DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING, MIT, MANIPAL

M.TECH. IN COMPUTER AIDED ANALYSIS AND DESIGN

Program Structure (Applicable to 2023 admission onwards)

YEAR	FIRST SEMESTER						SECOND SEMESTER					
	COURSE CODE	COURSE NAME	L	T	P	C	COURSE CODE	COURSE NAME	L	T	P	C
I	MIE 5111	Numerical Methods and Computer Programming	3	1	0	4	MIE 5211	Application of Computers in Bearing Design	3	1	0	4
	MIE 5112	Advanced Mechanics of Solids	3	1	0	4	MIE 5212	Non-Linear Finite Element Methods	3	1	0	4
	MIE 5113	Finite Element Methods	3	1	0	4	MIE ****	Program Elective-I	3	1	0	4
	MIE 5114	Applied Mechanical Vibrations	3	1	0	4	MIE ****	Program Elective-II	3	1	0	4
	MIE 5115	Fatigue, Fracture and Failure Analysis	3	1	0	4	MIE ****	Program Elective-III	3	1	0	4
	HUM 5051	Research Methodology and Technical Communication*	1	0	3	-	*** ****	Open Elective	3	0	0	3
	MIE 5141	CAD Lab	0	0	6	2	HUM 5051	Research Methodology and Technical Communication*	1	0	3	2
	MIE 5142	Design Engineering Lab	0	0	3	1	MIE 5241	Finite Element Analysis Lab	0	0	6	2
	Total		**16**	**5**	**12**	**23**			**19**	**5**	**9**	**27**
	THIRD AND FOURTH SEMESTERS											
II	MIE 6091	PROJECT WORK & INDUSTRIAL TRAINING							**0**	**0**	**0**	**25**

*TAUGHT IN BOTH SEMESTERS AND EVALUATED AND CREDITED IN THE SECOND SEMESTER

PROGRAM ELECTIVES		OPEN ELECTIVES	
COURSE CODE	**COURSE TITLE**	**COURSE CODE**	**COURSE TITLE**
MIE 5401	Biomechanics	MIE 5301	Design and Analysis of Experiments
MIE 5402	Bond Graph Modelling of Dynamic Systems	MIE 5302	Design of Curves and Surfaces
MIE 5403	Computational Fluid Dynamics	MIE 5303	Energy Storage Systems
MIE 5404	Design for Manufacturing	MIE 5304	Mechanics of Polymers
MIE 5405	Experimental Techniques in Vibration Analysis	MIE 5305	Principles of Lean in Production Systems
MIE 5406	Geometric Modelling for CAD	MIE 5306	Product Design and Development
MIE 5407	Kinematic Analysis and Synthesis of Robot Mechanisms	MIE 5307	Quality Control and Reliability
MIE 5408	Machine Learning and Its Application to Mechanical Engineering	MIE 5308	Renewable Energy Technology
MIE 5409	Mechanics of Composite Materials		
MIE 5410	Rotor Dynamics		
MIE 5411	Theory of Elasticity and Plasticity		
MIE 5401	Biomechanics		

FIRST SEMESTER – CORE COURSES

MIE 5111 NUMERICAL METHODS AND COMPUTER PROGRAMMING [3 1 0 4]

Approximations and Errors: Round-off Errors, Truncation Errors, Total Numerical Error, Model Errors. Roots Finding-Bracketing and Open methods: Roots in Engineering and Science, Newton-Raphson Method. Linear Algebraic Equations: Gauss elimination, LU factorization, Cholesky factorization, Jacobi Method, GaussSeidel method. Curve Fitting and Interpolation: Linear, polynomial and nonlinear Regression, Splines and piecewise interpolation. Numerical Differentiation and Integration: Richardson Extrapolation, Derivatives of unequally spaced data,

Partial Derivatives, The trapezoidal rule, Simpson's Rules, Higher-Order Newton-Cotes formulas, Numerical Integration of Functions-Romberg integration, Gauss quadrature. Differential Equations: Initial and Boundary value problems, Euler's Method, Runge-Kutta Methods, Applications using relevant Case Studies. Introduction to Programming: Environment, Mathematical Operations, Good Programming practices, built in functions and user defined functions.

References:

1. Rao, Singiresu S. *Applied numerical methods for engineers and scientists*. Prentice Hall Professional Technical Reference, 2001.
2. Bradie B., *A Friendly Introduction to Numerical Analysis*, Pearson Prentice Hall, 2006.
3. Ralston A. and Rabinowitz P., A First Course in Numerical Analysis, McGraw Hill, 2001
4. Mathews J. H. and Fink K. D., *Numerical methods using MATLAB.* Pearson Prentice Hall, 1999.
5. Chapra S. C., Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw Hill, 2017.
6. Chapra S. C. and Clough D, Applied Numerical Methods with Python for Engineers and Scientists, McGraw Hill, 2022.

MIE 5112 ADVANCED MECHANICS OF SOLIDS [3 1 0 4]

Analysis of Stresses and Strains in rectangular and polar coordinates: Cauchy's formula, Principal stresses and principal strains, 3D Mohr's Circle, Octahedral Stresses, Hydrostatic and deviatoric stress, Differential equations of equilibrium, Plane stress and plane strain, compatibility conditions. Introduction to curvilinear coordinates. Generalized Hooke's law and theories of failure. Energy Methods. Bending of symmetric and unsymmetrical straight beams, effect of shear stresses, Curved beams, Shear centre and shear flow, shear stresses in thin walled sections, thick curved bars. Torsion of prismatic solid sections, thin-walled sections, circular, rectangular and elliptical bars, membrane analogy. Thick and thin walled cylinders, Composite tubes, Rotating disks and cylinders. Euler's buckling load, Beam Column equations. Strain measurement techniques using strain gages, characteristics, instrumentations, principles of photoelasticity.

References:

1. M. H. Sadd, Elasticity: theory, applications, and numeric, 3rd edition, Academic Press, 2014.
2. L. S. Srinath, Advanced mechanics of solids, 3rd Edition, McGraw Hill, 2009.
3. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill, 1999.
4. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 6th Edition, John Willey and Sons, 2009
5. S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill, 2017.
6. P. Raymond, Solid Mechanics for Engineering, 1st Edition, John Willey & Sons, 2001.
7. J. W. Dally and W. F. Riley, Experimental Stress Analysis, 3rd Edition, McGraw Hill, 1991.

