression: Linear and polynomial regression and non-linear curve fitting	
4	**Numerical Differentiation and Integration** (a) Numerical Differentiation: Finite difference approximations and Error analysis in numerical differentiation (b) Numerical Integration: Trapezoidal rule, Simpson's rule, Gauss quadrature, Romberg integration, Error bounds, and estimates.	5
5	**Numerical Solutions of Ordinary Differential Equations (ODEs)** (a) Initial Value Problems: Euler's method, Improved Euler's method (Heun's method) and Runge-Kutta methods, RK Fourth order method (b) Boundary Value Problems: Finite difference method, shooting method, solution of Laplace & Poisson equations: Jacobi method, Gauss-Seidel method (Liebmann's iterative method) Relaxation method	6

TEXT BOOKS

1. Jain M.K., Iyengar S.R.K., and Jain R.K., "Numerical Methods for Engineering and Scientific Computation", 6th Edition, New Age International Publishers, New Delhi
2. Rajaraman V., "Computer Oriented Numerical Methods", 4th Edition, PHI Learning Pvt. Lt., Delhi
3. Grewal B.S., "Numerical Method in Engineering & Science with Programs in C, C++ & MATLAB", 10th Edition, Khanna Publishers, Delhi

REFERENCE BOOKS

1. Chapra Steven C. and Canale Raymond P., "Numerical Methods for Engineers" 7th Edition, McGraw-Hill Education, USA
2. Chapra Steven C., "Applied Numerical Methods with MATLAB for Engineers and Scientists" 4th Edition, McGraw-Hill Education, USA
3. Atkinson Kendall E., "An Introduction to Numerical Analysis", 2nd edition, Wiley
4. Burden Richard L. and Faires J. Douglas, "Numerical Analysis", 9th Edition, Cengage Learning, Inc., England
5. Hamming R.W., "Numerical Methods for Scientists and Engineers", 2nd Edition, Dover Publication Inc. New York

7ME5-17: Computational Fluid Dynamics

Credit: 2 Max **Marks: 100 (IA: 30, ETE: 70)**

2L+0T+0P **End Term Exam: 3 Hours**

Course Objective:

1. To study the basic governing equations and understand the basic properties of CFD.
2. To understand discretization techniques and solving methods for improving accuracy.

Course Outcomes:

Student will be able to

1. Understand the classification of PDEs, governing equations
2. Understand the basic principles of computational methods
3. Apply finite volume method to solve steady and unsteady diffusion, advection-diffusion problems
4. Understand Solution algorithms and various discretization schemes.

S. No	Contents	Hours
1	Introduction: Conservation equation; mass; momentum and energy equations; convective forms of the equations; Conservative forms of the equations and general description.	3
2	Classification and Overview of Numerical Methods: Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods.	3
3	Finite Difference Technique: Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, polynomial fitting, approximation of boundary conditions, applications to conduction and advection-diffusion problems.	4
4	Finite Volume Technique: Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem.	4
5	Finite Element Methods: Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications.	5
6	Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform.	4
7	Navier-Stokes Equations: Explicit and implicit methods; SIMPLE, SIMPLER and SIMPLEC type methods; fractional step methods.	4

TEXT BOOKS

1. J. C. Tannehill, D. A. Anderson, and R. H. Pletcher, Computational Fluid Mechanics and Heat Transfer, CRC Press, 2012.
2. J. D. Anderson Jr., Computational Fluid Dynamics, McGraw-Hill International Edition, 2017.
3. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 2017.

REFERENCE BOOKS

1. Ferziger, J. H. and Peric, M.(2003). Computational Methods for Fluid Dynamics. Third

Edition,SpringerVerlag,Berlin.

2. Versteeg, H.K. and Malalasekara, W.(2008). Introduction to Computational Fluid Dynamics: The Finite Volume Method.Second Edition (Indian Reprint) Pearson Education.
3. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H.(1997). Computational Fluid Mechanics and Heat Transfer. Taylor & Francis
4. J. H. Ferziger, and M. Peric, Computational Methods for Fluid Dynamics, Springer, 2001.

7ME4-20: Python Lab

Credit: 1 Max **Marks: 100 (IA: 60, ETE: 40)**

0L+0T+2P

Course Objective:

1. Equip students with a basic understanding of Python programming and its applications in Mechanical Engineering, ensuring they can write, debug, and execute Python programs efficiently.
2. Foster interdisciplinary skills by integrating Python programming with core mechanical engineering concepts, enabling students to solve engineering problems using computational methods.
3. Develop students' ability to apply Python programming to real-world mechanical engineering problems, including simulations, data analysis, and optimization, enhancing their industry readiness.

