K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Empowered Autonomous Institute, affiliated to Shivaji University, Kolhapur)

M. Tech. Design Engineering

Curriculum Structure and Evaluation Scheme (NEP 2020)

To be implemented for 2025-27 & 2026-28 Batch

F. Y. M. Tech						**Semester: I**					
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**					
		L	**T**	**P**	**Credits**	**Scheme**	**Theory Marks**			**Practical Marks**	
							Max	**Min. %for passing**		**Max**	**Min. %for passing**
MDE1017	Advanced Solid Mechanics	03	01	--	04	ISE	30	40	40	--	--
						ESE	70	40		--	--
MDE1027	Finite Element Analysis	03	01	--	04	ISE	30	40	40	--	--
						ESE	70	40		--	--
MDE1301	System Modelling and Dynamics	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Programme Elective I	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Programme Elective II	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
MDE1127	Finite element analysis and 3D printing Lab	--	--	02	01	ISE	--	--		50	50
						ESE	--	--		50	50
MDE1137	Experimental Stress Analysis and Tribology Lab	--	--	02	01	ISE	--	--		50	50
						ESE	--	--		50	50
SHP5513	Technical Communication	02	--	--	01	ISE	--	--		100	50
	TOTAL	**17**	**02**	**04**	**20**						

Total Contact Hours/week: 23

Total Credits: 20

ISE = In Semester Evaluation, ESE = End Semester Exam

Program Elective – I

Sr. No.	Course Code	Course
1.	MDE1047	Mechanics of Composite Materials
2.	MDE1057	Design for Manufacturing and Assembly
3.	MDE1067	Experimental Stress Analysis
4.	MDE1077	Reliability Engineering
5.	MDE1291	Vehicle Dynamics

Program Elective – II

Sr. No.	Course Code	Course
1.	MDE1087	Optimization Techniques
2.	MDE1097	Industrial Tribology
3.	MDE1107	Advanced Mathematical Methods in Engineering
4.	MDE1117	Smart Materials and Systems
5.	MDE1037	Computer Aided Design

Rajarambapu Institute of Technology Mech. Engg. Dept. 415 414 Rajaramnagar

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M. Tech. Design Engineering

Curriculum Structure and Evaluation Scheme (NEP 2020)

To be implemented for 2025-27 & 2026-28 Batch

F. Y. M. Tech						**Semester: II**					
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**					
		L	**T**	**P**	**Credits**	**Scheme**	**Theory Marks**			**Practical Marks**	
							Max	**Min. %for passing**		**Max.**	**Min. %for passing**
MDE1147	Mechanical Vibration	03	01	--	04	ISE	30	40	40	--	--
						ESE	70	40		--	--
MDE1157	Analysis and Synthesis of Mechanisms	03	01	--	04	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Programme Elective III	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
	Programme Elective IV	03	--	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
MDE1247	Research Methodology and IPR	02	01	--	03	ISE	30	40	40	--	--
						ESE	70	40		--	--
MDE1267	Vibration Lab	--	--	02	01	ISE	--	--		50	50
						ESE	--	--		50	50
MDE1271	Engineering Computation Lab	--	--	02	01	ISE	--	--		50	50
						ESE	--	--		50	50
MDE1287	Seminar	--	--	02	01	ISE	--	--		100	50
	TOTAL	**14**	**03**	**06**	**20**						

Total Contact Hours/week: 23

Total Credits: 20

ISE = In Semester Evaluation, ESE = End Semester Exam

Program Elective – III

Sr. No	Course Code	Course
1.	MDE1167	Acoustics and Noise Control
2.	MDE1177	Rotor Dynamics
3.	MDE1187	Product Design and Development
4.	MDE1197	Design of Pump, Compressor and Blower
5.	MDE1311	Design of Pressure Vessel and Piping

Program Elective – IV

Sr. No.	Course Code	Course
1.	MDE1207	Fracture Mechanics
2.	MDE1217	Failure Analysis and Design
3.	MDE1227	Industrial Robotics
4.	MDE1237	Multi-body Dynamics
5.	MDE1321	IOT Based Condition Monitoring & Diagnostics

S. Y. M. Tech						**Semester: III**				
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**				
		L	**T**	**P**	**Credits**	**Scheme**	**Theory Marks**		**Practical Marks**	
							Max	**Min. % for passing**	**Max**	**Min. % for passing**
MDE2017	Industry Internship	--	--	-	01	ISE	--	--	100	50
	Open Elective	03	--	--	03	ESE	100	40	--	--
MDE2027	Dissertation Phase I	--	--	12	06	ISE	--	--	100	50
MDE2037	Dissertation Phase II	--	--	20	10	ISE	--	--	100	50
						ESE	--	--	100	50
	TOTAL	**03**	**--**	**32**	**20**					

Total Contact Hours/week: 35
Total Credits: 20
ISE = In Semester Evaluation, ESE = End Semester Exam

Open Elective

Sr. No.	Course Code	Course
1.	MOE2012	Artificial Intelligence and Machine Learning
2.	MOE2022	Creative Thinking: Techniques and Tools
3.	MOE2032	MOOC Course
4.	MOE2041	Energy Audit and Management
5.	MOE2062	Augmented Reality and Virtual Reality
6.	MOE2072	Industrial Instrumentation
7.	MOE2082	Advanced Mechatronics systems
8.	MOE2091	Disaster Management

Note for Open Elective

An Open Elective course is included in the curriculum of S. Y. M. Tech (Semester-III), under which students need to learn either MOOC course or courses offered by department.

Guidelines for MOOC course under Open Elective

1. If students opt for MOOC course as an Open Elective, he/she should select this course from NPTEL platform only.
2. As three credits are allotted to open elective, selected MOOC course must be of minimum 8 weeks or 30 hours.
3. Students need to solve assignments given by platform and also, give the final certification exam at allotted NPTEL exam center.
4. Student must secure certification of NPTEL platform within program duration, otherwise he/she will not be eligible for final evaluation.
5. If student fails in NPTEL certification course, he or she should re-register for the course in the next semester.

Guidelines for other courses mentioned under Open Elective:

1. Student can opt for courses mentioned in the curriculum.
2. While selecting the course, students must take care that selected course from the list is not learned in UG or PG first year curriculum.
3. Lectures of these courses will be conducted by concerned department faculty by online mode.
4. Evaluation of these courses will be as mentioned in the curriculum.

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S. Y. M. Tech						**Semester: IV**				
Course Code	**Course**	**Teaching Scheme**				**Evaluation Scheme**				
		L	**T**	**P**	**Credits**	**Scheme**	**Theory Marks**		**Practical Marks**	
							Max	**Min.% for passing**	**Max**	**Min.% for passing**
MDE2047	Dissertation Phase III	--	--	16	08	ISE	--	--	100	50
MDE2057	Dissertation Phase IV	--	--	24	12	ISE	--	--	100	50
						ESE	--	--	100	50
	TOTAL		--	**40**	**20**					

Total Contact Hours/week: 40
Total Credits: 20
ISE = In Semester Evaluation, ESE = End Semester Exam

Class: **F. Y. M. Tech.**	Semester: **I**
Course Code: **MDE1017**	Course Name: **Advanced Solid Mechanics**

L	T	P	Credits
03	**01**	**--**	**04**

Course Description:
This course intends to develop strong base to nurture analysis and design skill sets by exploring fundamentals of solid mechanics. It is the essential duty of design engineer to comment on fail-safe design concept. Due to applied loading, macro-level deformation, strain and stress parameters emerges and it is utmost important to understand relationship and influence of one parameter over the other as a function of loading and material properties. Major focus of the course is to analyze the response of the material under triaxle state of stress. This course covers the fundamental principles used in analysis of stress, strain energy methods, bending of beams, torsion and axis symmetric cases.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Analyze state of stresses and strains in a 3-D continuum.
2. Establish stress-strain relations for deformable solids.
3. Analyze mechanical structures using energy methods.
4. Evaluate stresses in symmetrical and asymmetrical beams.
5. Analyze thin wall beams, torsional bars and axisymmetric problems.

Prerequisite: Strength of Material, Design of Machine Component

Course Content

Unit No	Description	Hrs.
01	**Analysis of Stress in Three Dimensions** Stress at a point – components of stress; Principal stresses; Determination of principal stresses; Stress invariants; Determination of maximum shear stresses; Octahedral shear stress, Hydrostatic and Deviatoric Stress Tensors Mohr's Circle for 2D and 3D stress problem.	06
02	**Analysis of Strain** Strain at a point – Components of strain; Differential equations of equilibrium; Conditions of compatibility, Hydrostatic and Deviatoric Strain Tensors, Mohr's Circle for 2D and 3D strain problem. **Stress Strain Relationship** Generalized Hooke's law, Elastic behavior for different materials (Isotropic, Orthotropic and Anisotropic).	06
03	**Energy Methods** Hooke's law and the principle of superposition, Work done by forces and elastic strain	06

	energy, Maxwell-Betti-Rayleigh Reciprocal theorem First and second theorem of Castigliano, expressions for strain energy when an elastic member is subjected to axial force, Shear force, Bending moment and Torsion. Theorem of virtual work, Kirchhoff's theorem	
04	**Bending of Beams** Straight beams and asymmetrical bending, shear center or center of flexure, shear stresses in thin walled open sections: Bending of curved beams (Winkler –Bach formula).	**06**
05	**Torsion** Torsion of general prismatic bars-solid sections, Torsion of circular, elliptical, triangular bars, Torsion of thin walled tubes and multiple closed sections, center of twist and flexure center.	**06**
06	**Axi-symmetric Problems** Thick walled cylinder subjected to internal and external pressures-Lames-problems, sphere with purely radial displacements, rotating disc of uniform thickness, rotating shafts and cylinders.	**06**

References:

Text Books:

- L.S. Srinath, Advanced Mechanics of Solids, TMH.
- Irving H. Shames, Mechanics of Deformable Solids, Krieger Pub Co.
- Timoshenko and Goodier, Theory of Elasticity, TMH.

Reference Books:

- Otto T. Bruhns, Advanced Mechanics of Solids, Springer.
- Sadhu Singh, Theory of Elasticity, Khanna Publishers.

Class: **F. Y. M. Tech.**	Semester: **I**
Course Code: **MDE1027**	Course Name: **Finite Element Analysis**

L	T	P	Credits
03	**01**	**--**	**04**

Course Description:
This course introduces the Finite Element Method (FEM) for solving structural, thermal, and fluid mechanics problems. Starting with the basics of elasticity and mathematical models, it covers techniques like the principle of virtual work, residual methods, and Rayleigh-Ritz methods. Students learn FEM applications for 1D problems like bars, trusses, and beams, progressing to 2D and 3D problems involving plane stress, plate bending, shells, and solid structures. Dynamic analysis, including vibration and damping, is also explored. The course extends FEM to heat transfer and fluid mechanics, covering conduction, convection, and potential flow problems. Practical examples, computer implementation, and pre/post-processing techniques ensure hands-on learning and real-world application.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Apply the concept of finite element method for solving machine design problems.
2. Solve problems in 1-D structural systems involving bars, trusses, beams and frames.
3. Develop 2-D and 3-D FE formulations involving triangular, quadrilateral elements and higher order elements.
4. Apply the knowledge of FEM for stress analysis, model analysis, heat transfer analysis and flow analysis.

Prerequisite: Strength of Materials, Engineering Mechanics and Engineering Mathematics

Course Content		
Unit No	**Description**	**Hrs.**
01	**Basics of FEM** Review of elasticity. Mathematical models for structural problems: Equilibrium of continuum-Differential formulation, Energy Approach- Integral formulation: Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models, Residual methods and weighted residual methods, Ritz, Rayleigh-Ritz and Gelarkin's methods. Philosophy of solving continuum problems using Finite Element Method.	**06**
02	**Finite Element Analysis For One Dimensional Structural Applications** Structural problems with one dimensional geometry. Bar element: formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method, Introduction to higher order	**06**

	elements and their advantages and disadvantages. Formulation for Truss elements, Case studies involving hand calculations with an emphasis on assembly, boundary conditions, contact conditions and multipoint constraints.	
03	**Beams and Frames** Review of bending of beams, higher order continuity (C0 and C1 Continuity), interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations. Algorithmic approach for developing computer codes involving 1-D elements.	**06**
04	**Two Dimensional Application** Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axisymmetric problems; Triangular and Quadrilateral elements, higher order elements, sub-parametric, Isoparametric and superparametric elements. Formulation of plate bending elements using linear and higher order bending theories, Shell elements, General considerations in finite element analysis of design problems, Choosing an appropriate element and the solution strategies. Introduction to pre and post processing of the results and analysis. **Three Dimensional Problems** Finite element formulation for 3-D problems, mesh preparation, tetrahedral and hexahedral elements, case studies.	**06**
05	**Dynamic Analysis** FE formulation in dynamic problems in structures using Lagrangian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion, Modelling of structural damping and formulation of damping matrices, Model analysis, Mode superposition methods and reduction techniques.	**06**
06	**FEM in Heat Transfer and Fluid Mechanics Applications** Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact problems. Finite element applications in potential flows; Formulation based on Potential function and stream function. Case studies.	**06**

References:

Text Books:

- Singiresu S.Rao, Finite element Method in Engineering, Elsevier.
- Seshu P, Textbook of Finite Element Analysis, PHI.
- Chandrapatla, T. R., and Belugunudu, A. D., Introduction to Finite element Method, Prentice Hall.