MIE 5113 FINITE ELEMENT METHODS [3 1 0 4]

Introduction: General procedure of FEM. **Formulation Methods - Direct Method:** Spring and truss elements, arbitrarily oriented elements, transformation matrix, plane truss. **Energy Method:** Principle of total minimum potential energy, Formulation of plane stress/strain elements.

Galerkin's Weighted Residual Method: Beam theory, formulation of beam element, arbitrarily oriented beam elements, plane frame.

Isoparametric Elements: Formulation of truss, plane and solid elements. **Introduction to Analysis Types**: Modal or frequency analysis, thermal analysis, thermos-structural analysis, axi-symmetric analysis, fluid flow analysis.

References:

1. Daryl L Logan, A First Course in Finite Element Method, Thomson Asia Pvt. Ltd, Bangalore, 2002.
2. Akin J.E., Finite Element Analysis for Undergraduates, Academic Press, London, 1989.

3. Martin H.C. and Carey G.F., Introduction to Finite Element Analysis, Tata McGraw Hill, New Delhi, 1975.
4. Segerlind L J., Applied Finite Element Analysis, John Wiley, New York, 1984.
5. Bathe K J, Finite Element Procedures, Prentice Hall of India New Delhi, 2003.
6. Cook Robert D, Concepts and Applications of Finite Element Analysis, John Wiley and Sons New York, 2000.

MIE 5114 APPLIED MECHANICAL VIBRATIONS [3 1 0 4]

Vibration fundamentals, Single degree freedom systems, damping, free and forced vibration, force transmissibility, vibration isolation, two-degree freedom systems-dynamic vibration absorber, multidegree freedom system, whirling of shaft**.** Continuous systems, Standard and nonstandard eigenvalue problem, concept of iteration and methods, Rayleigh damping. Nonlinear vibration solution methods, subharmonic & super harmonic oscillations, graphical methods, stability of equilibrium states, limit cycles and chaos, Perturbation method, Duffing's system, VanderPol's systems. Numerical methods – Modified Euler, Runge-Kutta. Stability Considerations- phase plane, Liapunov, Floquet's theory, Mathieu and Hills equations, numerical methods. Random vibration: Gaussian random process, Fourier analysis, power spectral density, wide band and narrow band processes, response of a single degree of freedom system. Vibration Transducers, electrodynamic and linear variable differential transformer transducers; Vibration pickups, Exciters-mechanical exciters, electrodynamic shaker**,** Signal analysis: modulation, spectrum analysers, bandpass filter, dynamic testing of machines and structures, Experimental modal analysis.

References:

1. Rao, S. S., Mechanical Vibrations, 6th Edition, Pearson Education Inc., 2018.
2. Ramamurti V. Mechanical Vibration Practice with Basic Theory, Narosa Publishing House, Chennai, 2000.
3. Rao J. S. and Gupta K., Theory and Practice of Mechanical Vibrations, 2nd Edition, New Age International Publishers, 1999.
4. Rao J. S. Advanced Theory of Vibrations Wiley Eastern Limited, Bangalore, 1992.
5. Balachandran B. Magrab, E. B., Vibrations Thomson – Brooks/Cole, 2004.
6. Thomson, W. T., Dahleh M. D., Theory of Vibrations with Applications, 5th Edition, Pearson Education Inc. 1997

MIE 5115 FATIGUE, FRACTURE AND FAILURE ANALYSIS [3 1 0 4]

Structure and deformation of materials, fatigue design philosophies, fatigue mechanisms, *Stress-life approach:* Stress-life (S-N) curves, mean stress effects on S-N behavior, factors influencing S-N behavior, computational life estimation. *Cyclic deformation and Strain-life approach:* Monotonic stress-strain behavior, cyclic stress-strain behavior, strain-life curve, fatigue properties, mean stress effects, strain-life equations, notch stresses and strains, computational life estimation. *Fatigue testing procedures, Variable amplitude loading, Cumulative damage theories, and Multi-axial fatigue. Linear elastic fracture mechanics:* Fracture modes, mechanisms of fracture & crack growth, stress intensity factor, crack tip plasticity, plane strain fracture toughness. *Fatigue fracture mechanics:* Fatigue crack growth, empirical fatigue crack growth equations, crack closure and fatigue threshold, prediction of fatigue crack growth and computational life estimation. *Failure Analysis:* Failure indications**,** modes of mechanical failure, creep, case studies. Comparison of life estimation methods, damage tolerance approach, fatigue life extension.

References:

1. Norman E Dowling, Mechanical Behaviour of Materials, (4e), Prentice Hall, 2012.
2. Stephens Ralph I, Fatemi Ali, Stephens Robert R and Henry, Metal Fatigue in Engineering, (2e), John Wiley and Sons Inc, New York, 2001.
3. Nithin S Gokhale, Practical fatigue and durability analysis, (1e), Finite to Infinite, 2021. 4. Lee YL, Barkey ME, Kang HT. Metal Fatigue Analysis Handbook: practical problem-solving techniques for computer-aided engineering. Elsevier; 2011.
5. Anderson, Ted L. Fracture mechanics: fundamentals and applications. CRC press, 2017.

MIE 5141 CAD LAB [0 0 6 2]

Construct geometrically constrained 2D objects; develop solid models of machine parts; develop surface models of engineering applications; assemble solid models of parts into machine components; develop the product drawings (orthographic, sectional and pictorial/isometric views) of assembled machine components. Kinematic analysis, product design exercises, miniproject and open-ended exercises

References:

1. Ascent - Center for Technical Knowledge, "3DEXPERIENCE 2022x: Introduction to CATIA Modeling - Part 1", 2022.

2. Ascent - Center for Technical Knowledge, “3DEXPERIENCE 2022x: Introduction to CATIA Modeling - Part 2”, 2022.
3. Ascent - Center for Technical Knowledge, “3DEXPERIENCE 2022x: Introduction to CATIA Surface Design”, 2022.
4. Nader G. Zamani, “CAD Modelling Essentials in 3DEXPERIENCE 2016x Using CATIA Applications”, SDC Publications, 2017.
5. Nader G. Zamani, “Mechanism Design Essentials in 3DEXPERIENCE 2016x Using CATIA Applications”, SDC Publications, 2017.

