

Open Electives (Course and Syllabus are same as 2023 scheme)

MEExxx: Basics of Materials Engineering
 MEExxx: Biomaterials
 MEExxx: Product Design and Manufacturing
 MEExxx: Joining Technology for Metals
 MEExxx: Operations Management
 MEExxx: Additive Manufacturing
 MEExxx: Renewable Energy

B.Tech. Mechanical Engineering - Syllabus of Core Courses (2025 scheme)

MEE2003 Engineering Economics [3 0 0 3]

Concept and Value Analysis, Economic Decision Making, Types of Estimates, Accounting and Control, Elements of Cost, Prime Cost, Overheads, Types of Cost, Process Cost & Cost of Production, Break Even Analysis, Inventory Control & Management, EOQ, Financial Analysis, Simple payback, Return on Investment, NPV (Net Present Value), IRR (Internal rate of Return), Life Cycle Cost Method, Sensitivity Analysis, Project Financing Options. Budget and Budgetary Control, Concept of Budgeting, Type of Budgets. Risk - Risk vs Return, System Concept and Value Analysis, System Analysis & System Engineering, Value Analysis. Replacement Analysis, Depreciation.

References:

1. C.S. Park, Fundamentals of Engineering Economics, Pearson Education, 3rd edition, 2017.
2. R. Panneerselvam, Engineering Economics, Prentice Hall of India, 2nd Edition, 2013.
3. L. Blank and A. Tarquin, Engineering Economy, McGraw Hill Education, 7th Edition, 2011.
4. G.J. Tiesen and W.J. Fabrycky, Engineering Economy, 9th edition, Pearson, 2000.

MBB2001 Principles of Management [3 0 0 3]

Management: Definition, Functions, Concept, Scope of Management, Nature of Management, Levels of Management, Managerial Skills, Roles of a Manager, Difference between Management and Administration Evolution of Management Thoughts: Classical Approach- scientific management, Administrative Management and Bureaucracy. Neo-Classical Approach- Human relations movement and Behavioural approach. Modern Approach- Quantitative approach, Systems approach, and Contingency approach. Forms of organization - Sole Proprietorship, Partnership, Co-operative Organization, and Company. Functions of Management: Planning: Concept, Importance, Strategies, Planning Premises; Decision making, Management by Objectives (MBO), Process of Planning. Organizing: Concept, Importance, Process of Organizing, Types of Organizational Structures, Span of Management, Line and Staff Relationship, Centralization and Decentralization. Staffing: Concept, Scope of Staffing, Manpower Planning, Selection & Training, Performance Appraisal. Directing: Concept, Importance. Motivation: Concept, Importance, Maslow's Need Hierarchy theory, Leadership: Concept, Characteristics of Leadership, and Leadership styles. Communication: Types, Process, Channels and Barriers of Communication. Coordinating: Definition, Characteristics, Principles and Techniques of Coordination, Concept of Managerial Effectiveness. Controlling: Concept, Importance, Process of Controlling, Management Control Techniques, Effective Control Systems.

References:

1. Stephen P. Robbins, Mary Coulter, David De Cenzo: Fundamentals of Management, Ninth Edition, Pearson Education India, 9th ed. 2016.
2. Mitra, J.K.: Principles of Management, 1st ed. Oxford Publication, 2017.
3. Koontz, H.: Essentials of Management, 1st Indian ed. Tata McGraw Hill Education, 2010.
4. Bhushan, Y.K.: Fundamentals of Business Organization and Management, Sultan Chand & Sons, 9th Edition, 2014.



MEE2104: Material Science & Metallurgy [4 0 0 4]

Classifications, application and properties of engineering materials, Crystal structure, Crystal directions and planes, Miller indices, Polymorphism or Allotropy, Diffusion processes. Crystallization, **Imperfections in Crystals:** Point, line and surface defects. Plastic deformation of metals and alloys, Role of dislocation; slip and twinning, grain growth. Solidification of metals and alloys, **Phase Diagrams**-Phase and Lever Rules, Iron-Carbon equilibrium diagram, Time-Temperature-Transformation Diagram, Heat treatment processes, Powder metallurgy, Corrosion of Metal and Alloys, Mechanical properties of metals, Microstructural characterization Non-destructive testing of materials. Polymeric materials, Ceramic Materials, Structure and properties of polymers and ceramics, Composites Materials, Advanced Materials Nanomaterials, Biocomposites, Nanocomposites, Smart materials, Biomaterials.

References:

1. Smith, W., and Hashmi, J., *Foundation of Materials Science and Engineering*, 7th Edition, 2023; Tata McGraw Hill, New Delhi, India, ISBN: 9781264654437.
2. Callister, W.D, Balasubramaniam, R., *Materials Science and Engineering: An introduction*, 10th Edition, June 2020; Wiley, ISBN 978-1-119-40549-8.
3. Hosford, W.F., *Mechanical Behavior of Materials*, 2nd Edition, 2009, Cambridge University Press, ISBN: 978-0521195690.
4. Vlack, L.H.V., *Elements of Material Science and Engineering*, Sixth edition, 2008; Pearson Education, Delhi, India, ISBN: 81-317-0600-1.

MEE2105: Thermal Engineering [3 1 0 4]

Fundamental concepts, Properties of steam, Laws of Thermodynamics: Applications to Non flow and flow processes, Carnot principle, Absolute thermodynamic temperature scale, Clausius Inequality, Entropy, Principle of increase-in-Entropy, Entropy generation; Availability: Concept of Available Energy, Availability of closed & open systems, Irreversibility; Gas Power cycles: Air standard cycle- Otto, Diesel, Dual, Brayton Cycle, Vapour Power: Rankine Cycle. Reverse Carnot Cycle, Vapour Compression Refrigeration Cycle, Air compressor: working and performance parameters, Steam turbines: impulse and reaction turbine, turbine efficiencies.

References:

1. Y.A. Cengel and M.A. Boles, *Thermodynamics: An Engineering Approach*, 8 th ed., McGraw Hill, 2015
2. P K Nag & Sudipta De, *Engineering Thermodynamics*, 7th Edition, McGraw Hill, 2025.
3. Y.V.C. Rao, *An Introduction to thermodynamics*, Revised 2 nd Edition, Universities Press (India) Private Limited, 2004.

MEE2106: Strength of Materials [3 0 0 3]

Stress and Strain of Solids, Deformation of simple and compound bars, Hooke's law, Stress-Strain diagrams for materials, Elongation of tapering bars of circular and rectangular cross sections, Saint Venant's principle, Thermal stress, Elastic constants, Strain energy, Analysis Biaxial state of stresses, Stresses on inclined plane, Principal planes and stresses, Mohr's circle of biaxial stresses, Theory of Failure. Shear force and Bending Moment in Cantilever, Simply supported and Overhanging beams, Theory of simple bending, Effect of shape of beam section on stress induced with different load, Expression for transverse shear stress in beams, Bending and shear stress distribution diagrams for circular, rectangular, 'I', and 'T' sections, Torsion: Analysis of torsion of circular bars, Shear stress distribution for Solid and hollow circular section, Stepped shaft, Twist and torsion stiffness, Introduction, short and long columns. Euler's theory; Assumptions, Buckling load for different end conditions, Limitations of Euler's theory. Rankine-Gordon's formula for columns.



References:

1. B. C. Punmia, A. K. Jain, and A. K. Jain, *SMTS-I Strength of Materials*, 10th ed., New Delhi, India: Laxmi Publications Pvt. Ltd., 2018.
2. S. M. A. Kazimi, *Solid Mechanics*, 2nd ed., New Delhi, India: Tata McGraw-Hill, 2017.
3. E. P. Popov, *Engineering Mechanics of Solids*, 2nd ed., New Delhi, India: Prentice-Hall of India, 2015.
4. R. C. Hibbeler, *Mechanics of Materials*, 6th ed. New Delhi, India: Pearson, 2014.
5. F. P. Beer, E. R. Johnston Jr., J. T. Dewolf, and D. F. Mazurek, *Mechanics of Materials*, 6th ed., New Delhi, India: McGraw-Hill Education (India) Pvt. Ltd., 2013.

MEE2107: Production Technology 1 [4 0 0 4]

Introduction to Sand Casting equipment, patterns, allowances, sands, cores, green sand moulding, Special Casting Process, Defects in casting, causes & remedies, casting furnaces. **Metal Joining processes:** Principles of welding, welded joints, welding processes, soldering and brazing, Welding defects. **Metal Forming:** Introduction to plastic deformation, Hot and cold working, Strain hardening, Recrystallization and grain growth. Rolling: Principle, Types of rolling mills, Roll passes, Forces in rolling and power requirements. **Extrusion:** Process, forces and power requirements. **Forging:** Process, forces and power requirements, defects, causes and remedies, Drawing process. **Sheet Metal Forming:** Spring back effect, processes. **Processing of Plastics:** Types of Plastics, Properties and applications, Processing Methods & Equipment (Blow & Injection Moulding). Introduction to additive manufacturing techniques. **Measurement methods,** Definition of standard terms, Limits, fits & tolerances, Gauges & comparators.

References:

1. S. Kalpakjian and S.R. Schmid, *Manufacturing Engineering and Technology*, Pearson Education, 2023.
2. A. Ghosh, and A.K. Malik, *Manufacturing Science*, Affiliated East West Press Pvt. Ltd., 2021.
3. P. N. Rao, *Manufacturing Technology Vol-1*, McGraw Hill 2018.
4. C.P. Paul and A.N. Jinoop, *Additive Manufacturing*, McGraw Hill 2021.