Reference Books:

- Reddy, J.N, Finite Element Method in Engineering, Tata McGraw Hill.
- Zeincowicz, the Finite Element Method, Elsevier.

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1301**	Course Name: **System Modelling and Dynamics**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course focuses on understanding and modeling dynamic systems using mathematical and simulation techniques. It covers system representation through block diagrams, signal flow graphs, and transfer functions for electrical, mechanical, fluid, and thermal systems. Students will explore modeling in both time and frequency domains, including state-space methods and linearization techniques. The course addresses system behavior, time response analysis, and stability using tools like the Routh-Hurwitz criterion, phase plane methods, and Lyapunov stability. Advanced topics include root locus and frequency response techniques, such as Bode and Nyquist plots, for analyzing system stability and performance. Practical applications of nonlinear modeling and simulation techniques are also included to prepare students for complex real-world systems.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Formulate mathematical models for a given system and predict its response to various inputs using appropriate methods.
2. Evaluate the stability of linear and nonlinear systems using established analytical and graphical techniques.
3. Design and implement advanced modeling and simulation techniques to analyze and optimize complex systems.

Prerequisite: Engineering Mathematics

Course Content		
Unit No	**Description**	**Hrs.**
01	**Introduction to System and Mathematical Modeling** System, environment and variables, the state of a system, Physical Laws for Modeling of System, Representation of System in terms of Block Diagram, Reduction of Multiple Subsystems, Signal Flow Graph, Mason's Gain Formula.	**06**
02	**Modeling in the Frequency Domain** Laplace Transform Review, The Transfer Function, Electrical Network Transfer Functions, Translational Mechanical System, Rotational Mechanical System, Transfer Functions for Systems with Gears, Electromechanical System, Fluid Systems, Thermal Systems, Electric Circuit Analogs, Nonlinearities, Linearization.	**06**
03	**Modeling in the Time Domain** The General State-Space Representation, Applying the State-Space Representation,	**06**

	Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function, Linearization.	
04	**Time Response** Poles, Zeros, and System Response, First-Order Systems, The General Second-Order System, Underdamped Second-Order Systems, System Response with Additional Poles, System Response With Zeros, Effects of Nonlinearities Upon, Time Response, Laplace Transform Solution of State Equations, Time Domain Solution of State Equations.	**06**
05	**Stability of System** Linear and Nonlinear System, Stability in Linear and Nonlinear System, Routh-Hurwitz Criterion, Routh-Hurwitz Criterion, Stability in State Space, Phase Plane Method for Nonlinear System. Root locus techniques - Introduction, Defining the Root Locus, Properties of the Root Locus, Sketching the Root Locus. Frequency response techniques - Introduction, Asymptotic Approximations: Bode Plots, Introduction to the Nyquist Criterion, Sketching the Nyquist Diagram, Stability via the Nyquist Diagram, Gain Margin and Phase Margin via the Nyquist Diagram, Stability, Gain Margin, and Phase Margin via Bode Plots	**06**
06	**Advanced Modeling and Simulation Techniques** Introduction to Lyapunov Stability and Modeling via Lyapunov, Nonlinear Modeling Techniques such as consideration of Structural Nonlinearity and Material Nonlinearity	**06**

References:

Text Books:

- Nicola Bellomoand Luigi Preziosi, Modeling Mathematical Methods and Scientific Computations, CRC Press.
- I.J. Nagarathand M. Gopal, Systems Modeling & Analysis, Tata McGraw Hill, New Delhi.
- Jan Willen Poldermanand Jan C. Willems, Introduction to Mathematical Systems Theory- A Behavioral Approach, Springer.
- J.L. Shearer, A.T. Murphy and H.H. Richardson, Introduction to System Dynamics, Addison and Wesley.
- Norman S. Nise, Control Systems Engineering, John Wiley and Sons, Inc.
- Ogata, Modern Control Engineering, Prentice Hall.

Reference Books:

- Ogata, System Dynamics, Pearson Education.
- Hung V Vu and R.S. Esfandi, Dynamics Systems - Modeling and Analysis, The McGraw-Hill Companies Inc.

Program Elective-I

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1047**	Course Name: **Mechanics of Composite Materials**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
Composites are becoming an essential part of today's materials because they offer advantages such as low weight, corrosion resistance, high fatigue strength, and faster assembly. Composites are used as materials in making aircraft structures to golf clubs, electronic packaging to medical equipment, and space vehicles to home building. Composites are generating incredible interest in students all over the world. They are seeing everyday applications of composite materials in the commercial market, and job opportunities are increasing in this field. The technology transfer initiative of the US federal government has opened new and large-scale opportunities for use of advanced composite materials.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Recognize the basic concepts and difference between composite materials with conventional materials.
2. Apply the knowledge of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3. Apply knowledge for finding failure envelopes and stress-strain plots of laminates.
4. Develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

Prerequisite: Mechanics of Deformable bodies

Course Content

Unit No	Description	Hrs.
01	**Introduction to Mechanics of Composite Materials** Definition and characteristics, Overview of advantages and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus.	**06**
02	**Basic Concepts and Characteristics** Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials.	**06**

03	**Elastic Behavior of Unidirectional Lamina** Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters.	06
04	**Strength of Unidirectional Lamina** Micromechanics of failure; failure mechanisms, Macro-mechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories.	06
05	**Elastic Behavior of Laminate** Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates.	06
06	**Stress and Failure Analysis of Laminates** Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials, sustainability of composites.	06

References:

Text Books:

- Isaac M. Daniels, Ori Ishai. Engineering Mechaincs of Composite Materials. Oxford University Press.
- Bhagwan D. Agarwal, Lawrence J. Broutman, Analysis and Performance of fiber composites. John Wiley and Sons, Inc.

Reference Books:

- Mathews, F. L. and Rawlings, R. D. Composite Materials: Engineering and Science. CRC Press, Boca Raton.
- Madhujit Mukhopadhyay. Mechanics of Composite Materials and Structures. University Press,
- Mazumdar S. K. Composaite Manufacturing – Materials, Product and Processing Engineering. CRC Press, Boca Raton,
- Robert M. Jones. Mechanics of Composite Materials. Taylor and Francis, Inc.

Program Elective-I

Class- **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1057**	Course Name: **Design for Manufacturing & Assembly**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:

This course provides an in-depth understanding of designing products and processes with a focus on manufacturability, automation, reliability, and sustainability. Students will explore advanced principles of design for manufacturing, automated and manual assembly, and disassembly. Emphasis is placed on selecting materials and processes to optimize production, ensure reliability, and incorporate Industry 4.0 technologies. The course also covers reliability analysis, predictive maintenance, and strategies for recyclability and sustainability in design. By the end of the course, students will have the tools to create efficient, reliable, and environmentally friendly designs aligned with modern industrial advancements.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Apply advanced design principles to optimize manufacturability and material selection processes.
2. Analyze automated assembly processes and evaluate their impact on production efficiency and Industry 4.0 integration.
3. Develop systematic Design for Assembly (DFA) strategies to enhance manual assembly and disassembly efficiency.
4. Evaluate reliability metrics and hazard rate models to improve product lifecycle and reliability testing approaches.
5. Design failure mode analysis frameworks, incorporating IoT and AI for enhanced system reliability and fault diagnosis.
6. Create sustainable designs emphasizing recyclability, predictive maintenance, and Industry 4.0-enabled monitoring systems.

Prerequisite: Engineering Materials and Metallurgy, Manufacturing Processes, Machine Design, Reliability Engineering, Industrial Automation and Robotics, Engineering Mathematics.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Design for Manufacturing** Design philosophy steps in the design process, General design rules for manufacturability, Basic principles for economical production, Creativity in design, Selection of materials for design, Developments in material technology, Criteria for	**06**

	material selection, Interrelationship between material and process selection, Advanced process selection charts.	
02	**Design for Automated Assembly** Development of automated assembly processes, Choice of assembly methods, Continuous and intermittent transfer mechanisms, Indexing mechanisms, Free-transfer systems, Automation advantages, social impacts of automation in Industry 4.0.	06
03	**Design for Manual Assembly and Disassembly** Integration of Design for Assembly (DFA) into the design process, General design guidelines for manual assembly and disassembly, Systematic DFA methodology, Factors affecting handling and insertion time (part symmetry, thickness, size, weight, chamfer design), Estimation of insertion time.	06
04	**Design for Reliability** Reliability function R(t), Hazard rate function Z(t), Mean time to failure (MTTF), Mean time between failures (MTBF), Probability mathematics and reliability relations, Hazard rate models, Product life cycles, Reliability testing methods (life testing, burn-in testing, acceptance testing, accelerated life testing), Industry 4.0-enabled reliability analysis.	06
05	**Failure Mode Analysis** Fault tree and success tree methods, Symbols, Tie sets, Cut sets, Failure Mode Effectiveness and Criticality Analysis (FMECA), Reliability of systems (series, parallel, redundancy, complex systems), IoT and AI for reliability improvement.	06
06	**Design for Maintenance and Recyclability** Mean time to repair (MTTR), Availability, Reliability design of elements (tension elements, I-beams, shafts), Predictive maintenance techniques, Condition monitoring equipment, Principles of recyclability, Sustainable design, Industry 4.0 applications in maintenance and recyclability.	06

References:

Text Books:

- Geoffrey Boothroyd, Assembly Automation and Product Design, Marcel Dekker Inc., NY.

Reference Books:

- George E. Deiter, Engineering Design - Material & Processing Approach, McGraw Hill.
- Geoffrey Boothroyd and Marcel Dekken, Handbook of Product Design, NY.
- A. Delbainbre, Computer Aided Assembly, London.
- Charles E. Ebiting, Introduction to Reliability Maintainability Engineering, Tata McGraw Hill.
- K.C. Kapur and L.R. Laimberson, Reliability in Engineering Design, John Wiley & Sons.
- L.S. Srinath, Reliability in Design, Tata McGraw Hill.
- S.S. Rao, Reliability-Based Design, Tata McGraw Hill.
- B.S. Dhillon, Engineering Maintainability, Prentice Hall of India.

Program Elective-I

Class: **F.Y. M. Tech**	Semester: **I**
Course Code: **MDE1067**	Course Name: **Experimental Stress Analysis**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
Design and construction of machines and structures is heavily dependent upon knowing state of stress at various points. In this course, the basic aspects of experimental stress analysis and its several variants ranging from conventional transmission photoelasticity to digital photoelasticity, are presented. The technique basically provides the difference of principal stresses/strains and their orientation at every point in the model domain. It is the only whole-field technique which can study the interior of a two- and three-dimensional model. The advancements in digital photoelasticity have made photo elastic analysis more efficient and reliable for solving engineering problems. Photoelasticity is useful as a design tool, to understand complex phenomenological issues, and as an excellent teaching aid for stress analysis.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Determine direction and magnitude of principal stresses by using various techniques of Experimental Stress Analysis.
2. Solve two and three dimensional problems of stress-strain analysis in the field of mechanical engineering.
3. Formulate solutions using digital image processing technique.

Prerequisite: Strength of Materials, Machine Design, Mathematic and Modern Physics.