MIE 5142 DESIGN ENGINEERING LAB [0 0 3 1]

Journal bearing, Air bearing, Rheometer, scratch test, wear test (2-body, 3-body), Measurement of natural frequency and mode shape of mechanical components by (i) impact hammer method (ii) Method of sine wave sweep, Determination of damping, Vibration with oil damper, Balancing of rotating masses, Field balancing, Measurement of amplitude and frequency of mechanical components, Active and passive vibration isolation, Vibration with single and double absorber, Natural Frequency and modal shape of two, three and multidegree of freedom string; Beat vibration, Open ended experiment – Design and conduct an experiment to acquire vibration signals form a rotating mechanical system, Effect of strain rate on yield strength and strain hardening coefficient’s from tension test, Programming for (i) analyzing undamped, damped, forced vibration systems; (ii) time domain, frequency domain, time-frequency domain. Programming for (i) simulating a bearing/gear vibration signal; (ii) pre-processing and analyzing the raw signals acquired from rotating machinery.

References:

1. Kenneth C Ludema, Friction, Wear, Lubrication: A Textbook in Tribology, CRC press, 1996.
2. Gwidon Stachowiak, Andrew Batchelor, Engineering Tribology, Elsevier, 4th ed., 2013.
3. Singiresu Rao S., Mechanical Vibration, Pearson Education, Delhi, 2004.
4. S. Graham Kelly, Fundamentals of Mechanical Vibrations, McGraw-Hill, Singapore, 1993.
5. Amiya R. Mohanty, Machinery Condition Monitoring: Principles and Practices, CRC Press, Taylor & Francis Group, 2015.
6. Anders Brandt, Noise and Vibration Analysis: Signal Analysis and Experimental Procedures, John Wiley & Sons, 2011.

SECOND SEMESTER – CORE COURSES

MIE 5211 APPLICATION OF COMPUTERS IN BEARING DESIGN [3 1 0 4]

Lubricants and their physical properties, lubricants standards, lubrication regimes, Hydrodynamic Lubrication Theory- Reynolds equation, Design of fluid film bearings, lubricant flow and delivery, Hydrodynamic instability. Elasto hydrodynamic lubrication, Hertzian stress equation, load capacity, stresses and deflection, bearing life calculation, rolling bearing failures. Computational hydrodynamics, Finite difference equivalent of the Reynolds equation, Numerical analysis of hydrodynamic lubrication in a real bearing. Hydrostatic lubrication: generalized approach to hydrostatic bearing analysis, Optimization of hydrostatic bearing design, Aerostatic bearings, Hybrid bearings, Stability of hydrostatic and aerostatic bearings. Solid lubrication: Lubrication by lamellar solids, Friction and wear characteristics of lamellar solids, Deposition methods of solid lubricants, Solid lubricants as additives to oils and polymers.

References:

1. Ghosh M.K., Majumdar B.C and Sarangi M., Fundamentals of Fluid Film Lubrication, McGraw-Hill Education, New York, 2014.
2. Bhushan, B., Introduction to Tribology, 2nd Edition, Wiley, 2013.
3. Williams J.A., Engineering Tribology, Cambridge University Press, UK, 2005.
4. Hamrock, B.J, Schmid, S. R., Jacobson B.O., Fundamentals of Fluid Film Lubrication, 2nd Edition, CRC Press, 2004.
5. Stachowiak, G.W. and Batchelor, A. W., Engineering Tribology, 4th Edition, Butterworth Heinemann, London, 2014.

MIE 5212 NONLINEAR FINITE ELEMENT METHODS [3 1 0 4]

Continuum mechanics - kinematics, balance laws, stress measures, frame indifference, stress rates and constitutive equations; Review of Linear FEM, Discretized FE equations using Iso-Parametric formulation; Introduction to directional derivatives, formulation of variational principles for nonlinear problems and linearization; Linearization of variational principles for nonlinear problems; Generalized Newton Raphson scheme; Applications to hyper elasticity, and metal plasticity; Introduction to plasticity, Constitutive equations for plasticity, Geometric and material stiffness matrices –

discussion, implementation details. Incorporating nonlinearity in FE software.

References

1. Ted Belytschko, Nonlinear Finite Elements for Continua and Structures. John Wiley & Sons, Ltd.
2. K. J. Bathe, Finite Element Procedures. Prentice – Hall Ltd.
3. M. A. Crisfield, Non-linear Finite Element Analysis: Essentials (Volume 1), John Wiley & Sons, Ltd.
4. M. A. Crisfield, Non-linear Finite Element Analysis: Advanced topics (Volume 2), John Wiley & Sons, Ltd.

HUM 5051 RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION [1 0 3 2]

Theory: (Handled by Humanities Dept.)

Research Methodology: Basic concepts: Types of research, Significance of research, Research framework. Sources of data, Methods of data collection. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, Characteristics and Types of hypothesis, Elements of research design, Introduction to various sampling methods Sources of data, Collection of data, Research reports, references styles, Effective Presentation techniques, Research Ethics.

Lab exercises: (Handled by the Mechanical Dept.)

Recap of basic concepts of Research Methodology, use of numerical computation tools for research, Presentation - 1 (Beginning level of research), Presentation - 2 (Intermediate level of research), Presentation - 3 (Analysis/Evaluate level of research), Report writing.

References:

1. Sekaran, U., & Bougie, R., Research methods for business: A skill building approach. John Wiley & Sons, 2016.
2. Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M., Business research methods. Cengage Learning, 2013.
3. Creswell, J. W., & Creswell, J. D., Research design: Qualitative, quantitative, and mixed methods approaches. Sage Publications, 2017.
4. Donald R Cooper & Pamela S Schindler, Business Research Methods, McGraw Hill International, 2018.

MIE 5241 FINITE ELEMENT ANALYSIS LAB [0 0 6 2]

Model and carry out structural analysis of plane/space trusses, plane/space frames, 2D, 3D, shells and contact problems using the GUI of a standard FEA software; Write Macros/codes for developing mapped mesh for 2D and 3D boundary value problems and analyze the same; Carry out the modal, harmonic and contact analysis of structural problems; Model and carry out 2D/3D thermal analysis and thermo-structural problems; Write and execute scripts/programs for analyzing 1D problems, plane/space trusses, plane/space frames and 2D structural problems; open ended exercise on Design failure mode and effect analysis (DFMEA).