MEE2132: Thermal Engineering Lab [0 0 2 1]

Fire and flash point tests; calorific value of fuels, Performance test and heat balance analysis of four stroke single cylinder CI engines test rig with DC generator; Performance assessment of CRDi engine, Performance test and Heat balance analysis of 4 stroke 4-cylinder Diesel engine with Electrical dynamometer; Evaluating friction power by Morse test rig and Williams line method, Four Stroke Four Cylinder Petrol Engine Test Rig With Electrical Dynamometer; Performance test and heat balance analysis of four stroke single cylinder CI engines test rig for alternate fuels, performance assessment of compressor.

References:

1. Çengel, Yunus A., and John M. Cimbala. *Fundamentals of Fluid Mechanics and Hydraulic Machines*. 2025 ed., McGraw-Hill, 2025.
2. Heywood John B, *Internal Combustion Engine Fundamentals*, 2nd Edition McGraw-Hill Education 2018

MEE2133: Computer Aided Drawing Lab [0 0 2 1]

Introduction to design process and drawings of CAD Software. Review of sectioning, drawing standards, dimensioning, and notes. Fasteners - screws, bolts, and nuts, Bearings - Bush Bearing, Couplings - Flange and Oldham's, Joints- Sleeve & Cotter joints. 2D Drafting of Machine Components - Screw Jack, Machine Vice, and Plummer Block. Assembly drawings with sectioning and bill of materials. Production drawings - limits, fits and tolerances, dimensional and geometric tolerances.

References:

1. K.L. Narayana, *Machine Drawing*, 6th Edition, New Age International, 2019.



2. S. Trymbaka Murthy, *A Textbook of Computer Aided Machine Drawing*, 3rd Edition, Medtech Publishers, 2019

MEE2134: Production Technology - I Lab [0 0 2 1]

Practice of foundry operations, preparation of green sand mold and casting, die casting machine. Smithy operation and temperature measurement. Welding Practice: Preparation of welding joints by gas welding, SMAW and spot welding, Demonstration of MIG, TIG and Laser Beam Welding. Demonstration of 3D printer, Measurement methods, Limits, Gauges & comparators.

References:

1. Bruce J Black, *Workshop Processes Practices and Materials*, Taylor and Francis, India, 2017.
2. S.K. Chaudhury and S.K. Hajara, *Elements of Workshop Technology Vol.1*, (14e), Media Promoters & Publishers Pvt. Ltd., 2010.

MAS22XX Statistics and Probability [3 0 0 3]

Probability Theory and Random Variables: Probability (Only One Lecture), Random variables, Cumulative distribution functions, Discrete random variables, Continuous random variables, Independent random variables, Probability mass and density functions, Expectation of random variables, Chebyshev's inequality, Central limit theorem. Probability distribution: Binomial, Poisson, Uniform, Normal, Exponential Theory of Estimation: Maximum Likelihood and method moment estimation, Sufficient statistics, Bayesian estimation, Confidence intervals for means. Tests of Statistical Hypothesis: Introduction, Parameter and Statistic, Standard error, Statistical hypotheses, Critical region, Tests of hypotheses and significance, Type I and Type II errors, level of significance. level of significance, Test about one mean, Test about equality of two means, Test of variances, Chi square test, Analysis of Variance.

References:

1. G. Casella and R. L. Berger, *Statistical Inference*, 2nd ed., Pacific Grove, CA, USA: Thomson Duxbury, 2024.
2. R. V. Hogg and E. A. Tanis, *Probability and Statistical Inference*, 10th ed., New York, NY, USA: Macmillan Publishing Co. Inc., 2021.
3. A. M. Goon, M. K. Gupta, and B. Dasgupta, *An Outline of Statistical Theory*, Vol. II, 3rd ed., Kolkata, India: World Press, 2005.
4. M. G. Kendall and A. Stuart, *The Advanced Theory of Statistics*, Vol. II, London, U.K.: Charles Griffin & Co. Ltd., 1979.

MEE2203: Theory of Machines [3 1 0 4]

Constrained motion, rigid and resistant bodies, link, kinematic pair and degrees of freedom. Kinematic chain: Linkage mechanism and structure, mobility and range of movement - Kutzbach and Grubler's criterion, number synthesis, Grashof's criterion, Four bar chain and slider crank chain and its inversions. Displacement, velocity and acceleration analysis of plane mechanisms, Gears and Gear Trains. flywheels; working principle of governors, centrifugal governors, characteristics of governors, controlling force curve; principle of gyroscopic couple, stability of plane, ships and vehicles; Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

References:

1. Rattan, *Theory of Machines*, Tata McGraw Hill, 5th Edition, 2019.
2. G. R. Pennock J. E. Shigley and Jr. J. J. Uicker, *Theory of Machines and Mechanisms*, Oxford University press, 5th Edition, 2017.
3. R L Norton, *Kinematics and Dynamics of Machinery* Tata McGraw-Hill Education, 1st Edition in SI unit, 2009.
4. Ghosh, Mallik, *Theory of Mechanisms and Machines* East West Press, 3rd Edition, 2008.



MEE2204 Fluid Mechanics and Machines [3 1 0 4]

Properties of Fluids: Introduction, Various properties, Newton's law of viscosity, deformation of fluids, Compressibility. Fluid Statics: Pressure and its measurement: Pressure gauge, Manometers, Pascal's law, Hydrostatic law: Forces on plane and curved surfaces, Centre of pressure; Buoyancy, equilibrium of submerged and floating bodies, metacentric height. Fluid Kinematics: Lagrangian and Eulerian description of fluid flow, Types of Fluid flow, Stream line, path line and streak lines, Continuity equation, Fluids subjected to Velocity and acceleration, Stream function, Velocity Potential function Fluid Dynamics: Euler's and Bernoulli's equation, Bernoulli's theorem, Applications of Bernoulli's equation Flow: Pipe flow: Darcy Weisback equation, Friction factor, Minor and major losses in pipe, power transmission in pipe flow. Dimensional analysis and similitude: Dimensionless groups, scaling, non-dimensionalization. Boundary layer concept: Boundary layer separation. Pumps and fluid machines - Centrifugal and positive displacement pumps, Characteristics, design aspects such as cavitation and priming, Impulse and reaction turbines such as Pelton, Francis, Kaplan.

References:

1. Frank M. White, *Fluid Mechanics* McGraw Hills Pub., Ninth Edition, 2022.
2. Sawan S. Sinha, *Fundamentals of Fluid Mechanics*, Ane Books Pvt Ltd., 2024,
3. R. C. Hibbeler, *Fluid Mechanics* Pearson Education, 2 nd Edition, 2022.
4. Yunus A. Cengel, John M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, 2024.
5. P. N. Modi and Seth, *Hydraulics and Fluid Mechanics*, Standard Book House Pub., 2019.

MEE2232: Numerical Methods and Computation Lab [0 0 2 1]

Introduction, Programming with MATLAB, Flow Control, Writing Functions, Loops and Conditional Statements, Functions, Symbolic Calculations in MATLAB, Polynomial Functions, Numerical Method Problems Through MATLAB, Solving Linear Algebraic Equations, Runge-Kutta Method, Simpson's Rule for Integration, Optimizations, etc, Applications of MATLAB in Physical Problems, Evaluating the Velocity of a jumper with Free Fall Jump, Modelling of Flow Through Pipe, Evaluating Stress in a Bar Under Axial Load.

References:

1. MATLAB R2025a, User Manual.
2. C.C. Steven, *Applied Numerical Methods*, McGraw-Hill, 4th Edition, 2018

MEE2233: Computer Aided Modelling Lab [0 0 2 1]

Introduction: CAD software and its applications. CAD Software: 2D Part Drawing, 3D Part modelling, Assembly of Engine parts and Machine Components - Piston, connecting rod, Screw jack, machine vice, tail stock, vane and gear pump, Sheet metal modelling.

References:

1. Toogood R. *Creo Parametric 9.0 Tutorial*. SDC Publications; 2022.
2. Rider M. *Designing with Creo Parametric 9.0*. SDC Publications; 2022

MEE2234: Fluid Mechanics and Machines Lab [0 0 2 1]

Verification of Bernoulli's Principle, determine coefficient of discharge of a rectangular notch and a V-notch, weir, a venturimeter and orificemeter, Characteristics and performance testing of a reciprocating, multistage centrifugal, variable speed centrifugal, gear oil pumps and Pelton turbine, Determine Friction factor through pipes.

References:

1. Çengel, Yunus A., and John M. Cimbala. *Fundamentals of Fluid Mechanics and Hydraulic Machines*. 2025 ed., McGraw-Hill, 2025.
2. White, Frank M. *Fundamentals of Fluid Mechanics*. 2025 ed., McGraw-Hill, 2025.