Course Content

Unit No	Description	Hrs.
01	**Photo Elasticity** Theory of Photo Elasticity, Plane Polariscope, Circular polariscope, Isoclinics and Isochromatics, Model Materials: Properties, Selection and methods of calibration, Different Methods of Analysis: Compensation Technique, Principle stress separation technique, Fringe sharpening, Fringe Multiplication, Scaling model to prototype stresses, Applications of photo elasticity for two dimensional. Three Dimensional Photo Elasticity: Casting Technique, Slicing Technique, Analysis Technique.	**06**
02	**Photostress Technique** Reflection Polariscope, Stress and strain optic relations for coatings, Coating and specimen stresses, Correction factor for Photo Elastic coating, Coating Materials, Bonding the coating, Selection of coating thickness, Calibration of coating material,	**06**

	Data collection and analysis, Applications.	
03	**Digital Photoelasticity** Introduction to digital photoelastcity, Use of color information for quantitative analysis, Three Fringe Photoelasticity(TFP), Refined TFP (RTFP) to solve variant problems, Paradigm shift in data processing, Processing of intensity data for photoelastic data extraction, Ten step method, Phasemaps.	06
04	**Electrical Resistance Strain Gauge Technique** Electrical Resistance strain gauges: types, gauge factor, sensitivity, applications. Materials, Bonding of strain gauge, Testing of gauge installations, Strain measuring Circuits, Commercial strain indicator, Cross sensitivity, Temperature compensation, Semi-Conductor strain Gauges, Strain gauge Rosettes and transducers.	06
05	**Holography and Brittle Coating Method** Fundamentals of Holography, Holography in photo elasticity, Advantages and applications. Brittle Coating- Coating stresses, Crack patterns, Crack detection method, Analysis, Advantages.	06
06	**Moire Fringe Method** Moire phenomenon and formation of Moire fringes; Geometric and displacement approach for in-plane problems, Moire grating production, printing and photography, Analysis technique, Applications.	06

References:

Text Books:

- Sadhu Singh, Experimental stress analysis, Khanna Publication New Delhi.
- Jindal U C, Experimental stress analysis, Pearson Publications, New Delhi.

Reference Books:

- Dally, J.W., and Riley, W.F. Experimental Stress Analysis, McGraw-Hill Inc., New York.
- L.S. Srinath, M.R. Raghava, K. Lingaiah, G. Garagesha, B. Pant, and K. Ramachandra. Experimental Stress Analysis, Tata McGraw-Hill, New Delhi.
- K. Ramesh. Digital Photo elasticity, Springer.
- Albert S. Kobayashi. Handbook on Experimental Mechanics, Society for experimental Mechanics (SEM).

Program Elective-I

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1077**	Course Name: **Reliability Engineering**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
The Reliability Engineering course is crucial for PG design engineering students as it equips them with the skills to design robust and dependable systems. It teaches failure analysis, reliability modeling, and risk management, helping students anticipate potential failures and optimize product performance. The course also covers life testing, reliability assessment, and allocation techniques, enabling students to ensure long-term reliability and cost-effectiveness. With an emphasis on industry standards and real-world applications, the course prepares students for interdisciplinary collaboration and enhances their employability in various fields like aerospace, automotive, where reliability is a key factor for success.

Course Outcomes:
After successful completion of the course, students will be able to
1. Apply the concepts of Reliability, Availability and Maintainability.
2. Develop hazard-rate models to know the behavior of components.
3. Build system reliability models for different configurations.
4. Assess reliability of components and systems using field and test data.
5. Implement strategies for improving reliability of repairable and non-repairable systems

Prerequisite: Mathematics, Engineering Mechanics, Materials Science, Manufacturing Processes, Machine Design.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Fundamentals of Probabilistic Reliability and Failure Analysis** Probabilistic reliability, failures and failure modes, repairable and non- repairable items, pattern of failures with time, reliability economics.	**06**
02	**Component Reliability Models** Basics of probability and statistics, hazard rate and failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent and stress-dependent hazard models, bath-tub curve.	**06**
03	**System Reliability Models** Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load sharing models, stress-strength models, and reliability block diagram.	**06**

04	**Life Testing and Reliability Assessment** Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems.	06
05	**Reliability Analysis and Allocation** Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets and tie sets approaches.	06
06	**Maintainability Analysis** Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.	06

References:

Text Books:

- Charles Ebeling, An Introduction to Reliability and Maintainability Engineering, TMH, New Delhi.
- Roy Billinton and Ronald N Allan, Reliability evaluation of Engineering systems, BS Publications.
- Elsayed A, Reliability Engineering, Prentice Hall Publications.

Reference Books:

- Igor Bazovsky, Reliability Theory and Practice, Dover Publications.
- Patrick O'Connor, Practical Reliability Engineering, John Wiley and Sons Inc.
- Gregg K. Hobbs, Accelerated Reliability Engineering: HALT and HASS, Wiley.
- R. Ramakumar, Reliability Engineering Fundamentals, Pearson Education.
- A K Govil, Reliability Engineering, Tata McGraw-Hill.
- E. Balagurusamy, Reliability Engineering, Tata McGraw-Hill Education.
- Dimitri Kececelogu, Maintainability, Availability, and Operational Readiness, Destech Publications, Inc.
- L. S. Srinath, Reliability Engineering, 3rd Edition, Affiliated East West Pvt Ltd.
- Alessandro Birolini, Reliability Engineering: Theory and Practice, Springer Publications.

Program Elective-I

Class: **F.Y. M. Tech**	Semester: **I**
Course Code: **MDE1291**	Course Name: **Vehicle Dynamics**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course delves into the fundamentals of vehicle dynamics, covering key aspects like vehicle motion variables, forces, and control. Students will explore axle loads, aerodynamic forces, tire mechanics, and factors influencing tire life. Road load analysis includes aerodynamic effects, rolling resistance, and fuel economy. The course also examines acceleration and braking performance, focusing on power, traction, braking forces, and road resistance. Vehicle vibration and ride characteristics are studied, including excitation sources and tire alignment. Suspension systems, including solid axles, independent and active suspensions, and roll center analysis, are analyzed. Steady-state cornering dynamics, understeer, oversteer, and suspension effects on turning are also covered.

Course Outcomes:
1. After successful completion of the course, students will be able to,
2. Analyze the principles governing the development and design of road vehicles under the influence of dynamic loads, and evaluate their impact on vehicle performance.
3. Analyze the performance and establish the design specifications for the acceleration and braking conditions.
4. Model, simulate and analyze the conventional road vehicles for better ride comfort.
5. Analyze the cornering forces and effects of tractive forces on cornering.
6. Design suspension systems for better damping and comfort.

Prerequisite: Automotive Engineering Basics, Dynamics of Machinery, Engineering Mathematics, Mechanical Vibrations.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Basics of Vehicle Dynamics** Hypothetical vehicle control loop, Fundamental Approach, Vehicle coordinates, motion variables. Forces – Dynamic axle loads, Static loads on level ground, aerodynamic forces on body, hitch forces, tire construction, size and load rating, terminology, mechanics of force generation, Tyre wear, tire life, factors affecting tire life – problems.	**06**
02	**Road Loads** Aerodynamic, Mechanics of pressure distribution – Aerodynamic forces: lift and drag, Spoilers, Lift force, side force and roll, pitch and yaw moments, Crosswind sensitivity.	**06**

	Rolling Resistance, Factors affecting pressure, velocity, slip temperature, etc. Total road loads – Fuel Economy Effects.	
03	**Acceleration and Braking Performance** Power limited, Traction limited acceleration, Static loads on level ground, aerodynamic forces on body, Fundamental Expressions, Constant retardation, Wind Resistance, Power, Braking forces, Brakes: disc and drum, front, rear and four-wheel braking, Braking Torque, Road friction rolling resistance, problems.	**06**
04	**Vehicle Vibration and Ride characteristics** Excitation sources – road roughness, wheel assembly, driveline excitation, engine transmission. Wheel Hop Resonance. Rigid body bounce, pitch motion. Effect of vibration on vehicle riding. Influence of pressure in tyre, alignment toe in and toe out, tire wear and tyre life.	**06**
05	**Suspension** Solid axes – Independent suspension, Anti-squat and anti- pitch suspension geometry, roll center analysis, Active suspension, suspension load – vehicle loading, load due to gyroscopic force on suspension, total load on suspension.	**06**
06	**Steady State Cornering** Introduction, Low and high speed turning –Tyre cornering forces, governing expressions, under steer gradient, over steer and neutral conditions. Characteristic speed, critical speed, yaw velocity gain, sideslip angle, static margin. Suspension effects on cornering.	**06**

References:

Text Books:
- Hans B Pacejka, Tire and Vehicle Dynamics, Elsevier Ltd.
- J H Smith, Butterworth Heinemann, An Introduction to Modern Vehicle Design, Oxford,\

Reference Books:
- Rao V Dukkipati, Road Vehicle Dynamics, Springer
- Werner and Karl, Ground Vehicle Dynamics, Springer Berlin Heidelberg
- Wong H, Theory of Ground Vehicles, McGraw Hill
- Thomas D Gillespie, Fundaments of Vehicle Dynamics, SAE Inc,

Program Elective – II

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1087**	Course Name: **Optimization Techniques**

L	T	P	Credits
03	--	--	03

Course Description:
This course focuses on advanced optimization techniques for engineering design. It covers numerical methods and mathematical models used in optimization, including linear and non-linear programming, with and without constraints. The course also explores static and dynamic applications, such as the design of shafts, springs, and linkage mechanisms. Advanced techniques like Genetic Algorithms, Neural Networks, and Fuzzy Logic are introduced to optimize design parameters. The course aims to equip students with the skills to apply these techniques in real-world engineering problems.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Formulate and apply mathematical models in optimization techniques.
2. Analyze and select appropriate optimization methods for non-linear programming problems with and without constraints.
3. Implement optimization techniques for static applications such as shafts and springs.
4. Utilize optimization methods for dynamic applications including linkage mechanisms.
5. Develop and apply Genetic Algorithms to optimize design parameters.

Prerequisite: Applied Numerical Methods, Engineering Design and Analysis, Linear Algebra and Calculus.

Course Content

Unit No	Description	Hrs.
01	**Introduction of Optimization** Introduction: Classification of optimization problems, mathematical models in engineering optimization. Concepts in linear optimization: General simplex method, revised simplex method, duality, integer programming, branch and bound technique.	06
02	**Non Linear Programming Without Constraints** Local and global maxima, minima, Hessian matrix, Fibonacci method, Golden section method, random search method, steepest descent method.	06
03	**Non Linear Programming with Constraints** Lagrange multipliers, Kuhn-Tucker conditions, Wolfe's and Beale's method, sequential linear programming approach, penalty methods.	06
04	**Static Applications and Dynamic Application** Structural applications – Design of simple truss members, design of simple axial,	08

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	transverse loaded members, design of shafts and torsionally loaded members, design of springs. Dynamic Applications: Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.	
05	**Complex Systems Modelling** Design of experiments, Orthogonal Array, response surface methodology, analysis of response variables (ANOVA).	**04**
06	**Multi-Objective Optimization Techniques** Grey Relational Analysis, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization, nature inspired optimization techniques.	**06**

References:

Text Books:

- S. S. Rao. Optimization: Theory and Applications. Wiley Eastern, New Delhi
- J.C. Pant. Introduction to Optimization. Jain Brothers, New Delhi
- Kanthi Swaroop, et.at. Operations Research. S. Chand & Co., New Delhi
- Kanthi Swaroop, P.K. Gupta, and K.S. Rao. Operations Research S. Chand & Co., New Delhi
- Kalyanmoy Deb. Optimization for Engineering Design: Algorithms and Examples. Prentice Hall of India, New Delhi.

Reference Books:

- Rao, Singiresu S. Engineering Optimization: Theory & Practice New Age International (P) Limited, New Delhi
- Johnson, Ray C. Optimum Design of Mechanical Elements. Wiley, John & Sons,
- Goldberg, David E. Genetic Algorithms in Search, Optimization, and Machine Learning. Addison-Wesley, New York
- Johnson Ray, C. Optimum design of mechanical elements. Wiley, John & Sons.

Program Elective-II

Class: **F. Y. M. Tech.**	Semester: **I**
Course Code: **MDE1097**	Course Name: **Industrial Tribology**

L	T	P	Credits
03	--	--	03

Course description:
The study of friction, wear, and lubrication has long been of enormous practical importance, since the functioning of many mechanical, electromechanical and biological systems depends on the appropriate friction and wear values. In recent decades, this field, termed tribology, has received increasing attention as it has become evident that the wastage of resources resulting from high friction and wear is greater than 6% of the Gross National Product. The potential savings offered by improved tribological knowledge, too, are great.
Tribology deals with design of fluid containment systems like seals and gasket, Lubrication of surfaces in relative motion to achieve reduced friction and wear. The structure of the bearing and the nature of fluid flow determine the loads that can be supported. Modelling systems as hydrostatic, squeeze film and elasto-hydrodynamic lubrication will be studied as infinite and later finite structures. Gas (air) lubricated and rolling contact type motions with deformation at contact will be studied as special systems.