References:

1. Eliahu Zahavi (1992) “The Finite Element Method in Machine Design” Prentice Hall Inc USA.
2. Ramamurthy V (1997) “Computer Aided Mechanical Design and Analysis” Tata McGraw Hill Delhi.
3. Daryl L Logan (2002) “A First Course in the Finite Element Method” Thomson Asia Pvt. Ltd. Bangalore.
4. Kent L. Lawrence, ANSYS Tutorial Release 2023, Structural & Thermal Analysis Using the ANSYS Mechanical APDL Release 2023 Environment
5. Huei-Huang Lee, Finite Element Simulations with ANSYS Workbench 2022, Theory, Applications, Case Studies, SDS Publications, 2022.
6. Huei-Huang Lee, Programming and Engineering Computing with MATLAB 2022, SDS Publications, 2022.
7. D. H. Stamatis, “Failure Mode and Effect Analysis: FMEA from Theory to Execution”, ASQ Quality Press Publication, 2nd edition, 2003.

PROGRAM ELECTIVES

MIE 5401 BIOMECHANICS [3 1 0 4]

Introduction to Biomechanics: Brief history, Contributions of Biomechanics to health science, Contributions of Biomechanics to the field of mechanics; Hemodynamics: Rheology of blood, Large artery hemodynamics, Small artery hemodynamic; Sports biomechanics : Movement patterns – the essence of sports biomechanics, Qualitative and quantitative analysis of sports

movements, forces and torques, The anatomy of human movement; Skeletal biomechanics:
Introduction to bone, Biomechanics of cortical and trabecular bone, Fracture and failure mechanics; Mechanobiology, Structure of ligament, tendon and cartilage and its biomechanics; Terrestrial locomotion: Jumping, Description of walking and running, Gait analysis; Biomechanics of Cardiovascular system: Biomechanical hierarchy in cardiovascular physiology, Structure-function relationship in cardiovascular tissues, Biomechanical feedback in the cardiovascular system, Experimental and computational methods

References:

1. Fung YC. Biomechanics: motion, flow, stress, and growth. Springer Science & Business Media; 2013 Mar 20.
2. Ethier CR, Simmons CA. Introductory biomechanics: from cells to organisms. Cambridge University Press; 2007 Mar 12.
3. Bartlett R. Introduction to sports biomechanics: Analyzing human movement patterns. Routledge; 2014 Jan 15.

MIE 5402 BOND GRAPH MODELING OF DYNAMIC SYSTEMS [3 1 0 4]

Introduction to Modeling and Simulation: Importance of Modeling, Models of Systems, Systems, Subsystems, and Components. Bond Graph Modeling of Systems: Engineering Ports, Bonds, and Power, Bond Graphs, Inputs, Outputs, and Signals, Basic Bond Graph Elements, Causality considerations for the basic Elements. Basic System Models: Mechanical systems involving translation, rotation, Hydraulic systems. Acoustic systems and Electrical systems. System Models of Combined Systems: Multi Energy Domain systems, Transducers, Transformers, Gyrators, Thermo-fluid system, Mechatronic system, Multibody systems. State-Space Equations and Automated Simulation: Standard form for System equations, Basic formulation and reduction. Analysis and Control of Linear Systems: Solution techniques for ordinary differential equations, free response and Eigen values for undamped and damped oscillator. Modeling and Simulation of dynamic systems using computer.

References:

1. Dean C. Karnopp, Donald L. Margolis and Ronald C. Rosenberg, System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems, John Wiley & Sons, Inc., (5e), 2012.
2. Mukherjee, A., Karmakar, R., & Samantaray, A. K., Bond graph in modeling, simulation and fault identification, IK International, New Delhi, 2008.
3. Shuvra Das, Mechatronic Modeling and Simulation Using Bond Graphs, CRC Press, 2009.
4. Wolfgang Borutzky, Bond Graph Methodology: Development and Analysis of Multidisciplinary Dynamic System Models, Springer, 2010.
5. Jean U. Thoma, Simulation by Bondgraphs: Introduction to a Graphical Method, SpringerVerlag, 2011.

MIE 5403 COMPUTATIONAL FLUID DYNAMICS [3 1 0 4]

Models of Flow and derivation of governing conservation differential equations for different models for conservation of mass, momentum and Energy. Discussion of characteristics and Boundary and Initial conditions. Basic numerical methods to solve first diffusion related flow physics followed by Convective dominated Diffusion flows. Difficulties and strategies to solve such flows.
Algorithmic approach and convergence as well as stability. Turbulence and related closure using turbulence modelling.

References:

1. John D Anderson Jr. (1995). “Computational Fluid Dynamics- The Basics with Applications”, International Edition, McGraw Hill, New York.
2. Suhas V. Patankar, (1980). “Numerical Heat Transfer and Fluid Flow”, Hemisphere / McGraw Hill, New York.
3. H. K. Versteeg and W. Malalasekera. (1995) “An Introduction to Computational Fluid Dynamics - The Finite Volume Method”, Longman Scientific & Technical. England
4. Ghoshdastidhar. (1998) “Computer Simulation of Flow and Heat Transfer”, Tata- McGraw-Hill Book Company, New Delhi
5. K. Muralidhar and T. Sundararajan (2003), “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi

MIE 5404: DESIGN FOR MANUFACTURING [3 1 0 4]

Significance of design for manufacturing (DFM), factors influencing design, selection of materials and manufacturing processes. Design for assembly, serviceability and environment. DFM of formed metal components, castings, machined components and non-metallic parts. Process engineering designing for heat treatment, sequence of operations for manufacturing of components. Manufacturing drawings-dimensioning for manufacturing, fits, tolerance and surface finish consideration in design, preparation of manufacturing drawings of components.

References:

1. Geoffrey Boothroyd, Peter Dewhurst and Winston A. Knight, Product Design for Manufacture and Assembly, (3e), CRC Press, 2011.
2. James G. Brala, Design for Manufacturability Handbook, (2e), McGraw Hill, New York, 1999.
3. Kevin Otto and Kristin Wood, Product Design, Pearson Education, Delhi, 2001.
4. Corrado Poli, Design for Manufacturing: A Structured Approach, Butterworth-Heinemann Ltd., 2001

MIE 5405 EXPERIMENTAL TECHNIQUES IN VIBRATION ANALYSIS [3 1 0 4]

Modal analysis: Review of basics of Mechanical Vibration. Idealization of complex real-world system to SDOF, Two-DOF and MDOF. Theoretical Basis and Terminology of vibration. Modal analysis of undamped and viscously damped SDOF dynamic Systems, Modal Analysis of undamped and Viscously damped MDOF Dynamic Systems. Numerical simulation of Modal analysis of SDOF and MDOF systems using MATLAB.