3. Panigrahi, S. K. *Fluid Mechanics and Hydraulic Machines Laboratory Manual*. 2025 ed., Katraia and Sons, 2025.

MEE3103: Design of Machine Elements [3 1 0 4]

Design process and considerations: function, strength, rigidity, wear resistance, safety, and economy. Factor of safety, service factor, and reliability. Stress concentration. Theories of failure, Fatigue loading: S-N curve, endurance limit, modifying factors. Design of Joints: Design of riveted joints - lap and butt joints under different loading conditions. Design of welded joints - parallel and transverse fillet welds, welds under combined loading. Shafts and Keys: Design of shafts subjected to torsion, bending, and combined loading. Design of keys under static and fatigue loading, Design of Springs, Power Transmission Elements: Design of flat belt and V-belt drives - length, tension, power capacity. Design of gears -Gear tooth stresses: Lewis equation, Buckingham's equation. Surface wear, dynamic load considerations.

References:

1. V.B. Bhandari, *Design of Machine Elements*, 4th Ed., Tata McGraw Hill, 2017.
2. Joseph Shigley, *Mechanical Engineering Design*, 10th Ed., McGraw Hill, 2015.
3. NPTEL, "*Design of Machine Elements-I*", <https://nptel.ac.in/courses/112105125>

MEE3104 Heat Transfer [3 1 0 4]

Introduction, Fourier's law of heat conduction, Heat equation in Cartesian, Cylindrical and Spherical coordinate system, one dimensional steady state conduction applied to various cases e. g. plane wall, cylinder, sphere, Internal Heat Generation, Critical radius of insulation for cylinder & sphere. Heat transfer from extended surfaces. Unsteady state heat conduction. Free and forced convection heat transfer, Application of dimensional analysis to free and forced convection, Dimensionless numbers, Empirical equations of convective heat transfer, Hydrodynamic and thermal boundary layer. Boiling and Condensation. Heat Exchanger, Heat Exchanger Analysis by LMTD and Effectiveness-NTU method. Radiation: - Radiation Intensity, Absorption, Reflection and Transmission by real surfaces, Kirchhoff's Law, Gray surface. Radiation exchange between surfaces, Radiation Shield.

References:

1. Holman. J.P & Bhattacharya Souvik, *Heat Transfer*, 10th edition, McGraw Hill, 2020
2. Cengel.Y. A., Ghajar. A.J., *Heat and Mass Transfer*, 6th Edition, Mc Graw Hill, 2020
3. Incopera.P.F., Dewitt D.P., Bergam L .Theodore., Lavine. S. Adrienne., *Incopera's Principle of Heat and Mass Transfer*, 8th Edition, John Wiley Publication.

MEE3105: Production Technology 2 [4 0 0 4]

Mechanics of Metal Cutting, Methods of Machining, Types of Cutting Tools, cutting tool materials, cutting fluids, Nomenclature of Single point cutting tool, Types of chips in machining process, Merchant's Theory, Tool wear and Tool life. Lathe: Introduction to Capstan and Turret lathe. Introduction to shaper, Planer & Slotter. Milling: Mechanics of Milling, Types of Milling Machines and Milling Cutters, Types of Milling processes, Concept of Indexing Mechanism/Dividing Head. Hole Making Operations: Mechanics of Drilling, Nomenclature of Twist Drill Bit, Types of Drilling Machines, Estimation of Machining time & Metal removal rate in Drilling operation. Finishing Operations: Mechanics of Grinding Operation, Specifications and Selection of Grinding Wheels. Lapping, Honing and Buffing, Broaching. Economics of metal machining. Non-traditional manufacturing process - Equipment, Process parameters, principle, Advantages, Limitations. Principle and analysis of locating and clamping methods, Types of Jigs and Fixtures.

References:

1. S. Kalpakjian and S.R. Schmid, *Manufacturing Engineering and Technology*, Pearson Education, 2023.
2. A. Ghosh, and A.K. Malik, *Manufacturing Science*, Affiliated East West Press Pvt. Ltd., 2021.



3. P. N. Rao, *Manufacturing Technology Vol-2*, McGraw Hill 2018.
4. Kaushik Kumar, Divya Zindani and J. Paulo Davim, *Advanced Machining and Manufacturing Processes*, Import, Pearson, 2018.
5. Beckwith Thomas, *Mechanical Measurements*, Pearson Education, 2013. **MEE3132:**

MEE3132: Production Technology 2 Lab [0 0 2 1]

Preparing turning Models using Lathe. Exercises involving plain turning, step turning, knurling, chamfering, taper turning, facing, free hand turning and "V" & Square thread cutting. Demonstrations on eccentric turning, internal threading, and taper turning. Milling Practice: Preparing milling models on Slot milling, spur gear, helical gear, Shaping Practice: Preparing Shaping models on flat surfaces, inclined surfaces, cutting of slots etc, Grinding Practice: Exercises on Surface grinding and cylindrical grinding, Demonstrations of advanced machines machining operations.

References:

1. B.S. Raghuvanshi, A course in Workshop Technology Vol.2, Dhanpat Rai & Sons, 2015.
2. S.K. Chaudhury, S.K. Hajara, *Elements of Workshop Technology Vol.1*, (14e), Media Promoters & Publishers Pvt. Ltd., 2010.

MEE3133: Heat Transfer Lab [0 0 2 1]

Conduction: Thermal conductivity of composite wall, insulating powder and heat flow through lagged materials in concentric pipes. Convection: Heat transfer rate through natural convection, forced convection and pin fin. Radiation: Emissivity of a test plate and determination of Stefan Boltzmann's Constant (σ). Heat Exchanger: Effectiveness of parallel and counter flow heat exchangers.

References:

1. Y. A. Çengel and A. J. Ghajar, *Heat and Mass Transfer: Fundamentals & Applications*, 6th edition, McGraw-Hill Education 2025.
2. J. Holman and Souvik Bhattacharyya, *Heat Transfer*, 10th edition, McGraw-Hill Education, 2017.

MEE3203: Finite Elements Methods [3 1 0 4]

Review of Matrix Algebra, Theory of Elasticity: Equilibrium equations, Stress-Strain relations, Compatibility equations, Plane stress and plane strain equations. Introduction of FEM, Minimization of functional as solution of governing equations: Variational approach, Potential energy approach, Rayleigh Ritz methods, weak formulations and weighted residual (Galerkin method) methods. One Dimensional Elements: Bars- uniform, varying and Trusses. Beams. Stiffness matrix, force and displacement vectors and governing differential equations for such problems. 2-D element formulation, Constant Strain Triangle (CST) elements, 4-noded rectangular element Lagrange's Element formulations, Isoparametric elements, elemental analysis in FE software.

References:

1. D. Logan, *A First Course in the Finite Element Methods*, Enhanced Edition, SI version, (6e), CL Engineering, 2022
2. J.N. Reddy, *An Introduction to the Finite Element Method*, (4e), Mc Graw Hill 2020.
3. T.R. Chandrupatla, A.D. Belegundu, *Introduction to Finite Elements in Engineering*, (4e), PHI Learning Private Limited, 2015
4. R.D. Cook, D.S. Malkus, M.E. Plesha and R.J. Witt, *Concepts and Applications of Finite Element Analysis*, (4e), WILEY, 2007.

MEE3204 Computer Integrated Manufacturing and Automation [3 0 0 3]

Introduction to NC machines, DNC Machine, CNC Machine, Part Programming, Maintenance, Economics of machining using CNC machines. Introduction to Computer Integrated Manufacturing Systems [CIMS]: Components, Types of Manufacturing Systems, Group



Technology: Classification and Coding Systems. Computer Aided Process Planning: Rotational and prismatic parts, Inventory management, Material Requirement Planning [MRP], Manufacturing Resource Planning [MRP II], Capacity planning, Shop Floor Control, Introduction to FMS: AGV, AS/RS, Co-ordinate Measuring Machines [CMM], Universal Measuring Machine [UMM]. Robot Anatomy and Related Attributes: Classification of Robots, Robot Control systems, End Effectors, Sensors in Robotics, Industrial Robot Applications.

Reference:

1. K. Yoram, *Computer Control of Manufacturing Systems*, McGraw Hill Education, 1st edition, 2017.
2. M.P. Grover, *Automation, Production Systems, and computer Integrated manufacturing*, Pearson International Edition, 5th Edition, 2024.
3. P. Radhakrishnan, *Computer Numerical Control Machines and Computer Aided Manufacture*, New Academic Science Ltd., 2nd Edition, 2014.
4. R. Panneerselvam, P. Senthilkumar, P. Sivasankaran, *Computer-integrated Manufacturing: Automation in Manufacturing*, Cengage India Private Limited, 2020

MEE3205: Refrigeration and Air-conditioning [3 0 0 3]

Introduction to Basic refrigeration cycles, Air refrigeration cycles and applications, Air refrigeration cycles for aircrafts. Ideal and actual vapour compression cycle, Compound vapour compression refrigeration system and cascade systems, Vapour Absorption refrigeration system. Refrigerants and their properties. Human Comfort. Factors affecting human comfort. Steam jet refrigeration, Thermoelectric Refrigerators. Air Conditioning, psychrometric processes and charts, summer and winter air conditioning system, calculation of air-conditioning loads, Design of air conditioning systems, Energy efficient Air-conditioning systems, Introduction to ASARE standards, Safety and maintenance measures.

References:

1. Arora C. P. *Refrigeration and Air conditioning*, 3rd Ed., Tata McGraw Hill, 2017.
2. Manohar Prasad, *Refrigeration and Air Conditioning*, 3rd edition, New Age International Publishers, 2015.
3. John Tomczyk, Eugene Silberstein, William C. Whitman, William M. Johnson, *Refrigeration and Air Conditioning Technology*, Delmar Pub; 8th edition, 2016.