Course Outcomes:
After successful completion of the course, students will be able to
1. Determine tribological parameters of mechanical systems analytically by using suitable theories of friction and theories of wear.
2. Select hydrostatic step bearing for real life application in mechanical engineering based on axial load applied and lubricant available.
3. Calculate the maximum load carrying capacity and pressure equation for hydrodynamic thrust bearing by using engineering principles.
4. Evaluate elasto-hydrodynamic lubrication occurred in gears, cams and rolling element bearing by using hertz and Ertel-Grubin equation.
5. Estimate pressure distribution in gas lubricated bearings by applying Reynolds equation for gas lubrication within elastic limits.

Prerequisite: Engineering Chemistry, Fluid Mechanics, Strength of Material.

Course Content		
Unit No.	**Description**	**Hrs.**
01	**Lubrication Theory** Introduction to Tribology, Tribology in Design, Tribology in industry, Lubricants properties, physical and chemical, lubricants standards, types of additives, extreme	**06**

	pressure lubricants. Lubrication – introduction, basic modes of lubrication. Types of sliding contact bearings. Comparison of sliding and rolling contact bearing.	
02	**Friction and Wear** Friction - Laws of friction, Friction classification, causes of friction, Theories of Dry Friction, Friction Measurement, Stick-Slip Motion. Wear - Wear classification, Wear between solids, Wear between solid and liquid, wear Measurement of wear, Theories of Wear, Approaches to Friction Control and Wear Prevention.	**06**
03	**Hydrostatic and Squeeze Film Lubrication** Hydrostatic Lubrication–Basic concept, Advantages and limitations, Viscous flow through rectangular slot, Load carrying capacity and flow requirement, Energy losses, Optimum design. Squeeze Film Lubrication - Basic concept, Squeeze action between circular and rectangular plates, Squeeze action under variable and alternating loads.	**06**
04	**Hydrodynamic Thrust Bearing** Introduction - Flat plate thrust bearing, Tilting pad thrust bearing, Pressure Equation - Flat plate thrust bearing, Tilting pad thrust bearing, Load, Flat plate thrust bearing, Tilting pad thrust bearing, Center of Pressure - Flat plate thrust bearing - Tilting pad thrust bearing, Friction - Flat plate thrust bearing - Tilting pad thrust bearing.	**06**
05	**Elasto-Hydrodynamic Lubrication** Principles and Applications, Pressure viscosity term in Reynolds's equation, Hertz's Theory, Ertel-Grubin equation, Lubrication of spheres, Gear teeth bearings, Rolling element bearings.	**06**
06	**Gas (Air) Lubricated Bearings** Introduction, Merits, Demerits and Applications, Hydrodynamic bearings with air lubrication, Hydrostatic bearings with air lubrication, , Tilting pad bearings with air lubrication.	**06**

References:

Text Book:

- B.C. Majumdar, Introduction to Tribology of Bearings, S. Chand and Company Ltd.
- Prasanna Sahoo, Engineering Tribology, PHI Learning Pvt. Ltd.
- Mervin H. Jones and Douglas Scott, Industrial Tribology the Practical Aspects of Friction, Lubrication and Wear, Elsevier Scientific Publishing Company Amsterdam-Oxford-New York.
- Cameron A. Basic, Lubrication Theory, Wiley Eastern Ltd.

References Book:

- Neale M. J. Butterworth's, Tribology Handbook.
- Bharat Bhushan, Handbook of Tribology, Krieger Publishing Company.

Program Elective-II

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1107**	Course Name: **Advanced Mathematical Methods in Engineering**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:

Advanced Mathematical Methods in Engineering is a first-semester elective in the M.Tech. Mechanical Design Engineering program, designed to equip students with advanced mathematical tools for engineering analysis and research. The course covers Fourier series and transforms, classification and solution techniques for partial differential equations, and their applications in wave phenomena and vibrations. It also includes numerical methods such as Gaussian elimination, LU decomposition, and eigenvalue problems, along with advanced root-finding techniques. Additionally, students explore statistical methods like ANOVA and experimental design principles, including Latin-square, completely randomized, and randomized block designs. By integrating analytical, numerical, and statistical approaches, the course enhances problem-solving skills and prepares students for tackling complex engineering challenges in both academic and industrial research.

Course Outcomes:

After successful completion of this course students should be able to

1. Evaluate Fourier Series for given function and apply it to solve the partial differential equations in Engineering problems
2. Apply the specific method of solution of partial differential equations for solving the given problems
3. Formulate and solve a boundary value problem (Partial differential equation, boundary and initial conditions).
4. Use the relevant method for solving the simultaneous linear equations and compute the Eigen values.
5. Estimate numerically the solution of given algebraic equation.
6. Analyze the variance and explain the different research designs

Pre-requisite: Undergraduate Engineering Mathematics.

Course Content		
Unit No.	**Description**	**Hrs.**
01	**Fourier Series and Fourier Transforms** Fourier series: The Fourier series of a function, convergence of a Fourier series, Fourier cosine and sine series, integration and differentiation of Fourier series. Fourier series of an arbitrary periods, Even, odd functions and half range series of Fourier.	**06**

02	**Partial Differential Equations** First order partial differential equations; second order linear partial differential equation: canonical forms: second order equation (parabolic, elliptic and hyperbolic) in rectangular, Lagrange's linear equations, cylindrical, polar and spherical coordinate systems; solution techniques: separation of variables, Eigen function expansions.	06
03	**Applications of Partial Differential Equations** The wave equation and initial and boundary conditions, Fourier series solution of the wave equation, Fourier transform solution of problems on unbounded domains, characteristics and D'Alembert's solution: D'Alembert's solution for the wave equation, a nonhomogeneous wave equation, forward and backward waves, normal modes of vibration of a circular elastic membrane, vibration of rectangular membrane.	06
04	**Simultaneous Linear Equations** Gaussian elimination method, gauss Jordan method, LU- decomposition from Gaussian elimination method, solution of tridiagonal systems, Eigen value problems.	06
05	**Numerical Methods** Muller's method, Horner's method, multiple roots, Lin Bairtow's method, Graeffe's squaring method.	06
06	**ANOVA** One-way, two-way with/without interactions. Anova technique, principles of design of experiment: some standard designs such as Latin-square design (LSD), completely randomized design (CRD), and randomized block design (RBD).	06

References:

Text Books

- Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, New Delhi.
- Dr. B.S.Grewal, Numerical Methods in Engineering & Science with Programs in C, C++ & Matlab, Khanna Publishers.

Reference Books:

- Larry C. Andrews, Ronald L. Phillips, Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Private Ltd. New Delhi.
- J. B. Doshi, Differential Equations for Scientients and Engineers, Narosa.
- Peter O'Neil, Advanced Engineering Mathematics, Seventh Edition, Cengage Learning
- Michel Greenberg, Advanced Engineering Mathematics, Second Edition, Pearson's Education.
- Ramamurthy. V., Computer Aided Design in Mechanical Engineering. Tata McGraw Hill Publishing Co.
- Hicks and Turner Fundamental Concepts in the Design of Experiments.
- Devore, Jay L., Probability and Statistics for Engineering and the Sciences

Program Elective-II

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1117**	Course Name: **Smart Materials and Systems**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:/
Smart materials and systems is an emerging technology with numerous potential applications in industries as diverse as consumer, sporting, medical and dental, computer, telecommunications, manufacturing, automotive, aerospace, as well as civil and structural engineering. The course introduces the student to the basic principles and mechanisms of smart materials and devices and provides a spring board for further study. It is also designed to give an insight into the latest developments regarding smart materials and their use in mechanical structures. Further, this also deals with structures which can self-adjust their stiffness with load.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Illustrate the behavior and applicability of various smart materials.
2. Demonstrate the design methods of smart sensors and actuators.
3. Model smart sensors and actuators for specific application.
4. Demonstrate the techniques of fabrication of smart systems.
5. Design simple smart systems for specific application.

Prerequisite: Mechanics of Materials, Metallurgy.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Overview of Smart Systems** Evolution of smart materials and systems, smart system and its components, Active and passive smartness, processing of smart materials, Semi-conductors and their processing, Metals and metallization techniques, Ceramics, silicon micromachining techniques, UV radiation curing of polymers, Deposition techniques for polymer thin films, properties and synthesis of carbon nanotubes.	**06**
02	**Smart Solids & Fluids** Piezoelectric materials, piezoelectric effect and materials, properties of piezoelectric material, Mathematical description of piezoelectric effect, PVDF, Shape Memory Alloys (SMA) : Phenomenology of phase transformation, Shape memory effects, Psedo-elasticity, effect of alloying on the transformation behavior of SMAs, Characterization of SMAs, Magneto-rheological Elastomers (MRE), Electro-rheological (ER) and Magneto-rheological fluids, Magnetostrictive, Self-healing materials, fiber optics.	**06**

03	**Design Principles of Sensors and Actuators** Sensors: Piezoelectric, Magnetostrictive, Optical, Resonant, Semi-conductor based, Acoustic, Polymeric and carbon nanotubes sensors, Actuators : Electrostatic, Electromganetic, Electrodynamics, Piezoelectric, Electrostrictive, Magnetostrictive actuators, Design Examples for sensors and actuators.	06
04	**Modeling of Smart Sensors and Actuators** Modeling of a 3D composite laminate with embedded piezoelectric sensors and actuators, Modeling of magnetostrictive sensors and actuators, Modeling of micro electromechanical systems, Modeling of carbon nanotubes (CNTs).	06
05	**Fabrication Methods for Smart Systems** Silicon Fabrication Techniques for MEMS, Fabrication processes for silicon MEMS, Deposition techniques for thin films, Bulk micromachining for silicon-based MEMS, Silicon surface micromachining, processing by both bulk and surface micromachining, Polymeric MEMS fabrication techniques, Fabrication examples of smart microsystems.	06
06	**Applications of Smart Materials and Systems** Structural health monitoring – Monitoring of composite wing-type structures using magnetostrictive sensors/actuators, Assessment of damage severity and health monitoring using PZT sensors / actuators, Wireless MEMS – IDT microsensors for health monitoring of structures, Vibration and noise control applications, Applications in the field of aerospace and medical, Futuristic applications of smart materials.	06

References:

Text Books:

- Vijay k. Varadan, K.J. Vinoy, S. Gopalkrishana, Smart Materials Systems and MEMS: Design and Development Methodologies, John Wiley and Sons.
- B. Culshaw, Smart Structures and Materials, Artech House, Boston.
- M. V. Gandhi and B.S. Thompson, Smart Materials and Structure, Chapman and Hall, London; New York.

Reference Books:

- Dimitris C. Lagoudas, Shape Memory Alloys: Modelling and Engineering Applications, Springer Publication.
- Ashwin Rao, A.R. Shrinivasa, J.N. Reddy, Design of Shape Memory Alooy (SMA) actuators, Springer briefs in Applied Sciences and Technology.
- Chee - Kiong Soh, Yaowen Yang, Suresh Bhalla, Smart materials in Structural Health Monitoring, Control and Biomechanics, Zhejiyang University Press, Springer Publication.
- Mel Scwartz, Encyclopedia of Smart Materials, John Wiley & Sons
- H. Janocha, Actuators - Basics and Applications, Springer Publication.
- A. V. Srinivasan, Smart Structures: Analysis and Design, Cambridge University Press,Cambridge; New York.

Program Elective-II

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1037**	Course Name: **Computer Aided Design**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
The CAD is the important tool in design process and the user should be well acquainted with hardware, software's and related processes of this tool in order to use it effectively. The course Computer Aided Design deals with the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems. Also, Demonstrate 2D, 3D transformations and projection transformations; Describe various approaches of geometric modeling and representation of 2D and 3D entities mathematically.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Describe the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
2. Demonstrate 2D, 3D transformations and projection transformations.
3. Describe various approaches of geometric modelling.
4. Represent 2D and 3D entities mathematically.

Prerequisite: Computer software and hardware.