Vibration Measurement: Vibration Transducers and Sensors, Time Domain Methods, Frequency Domain Methods of vibration signal analysis. FFT, receptance, mobility, accelerance, and transmissibility plots. Signal Processing and Spectral Analysis.

Free and forced vibration: Free vibration response measurement of SDOF systems with longitudinal, transverse and rotational degrees of freedom. Forced vibration response measurement techniques: Impulse hammer method. Vibration exciter under sweep and steady-state excitation.

Modal Parameters Identification. Peak picking methods, circular fit methods, Hysteresis loop, decomposition of real and imaginary components of the response.

Operational Deflection Shapes (ODS) and Operational Modal Analysis (OMA) Test planning, structure preparation and practical use of excitation equipment and recording of data. Modal testing of beam- and plate-like structures.

References

1. D. J. Ewins, Modal Testing: Theory and Practice, Research Studies Press LTD., John Wiley and Sons Inc., 1995.
2. N. M. M. Maia and J. M. M. Silva, Theoretical and Experimental Modal Analysis, Taunton, Somerset, England: Research Studies Press; New York: Wiley, 1997.
3. J. He and Z. F. Fu, Modal Analysis, Oxford; Boston: Butterworth-Heinemann, 2001.
4. Peter Avitabile, Modal Testing: A Practitioner's Guide, Wiley/SEM Series on Experimental Mechanics, 2017
5. Wilam T Thomson et.al, Theory of vibration with applications, 5th edition, Pearson Education
6. Leonard Meirovith, Elements of vibration analysis, 2nd Edition, McGraw-Hill Book Company

MIE 5406 GEOMETRIC MODELING FOR CAD [3 1 0 4]

Hardware and software for Computer Aided Design (CAD), geometric modelling concepts of CAD; Mathematical representation in parametric form of analytic curves (line, circle, ellipse and hyperbola), synthetic curves (Hermite cubic splines, Bezier curves, B-spline curves, NURBS), analytical surfaces (plane, ruled, tabulated, revolved), synthetic surfaces (Bi-cubic, Bezier, B-spline, NURBS, Coons, Ferguson’s and Bi-linear surface patches); Solid modeling techniques (Half spaces, Boundary representation, Constructive solid geometry, Sweep representation, Analytic solid modeling); rasterization of lines, circles and ellipse; 3D transformation (translation, scaling, rotation and concatenation) of geometric entities and their projections; principles of visual realism and mechanical assembly.

References:

1. Michael E. Mortenson, GEOMETRIC MODELING, Wiley Computer Publishing, John Wiley and Sons, Inc. (Second Edition), 1996.
2. Ibrahim K Zeid, CAD/CAM Theory and Practice, Tata McGraw Hill, New Delhi, 1998.
3. David F Rogers and J Alan Adams, Mathematical Elements for Computer Graphics, Tata McGraw Hill, New Delhi, 2002.
4. David F Rogers and J Alan Adams, Procedural Elements for Computer Graphics, McGraw Hill, New York, 2001.
5. Ram B, Computer Fundamentals Architecture and Organization, New Age International Ltd New Delhi, 2000.
6. Donald Hearn and M Pauline Baker, Computer Graphics, Prentice Hall of India, New Delhi, 2000.

MIE 5407 KINEMATIC ANALYSIS & SYNTHESIS OF ROBOT MECHANISMS [3 1 0 4]

Basic Concepts, Robotics and automation, Robot Anatomy – Links, Joints and Joint, Notation scheme, Degrees of Freedom (DOF), Required DOF in a Manipulator, Arm and Wrist Configuration. Analysis and modelling of mechanisms, Robot motion analysis. Kinematic Manipulators, Direct kinematics model mechanical structure & Notations Description of links & Joints. Robot end effectors. Differential Motion and Statics: Differentia kinematics, linear and angular velocity, Manipulator Jacobian, Jacobian Inverse, Jacobian singularities, Static Dynamics of Mechanisms: Lagrangian Mechanics, Lagrange – Euler formulation - Velocity of a point on the manipulator. Trajectory Planning, the Assembly Tasks.

References:

1. J. J. Uicker, G. R. Pennock and J. E. Shigley, Theory of Machines and Mechanisms, Oxford University Press, 4th edition, 2014, ISBN: 9780199454167
2. R. L. Norton, Design of Machinery- An Introduction to the Synthesis and Analysis of Mechanisms and Machines, McGraw Hill, 6th edition, 2020, ISBN: 9780077421717
3. Groover M. P., Wiess M., Nagel R. N. and Odery N. G. Industrial Robotics Technology, Programming and Applications, McGraw Hill Inc. Singapore 2000.
4. Mittal R. K. & Nagrath, I. J., “Robotics and Control”, TMH, 2003 (Reprint 2010 or later).
5. Groover, M. P., et al., “Industrial Robotics”, McGraw Hill ISE, 1986.
6. Fu, K. S., et al., Robotic: Control, Sensing, Vision & Intelligence, McGraw Hill ISE, 1987
7. Robert J., Schilling, Fundamentals of Robotics: Analysis and Control, Prentice Hall, NJ, 2002.
8. Introduction to Robotics by S K Saha, Mc Graw Hill Education
9. Ashitava Ghosal, “Robotics-Fundamental concepts and analysis”, Oxford University press.

MIE 5408 MACHINE LEARNING AND ITS APPLICATION TO MECHANICAL ENGINEERING [3 1 0 4]

Introduction to machine learning, machine learning models, applications; supervised learning; model performance and evaluation; artificial neural networks, deep learning approaches; computer implementation and mini-project using MATLAB/PYTHON, open ended exercise/miniproject on machine learning application to model and solve mechanical engineering problems.