MEE3232: Refrigeration and Airconditioning Lab [0 0 2 1]

Experimental study and analysis of simple vapour compression cycle with T-S and P-H diagram, determination of the cooling capacity (TR) of vapour compression refrigeration unit, determination of the coefficient of performance(COP) of vapour compression refrigeration unit using various types of expansion valve such as capillary expansion valve & thermostatic expansion valve, determination of the COP of vapour absorption refrigeration system, experimental study of the various components of an Air conditioning system, determination of the cooling capacity (TR) and the COP of an Air conditioning system, determination of the effectiveness of cooling tower, Evaluation/determination of thermal/cooling load calculation by using human comfort and psychrometric chart.

References:

1. Arora C. P. *Refrigeration and Air conditioning*, 3rd Ed., Tata McGraw Hill, 2017.

MEE3233: Computer Aided Engineering Lab [0 0 2 1]

Introduction to FEA, Demo and Practice of Typical FE Analysis, One-Dimensional Practice Problems, Problem of Stepped Bar, Truss Problems, Simply Supports Beam Problems, Other Beam Problems, Thermal Analysis, Modal Analysis, Additional Problems, Project-based Problems, 2D and 3D Problems.

References:

1. ANSYS/ABAQUS latest user manuals
2. R.D. Cook, D.S. Malkus, M.E. Plesha and R.J. Witt, *Concepts and Applications of Finite Element Analysis*, (4e), WILEY, 2007.



MEE3234: Computer Integrated Manufacturing and Automation Lab [0 0 2 1]

CNC Part Programming for turning and milling operations, simulation software, Robot application for loading and unloading, Pneumatics and hydraulic systems, automated material handling system, automated inspection system, Programmable Logic Control (PLC).

References:

1. M.P. Grover, *Automation, Production Systems, and computer Integrated manufacturing*, Pearson International Edition, 5th Edition, 2024.
2. W. Bolton, *Programmable Logic Controllers*, Newnes, 6th Edition, 2015.
3. Andrew Parr, *Hydraulics and Pneumatics: A Technician's and Engineer's Guide*, Butterworth-Heinemann, 3rd Edition, 2011

MEE 4171 Internship (Industry/Research/Industry Certification) [0 0 4 2]

Each student has to undergo industrial training. This may be taken in a phased manner during the vacation starting from the end of sixth semester; the student has to submit to the department a training report in the prescribed format with a power point presentation followed by viva. The report should include the certificates issued by the industry.

MEE4271: Capstone Project [0 0 0 12]

Project Introduction, Introduction to the course structure and expectations, Project Proposal Development, Problem identification, Literature review, Defining objectives, scope, and deliverables, Submission of project proposal, Research and Preliminary Design, Data collection and analysis, Detailed Design and Development, Finalization of design/solution approach, Development of prototypes or models (if applicable), Progress report submission, Implementation of design/solution. Testing and validation, Troubleshooting and iterative refinement, Final Report and Presentation Preparation

References:

- 1.No specific textbook is required for this course. Students must use academic journals, conference papers, technical manuals, and other resources relevant to their project.
- 2.Software: Depending on the project, students may need to use CAD software, simulation tools, data analysis packages, etc.



B.Tech Mechanical Engineering - Syllabus of Flexi core (2025 scheme)

Flexi Core 1

MEE2123: Optimization Techniques [3 0 0 3]

Introduction to optimization: formulation and classification of optimization problems, engineering applications; Convexity in optimization; Linear programming: Model formulation and assumptions, simplex method, Duality theory, Large-scale linear programming; dynamic programming, integer programming and queuing theory ; Optimality conditions, Modern methods of optimization: single solution methods, population based methods; Solving optimization problems using MATLAB.

References:

1. K. Deb, Optimization for Engineering design algorithms and Examples, Prentice Hall, 2nd edition 2012.
2. J. S. Arora, Introduction to optimum design. Elsevier, 2012.
3. S. S. Rao, *Engineering Optimisation: Theory and Practice*, Wiley, 2008.
4. C.J. Ray, *Optimum Design of Mechanical Elements*, Wiley, 2007.
5. NPTEL, "Optimization Methods",
https://www.iitg.ac.in/rkbc/CE602/ce602_2024.htm#overview

MEE2124: Vehicle Architecture [3 0 0 3]

Automotive chassis and frames, functions, requirements, classification. chassis layout for conventional and electric vehicles, Braking systems: requirements, principle of operation, classification, different types of vehicle brakes. Steering systems: condition for true steering, steering linkages, and power steering. Suspension systems: classification, functions, rigid and independent suspension systems and suspension for electric vehicle. Automotive wheels and tyres. Dismantling and assembling of different types of braking systems, steering systems and suspension systems. Wheel balancing and alignment, battery pack layouts.

References:

1. T.R. Banga and N. Singh, Automobile Engineering, Khanna Publications, 2020.
2. G.B.S. Narang, *Automobile engineering*, Khanna Publications, New Delhi, 2018.
3. C. Mi, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley Publication, 2017.
4. N.K. Giri, *Automotive Mechanics*, Khanna Publications, New Delhi, 2003.

Flexi Core 2

MEE3123: Industrial Engineering [3 0 0 3]

Definition of Industrial Engineering, Method study, Principle of motion economy, Techniques of method study, Work measurement, time study, PMTS, Work sampling, Productivity, Various methods of measurement, Factors effecting productivity, Strategies for improving productivity. Manufacturing Cost Analysis: Fixed & variable costs, Direct, indirect & overhead costs, & Job costing, Cost control, Cost variance Analysis Break even Analysis. Materials Management: Relevant costs, Inventory control models - Economic order quantity (EOQ), Economic batch quantity (EBQ) with & without shortage, Inventory control systems Selective inventory control, Supply Chain Management, Quality Management: Costs of quality, Statistical quality Control (SQC), Variables & Attributes, X, R, P & C - charts, Acceptance sampling, OC - curve, Concept of AOQL, Sampling plan. Simple & Weighted moving average methods, Aggregate planning, Master production schedule (MPS), Sequencing - Johnson algorithm.

References:

1. S.N. Chary, *Industrial Engineering & Management*, 6th Edition, McGraw Hill Publication, 2019.
2. E. E. Adam, R. J. Ebert, *Production and Operation Management*, 5th Edition, Concepts, Models, and Behaviour, Prentice Hall Publishers, 2009.
3. Monks, *Operation Management*, 2nd Edition, McGraw Hill ISE, Latest Ed., 2004



MEE3124: Electric and Hybrid Vehicle Technology [3 0 0 3]

Overview and classification of EVs and HEVs (BEV, PHEV, series, parallel, series-parallel); comparison with conventional drivetrains. Architecture and components: power flow, battery, motor, controller, inverter, charger, DC-DC converter. Electric propulsion: BLDC, PMSM, induction motors, control, regenerative braking, torque vectoring. Battery technology: Li-ion, NiMH, lead-acid; SOC, DOD, SOH, BMS, thermal management, charging methods. Power electronics: inverters, converters, motor controllers. Energy management: power split strategies, control, and optimization. Charging infrastructure: levels, types, standards (CHAdeMO, CCS, GB/T). Testing and simulation: protocols, modelling with MATLAB/Simulink. Future trends: ultracapacitors, fuel cells, solar EVs, V2G, policy and grid integration.

References:

1. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2nd Ed., 2011.
2. C. Mi, M. A. Masrur, and D. W. Gao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley, 2011.
3. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Ed., 2012.
4. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2nd Ed., 2009.
5. Sandeep Dhameja, *Electric Vehicle Battery Systems*, Butterworth-Heinemann, 2002.

Flexi Core 3

MEE3220: Green Energy Technology [3 0 0 3]

Introduction to energy and green energy sources, Fundamentals of energy conversion, Solar PV systems, Solar Thermal Systems, Wind Energy Technology, Bioenergy systems, Hydro-power Generation, Tidal Energy systems, Ocean Thermal and other Green Energy Sources, Thermochemical energy conversion systems, Hydrogen as a fuel, Hydrogen generation and storage, Electro-chemical energy devices, Energy storage technologies.

References:

14. Sukhatme S.P. and Nayak J.K., *Solar Energy*, 4th Edition, McGraw-Hill Education Pvt., 2018, ISBN 978-93-5260-711-2.
15. Duffie J. A. and Beckman W. A., *Solar Engineering of Thermal Processes*, 4th Edition, Wiley, 2013, ISBN 978-0-470-87366-3.
16. Christopher D. R. and Chao-Yang Wang, *Battery system engineering*, 1st Edition, Wiley, 2013, ISBN: 9781119979500.
17. Yogi Goswami. D, Frank Kreith, Jan F. Kreider, *Principles of Solar Engineering*, 3rd Edition, Taylor & Francis, 2015. ISBN: 978-1-4665-6379-7.

MEE3221: Automotive Service Operations [3 0 0 3]

Service office Management: Service Parameters- Customer engagement index, technician skill enhancement, Function and role of service advisor and area technical lead. Warranty Processing system, Spare Parts Management at dealership, Customer Care management at service center.

References:

1. A Rezin, *Automotive Service Management- Principle to service*, PHI publication, 2018.
2. A Chikara, *Automobile Marketing & workshop techniques: Automobile Engineering Vol-3*, Satya publication, 2016.
3. C E Oven, *Basic Automotive Service and System*, Delmar Cengage Learning, 2015.
4. A A Rezin, *Automotive Service Management Principles into Practice*, (3e), Pearson, 2013.
5. J A Doshi, *Vehicle Maintenance and Garage Practice*, PHI Publication, 2014.