Course Content

Unit No.	Description	Hrs.
01	**CAD Hardware and Software** Types of systems and system considerations, input and output devices, Software modules, Principle of networking, classification networks.	06
02	**Overview of PLM Software** Integration of CAD with PLM, PLM Software: Team Centre / Wind Chill. Evolution of CAD Data Exchange Format – Shape-Based format, Product data-based format.	06
03	**Computer Graphics** Introduction, transformation of geometric models: translation, scaling, reflection, rotation, homogeneous representation, concatenated transformations; mappings of geometric models – Translation, rotational, general mapping, Inverse transformations, Projections. Augmented reality and virtual reality.	06
04	**Geometric Models** Projections of geometric models, Geometric Modeling, Parametric Modeling, Curve representation: Parametric representation of analytic curves, parametric representation	06

	of synthetic curves, curve manipulations, Surface representation, surface manipulations, Tutorials.	
05	**Solid Modeling** Fundamentals of solid modeling, Boundary representation (B-rep), Constructive Solid Geometry (CSG), Sweep representation, Analytic Solid Modeling (ASM), Solid manipulations, solid modeling based applications: mass properties calculations, mechanical tolerancing, coloring, rendering, assembly modeling, etc.	**06**
06	**Finite Element Modeling and Analysis** Finite Element Analysis, Development of integral equations, Finite elements, Assembly of element equations, Applying boundary conditions, Finite element solutions, Finite element modelling, Mesh generation, Tutorials.	**06**

References:

Text Books:

- Ibrahbim Zeid, Mastering CAD / CAM, McGraw Hill Publication
- Jim Browne, Computer Aided Engineering and Design.
- P. Radhakrishnan, V. Raju and S. Subramanyam, CAD / CAM / CIM.
- P.N. Rao, CAD / CAM principles and applications, Tata Mcraw-Hill

Reference Books:

- Rogers, Adams, Mathematical Elements for Computer Graphics.
- Rooney and Steadman, Principles of Computer Aided Design.
- Jerry Banks, John Carson, Barry Nelson, David Nicol, Discrete-Event System Simulation.

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1127**	Course Name: **Finite Element Analysis and 3D Printing Lab**

L	T	P	Credits
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Course Description:
Looking into the wide applications of FEM, especially in the areas of aeronautical, automotive, civil, chemical, marine, electrical engineering, the basic fundamental knowledge of finite element packages is essential to address the wide variety of engineering problems. Hence this Design Engineering Lab I will basically focus on using finite element software like ANSYS to solve structural, thermal and dynamic analysis problems. Moreover, students will be engaged in fabrication of optimized mechanical component using 3D printing technology, translating virtual design into physical prototypes.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Solve 1D, 2D and 3D structural analysis problems using the ANSYS software
2. Evaluate dynamic behavior of components
3. Appraise Linear buckling concept in Design of members which are succumbed to buckling
4. Solve structural analysis problems subjected to fatigue load.
5. Appraise steady state and transient thermal concept in design of members.
6. Develop optimized component using 3D printing technology

Prerequisite: Strength of Material, Heat Transfer. Basics of Finite Element Analysis. Basics of Mechanical Vibration

Course Content

Experiment No.	Description	Hrs.
01	Introduction of ANSYS software (Workbench).	**02**
02	Analysis of Plane stress and plane strain problems.	**02**
03	Analysis of beam subjected to bending and axial deformation	**02**
04	Structural analysis of Three-Dimensional Machine Components	**02**
05	Topology Optimization of Machine Components under structural loading condition.	**02**
06	Modal and Harmonic Response analysis	**02**
07	Linear Buckling Analysis	**02**
08	Fatigue Analysis of mechanical component.	**02**

09	Steady state thermal analysis of mechanical component.	**02**
10	Transient response : structural and thermal Analysis	**02**
11	Fabrication of 3D part using 3D Printer optimized in ANSYS software	**02**

Any ten experiment from Above list of experiments.

References:

Text Books:

- Nitin Gokhale, (Finite to Infinite, Pune) Practical Finite Element Analysis.

Reference Books:

- Fagan, (Longman Scientific & Technical) Finite Element Analysis - Theory & Practice
- J. N. Reddy, An Introduction to Finite Element Analysis Tata McGraw- Hill Pub. Co.

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **MDE1137**	Course Name: **Experimental stress analysis and Tribology Lab**

L	T	P	Credits
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Course Description:

This course is designed to expand the knowledge and skills in the field of experimental stress analysis and its application to structural analysis, machine design and material processing. The students will be equipped with essential analytical and practical skills that have a particular bearing on professional practice as a mechanical engineer. On completion of this course you should have sufficient knowledge of advanced stress analysis to enable you to solve advanced practical problems.

The course will specifically address the following topics: Advanced experimental stress analysis lab that includes exhaustive treatment of the most versatile techniques like photoelasticity and strain gauges and also a brief introduction to the emerging techniques like digital image correlation Photostress technique. These experiments are important for mechanical design applications and also finite element non-linear analysis.

Some concepts of tribology are also included like Friction and Wear measurement using Pin on disc setup (Dry and wet condition) and find lubricant property using- 4-ball tester abrasive wear test.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Apply Photoelastic Techniques for Stress Analysis
2. Analysis of stresses and strain using Reflection Polariscope
3. Measurement of Strain Using Strain Gauges and Transducer Applications
4. Measure friction and wear using pin on disc.
5. Find lubricant properties using 4-ball tester.

Prerequisite: Strength of Materials, Machine design

Course Content:

Experiment No.	Description	Hrs.
01	Determination of fractional fringe order by transmission polariscope (Tardy's Technique)	02
02	Sheet casting and preparation of photoelastic model.	02
03	Calibration of Photo elastic model material	02
04	Separation of stresses using oblique incidence method	02
05	Sheet casting by using photo-stress coating method	02
06	Determination of strain/stresses in photoelastic coated machine component by using reflection polariscope.	02

07	Bonding of strain gauge and checking its installation.	**02**
08	Determination of gauge factor for one arm, two arm sensitive and four arm sensitive configurations.	**02**
09	Determination of gauge factor for four arms sensitive and two linear and two lateral configurations.	**02**
10	Transducer applications of strain gauge-determination of unknown weight using load cell.	**02**
11	Transducer applications of strain gauge–determination of unknown torque using torque transducer.	**02**
12	To determine dry coefficient of friction of ferrous/non-ferrous material by using "pin on disc"	**02**
13	To determine abrasive wear of ferrous / non-ferrous material	**02**
14	Extreme pressure test of lubricant on four ball tester.	**02**

Any ten experiment from Above list of experiments.

References:

Text Books:

- K. Ramesh, "Experimental Stress Analysis," IIT Madras.
- K. Ramesh, "Digital Photoelasticity – Advanced Techniques and Applications," Springer.
- J.W. Dally and W.F. Riley, "Experimental Stress Analysis," McGraw-Hill.

Reference Books:

- L. S. Srinath, M. R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, "Experimental Stress Analysis," Tata Mc Graw Hill

Class: **F. Y. M. Tech**	Semester: **I**
Course Code: **SHP5513**	Course Name: **Technical Communication**

L	T	P	Credits
02	**--**	**--**	**01**

Course Description:
This course is designed to enhance students' ability to create well-structured technical documents and deliver impactful oral presentations. It emphasizes the principles of effective technical writing and explores various document types commonly used in technical fields and research. While the primary focus is on writing skills, the course also integrates oral communication skills, preparing students for professional presentations in diverse workplace settings.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Construct grammatically correct sentences in different types of technical writing, such as reports and proposals.
2. Apply technical writing skills to improve the readability of documents.
3. Demonstrate professional skills required in job interviews and at workplaces.

Prerequisite: Students enrolling in this course should have adequate LSRW abilities in English language.

Course Contents

Unit No.	Description	Hrs.
1.	**Planning and Preparation** Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	04
2.	**Paraphrasing and Plagiarism** Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism	03
3.	**Structural Framework of Research Article** Abstract, Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions, and The Final Check.	03
4.	**Sections of Research Article: Part- I** Key skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature,	04
5.	**Sections of Research Article: Part- II** Skills needed when writing the Methods, skills needed when writing the Results,	04

	skills needed when writing the Discussion, skills needed when writing the Conclusions, useful phrases, how to ensure good quality of the paper at the time of submission	
6.	**Professional skills** Resume Writing, e-mails, Interview skills, Dos and Don'ts while Answering, FAQs, GROUP DISCUSSION: Structured and Unstructured GD, Opening and Closure, Showing Agreement and Disagreement	**06**

Reference Books:

- Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London.
- Day R, How to Write and Publish a Scientific Paper, Cambridge University Press.
- Goldbort R, Writing for Science, Yale University Press (available on Google Books).
- Jeff Butterfield, Soft Skills for Everyone, Cengage Learning India Private Limited.
- John Seely, Oxford Guide to Effective Writing and Speaking; Oxford University Press.
- Thomas N. Huckin and Leslie A. Olsen, Technical Writing and Professional Communication for Nonnative Speakers of English; Tata McGraw Hills, International Edition.

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1147**	Course Name: **Mechanical Vibration**

L	T	P	Credits
03	**01**	**--**	**04**

Course Description:
This course provides a comprehensive study of vibration theory and its applications in mechanical systems. It covers causes, effects, and classification of vibrations, focusing on single, two, and multi-degree-of-freedom (MDOF) systems. Topics include formulation of equations of motion using methods like Newton-Euler and Lagrangian, free and forced vibration responses, resonance, transmissibility, and vibration design case studies such as machine foundations and suspension systems. Advanced topics include MDOF systems, modal analysis, continuous systems, and approximate methods like finite element analysis. The course also explores vibration control techniques, including passive, active, and semi-active control, and introduces piezoelectric sensors and actuators.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Analyze the causes and effects of vibrations in mechanical systems and identify discrete and continuous systems.
2. Model the physical systems into schematic models and formulate the governing equations of motion.
3. Compute the free and forced vibration responses of multi degree of freedom systems through modal analysis and interpret the results.
4. Analyze and design systems involving unbalance, transmissibility, vibration isolation and absorption.
5. Analyze and design to control and reduce vibration effects in machinery.

Prerequisite: Engineering Mechanics, Mathematics for Engineers, Dynamics of Machinery.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Vibrating Systems** Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.	**06**
02	**Single Degree of Freedom (SDF) Systems** Formulation of equation of motion: Newton –Euler method, De Alembert's method, Energy method, Free Vibration: Undamped Free vibration response, Damped Free vibration response, Case studies on formulation and response calculation. Forced	**06**

	vibration response of SDF systems: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances. **Design Case Studies:** Design case studies dealing with Transmissibility of forces and motion, Vehicular suspension, Analysis of Vehicles as single degree of freedom systems -vibration transmitted due to unevenness of the roads, preliminary design of automobile suspension. Design of machine foundations and isolators.	
03	**Two Degree of Freedom Systems** Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion, Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, coupled pendulum, free vibration response case studies, Forced vibration response, Automobile as a two degree of freedom system – bouncing and pitching modes undamped vibration absorbers, Case studies on identification of system parameters and design of undamped vibration absorbers. Analysis and design of damped vibration absorbers.	**06**
04	**Multi Degree of Freedom Systems** Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of modal vectors, normalization of modal vectors, Decoupling of modes, modal analysis, mode superposition technique, Free vibration response through modal analysis, Forced vibration analysis through modal analysis, Modal damping, Rayleigh's damping, Introduction to experimental modal analysis.	**06**
05	**Continuous Systems** Introduction to continuous systems, discrete vs continuous systems, Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems Case studies, Approximate methods for continuous systems and introduction to Finite element method	**06**
06	**Vibration Control in Structures** Introduction, State space representation of equations of motion. Passive control, active control and semi active control, Free layer and constrained damping layers, Piezo-electric sensors and actuators for active control, semi active control of automotive suspension systems.	**06**

References:

Text Books:

- L. Meirovich, Elements of Vibration Analysis, Tata Mc-Graw Hill
- Singiresu S Rao, Mechanical Vibrations, Pearson education
- P. Srinivasan, Mechanical Vibration Analysis, McGraw Hill.
- Ashok Kumar Mallik, Principles of Vibration Control, Affiliated East-West Press.

Reference Books:

- W.T, Thomson, Theory of Vibration, CBS Publishers
- Clarence W. De Silva, Vibration: Fundamentals and Practice, CRC Press LLC
- Venkatachalam R., Mechanical Vibrations, PHI Publications

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1157**	Course Name: **Analysis and Synthesis of Mechanisms**

L	T	P	Credits
03	01	--	04

Course Description:
In the mechanical designing of any component/system it is necessary to know the synthesis and analysis of mechanisms and machines incorporated therein. This course will provide the engineers the necessary tools to systematically synthesis, which means scientifically arriving at the critical shapes and dimensions of the bodies constituting the system. Various analytical and graphical methods required for the synthesis and analysis of mechanisms and machines have also been elaborated in this course.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Analyze the motion of mechanisms using velocity and acceleration methods, incorporating Chebyshev polynomials for synthesis.
2. Apply curvature theory concepts to analyze the geometric properties of mechanisms.
3. Synthesize planar mechanisms using geometric methods by determining link positions and analyzing poles with accuracy points.
4. Apply displacement equations for four-bar linkages to conduct synthesis based on prescribed velocities and accelerations.
5. Examine coupler curves using Robert Chebyshev's theorem to analyze curvature properties and symmetry in mechanisms.
6. Perform kinematic analysis of spatial mechanisms using Denavit-Hartenberg parameters and matrix methods for velocity and acceleration analysis.