References:

1. Jo, T. (2021). Machine Learning Foundations Supervised, Unsupervised, and Advanced Learning. In Machine Learning Foundations. Springer International Publishing. https://doi.org/doi.org/10.1007/978-3-030-65900-4
2. Kramer, O. (2016). Machine learning for evolution strategies. Springer International Publishing. https://doi.org/10.1007/978-3-319-33383-0 ISSN
3. Rebala, G., Ravi, A., & Churuwala, S. (2021). Introduction to Machine Learning. In Studies in Computational Intelligence (Vol. 975). https://doi.org/10.1007/978-3-030-74640-7_4
4. Manohar Swamynathan. (2019). Mastering Machine Learning with Python in Six Steps, A Practical Implementation Guide to Predictive Data Analytics Using Python, Second Edition, APress
5. Rodrigo Fernandes de Mello and Moacir Antonelli Ponti (2018). Machine Learning, A Practical Approach on the Statistical Learning Theory, Springer International Publishing AG
6. Oliver Theobald. (2021). Machine Learning for Absolute Beginners: A Plain English Introduction, Third Edition

MIE 5409 MECHANICS OF COMPOSITE MATERIALS [3 1 0 4]

Introduction: Definition, need, general characteristics, applications. Fibers and matrices, Types of fibers, Glass, Carbon, Aramid, Kevlar fibers, Types of matrices, polymer, metal and ceramic matrices, characteristics of fibers and matrices; **Mechanics and Performance:** Characteristics of fiber reinforced lamina, micromechanics of unidirectional lamina, Volume and Mass Fractions, Density and Void Content, Elastic modulus, Ultimate strength of unidirectional lamina, macro-mechanics of unidirectional lamina, Hooke’s law for different types of materials, plane stress assumption, engineering constants of an angle lamina, macro-mechanics of laminates, Classical Laminate Theory (CLT), inter laminar stresses, static mechanical properties, fatigue and impact properties, environmental effects, fracture behavior, toughening mechanism and damage tolerance, failure modes; **Manufacturing**: Bag moulding, compression moulding, pultrusion, filament winding, other manufacturing processes, Quality inspection methods; **Analysis:** Stress analysis of laminated composite beams, plates, and shells, vibration and stability analysis, reliability of composites, FEM of analysis, analysis of sandwich structures. **Design:** Failure prediction, Maximum stress theory, Maximum strain theory, Azzi–Tsai– Hill theory, Tsai–Wu failure theory, laminate design consideration of bolted and bonded joints. Design examples. Micromechanical analysis of composite material using computer programming.

References:

1. Mallick. P.K., Fiber Reinforced Composites: Materials, Manufacturing and Design (2e), CRC Press, 2010
2. Agarwal, B. D., Broutman, L. J., & Bert, C. W., Analysis and performance of fiber composites, Wiley, (4e), 2017.
3. Kaw, Autar K. Mechanics of composite materials. CRC press, (2e), 2005.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, McGraw Hill Publication, 2014.
5. Robert M. Jones, Mechanics of Composite Materials, CRC Press, 1998.
6. Mukhopadhyay, Madhujit, Mechanics of composite materials and structures, Universities press, 2005.

MIE 5410 ROTOR DYNAMICS [3 1 0 4]

Torsional vibration in rotating and reciprocating machinery - Modeling of rotating machinery shafting, transfer matrix analysis for free vibrations, transient response in torsional vibration, modeling of the reciprocating machine systems, free & forced vibrations, finite element analysis. Bending critical speeds of simple shafts - Whirling of an unbalanced elastic rotor, shafts with several discs, shafts with overhangs. Out of balance response of rotors with rigid supports,

Rotors mounted on Fluid Film bearings. Gyroscopic effects - Gyroscopic of a spinning disc, synchronous whirl of an overhung rotor, nonsynchronous whirl, rotor system with a coupling, finite element method and whirl speed analysis. Stability and whirling of a shaft with dissimilar moments of area. Instability due to fluid film forces and hysteresis, Instability in torsional vibration, Balancing of rigid and flexible rotors.

References:

1. Rao J. S., Rotor Dynamics, New Age International (P) Ltd., New Delhi, 1996.
2. Agnieszka Muszynska, Rotordynamics, CRC Taylor & Francis, 2005.
3. Chong-Won Lee, Vibration Analysis of Rotors, Springer Science Business Media, 2012.
4. Krzysztof Czolczynski, Rotordynamics of GasLubricated Journal Bearing Systems, Springer 2012.
5. Friswell M. I., Dynamics of Rotating Machines, Cambridge, 2010.

MIE 5411 THEORY OF ELASTICITY AND PLASTICITY [3 1 0 4]

Analysis of Stresses and Strains - Cauchy Stress Tensor, Stresses on Arbitrary Plane, Balance Laws for 3D Elasticity, Formulation in Cartesian and Polar coordinates, Hydrostatic and deviatoric stresses, strain displacement relationship, small deformation theory, Compatibility equations; Generalized Hooke's law, Formulation of constitutive equations for anisotropic, orthotropic and isotropic materials; 2D and 3D applications of Elasticity - Plane stress, Plane strain and Axisymmetric problems, Saint-Venant's principle, principle of super-position and reciprocal theorem, Airy's stress function, Applications. Strain energy density, Betti-Maxwell Reciprocal Theorem, Applications.

Introduction to Plasticity - Stress - strain diagram in simple tension, yielding, hardening; Failure theories, yield criteria, Tresca and Von-Mises criteria of yielding, Strain-Hardening Hypothesis, Elastic–Plastic Stress–Strain Relations, Drucker's Postulate, Associated Flow Rule, Objective Stress Rate Tensors; Applications of plasticity - Eulerian and Updated Lagrangian Formulations, A Wire Drawing Problem, Forging of a Cylindrical Block.

References

1. Timoshenko and Goodier, Theory of Elasticity, Mc-Graw Hill Book Company, 2nd Edition, 1951.
2. L. S. Srinath, Advanced Mechanics of Solids, Tata Mc-Graw Hill Book Company, 3rd Edition, 2009.
3. Sadd M. H., Elasticity, Elsevier Publishers, 2014, New Delhi.
4. PM Dixit and US Dixit, Plasticity, Fundamentals and Applications, CRC Press, 2015.
5. J. Chakrabarty, Theory of Plasticity, McGraw-Hill Book Company, New York 2006

OPEN ELECTIVE COURSES

MIE 5301 DESIGN AND ANALYSIS OF EXPERIMENTS [3 0 0 3]

Understanding basic experimental design principles, Working in simple comparative experimental contexts, introduction to R language and its applications in DOE problems, Working with single factors or one-way ANOVA in completely randomized experimental design contexts, Implementing randomized blocks, Latin square designs and extensions of these, Understanding factorial design contexts, Working with two level, 2*k*, designs, Implementing confounding and blocking in 2*k* designs, Working with 2-level fractional factorial designs, Working with 3-level and mixed-level factorials and fractional factorial designs, Simple linear regression models, Understanding and implementing response surface methodologies, Understanding robust parameter designs, Working with random and mixed effects models, Design of computer experiments and the applications in industrial engineering problems.