B.Tech Mechanical Engineering - Syllabus of Program Electives (2025 scheme)

Program Elective 1

MEE3150: Design Thinking [2 0 2 3]

Introduction to Design Thinking. Principles and stages: Empathize, Define, Ideate, Prototype, Test. Role of empathy and creativity in innovation. User Research and Empathy Building. Field observations, interviews, persona creation. Journey mapping and identifying user pain points. Problem Framing and Opportunity Finding. Defining Point-of-View (POV) statements. Crafting “How Might We” (HMW) questions. Ideation Techniques and Concept Development. Brainstorming, SCAMPER, idea clustering. Concept evaluation and selection. Prototyping and Testing. Low- and high-fidelity prototyping. User testing, feedback integration, iteration. Value Proposition and Product Positioning. Lean Canvas basics, customer segments, solution fit. Storytelling for products. Final Product Pitch and Showcase. Presenting the product concept and MVP. Peer reviews and reflective learning.

References.

1. Norman, D. A. *The design of everyday things*. MIT Press, 2013.
2. Brown, T. *Change by design: How design thinking creates new alternatives for business and society*. Harvard Business Press, 2009.
3. Ulrich, K. T., Eppinger, S. D., & Yang, M. C. *Product design and development* (7th ed.). McGraw-Hill Education, 2019.
4. Knapp, J., Zeratsky, J., & Kowitz, B. *Sprint: How to solve big problems and test new ideas in just five days*. Simon & Schuster 2016.
5. Croll, A., & Yoskovitz, B. *Lean analytics: Use data to build a better startup faster*. O'Reilly Media, 2013.

MEE3151: Quality Control and Management [3 0 0 3]

Introduction to Quality: Evolution of Quality, Definition, Dimensions of Quality, Inspection, Quality Control, Quality Assurance, Total Quality Management, Quality Gurus. Variation, its causes and types. Quality Control Tools: Check Sheet, Histogram, Pareto Chart, Cause & Effect Diagram, Scatter Diagram, Control chart, and Graphs. Control Charts: Control chart for variables- X-bar-R chart, X-bar sigma, IMR chart, Control chart for attribute - defectives chart p and np, defects charts c and u chart, process capability. Acceptance sampling: 100% inspection vs samplings, types of sampling and sampling plans. Operating characteristic curve, AOQ curve, AOQL, Producer's and Consumer's risks, Quality Management: type of quality costs, cost of poor quality, six-sigma, Quality Circles, Strategic quality management, Quality and Reliability. Quality 4.0: Data Analytics, Big data analytics, Framework, principles and tools for Q4.0.

References:

18. J.A. Defeo, and J. Defeo, *Juran's Quality Essentials: For Leaders*. United Kingdom: McGraw Hill LLC, 2014.
19. D.C. Montgomery, *Introduction to Statistical Quality Control*. United Kingdom: Wiley, 2020.
20. Poornima M. Charantimath *Total Quality Management*. 3rd edition Pearson India 2017.
21. E.L. Grant, *Statistical Quality Control*, 7th Edition, McGraw Hill Publications, New York, 2017.

MEE3152: Composite Materials [3 0 0 3]

Definition and Classification of Composites. Reinforcing fibres- Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids, etc. Short and continuous fibre reinforced composites. Particulate fillers-importance of particle shape and size. Matrix resins-thermoplastics and thermosetting matrix resins. Coupling agents-surface treatment of fillers and fibres, significance of interface in composites. Fabrication techniques pultrusion, filament winding, prepreg technology, injection and compression moulding, resin



transfer moulding, reaction injection moulding etc. Biocomposites, Nanocomposites
Micromechanics of composites. Properties and performance of composites. Applications.
Mechanisms of fracture in composites. Property evaluation and NDT of composites.

References:

1. Chawla, K.K., *Composite Materials - Science & Engineering*, 4th Edition, January 2021, Springer Cham, New York, ISBN: 978-3-030-28985-0.
2. Carlsson, L. A., Adams, D.F., and Pipes, R.B., *Experimental Characterization of Advanced Composite Materials*, 4th Edition, March 2014; CRC Press, New Jersey, ISBN: 9780429109393.
3. Nielsen, L.E., and Landel, R.F., *Mechanical Properties of Polymer and Composites*, 2nd Edition, 2014, CRC Press, USA, ISBN: 978-1-4822-7743-2.
4. F.L. Matthews and R.D. Rawlings, *Composite Materials: Engineering and Science*, 1st Edition, Reprint 2008, Woodhead Publishing, London, ISBN: 978-1-85573-473-9.

MEE3153: Computer Aided Design [3 0 0 3]

Overview of computer aided engineering design, Representation of points; Transformation matrix; Transformation of a point; Homogeneous coordinates; General transformation - rotation, reflection, translation, scaling and shearing. Representation of curves, curve fitting techniques, Cubic curves, Beziers and B-splines, Hermite curve, Rational curves\NURBS. Types and representation of surfaces, Analytic surfaces, Synthetic types, Polygon surfaces, Quadric and super quadric surface, Bezier and B-spline surface, Hermite surface, Coon's surface, Blobby objects. Solid Modeling: Constructive solid geometry, Boundary representation, CAD standards, Graphical kernel system (GKS), Data exchange standards for modelling data.

References:

1. I. K. Zeid, *Mastering CAD/CAM - SI Edition*, McGraw Hill Education, New Delhi, 2024.
2. D. F. Rogers and J Alan Adams, *Mathematical Elements for Computer Graphics*, Tata McGraw Hill New Delhi, (2e), 2017.
3. C K Maiti, *Introduction to Computer Aided Design*. Jenny Stanford Publishing, (1e), 2017
4. I. K. Zeid, *CAD/CAM Theory and Practice*, McGraw Hill Education, New Delhi, 2009.

Program Elective 2

MEE3257: Control Systems [3 0 0 3]

Introduction to control systems, difference between open-loop and closed-loop systems, and the importance of feedback. Basics of mathematical modeling of simple mechanical systems and representation using block diagrams. Introduction to transfer functions and simple signal flow graphs. Time-domain analysis of first- and second-order systems with step and ramp inputs, and basic performance measures like rise time, settling time, and steady-state error. Fundamentals of stability with Routh-Hurwitz criterion and root locus concepts. Basics of frequency response using Bode plots and Nyquist plots. Introduction to PID controllers and simple tuning. Applications of control systems in mechanical engineering such as motor speed control, vibration reduction, and process control. Basic use of MATLAB/Simulink for modelling and simulation.

References:

1. K. Ogata, *Modern Control Engineering*, Pearson, 5th Edition, 2010.
2. Norman S. Nise, *Control Systems Engineering*, Wiley, 7th Edition, 2015.
3. J. L. Nagrath and M. Gopal, *Control Systems Engineering*, New Age International, 5th Edition, 2012.
4. NPTEL, "Control Engineering," <https://nptel.ac.in/courses/107106081>

MEE3258: Industrial Robotics [3 0 0 3]

Fundamentals and scope of industrial robotics. Classification and structure of robotic manipulators. **Robot kinematics:** coordinate frames, forward and inverse kinematics,



Denavit-Hartenberg (D-H) parameters, Jacobian and velocity kinematics, singularities, and workspace analysis. **Robot dynamics:** Lagrangian and Newton-Euler formulations, dynamic modeling of manipulators, trajectory generation, and motion planning. **Robot control:** position and force control, feedback systems, stability analysis. Actuators (electric, pneumatic, hydraulic) and industrial sensors (vision, tactile, force/torque). Introduction to robot programming and simulation tools. Case studies of kinematics and dynamics applications in industrial tasks such as pick-and-place, welding, and assembly. Emerging trends in advanced robotics and Industry 4.0 integration.

References:

1. M. P. Groover, *Industrial Robotics: Technology, Programming, and Applications*, McGraw Hill, 2020..
2. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson, 4th Ed., 2018.
3. S. K. Saha, *Introduction to Robotics*, McGraw Hill, Standard Edition, 2024.

MEE3259: Production Design and Development [3 0 0 3]

New product development, characteristics, challenges, economics, value, concurrent and reverse engineering. Product development process: planning, concept development, system-level design, detailed design, testing and refinement, production ramp-up. Identifying Voice of Customer: Product opportunity identification, Perceptual mapping, Kano model, Quality function deployment, benchmarking, product specifications, conjoint analysis, Failure mode and effects analysis. Concept selection, testing and prototyping, Product Architecture: Integral and modular design, Robust design, Industrial design, Design for manufacturing, Design for X, Product Lifecycle Management, Rapid prototyping - needs, advantages, working principles of SLA, LOM, and SLS. Intellectual Property Rights: Patents, copyrights, trademarks, geographical indicators.

References:

1. Ulrich., Eppinger, and Yang, *Product Design and Development*, Tata McGraw Hill 7e, 2020.
2. Chitale, A. K. and Gupta, R. C., *Product Design and Manufacturing*, PHI 7e, 2013.
3. Jamnia., A., *Introduction to Product Design and Development for Engineers*, CRC Press, 2018
4. Otto K, Wood K, *Product Design: Techniques in Reverse Engineering and New Product Development*, Pearson, 2001.
5. NPTEL, “*Product Design and Development*,”, <https://nptel.ac.in/courses/112107217>, Accessed on: August 2025.