Prerequisite: Theory of Machine, Machine Design and Mathematics.

Course Content

Unit No	Description	Hrs.
01	**Kinematics** Kinematics in elements in pairs Mechanism with lower and higher pairs, geometry of motion type's number of dimensional synthesis of mechanisms, Chebyshev Polynomials, spacing of accuracy points. Analysis of kinematically simple mechanisms, velocity acceleration, analysis of complex mechanism by normal acceleration and auxiliary point method.	06
02	**Curvature Theory** Fixed and moving centrodes, inflection circle, Euler-Savary equation, cubic of stationary curvature.	06

03	**Geometric Methods of Synthesis of Planner Mechanisms** Two finitely separated link positions, three finitely separate link positions, poles and relative poles, synthesis with three accuracy points, four finitely separated link positions poles triangle, Image poles-opposite poles, quadrilateral circle points and center points curves, synthesis with four accuracy points.	06
04	**Algebraic Method of Synthesis of Planer Mechanisms** Displacement equations of the four bar linkage, Synthesis with three accuracy points-synthesis with prescribed velocity and acceleration, synthesis with four accuracy points, mechanical error in linkages. Velocity and acceleration synthesis of four bar mechanism using complex number method, couple synthesis.	06
05	**Coupler Curves** Equation of coupler curves, Robert Chebyshev Theorem, double points and symmetry, Euler Savary equation and cube of stationery curvature.	06
06	**Kinematic Analysis of Spatial Mechanisms** Denavit-Hartenberg parameters, Velocity and acceleration analysis of spatial linkages. matrix method of analysis of spatial mechanisms	06

References:

Text Books:

- Asok Kumar Mallik, A. Ghosh, G. Dittrich. Kinematic analysis and synthesis of mechanisms, CRC Press.

Reference Books:

- Arthur G. Erdman and George. N. Sander. Mechanisms Design Analysis and Synthesis Vol.-I Vol.-II. Prentic Hall of India.
- Charles E. Wilson. Kinematic and Dynamics of Machinery. J.Peter Sadler. Pearson.
- Robort L. Norton. Design of Machinery. Tata Mc Graw Hill.
- Robort L. Norton. Kinematic and Dynamics of Machinery. Mc Graw Hill.
- J.E. Shigley and J.J. Vicker. Theory of Machines and Mechanisms. Oxford university press.
- Kenneth J.Waldran, Gary L. Kinzel. Kinematics, Dynamics and Design of Machinery. Wiley
- Rattan. Theory of Machine. Tata Mc Graw Hill.
- Richard Scheunemann Hartenberg, Jacques Denavit. Kinematic synthesis of linkages. McGraw Hill.
- Jeremy Hirschhorn. Kinematics and dynamics of plane mechanism McGraw Hill.

Program Elective – III

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1167**	Course Name: **Acoustics and Noise Control**

L	T	P	Credits
03	-	--	03

Course Description:

Engineering Acoustics is an exciting area offering multidisciplinary studies of sound and vibration phenomena. It relates to recorded music, to speech and hearing, to the behavior of sound in concert halls and buildings, and to noise in our environment. Sound waves are used in medical diagnosis, for testing critical materials, and for locating fish in the ocean or oil-bearing rock formations underground. The rapidly developing research in this area includes theoretical, numerical and experimental aspects. Engineering Acoustics aims to provide the conceptual framework and research training required for advanced professional work in the fields of: Human hearing science & audiology, Transducer technology and systems, Sound recording and reproduction, Acoustic design of rooms & auditoria, Outdoor sound & noise abatement, Noise control in buildings, Vibration and noise control in vehicles and machinery.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Determine acoustic parameters in terms of decibel levels for pressure, power, intensity and impedance.
2. Formulate 1- d wave equation for air-borne sound.
3. Estimate absorption coefficient for different acoustic materials.
4. Measure sound levels for mechanical systems and reduce it up to audible range by using suitable method.

Prerequisite: Physics, Complex Variables, Engineering Mathematics and Vibration.

Course Content

Unit No	Description	Hrs.
01	**Wave Propagation and The Decibel** Wavelength, Frequency, and Speed of Sound, Combining Sine Waves , Combining Delayed Sine Waves, Diffraction of Sound, Effects of Temperature Gradients on Sound Propagation, Effects of Wind Velocity and Gradients on Sound Propagation, Effect of Humidity on Sound Propagation, The Decibel : Introduction, Power Relationships, Voltage, Current, and Pressure Relationships, Sound Pressure and Loudness Contours, Inverse Square Relationships, Adding Power Levels in dB, Reference Levels, Peak, Average, and RMS Signal Values.	06

02	**Propagation and Radiation of Sound** Omnidirectional sound radiation of point sources, Omnidirectional sound radiation of line sources, volume velocity sources, sound field of two sources, loudspeaker arrays: one dimensional piston, formation of main and side lobes, electron beam steering, far-field conditions. sound radiation from plane sources.	
03	**The Wave Equations and Solutions** Derivation of the wave equation, the wave equation in rectangular co-ordinates, the wave equation in spherical co-ordinates. Solutions of the wave equation-General solution of the one-dimensional wave equation, Steady-state solution, Freely Travelling plane wave, freely travelling spherical wave.	**06**
04	**Acoustical Materials** Absorbing materials, Barrier materials. Room acoustics- Average absorption coefficient, Room constant, Sound pressure and sound power relations, atmospheric attenuation, implications of opening. Enclosure Design- Design for maintenance, inspection and ventilation.	**06**
05	**Acoustic Transducers** Microphones-technical considerations, the carbon granule microphone, condenser microphone, electrets capacitor microphone, electrodynamics/moving coil microphone, piezoelectric microphone, The ribbon microphone. Acoustic exciters-electrostatic loudspeaker, electrodynamics loudspeaker, electropnuematic transducer. Acoustic calibrators.	**06**
06	**Fundamentals of Noise Control** Noise criteria, Basic mechanisms of noise generation, Primary noise control, Secondary noise control, Personal hearing protection. **Case Studies** Sound intensity measurement on Helicopter, sound measurement on internal combustion engine, gearbox, centrifugal pump, reciprocating compressor and steam turbine, Equipment from textile industries.	**06**

References:

Text Books:

- Leo L. Bernack, Noise and Vibration Control, Tata McGraw Hill, New Delhi.
- A.G. Ambekar, Mechanical Vibration and Noise Engineering, Prentice Hall of India
- C. Sujatha, Vibration and Acoustics, Tata McGraw Hill, New Delhi.
- Heinrich Kuttruf, Acoustics:An Introduction, Taylor and Francis, London.
- Dhanesh N. Manik, Vibro-Acoustics Vibro-Acoustics Fundamentals and Applications, Taylor and Francis, London.

Reference Books:

- Leo L. Beranek, Acoustics, Acoustical Society of America.
- F. Alton Everest, The master Handbook of Acoustics, Tata McGraw Hill, New Delhi.

Program Elective - III

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1177**	Course Name: **Rotor Dynamics**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course focuses on the study of rotor dynamics, which examines the behavior of rotating machinery like turbines, motors, and pumps. It covers the fundamentals of vibrations in rotors, including the effects of unbalance and damping. Students will learn about the modeling of rotating systems with varying complexities, such as single, multi-degree of freedom, and gyroscopic systems. The course also introduces methods like transfer matrices and finite element analysis for analyzing rotor vibrations, critical speeds, and unbalance responses. Topics include rotor-bearing interaction, shaft modeling, and the impact of anisotropy on rotor behavior. This knowledge is essential for improving the stability and performance of rotating machinery in industrial applications.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Formulate and solve the governing equations for rotor-bearing systems, incorporating relevant system dynamics.
2. Analyze the influence of damping, gyroscopic, centrifugal, stiffness, and inertial effects on the dynamic behavior of rotors.
3. Calculate the critical speeds and stability boundaries of rotors for axial, transverse, and torsional vibration modes.
4. Evaluate the dynamic performance of rotor-bearing systems using the Transfer Matrix Method and Finite Element Method.
5. Predict the transient response of rotors under various operational conditions.

Prerequisite: Mechanical Vibrations

Course Content

Unit No	Description	Hrs.
01	**Basics of Rotor Dynamics** Introduction to rotor dynamics, Rotating and reciprocating unbalances, Classification of Discrete and continuous systems, Review of free and forced vibrations of single and multi-degree of freedom systems.	06
02	**Linear Rotor Dynamics** Equation of motion, Rotating systems, Complex coordinate representation, Undamped Jeffcott Rotor – Free whirling, Unbalance response, Shaft Bow Jeffcott Rotor with viscous damping – Free whirling, Unbalance response, Shaft Bow With structural	06

	damping – Free whirling, Unbalance response, frequency dependent loss factors with non-synchronous damping, Effect of Bearing Compliance, Stability in supercritical region.	
03	**Modelling with Four Degrees of Freedom** Generalized coordinates and equations of motion in real and complex coordinates, Static and couple unbalance and their effects, uncoupled gyroscopic systems, Free whirling of coupled undamped systems, Unbalance response and Shaft bow. Model uncoupling of gyroscopic systems, Configuration and state space approaches.	**06**
04	**Discrete Multi-Degree of Freedom** Introduction, Transfer matrix approach for undamped systems, Damped systems, The finite element method for rotors, Beam elements, spring elements, Mass elements, Assembly and constraints, Damping matrices, Choice of coordinates: fixed Vs Rotating and Real Vs Complex coordinates, Computation of critical speeds, Computation of unbalance response. Campbell and root locus diagrams, Reduction of DOF: Nodal reduction, model reduction and component mode synthesis.	**06**
05	**Transmission Shafts** Modelling of rotors as continuous systems, Euler-Bernoulli and Timoshenko beam models, Dynamic stiffness, Analytical and approximate solutions. **Anisotropy of Rotors and Supports** Isotropic rotors on Anisotropic supports – Influence of damping, non-isotropic rotors on isotropic supports.	**06**
06	**Rotor-Bearing Interaction** Rigid body and flexural modes, Linearization of bearing Characteristics, Rolling element bearings, Fluid film bearings, Magnetic bearings, bearing alignment in multi rotor bearings.	**06**

References:

Text Books:

- Giancarlo Genta, Dynamics of Rotating Systems, Springer.
- Rao, J.S., Rotor Dynamics, New Age International.
- S. R. Timoshenko, Vibration Problems in Engineering, D. Van Nostrand Company.
- W. J. Boley, Theory of Rotating Shafts, Wiley.

Reference Books:

- Chong-Won Lee, Vibration Analysis of Rotors, Kluwer Academic Publishers, London.
- Muszynska A, Rotor dynamics, Taylor & Francis, New York,
- W. T. Thomson, Theory of Vibration with Applications, Prentice-Hall.
- S. P. Timoshenko and D. H. Young, Vibration Problems in Engineering, John Wiley & Sons.
- J. L. T. D. R. Owen and R. E. Jones, Structural Vibration Analysis, Springer.
- D. H. Watkins and K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall.

Program Elective - III

Class: **F. Y. M. Tech**	Semester-**II**
Course Code: **MDE1187**	Course Name: **Product Design and Development**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
The main objective of the course is to acquaint the learners/students with the practical knowledge regarding conceptualization, design and development of a new product. The need of a new product, the product life cycle, the product design process, the application of Value Engineering principles in product design, various product design tools such as CAD, DFM, DFA and DFMA have been explained with relevant and specific examples/ case studies. The concept of Ergonomics in context of the product design has been explained with the help of case studies. The fundamental concept of Rapid Prototyping as well the working principles of the basic rapid prototyping techniques has also been explained. With this intention and objectives mentioned herein this subject has been introduced for students.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Explore and analyse product development processes used in product design and development.
2. Apply various product development techniques.
3. Analyse, evaluate and apply design consideration like concurrent engineering, aesthetic and ergonomics for industrial product design.
4. Apply different methods, tools and technique to create new product design for consumer product.

Prerequisite: Mechanical Component Design Process and Techniques, Development Tools.