References:

1. Montgomery, D. C. (2001), *Design and Analysis of Experiments,* John Wiley & Sons. Inc. ISBN: 0-471-31649-0.
2. Dean, A. M. and Voss, D. T. (1999), *Design and Analysis of Experiments (Springer text in Statistics),* Springer Science + Business Media, Inc. ISBN: 0-387-98561-1.
3. Box, G. E. P., Hunter, W. G., and Hunter, J. S. (1978), *Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building,* John Wiley & Sons. Inc. ISBN: 0-471-09315-7.
4. Diamond, W. J. (2001), *Practical Experiment Designs for Engineers and Scientists,* John Wiley & Sons. Inc. ISBN: 0-471-39054-2.
5. Jeff Wu, C. E. and Hamada, M. I. (2000), *Experiments: Planning, Analysis, and Parameter Design Optimization,* John Wiley & Sons. Inc. ISBN: 0-471-39054-2.

MIE 5302 DESIGN OF CURVES AND SURFACES [3 0 0 3]

Hardware and software for Computer Aided Design (CAD), geometric modelling concepts of CAD; parametric representation of analytic curves (line, circle, ellipse and hyperbola), synthetic curves (Hermite cubic splines, Bezier curves, B-spline curves, NURBS), analytical surfaces (plane, ruled, tabulated, revolved), synthetic surfaces (Bi-cubic,
Bezier, B-spline, NURBS, Coons, Ferguson's and Bi-linear surface patches); 3D transformation (translation, scaling, rotation and concatenation) of geometric entities and their projections.

References:

1. Michael E. Mortenson, GEOMETRIC MODELING, Wiley Computer Publishing, John Wiley and Sons, Inc. Second Edition), 1996.
2. Ibrahim K. Zeid, CAD/CAM Theory and Practice, Tata McGraw Hill, New Delhi, 1998.
3. David F. Rogers and J Alan Adams, Mathematical Elements for Computer Graphics, Tata McGraw Hill, New Delhi, 2002.
4. David F. Rogers and J Alan Adams, Procedural Elements for Computer Graphics, McGraw Hill, New York, 2001.
5. Donald Hearn and M Pauline Baker, Computer Graphics, Prentice Hall of India, New Delhi, 2000.
6. Mikell P. Groover and Emory W. Zimmers, Jr, CAD/CAM: Computer Aided Design and Computer Aided Manufacturing, Pearson Education India, 2013.

MIE 5303 ENERGY STORAGE SYSTEMS [3 0 0 3]

Introduction: Need for energy storage, Different modes of energy storage. **Potential energy**: Pumped hydro storage, Kinetic energy and compressed gas system, Flywheel storage, Compressed air energy storage, Electrical and magnetic energy storage, Capacitors, Electromagnets, Chemical energy storage, Thermo-chemical, photo-chemical, biochemical, electro-chemical, fossil fuels and synthetic fuels, Hydrogen for energy storage, Solar ponds for energy storage. **Electrochemical, Magnetic and Electric Energy Storage Systems**: Batteries, Primary, Secondary, Lithium, Solid-state and molten solvent batteries, Lead acid batteries, Nickel Cadmium Batteries, Advanced batteries, Superconducting Magnet Energy Storage (SMES) systems, Capacitor and Batteries, Comparison and application, Super capacitor, Electrochemical Double Layer Capacitor (EDLC. **Sensible and Latent Heat Storage**: SHS mediums, Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage, Phase Change Materials (PCMs), Selection criteria of PCMs, Solar thermal LHTES systems, Energy conservation through LHTES systems, LHTES systems in refrigeration and air-conditioning systems, Numerical heat transfer in melting and freezing process. **Application of Energy Storage:** Food preservation, Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries.

References:

1. Johannes Jensen Bent Squrensen, *Fundamentals of Energy Storage*, John Wiley, NY, 1984.

2. *IEE Energy Series*, Electro-chemical Power Sources.
3. Baader, W., Dohne, E., Brenndorfer, *Bio-gas in Theory and Practice*.
4. P. D. Dunn, *Renewable Energies*. Peter Peregrinus Ltd, London, United Kingdom, First Edition, 1986.
5. Ibrahim Dincer, *Thermal Energy Storage: Systems and Applications*, Wiley Publications, 2010.

MIE 5304 MECHANICS OF POLYMERS [3 0 0 3]

Introduction, Overview of Polymeric Materials, Polymerization and Crosslinking, Crystallinity, Glass Transition Temperature, Molecular Orientation; Processing of polymers Thermoplastics and thermosets processing techniques; Kinetic Theory of Rubber Elasticity, Linear elastic relations for rubber elasticity, Mechanics of Elastomers, thermomechanical behavior of polymers; Viscoelasticity **-** Linear and fractional order models, Maxwell Models, Creep, Stress Relaxation, Dynamic Response; Mechanical response during plastic deformation and fracture Yielding and Crazing, viscoplasticity, Linear Fracture Mechanics, Elastic-plastic Fracture, Brittle Fracture, Toughening. Failure mechanisms in polymer matrix composites.

References

1. R.J. Young and P.A. Lovell, Introduction to Polymers: 3rd Edition, CRC Press, 2011
2. I.M. Ward, J. Sweeney, Mechanical Properties of Solid Polymers, 3rd ed. Wiley
3. R.S. Dave, A.C. Loos, Processing of Composites, Hanser, 2000.
4. Jorgen S Bergstrom, Mechanics of solid polymers: theory and computational modelling, Elsevier, 2015.

MIE 5305 PRINCIPLES OF LEAN IN PRODUCTION SYSTEMS [3 0 0 3]

Introduction: Evolution of Mass production – Traditional vs. Mass production – Evolution of Toyota Production System (TPS) – Business Dynamics of Lean production – Principles of Lean production: Value, Value Stream, Flow, Pull, Perfection. PS – Tools & Techniques - 1: 3Ms: Muda, Mura, Muri – 7 Wastes in Manufacturing – Lean Tools to eliminate Muda – 5S –, Plan-DoCheck-Act (PDCA), Standardised work, TPM – SMED – Jidoka – Poka Yoke – JIT – Heijunka – Kanban – One piece production, Kaizen, Visual Management, Production smoothing, Shortening production lead time, Shortening setup time – concepts and techniques.