MEE3260: Production and Operations Management [3 0 0 3]

Introduction to production and operations management. Forecasting: Concept, Basic elements, Classification, Purpose of forecasting, Qualitative and Quantitative techniques of forecasting, Inventory Models, Supply Chain Management, Quality Control, TQM. Production planning and control: Nature, Types, Elements, strategy and aggregate production planning, production control>Loading and scheduling, Line balancing, Sequencing, Facility capacity, JIT, Lean Manufacturing and Kanban, Plant location and layout: Types of layout, Methodology of layout planning, Computer aided plant layout.

References:

1. S. Paton, B. Clegg, J. Hsuan, and A. Pilkington, *Operations Management*, (2e), McGraw Hill Publication, 2021.
2. S. N. Chary, *Production and Operations Management*, (6e), McGraw Hill Publication, 2019.
3. W. J. Stevenson, *Operation Management*, (13e), McGraw Hill Publication, 2017.
4. J. Heizer, B. Render, C. Munson, (12e), *Operations Management*, (12e), Pearson Publication, 2017.



5. MOOC Course on *Production and Operation Management* IIT Roorkee Prof. Rajat Agarwal. https://onlinecourses.nptel.ac.in/noc22_mg15/preview (accessed on 25-08-2025)

MEE3261: Smart Manufacturing

[3 0 0 3]

Introduction: definition, scope, Evolution and historical perspective, Smart Manufacturing ecosystem, Industry 4.0 framework, Key components of Industry 4.0 and its applications, Internet of Things (IoT), Components, working, Types and Devices, Common Communication Protocols, IIoT, Applications, Privacy, Security Issues and Policy, and Case Study, Cyber Physical Systems, Machine Learning: Concept, Learning algorithms- Supervised, Unsupervised, and Deep learning, Introduction to Big Data, Neural Networks, Applications in manufacturing, Examples in manufacturing Systems, Smart Design/Fabrication, Digital Tools, Product Representation and Exchange Technologies and Standards, Smart Machine Tools, Robotics and Automation. Smart Applications: Online Predictive Modelling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes.

References:

1. Anthony Tarantino, *Smart Manufacturing; The Lean Six Sigma Way*, 2018, O'Reilly.
2. Masoud Soroush, Michael Baldea, Thomas F. Edgar, *Smart Manufacturing, Concepts and Methods*, 2020, Elsevier.
3. Amit Kumar Tyagi, Shrikant Tiwari, Senthil Kumar Arumugam, Avinash Kumar Sharma, *Artificial Intelligence-Enabled Digital Twin for Smart Manufacturing*, 2024, Wiley.
4. A. McEwen and H. Cassimally, *Designing the Internet of Things*, Reprint, 1st edition, 2018, Wiley.
5. Ajay, Hari Singh, Parveen, Bandar Al Mangour, *Handbook of Smart Manufacturing: Forecasting the Future of Industry 4.0*, 2023, Boca Raton, CRC Press.

Program Elective 3

MEE4150 Computational Fluid Dynamics [3 0 0 3]

Introduction to CFD, models of flow, laws of physics, derivations of Continuity, Momentum and Energy equations in Cartesian coordinate system, Transformation of these equations from Non conservative form to conservative; Initial and boundary conditions: One-way and two-way co-ordinates, Discretization Process- concept and structure, Methods of deriving the discretised equations, Explicit Taylor series expansion, Implementation of boundary conditions, The Four basic rules in control volume formulation. The derivation of the pressure correction equation as Poisson's Pressure equation, Implementation of boundary conditions in CFD. Grid generation using algebraic and partial differential equations; N-S equations in irregular geometry: transformation of N-S equation in curvilinear coordinate system, non-orthogonal grid.

References:

1. J.D. Anderson Jr., *Computational Fluid Dynamics- The Basics with Applications*, (6e), International Edition, McGraw Hill, 2017.
2. H.K. Versteeg, W. Malalasekera, *An Introduction to Computational Fluid Dynamics- The Finite Volume Method*, (2e), Longman Scientific & Technical, 2007.
3. K.Muralidhar, T. Sundararajan, *Computational Fluid Flow and Heat Transfer*, (2e), Narosa Publishing House, 2009.
4. B. Andersson, R. Andersson, L. Hakansson, M. Mortensen, R. Sudiyo, B. V. Wechen, *Computational Fluid Dynamics for Engineers*, (1e), Cambridge Press, 2011.

MEE4151 Micro-Electromechanical Systems [3 0 0 3]

Introduction to miniaturization, overview of micro-electromechanical systems, Fabrication Technologies: dry etching, plasma etching; wet etching; High Aspect-Ratio device fabrication: LIGA process, Deep Reactive Ion Etching (DRIE); Thin film deposition: Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD); Evaporation and sputtering,



Sensing and Actuation: Micro sensors and actuators, including piezoelectric devices and shape memory alloys, Bulk micromachining, Surface Micromachining, MEMS Metrology, Microfluidics, micro-robots, mechanical packaging of microelectronics, assembly of microsystems, packaging materials, modelling and simulation for MEMS devices, MEMS devices in commercial applications: digital micromirror devices (DMD), radio frequency MEMS switches, scanning tunnelling microscopes (STM).

References:

1. Tai-Ran Hsu, *MEMS and Micro systems Design and Manufacture*, (Indian edition), McGraw Hill Education, 2017
2. Marc Madou, *Fundamentals of microfabrication: the science of miniaturization*, CRC Press, 2018.
3. Nitaigour P. Mahalik, *Micromaufacturing and Nanotechnology*, Springer-Verlag Berlin, 2007.
4. Chang Liu, *Foundation of MEMS*, (2e), Pearson Education Inc., 2011.
5. G.K. Ananthasuresh, *Micro and Smart Systems*, (1e), Wiley, India, 2010.

MEE4152 Noise, Vibration and Harshness [3 0 0 3]

Introduction to NVH: Noise, Vibration, and Harshness (NVH) and its role in mechanical design and development. Physiological effects of harshness due to noise and vibration, sources of vibration and noise in mechanical systems. Basics of Vibration Analysis: Basic concepts, Harmonic motion, derivation of equations using Newton's laws, D'Alembert's principle, and energy methods. Mathematical models, formulating the equations of motion for linear and torsional system characteristics and response - damped and undamped single & two degree of freedom systems under harmonic force, coordinate coupling, generalized coordinates, and modal analysis. Vibration Control Techniques: Vibration isolation, tuned absorbers, viscous dampers, damping treatments, and Metamaterials. Passive, Active, and Semi-Active Vibration Control. Noise Fundamentals: Fundamentals of acoustics - general sound propagation: structure-borne sound & air-borne sound. NVH Measurements: Vibration and Noise Standards - Pass/Drive by noise, noise from stationary vehicles, interior noise in vehicles, NVH measurement tools and techniques. Noise control strategy, noise control at source - along the path - isolation, damping, balancing, resonators, absorption, barriers, and enclosure, acoustic metamaterials. Case studies of noise and vibration in mechanical systems: Passenger car, passenger train.

References:

1. S. S. Rao, *Mechanical Vibrations*. Pearson Education. 2018
2. W. T. Thomson, *Theory of Vibration with Applications*. CRC Press, (1e), eBook, 2018
3. M. L. Munjal and B. Venkatesham. *Noise and Vibration Control*, World Scientific. 2024.
4. M. P. Norton and D. G. Karczub, *Fundamentals of Noise and Vibration Analysis for Engineers*. Cambridge University Press, 2003.
5. NPTEL, "Noise Control in Mechanical Systems", <https://nptel.ac.in/courses/112107619> , Accessed on: August 2025.

MEE4153: Artificial Intelligence in Mechanical Engineering [3 0 0 3]

Introduction to AI in Mechanical Engineering, fundamental concepts, impacts and examples in mechanical engineering, Probability Theory and Hypothesis Testing, Dimensionality Reduction and Transforms, Classification Model, Singular value decomposition (SVD), Fourier and wavelet transform. Sparsity and compressed sensing, Machine Learning and Data Analysis, Fuzzy Logic Analysis, Regression and model selection, Clustering and classification, Clustering Model, Neural Network and Deep Learning, Soft Computing Applications, properties of Biological Neural Networks, Feed Forward Neural Networks, Recurrent Neural Networks-Perceptron's classification- Activation Functions- Back Propagation Networks-Image classification using CNN, YOLO Algorithm, Pooling layer and Feature extraction, Dynamics and Control, Dynamic Programming, Data-driven dynamical systems. Linear



control theory, Balanced models for control, Data-driven control, Application of Artificial Intelligence in Mechanical Manufacturing Industries.

References:

1. Tom M Mitchell, *Machine Learning*, First Edition, McGraw Hill Education, 2013.
2. Jason Bell, *Machine learning - Hands on for Developers and Technical Professionals*", First Edition, Wiley, 2014.
3. NPTEL course, *Artificial Intelligence: Concepts and Technique*, https://onlinecourses.nptel.ac.in/noc25_cs159/preview, August 2025.
4. Haykin Simon, *Neural networks a comprehensive foundation*, Pearson Education, 2nd Edition, 1997.