Course Content		
Unit No.	**Description**	**Hrs.**
01	**Product Development Processes** Development process tools, Concept development: The front end process, Generic product development process, Opportunity identification, Product planning, Customer needs, Product specifications.	**06**
02	**Product Development Techniques** Product tear down and experimentation, Benchmarking and establishing product specifications, Product design using Design for Six Sigma (DFSS): Phases and gates, Product commercialization using Concept-Design-Optimize-Verify (CDOV) process.	**06**
03	**Product Architecture, Concept Generation, Selection and Testing** Architecture types, Implications of the Architecture, Establishing the Architecture, Modular design. Concept generation process and Methods, Concept selection	**06**

	mechanism and techniques. Concept Testing: purpose, process, methods, interpretation of results.	
04	**Industrial Product Design Considerations** Need, Impact and process of Industrial product design. Concept of Concurrent Engineering: DFMA, DFE, DFR. Prototyping. Aesthetic and Ergonomic design considerations: Concept of purpose, style and environment, Aesthetic expressions of Symmetry, balance, contrast, continuity, proportion, rhythm, radiance. Form and style of product, Effects of colours, conversions of colour of engineering products, Anthropometry, Ergonomic design of machine tools, testing equipment, work stations, automobiles etc.	06
05	**Product Development Economics and Intellectual Property** Elements of economic analysis, economic analysis process, sensitivity analysis, Product Life cycle cost management, Value engineering, Standards and legal requirements, Types of Intellectual property, overview of Patents, patent registration process, Licensing.	06
06	**Managing Projects** Case studies- Simple cases considering engineering products like toothbrush, refrigerator, washing machine, electric bicycle etc. An Integrated Approach in Product, Understanding and representing tasks, Baseline project planning, Accelerating projects, Project execution.	06

References:

Text Books:

- Karl T. Ulrich and Steven D. Eppinger Product Design and Development. McGraw Hill.

Reference Books:

- Kevin Otto and Wood. Product Design. Pearson Education.
- Charles Flurscheim, Industrial Design in Engineering, the Design Council, London.
- Devdas Shetty, Design for product success, Society for Manufacturing Engineering.

Program Elective - III

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1197**	Course Name: **Design of Pump, Compressor and Blower**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
Mechanical pumps, compressors, blowers, and fans play a critical role in a wide range of industrial and commercial applications. They are used for fluid transportation in sectors such as automotive, energy, HVAC, and manufacturing, as well as for specialized applications like artificial heart devices and vacuum systems. Air compressors serve purposes ranging from filling gas cylinders to powering pneumatic systems, while fans and blowers ensure proper ventilation and air movement in industrial settings.
This course provides students with a comprehensive understanding of the design, operation, and performance evaluation of pumps, compressors, blowers, and fans. It covers fundamental principles of turbomachinery, performance characteristics, design considerations, and system integration. Through analytical and simulation-based approaches, students will develop the ability to model, select, and optimize these machines for various engineering applications.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Select suitable pump, blower, fan and compressor for a given application.
2. Design pump, blower, fan or compressor for a given application.
3. Analyze the performance of compressor and pump
4. Model and simulate pump, blower, fan and compressor.

Prerequisite: Fluid Mechanics, Turbo machines and Engineering Thermodynamics.

Course Content		
Unit No.	**Description**	**Hrs.**
01	**Principles of Turbo Machinery** Introduction to turbo machines - Transfer of energy to fluids - Performance characteristics - fan laws - Dimensionless parameters - Specific speed - selection of centrifugal, axial, and mixed flow machines	**06**
02	**Pump Performance and Testing** Pump Characteristic Curves, main characteristics curves, operating characteristic curves, constant efficiency curves, Affinity Laws, System Curves, Pumps in series and parallel operation, Factors affecting pump performance, Measuring pump performance, Measurement of the pump's NPSH.	**06**
03	**Centrifugal and Axial-Flow Pumps** Nomenclature and Mechanical Design, Materials of Construction, Pump Performance,	**06**

	Installation, Operation, Maintenance. **High-Vacuum Pumps** Installation, Vapor Contamination, Flow of Gases at Low Pressure, Applications of High-Vacuum Pumps	
04	**Reciprocating Compressors** Compressed-Air and Gas Usage, Standard Units and Conditions, Thermodynamics of Compression, Adiabatic Analysis, Polytropic Process, Real-Gas Effects, Multistaging and Intercooling, Positive-Displacement Compressors versus Dynamic Compressors Surging, Reciprocating Compressors, Compressor Valves, Piston Rings, Piston-Rod Packing, Nonlubricated Cylinders, Lubrication, Compressor Accessories, Cylinder Cooling.	**06**
05	**Other Types of Compressors** Rotary-Vane Compressors, Rolling-Piston Compressors, Rotary Twin-Screw Oil-Flooded Compressors, Rotary Single-Screw Compressors, Dry Rotary Twin-Screw Compressors, Orbiting Scroll Compressors, Dynamic Compressors, Thrust Pressures	**06**
06	**Fans** Fan Types and Nomenclature, Centrifugal fans, axial fans, propeller fans, mixed-flow fans, and industrial blowers, Fan Performance and Testing, Flow characteristics, efficiency evaluation, noise and vibration considerations, Computational Fluid Dynamics (CFD) analysis of fan performance, aerodynamic design improvements, Modeling and Simulation for performance prediction of pumps, blowers, fans, and compressors.	**06**

References:

Text Books:

- Yahya, S. M. Turbines, compressors, and fans Tata McGraw-Hill.
- Rajput, R. K. Fluid mechanics and hydraulic machines S. Chand.
- Bansal, R. K. Fluid mechanics and hydraulic machines Laxmi Publications.
- Ganesan, V. Gas turbines Tata McGraw-Hill.
- Yadav, R Steam and gas turbine Central Publishing House.

Reference Books:

- Shepherd, D. G. Principles of turbomachinery. Macmillan.
- Tuzson, J. Centrifugal pump design. Wiley.
- Stepanoff, A. J. Blowers and pumps John Wiley & Sons.
- Church, A. H. Centrifugal pumps and blowers John Wiley & Sons.
- Labanoff, V. S., & Ross, R. Centrifugal pumps: Design and application Jaico Publishing House.
- Karassik, I. J. Pump handbook McGraw-Hill International.
- Csanady, G. T. Theory of turbomachines. Cambridge University Press.
- White, F. M. Fluid mechanics McGraw-Hill.
- Dixon, S. L., & Hall, C. A. Fluid mechanics and thermodynamics of turbomachinery Elsevier.

Program Elective – III

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1312**	Course Name: **Design of Pressure Vessels and Piping**

L	T	P	Credits
03	--	--	03

Course Description:
This course covers in-depth design & Engineering calculation of pressure vessel as per ASME Section VIII Division I including Process equipment. (Vessels, Reactors, Heat Exchangers, Distillation Columns). Overview/ detailed topic of PFD, P&ID, Process Data Sheets, Inputs required, relevant Codes and Standards used in Industry including ASME Section VIII, Materials Specifications (ASTM / ASME), Pressure Vessel Service Classification and Mechanical Properties of Steels.
The pressure vessel design course is more concentrated on Engineering and design calculations of Stresses in Pressure Vessels, Pressure Vessels Shell and Head Thickness, Dead Weight, Hydrostatic Test Weight of Pressure vessels and Calculating Nozzle Necks.
The pressure vessel design course provides a systematic development of skills and knowledge of Pressure Vessel for design, development and manufacturing process as per the International standards.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Apply the design consideration of pressure vessel.
2. Design the support of the pressure vessel.
3. Design nozzle for pressure vessel.
4. Design piping system for pressure vessel.

Prerequisite: Machine Design, Solid Mechanics

Course Content

Unit No	Description	Hrs.
01	**Stresses in Pressure Vessel** Introduction to stresses in pressure vessel and its application to shells and end closures, stresses in circular plate, Thermal stresses, Stresses in plate having the circular hole due to bi-axial loading, excessive elastic deformation, plastic instability, brittle, rupture and creep.	06
02	**Pressure Vessel Design Code** Introduction to ASME codes for pressure vessel design, Pressure vessel and related components' design using ASME codes; Supports for short vertical vessels, Stress concentration at a variable thickness transition section in a cylindrical vessel; Design of nozzles.	06

03	**Supports Design for Pressure Vessel** Design of base plate and support lugs, Types of anchor bolt, its material and allowable stresses, Design of saddle supports.	06
04	**Design Consideration in Pressure Vessel** Buckling phenomenon, Elastic Buckling of circular ring and cylinders under external pressure, collapse of thick walled cylinders or tubes under external pressure, Effect of supports on elastic buckling of cylinders, Design of circumferential stiffness, Buckling under combine External pressure and axial loading, Fatigue, shock high pressure high temperature irradiation corrosion and other hostile environments, high strength, light weight pressure vessels resistant to external high pressures found in undersea exploration.	06
05	**Buckling and Fracture Analysis in Vessels** Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.	06
06	**Piping Design** Flow diagram, piping layout and piping stress analysis; Flexibility factor and stress intensification factor; Design of piping system as per B31.1 piping code. Piping components - bends, tees, bellows and valves. Types of piping supports and their behavior; Introduction to piping Codes and Standards. Pressure Relief Valve / Pressure Safety Valve / Rupture Disc / Safety Devices.	06

References -

Text Books:

- John F. Harvey, Theory and Design of Pressure Vessels, CBS Publishers and Distributors.

Reference Books / Journals:

- Brownell L.E and Young E.D. "Process equipment design, Willey Esstern Ltd. India.
- ASME, ASME Pressure Vessel and Boiler code, Section VIII Div. 1, 2, and 3.
- ASME, American standard code for pressure piping, B 31.1.
- Henry H Bednar, Pressure vessel Design Handbook, CBS publishers and distributors.
- J. Phillip Ellenberger, Pressure Vessels: ASME Code Simplified, ASME.
- Smith P, Fundamentals of Piping Design, Elsevier.
- William. J., Bees, Approximate Methods in the Design and Analysis of Pressure Vessels and Piping, Pre ASME Pressure Vessels and Piping Conference.
- Stanley, M. Wales, Chemical process equipment, selection and Design. Buterworths series in Chemical Engineering,
- Sam Kannapan, Introduction to Pipe Stress Analysis. John Wiley and Sons.

Program Elective - IV

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1207**	Course Name: **Fracture Mechanics**

L	T	P	Credits
03	--	--	03

Course Description:
The course covers the fundamental concepts of fracture mechanics and failure criteria, linear elastic fracture mechanics (LEFM), elastoplastic fracture, fracture in metals, polymers, ceramics and composites, and the mechanisms, such as J-Integral and COD, to measure the severity of the crack. Fatigue crack growth mechanisms, microcracks, and how cracks are developed and controlled are part of the course. The computational schemes describing how to evaluate fracture parameters using finite elements, multiscale fracture mechanics, and fracture at different scales will be covered.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Discuss the various failure modes and associated parameters to quantify the magnitude of failure.
2. Compute stress intensity factor for the edge crack, central crack and its relationship with the dimensions of the component.
3. Evaluate J-integral numerically and critical J-integral experimentally to explore the knowledge of failure conditions in cracked components.
4. Determine experimentally the crack tip opening displacement and stress intensity factor to ascertain the stability of the crack.
5. Summarize direct and indirect methods employed to determine fracture parameters for mixed mode crack propagation.
6. Analyze the mechanical components against fracture by Detection of crack and its growth through Non-Destructive Testing.

Prerequisite: Engineering Mathematics, Strength of Material, Design of Machine component.