Course Outcomes:

Student will be able to

1. Programming Proficiency: Students will be able to write and execute Python programs confidently, utilizing control structures, functions, and data structures to solve computational problems.
2. Engineering Problem Solving: Students will demonstrate the ability to integrate Python programming with mechanical engineering principles to simulate, analyze, and solve engineering problems such as thermodynamics calculations, FEA, and vibration analysis.
3. Data Analysis and Visualization: Students will acquire skills in data handling, analysis, and visualization, enabling them to interpret and present engineering data effectively, enhancing their decision-making and communication skills in an engineering context.

S. No	Contents	Hours
1	**Introduction to Python-** Write and execute a simple Python program & Basic syntax, variables, and data types.	
2	**Control Structures -** Write programs using if, else, elif statements. Implement for and while loops. Create a program to calculate the displacement of a piston over time.	
3	**Functions and Modules -** Define and call functions. Pass arguments and return values. Import and use standard modules.	
4	**Data Structures -** Create and manipulate different data structures. Use data structures to store and process mechanical data.	
5	**File Handling -** Read data from text files. Write results to a file. Perform simple data analysis and report generation.	
6	**Numerical Methods -** Solve linear equations using Python. Implement numerical integration and differentiation. Apply these methods to solve mechanical engineering problems like stress-strain analysis.	
7	**Data Visualization -** Plot graphs and charts for temperature distribution in a rod. Customize plots for better presentation.	
8	**Object-Oriented Programming -** Define classes and objects. Create a simple class to model a mechanical component (a spring).	
9	**Simulating Mechanical Systems -** Write a program to simulate the motion of a simple pendulum and analyze the behavior of the system under different conditions.	

10	**Basic Finite Element Analysis (FEA) -** Implement a simple FEA algorithm to solve a truss problem.	
11	**Machine Learning Concepts -** Implement a linear regression model to predict mechanical properties such as tensile strength from material composition data.	
12	**Classification of Materials Using Machine Learning -** Use a decision tree or support vector machine to classify different types of materials based on their properties.	
13	**Heat Transfer Analysis -** Implement 1D heat conduction equation and Solve for temperature distribution in a rod.	
14	**Vibration Analysis -** Solve the equation of motion for a single-degree-of-freedom system and Analyze the response of the system to different types of inputs.	
15	**Fluid Mechanics Simulations -** Implement basic fluid mechanics equations. / Simulate flow in a pipe.	
16	**Optimization Techniques -** Optimize the design of a mechanical component (e.g., minimize weight while maintaining strength).	

7ME4-21: Modeling and Simulation Lab

Credit: 1 Max **Marks: 100 (IA: 60, ETE: 40)**

0L+0T+2P

Course Objective:

1. To acquire basic understanding of Modeling and Analysis software.
2. To understand the different kinds of analysis and apply the basic principles to find out the stress and other related parameters of bars, beams loaded with loading conditions.
3. To learn to apply the basic principles to carry out dynamic analysis.
4. Analyzing vibration and heat transfer in mechanical components..

Course Outcomes:

Student will be able to

1. Utilize the analysis software to create geometry, discretize, apply boundary condition to solve stress related problems on bars, Trusses and plate for different loading conditions.
2. Demonstrate the deflection of beams subjected to point, uniformly distributed and varying loads further to use the available of results to draw shear force and bending moment diagrams.
3. Analyze the given problem by applying basic principle to solve and demonstrate 1D and 2D heat transfer with conduction and convection boundary conditions
4. Predict the dynamic Characteristics and nature frequency of 2D components for various boundary condition and also analyze with forcing function.

Perform the following experiments using any suitable available Simulation software(s) in the lab.

S. No	Experiment (Perform any 10 taking at least 2 from each group)	Hour
1	**Part A** Stress analysis of a plate with a circular hole. Stress analysis of rectangular L bracket. Stress analysis of simply supported beam with point load, UDL, with varying load etc. Stress analysis of cantilever with point load, UDL, with varying load etc. Stress analysis of a truss.	
2	**Part B** Dynamic Analysis - • fixed beam for natural frequency determination • Bar subjected to forcing function • fixed beam subjected to forcing function Mode frequency analysis of cantilever beam Mode frequency analysis of simply supported beam Harmonic analysis of a 2D component Simulation of Spring-mass system / Cam-follower system	
3	**Part C** Thermal stress analysis of a 2D component	

	Conductive heat transfer analysis of a 2D component Convective heat transfer analysis of a 2D component Design of experiments Perform optimization of any design	