B.Tech Mechanical Engineering (honours) - Syllabus (2025 scheme)

MEE3181: Vehicle Dynamics and Control [3 0 0 3]

Introduction to vehicle coordinate systems and axle loads in static and dynamic conditions. Analysis of acceleration performance under power and traction limits. Tire dynamics including construction, force generation, slip, and cornering behavior. Aerodynamic effects: airflow mechanics, pressure distribution, and vehicle stability moments. Braking performance with force analysis and control systems (ABS, traction control). Steering system geometry, steer characteristics, and directional stability. Suspension types, geometry, damping, ride dynamics, and active control. Roll-over analysis covering quasi-static and transient behavior using yaw-roll models.

References:

1. H.B. Pacejka, "Tyre and Vehicle Dynamics", Germany: Butterworth-Heinemann, 2012.
2. R. Rajamani, "Vehicle Dynamics and Control", Springer 2012.
3. Reza N. Jazar, "*Vehicle Dynamics: Theory and Application*", Springer, 2008.
4. N.K. Giri, *Automobile Mechanics*, Khanna Publishers, 2008.
5. T.D. Gillespie, *Fundamental of Vehicle Dynamics*, SAE Press 1995.

MEE3182: Biomaterials and Regenerative Engineering [3 0 0 3]

Importance and classification of biomaterials, Natural and synthetic biomaterials, nano biomaterials for long-term biomedical applications. Product Testing, physical, mechanical, chemical and biological properties of Biomaterials, regulatory approvals, ethical issues. Tissue engineering, wound healing and the foreign body response, degradation of biomaterials in biological environment. Methods of manufacturing soft and hard tissue implants, hydrogels, organ-on a chip, scaffolds: design and fabrication, 3D printing, bioprinting. Applications of Biomaterials including cardiovascular, neurological, orthopaedic, dental, drug delivery, sutures and biosensors.

References:

1. Wagner, W., Sakiyama-Elbert, S., Zhang, G., Yaszemski, M.J. *Biomaterials Science: An introduction to Materials in Medicine*; 4th Edition, June 2020; Academic Press, California, USA; ISBN: 9780128161371 (Hardback), 9780128161388 (eBook).
2. Sultana, N., Bandyopadhyay-Ghosh, S., and Phong, S.C., *Tissue Engineering Strategies for Organ Regenerations*, 1st Edition, April 2020; CRC Press, USA, ISBN: 9780429749612.
3. Black, J., *Biological Performance of Materials: Fundamentals of Biocompatibility*, 4th edition, December 2005; Taylor and Fransis, CRC Press, USA, ISBN: 9780849339592.

MEE3281: Biomechanics [3 0 0 3]

Introduction of Fundamentals of Biomechanics- Definition of Biomechanics & Sports Biomechanics, Importance of Biomechanics, Goals of Sports Biomechanics - Performance Enhancement, Technique, Equipment, Training, Injury Prevention and Rehabilitation. Linear and Angular Kinematics, Linear Kinetics, Angular Kinetics of Human Movement. Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties. Soft Tissues: Structure and functions of Soft Tissues: Cartilage, Tendon, Ligament, and Muscle. Modelling of soft tissues: Cartilage, Tendon, Ligament, and Muscle, Hills's muscle model. Applied Biomechanics: Engineering approaches to standing, sitting and lying, Biomechanics of gait, application of gait and locomotion analysis, Fluid mechanics and energetics: Forms of energy and energy transfer.

References:

1. Duane knudson, *Fundamental of biomechanics*, springer, 2nd edition 2007
2. D. J. Schneck and J. D. Bronzino, *Biomechanics- Principles and Applications*, CRC Press, 2nd Edition, 2000



3. Mow, Van C.; Huiskes, Rik, *Basic Orthopaedic Biomechanics and Mechano-Biology*, 3rd Edition, 2005, Lippincott Williams & Wilkins.

MEE3282: Sustainability and Life Cycle Assessment [3 0 0 3]

Sustainability concepts (triple bottom line, SDGs, resource efficiency), engineering and industry practices (footprints, circular economy, green supply chains), and Life Cycle Assessment (LCA) including phases, types, ISO standards, inventory, and impact assessment. It also includes applications of LCA (automotive, energy, packaging, buildings, consumer goods), and future aspects like policy integration, digitalization, and life cycle sustainability assessment.

References:

1. Finkbeiner et al., *Introduction to Life Cycle Assessment*, Chapman & Hall/CRC Press, 2022.
2. M. Hauschild, R. K. Rosenbaum, S. I. Olsen, *Life Cycle Assessment: Theory and Practice*, Springer, 2018.
3. M.Z. Hauschild, J. Jeswiet, L. Alting, *Sustainable Manufacturing*, CIRP Annals, Elsevier, 2005.
4. M. Curran (Ed.), *Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products*, Wiley, 2012.
5. G. Rebitzer et al., *Life Cycle Assessment: Part 1: Framework, Goal and Scope Definition, Inventory Analysis, and Applications*, Environment International, 2004.

MEE3283 Rubber Technology [3 0 0 3]

Fundamentals of rubber (history, classification, structure, elasticity), chemistry of elastomers (polymerization, vulcanization, compounding), processing and manufacturing (mixing, molding, extrusion, calendaring, defects), testing and characterization (mechanical, thermal, dynamic, standardization), and applications in automotive, medical, aerospace, defence, and sustainable technologies (recycling and reclaiming). devulcanization for eco-friendly practices.

References:

4. J.S. Dick, *Rubber Technology: Compounding and Testing for Performance*, 3rd Ed., Hanser Publishers, 2020.
5. J.S. Dick, H. Pawlowski, *Practical Rubber Rheology and Dynamic Properties*, Hanser Publishers, 2023.
6. J.S. Dick, *Testing Rubber Products for Performance*, ASTM International, 2023.
7. S. Kohjiya, Y. Ikeda, A. Kato, *Chemistry, Manufacture and Applications of Natural Rubber*, 2nd Ed., Elsevier, 2021.
8. S. Kohjiya, A. Kato, *Innovations of Rubber Chemistry and Technology for Sustainability*, The Royal Society of Chemistry, 2025.

MEE4182 Energy Conservation and Management [3 0 0 3]

Energy types, needs, scenario, energy security, Environmental Impact, energy reforms, material & energy balance, consumption pattern, Sankey Diagram, Energy Policy, Energy Conservation Act 2001, Electricity Act 2003, Energy Reforms, National Action Plan for Climate Change (NAPCC), Energy Codes and Standards, Energy Audit concepts: Audit Purpose & Scope, types of Energy Audit & methodologies, Audit Instruments, Energy Management principles, Benchmarking and Strategies, performance assessment of electrical utilities, performance assessment of thermal utilities, Energy Economic Analysis, Role of ESCOs, Financial Management: Investment-need, appraisal and criteria, Financial analysis techniques- Simple payback period, Return on Investment, Net Present Value, Internal Rate of Return, Cash flows, Risk and Sensitivity analysis, Financing options, Demand Side Management(DSM).

References:



1. Y.P. Abbi, and S. Jain, *Handbook on Energy Audit and Environment Management*, The Energy and Resources Institute, 2009.
2. Frank Kreith and D. Yogi Goswami, *Introduction to Energy Conservation and Management*, CRC Press, 2017.
3. Paul O'Callaghan, *Energy Management*, McGraw-Hill Education.
4. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, *Energy Management Handbook*, (7e), CRC Press, 2011.
5. Steve Doty and Wayne C. Turner, *Energy Management Handbook(7e)*, Fairmont Press, USA, 2009.

MEE4183: Drone Technology [3 0 0 3]

Definition and history of drones, Types of drones and their applications, Drone components and terminology, Regulations and Guidelines for drone usage, Design considerations for drone airframe and propulsion systems, Selecting and assembling drone components such as motors, batteries, flight controllers, and cameras, Basic wiring and soldering techniques. Drone Motors and ESC: Working, Types: Brush and Brushless Motors, motor sizing and identification, mounting patterns and thread size, Thrust to Weight ratio, KV ratings, advanced motor selection.

References:

1. S. K. Koppa, *Drone Technology: Theory and Practice*, Springer, 2020.
2. P. Horowitz and W. Hill, *The Art of Electronics*, Cambridge University Press, 2015.
3. D. McLeod, *Getting Started with Drone: How to Build, Fly, and Program Your Own Drone*, Apress, 2019.
4. M. A. Banks, *Building and Flying Electric Model Aircraft*, O'Reilly Media, Inc., 2014.
5. G. C. Camara Leal, *Flying Robots: An Introduction to Autonomous Aerospace Systems*, Springer, 2017.

MEE4184 Engineering Fracture Mechanics [3 0 0 3]

Introduction: Historical perspective, Stress concentration effects of flaws, Fracture Mechanics approach to design, Effect of material properties on fracture, Damage tolerance. Linear Elastic Fracture Mechanics (LEFM): An atomic view of fracture, Stress concentration effect of flaws, Mathematical foundation of LEFM, The Griffith energy balance, The energy release rate, The path independent, J-, L-, and M-integrals, The Westergaard stress function, Stress analysis of cracks, The stress intensity factor, Edge crack, Elliptical crack, Relationship between K and G, Crack Tip Plasticity, The Irwin's approach, The strip yield model, comparison of plastic zone correction, Plane stress vs Plane strain, K as a failure criterion, Effect of loading mode and specimen dimension. Introduction to Fracture Toughness Testing.