References:

1. Monden Y., Toyota Production System: An Integrated Approach to Just-In-Time, (4e), CRC Press, U.S.A, 2011.
2. Rother and Shook, Learning to See: Value Stream Mapping to add Value and Eliminate Muda, The Lean Enterprise Institute, U.S.A., 1999.
3. Gross and McInnis, Kanban Made Simple: Demystifying and Applying Toyota's Legendary
4. Manufacturing Process, AMACOM Books, U.S.A., 2003.
5. Fled W., Lean Manufacturing: Tools, Techniques and How to Use Them, CRC Press, U.S.A., 2001.
   Dailey K. W., The Lean Manufacturing Pocket Handbook, D.W. Publishing Co., 2003.

MIE 5306 PRODUCT DESIGN AND DEVELOPMENT [3 0 0 3]

Introduction: Characteristics, design, cost, duration and challenges of successful design and development of products. **Development Processes and Organizations:** A generic development process and concept of development process, the AMF development process, product development organizations, the AMF organization. **Product Planning:** The product planning process, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning. **Identifying Customer Needs:** Gather raw data, interpret raw data, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. **Product Specifications:** What are specifications, establishing target specifications, setting the final specifications. **Concept Generation:** The activity of concept generation, search externally and internally, explore systematically, reflect on the results and the process. **Concept Selection:** concept screening, and concept scoring, **Concept Testing:** Define the purpose of concept test, choose a survey population, survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. **Product Architecture:** Product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. **Industrial design:** need and impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design. **Design for**

Manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. **Prototyping:** Prototyping basics, principles of prototyping, technologies, planning for prototypes. **Product Development Economics:** Elements of economic analysis, base case financial mode, Sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

References:

1. Karl T. Ulrich, Steven D Eppinger - Product Design and Development - Irwin McGraw-Hill - 2000.
2. A C Chitale and R C Gupta, Product Design and Manufacturing - PH1, - 3rd Edition, 2003. 3. Timjones. Butterworth Heinmann -New Product Development -Oxford. UCI -1997
4. George E Deiter, Engineering Design, 5th Edition, McGraw-Hill, 2012 .
5. Boothroyd G, Dewhurst P and Knight W, Product Design for Manufacture and Assembly, 2nd Edition, Marcel Dekker, New York, 2002.
6. G Altshuller, H Altov, Lev Shulyak, And Suddenly the Inventor Appeared: TRIZ, The theory of Inventive Problem Solving, Technical Innovation Centre, 2nd Edition, May 1996.
7. Vladimir Petrov, Theory of Inventive Problem Solving, Level 1, Springer Series, 2019, ISBN: 978-3-030-04253-0.

MIE 5307 QUALITY CONTROL AND RELIABILITY [3 0 0 3]

Definitions of the term quality, Inspection and quality control, Causes of variation, Patterns of variation, Frequency distribution, Measures of central tendency and dispersion, The Normal distribution curve, Inequality theorems, Shewhart's bowl drawing experiments, Control charts for variables ($\bar{X}$, R and s charts), Type I and Type II Errors, Process capability analysis, Process capability indexes, Control charts for attributes (p, np, c and u charts), Importance of Acceptance sampling, Single and Double sampling plans, Operating characteristic curve, Acceptable quality level, Lot tolerance percent defective, Average outgoing quality, Average total inspection, Average fraction inspected, Producers risk, Consumers risk, Introduction to life testing and reliability, Equipment failure pattern, Failure rate, Mean Time Between Failure (MTBF), Mean Time To Failure (MTTF), Product rule, Parallel connection, System reliability.

References:

1. Grant E. L and Levenworth R., *Statistical Quality Control*, McGraw Hill Publications, New York, 2005.
2. Mahajan M.S., *Statistical Quality Control*, Dhanpat Rai and Co. Pvt. Ltd., Delhi, 2012.
3. Montgomery D.C., *Introduction to Statistical Quality Control*, John Wiley and Sons, New York, 2005.
4. Juran J.M. and Gryna F.M., *Quality Planning and Analysis*, Tata McGraw Hill Publications, Delhi, 1995.
5. Bertrand L. Hansen, *Quality Control- Theory and Applications*, Prentice Hall India, Delhi, 1987.

MIE 5308 RENEWABLE ENERGY TECHNOLOGY [3 0 0 3]

Solar energy –Production and transfer of solar energy – Sun-Earth angles –Availability and limitations of solar energy – Measuring techniques and estimation of solar radiation. Applications of Solar energy, Energy from biomass – Sources of biomass – Different species – Conversion of biomass into fuels, Aerobic and anaerobic bioconversion – Properties of biomass, Biogas plants– Design and operation, Wind energy – Principles of wind energy conversion – Site selection considerations –Wind power plant design – Types of wind power conversion systems – Operation, maintenance and economics, fuel cells, fuel cell power plant, Geothermal fields- Hot dry rock, Energy conversion technologies, Ocean thermal energy conversion, Wave and tidal energy: Scope and economics – Introduction to integrated energy systems.

References:

1. J.A. Duffie and W.A. Beckman: *Solar Energy Thermal Processes*, J. Wiley, 1994.
2. A.A.M. Saigh (Ed): *Solar Energy Engineering*, Academic Press, 1977
3. F. Kreith and J.F. Kreider: *Principles of Solar Engineering*, McGraw Hill, 1978
4. G.N. Tiwari: *Solar Energy-Fundamentals, Design, Modelling and Applications*, Narosa Publishers, 2002
5. H.P. Garg, S.C. Mullick and A.K. Bhargava: *Solar Thermal Energy Storage*, 1985
6. K.M. Mittal: *Non-conventional Energy Systems-Principles, Progress and Prospects*, Wheeler Publications, 1997.

THIRD AND FOURTH SEMESTER

MIE 6091 PROJECT WORK & INDUSTRIAL TRAINING [0 0 0 25]

Students are required to undertake innovative and research-oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflect additional knowledge gained from their own effort. The project work can be carried out in the institution / industry /research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid- term evaluation. After completing the project work, each student has to submit a project report in the prescribed format, to the department / institution. The final project evaluation and viva voice will be conducted only after submission of the report approved by both internal and external guides. Each student has to make a presentation on the project work carried out, before the departmental M. Tech. project evaluation panel for the project evaluation. The mid-term & end semester project evaluation will be done by the departmental project evaluation panel including the internal as well as external guides.

The students carrying out their project work within the institution need to mandatorily undergo an industrial training for a minimum period of 4 weeks. For the students carrying out their project work in an industry/research laboratory/organization, industrial training is not mandatory.