References:

1. T.L. Anderson, *Fracture Mechanics: Fundamentals and Applications*, (4e), CRC Press, 2017.
2. E.E. Gdoutos, *Fracture Mechanics: An Introduction*, (2e), Springer, 2006.
3. P Kumar, *Elements of Fracture Mechanics*, McGraw Hill Education India, 2009.

MEE4185: TRIBOLOGY [3 0 0 3]

Introduction to Tribology, Engineering surfaces, surface contact, adhesion. Causes of friction, friction theory, laws of rolling friction, friction of non-metallic material. Introduction, adhesive wear, abrasive wear, corrosive wear, wear analysis and wear mechanisms for various materials, abrasive wear, delamination theory, tool wear, erosive wear, wear of polymers and composites; Importance of lubrication, boundary lubrication, mixed lubrication, full fluid film lubrication, Elasto-hydrodynamic lubrication, types and properties of lubricants, lubricants additives. Fluid mechanics concepts, equation of continuity and motion, Generalized Reynold's equation with compressible and incompressible flow. Rolling contact bearing, sliding contact bearing.

References:



1. G.W. Stachowiak, A.W. Batchelor, *Engineering Tribology*, (3e), Elsevier Inc., 2005.
2. J. Halling, *Principles of Tribology*, The Macmillan Press Ltd, 1975.
3. P. Sahoo, *Engineering Tribology*, PHI, 2005.
4. K.C. Ludema, *Friction, Wear, Lubrication: A textbook in Tribology*, CRC Press, 2010.
5. B. Bhushan, *Introduction to tribology*, (2e), Wiley, 2013.
6. *Tribology of Polymers, Polymer Composites, and Polymer Nanocomposites*, 2023

MEE4186: Blockchain Technology [3 0 0 3]

Introduction to blockchain technology and its role in digitalization; Cryptographic concepts: hashing, public key cryptosystems; Public vs. private blockchains and their use cases; Bitcoin blockchain and scripting language applications; Limitations of Bitcoin and mining challenges; Alternative cryptocurrencies: Ethereum, Smart Contracts, and IOTA; Consensus mechanisms and Byzantine Generals Problem; Permissioned blockchains: Hyperledger and Corda; Applications of blockchain in e-Governance, land registration, healthcare, and other sectors

References:

1. Bashir, I. (2020). *Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more*. Packt Publishing Ltd.
2. Julie, E. Golden, J. Jesu Vedha Nayahi, and Noor Zaman Jhanjhi, eds. (2020) *Blockchain Technology: Fundamentals, Applications, and Case Studies*. CRC Press.
3. Ethereum Development Resources - <https://ethereum.org/en/developers>
4. SWAYAM, "Blockchain and its Applications", https://onlinecourses.nptel.ac.in/noc20_cs01/preview , Accessed on: September 2025.

MEE4281: Honors Project [0 0 0 6]

Project Introduction, Introduction to the course structure and expectations, Project Proposal Development, Problem identification, Literature review, Defining objectives, scope, and deliverables, Submission of project proposal, Research and Preliminary Design, Data collection and analysis, Detailed Design and Development, Finalization of design/solution approach, Development of prototypes or models (if applicable), Progress report submission, Implementation of design/solution. Testing and validation, Troubleshooting and iterative refinement, Final Report and Presentation Preparation

References:

- 1.No specific textbook is required for this course. Students must use academic journals, conference papers, technical manuals, and other resources relevant to their project.
- 2.Software: Depending on the project, students may need to use CAD software, simulation tools, data analysis packages, etc.

B.Tech Mechanical Engg with minor specialization - syllabus (2025 scheme)

Minor Specialization (Automobile Engineering)

MEE3190: Vehicle Drive Line Systems [3 0 0 3]

Introduction to transmission: Power Required for Propulsion: Resistances to Motion of the Automobile. Clutch: Types of clutches, construction and operation of all types. Gearbox: types of gearboxes, Performance characteristics of different gears, Propeller shaft, Differential. Fluid Coupling and Torque converters: Constructional details, performance characteristics, Epicyclic Transmission: Principle of operation, types of planetary transmission, Calculation of gear ratio in different speeds, Hydrostatic Drives: Principles of hydrostatic drives, different systems of hydrostatic drives, construction and operations. Automatic and Electric Transmissions.

References:

1. Kirpal Singh, Automobile Engineering Vol.1, Standard Pub, 14th edition, 2019.
2. G.B.S.Narang, Automobile Engineering, Khanna publication, New Delhi, 2008.
3. W.H.Crouse, *Automotive transmissions and power trains*, McGraw Hill Co. 6th edn, 1983.
4. K.Newton and W. Steeds, *Motor Vehicle*, W. Butter Worths and Co., Publishers Ltd, 1977.

MEE3290: Vehicle Electronics Systems [3 0 0 3]

Introduction to Vehicle Electronics: Overview of electronic architecture in modern vehicles, Functional requirements of automotive electronic systems, Electronic Control Units (ECUs): Sensors in Vehicles, Actuators in Vehicles, Automotive Networking & Communication, Automotive Control Applications: Digital engine control systems, vehicle motion control, cruise control systems, stepper motor-based actuators, ABS, traction control systems, electronically controlled power steering. Future Trends in Automotive Electronic, ADAS, ESP, lane assistance, adaptive cruise control, Cybersecurity in vehicle electronics.

References:

1. Najamuz Zaman, Automotive Electronics Design Fundamentals, Springer, 2020.
2. William B. Ribbens, *Understanding Automotive Electronics*, Butterworth-Heinemann, 8th Ed., 2017.
3. Tom Denton, Automobile Electrical and Electronic Systems, Routledge, 5th Ed., 2017.
4. Konrad Reif (Ed.), Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics (2nd Ed.), Springer, 2015.
5. U. Kiencke and L. Nielsen, *Automotive Control Systems: For Engine, Driveline, and Vehicle*, Springer, 2005.

MEE4190: Vehicle Body Engineering [3 0 0 3]

Introduction to vehicle Body engineering, Types of car bodies, Visibility: Regulations, driver's visibility, tests for visibility, methods of improving visibility and space in cars. Safety: Safety design, safety equipment for cars. Car body construction: Design criteria, prototype making, initial tests, crash tests on full-scale models, Dummies and Instrumentation. Vehicle Aerodynamics: Vehicle drag and types; forces and moments, side wind effects, body optimization techniques for minimum drag. Wind tunnel testing: Flow visualization techniques, scale model testing, component balance to measure forces and moments. Bus Body: Types, layout, entrance, exit and seating dimensions. Constructional details: Frame construction, double skin construction, types of metal sections used, Regulations, Conventional and integral type construction. Commercial Vehicle body, Driver's cab design.

References:

1. R. Srinivasan, Automobile Engineering - Vol. 2: Body Engineering, McGraw Hill Education, 2016



2. David A. Crolla, *Automobile Engineering, Power train chassis system and vehicle body*, Butterworth-Heinemann Publication 2009.
3. H. Heisler, *Advanced Vehicle Technology*, Butterworth-Heinemann, 2002
4. Jason C. Brown, *Vehicle Body Layout and Analysis*, SAE International, 2002
5. Julian Happian smith, *A Introduction to Modern vehicle design*, Butterworth-Heinemann Publication 2001.

MEE4191: Energy Storage in Electric Vehicles [3 0 0 3]

Energy storage requirements for vehicle applications, , Distribution of Energy, Storage Form of Energy, Intermediary Conversion, Control and Diagnostic, Ragone Plot of a Battery, Case of the Capacitor, Different Types of Accumulators Lead-Acid, Alkaline, The Nickel-Iron Battery Nickel-Cadmium, Ni- MH, Lithium-Ion, Sodium-Sulphur (NaS) Battery, Modelling of Batteries, Thermal Behaviour of a Battery. Battery Management Systems (BMS), Lithium-Ion Batteries Aging Effects. Battery characterisation and testing systems & Battery life cycle, Modular battery packs, packaging, thermal control and legislative implications. Supercapacitors, Hydrogen Fuel Cells: Hydrogen Generation and Storage of Hydrogen, Conversion from Hydrogen to Electricity. Solid-state batteries, fuel cells, and energy harvesting technologies.

References:

1. Chris Mi, *Hybrid Electric Vehicles: Principles and Applications*, Wiley, 2017.
2. A Rufer, *Energy Storage Systems*, CRC Press, 2017.
3. C Wayne and Turner, *Energy Management Handbook*, (5e) The Fairmont Press Inc., 2015.
4. C Glaize and S Genies, *Lithium Batteries and Other Electrochemical Storage Systems*, (1e), Wiley, New York, 2013.
5. M. Ehsani, Y. Gao, S. E. Gay, A. Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2009.

MEE4282: Minor Specialization Project [0 0 0 6]

Project Introduction, Introduction to the course structure and expectations, Project Proposal Development, Problem identification, Literature review, Defining objectives, scope, and deliverables, Submission of project proposal, Research and Preliminary Design, Data collection and analysis, Detailed Design and Development, Finalization of design/solution approach, Development of prototypes or models (if applicable), Progress report submission, Implementation of design/solution. Testing and validation, Troubleshooting and iterative refinement, Final Report and Presentation Preparation

References:

- 1.No specific textbook is required for this course. Students must use academic journals, conference papers, technical manuals, and other resources relevant to their project.
- 2.Software: Depending on the project, students may need to use CAD software, simulation tools, data analysis packages, etc.