Course Content

Unit No	Description	Hrs.
01	**Introduction** Brittle and Ductile Fracture, Modes of Fracture Failure, Surface Energy, Griffith's Dilemma, Realization and Analysis. Energy Release Rate, Energy Release Rate of DCB Specimen, Anelastic Deformation at Crack-tip, Crack Resistance, Stable and Unstable Crack Growth, Critical Energy Release Rate.	06
02	**Stress Intensity Factor** Linear Elastic Fracture Mechanics (LEFM), Westergaard's Approach, Applications of Westergaard Approach, Crack in a Plate of Finite Dimensions, Edge Cracks, Embedded	06

	Cracks, The Relation between GIand KI, Critical Stress Intensity Factor, Bending and Twisting of Cracked Plates. Approximate Shape and Size of the Plastic Zone, Effective Crack Length, Effect of Plate Thickness.	
03	**Evaluation of Integral:** Definition of the J-Integral, Path Independence, Stress-Strain Relation, Experiments to Determine the Critical J-Integral, Comments on the Numerical Evaluation ofJ-Integral, A Simplified Relation for the J-Integral, Applications to Engineering Problems. Crack Tip Opening Displacement, Relationship between CTOD, Kr and Gr for Small Scale Yielding, Equivalence between CTOD and J.	**06**
04	**Test Methods** KIC-Test Technique, Test Methods to Determine JIC, Test Methods to Determine GIC and GIIC , Determination of Critical CTOD.	**06**
05	**Fracture Parameters** Direct Methods to Determine Fracture Parameters. Indirect Methods to Determine Fracture Parameters. Mixed Mode Crack Initiation and Growth.	**06**
06	**Crack Detection through Non-Destructive Testing** Examination through Human Senses, Liquid Penetration Inspection, Ultrasonic Testing, Radiographic Imaging, Magnetic Particle Inspection.	**06**

References:

Text Books:

- Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Education
- Anderson, Ted L., Fracture Mechanics: Fundamentals and Applications. CRC press

Reference Books:

- Broek, David, Elementary engineering fracture mechanics, Springer Science & Business 2. Media
- S.T. Rolfe and J.M. Barson, Fracture and Fatigue Control in Structures, Prentice Hall Inc. New Jersey
- M.F. Kanninen and C.H. Popelar, Advanced Fracture Mechanics, Oxford University Press

Program Elective - IV

Class:-**F. Y. M. Tech.**	Semester – **II**
Course Code: **MDE1217**	Course Name: **Failure Analysis and Design**

L	T	P	Credits
03	--	--	03

Course Description:
The course on Failure Analysis and Design provides an in-depth understanding of the principles and practices involved in preventing and analyzing failures in mechanical systems. It covers key failure modes such as brittle and ductile fracture, fatigue, wear, and creep, along with advanced stress analysis techniques and failure theories. The course explores fatigue and fracture mechanics, experimental testing methods, and data interpretation to enhance design reliability. Students will also learn about advanced failure analysis techniques, component-specific failure considerations, and preventive measures to optimize design and performance in high-stress applications.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Analyze different material failure modes and evaluate their significance in real-world mechanical system failures through case studies.
2. Apply advanced failure theories and synthesize stress analysis results for components subjected to complex loading conditions.
3. Evaluate fatigue life and crack propagation under various loading conditions and design systems to mitigate fatigue failure using fracture mechanics.
4. Conduct fatigue tests and analyze statistical data to enhance reliability-based design.
5. Recommend failure analysis and non-destructive testing techniques to identify causes and prevent failures.
6. Develop optimized design solutions to address operational challenges and improve durability.

Prerequisite: Solid Mechanics, Material Science, Machine Design and Structural Analysis

Course Content

Unit No	Description	Hrs.
01	**Basics of Failure Analysis** Advanced principles of failure prevention in mechanical design. Modes of material failure: brittle fracture, ductile fracture, fatigue, wear, and creep. Failure case studies in high-performance mechanical systems (e.g., aerospace, automotive). Importance of failure investigation in design and reliability.	08
02	**Advanced Stress Analysis and Failure Theories** Detailed stress analysis: multi-axial stress states, principal stresses, and strain energy methods. Advanced failure theories: Maximum Shear Stress, Distortion Energy, and	04

	Fracture Mechanics principles. Static and dynamic loading, combined loading scenarios, and their impact on design. Computational techniques for stress and strain analysis using FEA tools.	
03	**Fatigue and Fracture Mechanics in Design** High-cycle and low-cycle fatigue: S-N-P curves, endurance limits, and life prediction techniques. Fracture mechanics: stress intensity factor, crack propagation theories, and Paris law. Fatigue design under multi-axial stress and high-temperature conditions. Advanced cumulative damage models and fatigue under corrosive environments.	06
04	**Experimental Techniques and Data Interpretation** Advanced fatigue testing methods: ultrasonic fatigue testing, thermographic analysis, and crack detection techniques. Statistical methods for data analysis: Weibull distribution, reliability-based design, and Monte Carlo simulation. Failure testing in extreme conditions: thermal shocks, impact loading, and vibratory loads. Experimental correlation with simulation-based models.	06
05	**Failure Analysis Techniques and Preventive Measures** Advanced Non-Destructive Testing (NDT) techniques: ultrasonic phased array, acoustic emission, and 3D tomography. Metallographic failure analysis: grain structure analysis, phase identification, and micro-hardness mapping. Preventive measures: surface treatment methods, coatings, and residual stress management techniques. Application of failure analysis in the design optimization process.	06
06	**Component-Specific Failures and Design Considerations** Advanced design considerations for high-stress components: bearings, gears, chain and belt drives, and shafts. Failures in pressure vessels and heat exchangers under extreme operating conditions. Failure mechanisms in composite materials and their hybrid structures. Case studies on failures in lifting equipment, welded constructions, and springs with solutions to improve design.	06

References:

Text Books:

- S.Suresh, Fatigue of Materials, Cambridge University Press.
- Prashanth Kumar, Elements of Fracture Mechanics, Mc-Graw Hill.
- C. Brooks and A. Choudhury, Failure Analysis of Engineering Materials, McGraw-Hill education, ISBN-13: 978-0071357586.

Reference Books:

- Jacks A.Collins, Failure of Materials in Mechanical Design: Analysis, Prediction and Prevention, John Wiley & Sons,
- Norman E. Dowling, Mechanical behaviour of Materials, Pearson,
- Failure Analysis and Prevention (ASM Hand Book), Metals Hand Book
- A. J. McEvily and J. Kasivitamnuay, Metal failures: Mechanisms, Analysis and Prevention, Wiley, ISBN: 978-1-118-42116-1

Program Elective – IV

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1227**	Course Name: **Industrial Robotics**

L	T	P	Credits
03	--	--	03

Course Description:
Industrial robots are changing the way of manufacturing and it also increasing the production capacity of the industry. Current robots come with intelligent systems to collaboratively work with the humans for flexible manufacturing systems. Due to this increasing demand of industrial robotics in industries the students should learn this course for understanding the basics of robotics and its various applications.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Illustrate the basic concepts of robots.
2. Model forward and inverse kinematics of robot manipulators.
3. Select an end effector and sensor for particular application.
4. Program a robot to perform tasks in industrial applications.

Prerequisite: Mathematics, Sensors and Actuators, Computer Programming.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Fundamentals of Robotics** History of Robotics, definitions of industrial robot, type and classification of robots, laws of robotics, robot configurations, robot components, robot degree of freedom, work volume and work envelope, robot joints and symbols, robot coordinates, robot reference frames, precision of movement: resolution, accuracy and precision of robot, dexterity, compliance, RCC device, work cell control, speed of response and load carrying capacity	**06**
02	**End Effectors and Sensors for Robotics** End effectors: Grippers, mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, internal & external grippers, advanced grippers, soft grippers, tactile sensor grippers, various process tools as end effectors, active and passive compliance, selection and design considerations. Sensor: Internal state sensors, external state sensors, encoder, optical position sensors, velocity sensors, proximity sensors, touch and slip sensors, force and torque sensors, selection considerations.	**06**
03	**Motion Analysis** Link equations and relationships, direct kinematics, co-ordinate and vector	**06**

	transformation using matrices, rotation matrix, inverse transformations, composite rotation matrix, homogeneous transformations, joint co-ordinate and world co-ordinate system, inverse kinematics of two joints, DH parameters, Jacobian transformation in robotic manipulation.	
04	**Trajectory and Motion Planning** Introduction, linear trajectory function, polynomial trajectory function, gross and fine motion planning, motion planning schemes-visibility graph, vornoi diagram, tangent graph, accessibility graph, path velocity decomposition, incremental planning, relative velocity approach, reactive control strategy and potential field approach.	**06**
05	**Robot Programming** Introduction to robotic programming, on-line and off-line programming, programming examples, various teaching methods, survey of robot level programming languages, A robot program as a path in space, motion interpolation, programming languages: generations of robotic languages, introduction to various types such as VAL, RAIL, AML, Python, ROS etc., sample program examples a robot –based manufacturing system.	**06**
06	**Applications of Robotics in Industry** Applications of robot in welding, machine tools, material handling, and assembly operations, parts sorting and parts inspection, AI in robotics, machine vision in robot for object picking, robot intelligence and task planning, modern robots, cobotics, robot applications in medical industries, future applications and challenges and case studies.	**06**

References:

Text Books:

- Richard D. Klafter, Thomas A. Chemielewski, Michael Negin, Robotic Engineering: An Integrated Approach, Prentice Hall, India.
- Mikell P. Groover, Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International.
- John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley.

Reference Books:

- R.C. Dorf, Handbook of design, manufacturing & Automation: John Wiley and Sons.
- Shimon Y. Nof, Handbook of Industrial Robotics, John Wiley Co.
- M. P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education.
- W.P. David, Industrial Automation: John Wiley and Sons.

Program Elective – IV

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1237**	Course Name: **Multi-Body Dynamics**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
The Multi-Body Dynamics course provides an in-depth exploration of the kinematic and dynamic analysis of interconnected mechanical systems. Students will learn about planar kinematic analysis using various constraints, including revolute, prismatic, gear, and cam pairs. The course covers principles for automatic assembly of equations for position, velocity, and acceleration, alongside the application of Lagrange's equations. Topics include dynamics of planar systems, kinematics of rigid bodies in space, and the computation of forces and generalized forces. Through numerical methods and simulation techniques, students will develop skills to analyze and design complex multi-body systems in engineering applications.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Derive equations of motion for interconnected bodies in multi-body systems with three dimensional motion.
2. Implement and analyze methods of formulating equations of motion for interconnected bodies.
3. Write programs to solve constrained differential equations for analyzing multi-body systems.
4. Simulate and analyze all types of static and dynamic behaviours of the multi-body systems.
5. Lead team projects in academic research or the industry that require modelling and simulation of multi-body systems.

Prerequisite: Kinematics and Dynamics of Machinery, Engineering Mathematics

Course Content		
Unit No	**Description**	**Hrs.**
01	**Introduction** The method of constraints for planar kinematic analysis. Revolute, prismatic, gear and cam pairs are considered together with other 2 degrees-of-freedom types of constraints.	**06**
02	**Basic Principles for Analysis of Multi-Body Systems** The automatic assembly of the systems of equations for position, velocity and acceleration analysis. Iterative solution of systems of nonlinear equations. Geometry of masses. The principle of virtual work and Lagrange's equations.	**06**
03	**Dynamics of Planar Systems** Dynamics of planar systems. Systematic computation and assembly of mass matrix.	**06**

	Computation of planar generalized forces for external forces and for actuator-spring-damper element. Simple applications of inverse and forward dynamic analysis. Numerical integration of first-order initial value problems. The method of Baumgarte for the solution of mixed differential-algebraic equations of motion. The use of coordinates partitioning, QR and SVD decomposition for the orthogonalization of constraints.	
04	**Kinematics of Rigid Bodies in Space** Reference frames for the location of a body in space. Euler angles and Euler parameters. The formula of Rodrigues. Screw motion in space. Velocity, acceleration and angular velocity. Relationship between the angular velocity vector and the time derivatives of Euler parameters.	**06**
05	**Kinematic Analysis of Spatial Systems** Basic kinematic constraints. Joint definition frames. The constraints required for the description in space of common kinematic pairs (revolute, prismatic, cylindrical, spherical). Equations of motion of constrained spatial systems.	**06**
06	**Computation of Forces** Computation of spatial generalized forces for external forces and for actuator-spring-damper element. Computation of reaction forces from Lagrange's multi- pliers.	**06**

References:

Text Books:

- Rajiv Rampalli, Gabriele Ferrarotti & Michael Hoffman. Why Do Multi-Body System Simulation. NAFEMS Publications.
- Donald T. Greenwood. Principles of Dynamics. Prentice Hall.

Reference Books:

- Wittenburg, J. Dynamics of Systems of Rigid Bodies. B.G. Teubner, Stuttgart.
- Kane, T.R, Levinson, D.A., Dynamics: Theory and Applications, McGraw-Hill
- Nikravesh, P.E., Computer Aided Analysis of Mechanical Systems, Prentice-Hall Inc., Englewood Cliffs, NJ.
- Roberson, R.E., Schwertassek, R. Dynamics of Multibody Systems. Springer-Verlag, Berlin.
- Haug, E.J. Computer-Aided Kinematics and Dynamics of Mechanical Systems-Basic Methods, Allyn and Bacon.
- Huston, R.L. Multibody Dynamics. Butterworth-Heinemann.
- Schielen, W. ed. Multibody Systems Handbook. Springer-Verlag, Berlin.
- De Jalo n, J.C., Bayo, E. Kinematic and Dynamic Simulation of Multibody Systems. Springer-Verlag.

Program Elective – IV

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1321**	Course Name: **IOT Based Condition Monitoring & Diagnostics**

L	T	P	Credits
03	--	--	03

Course Description:

This course introduces Artificial Intelligence (AI) and Machine Learning (ML) with a focus on applications in mechanical engineering. It covers the history of AI, its comparison with Data Science, and its necessity in modern engineering. Key concepts include reasoning, problem-solving, learning, and perception, alongside ML approaches like supervised, unsupervised, and reinforcement learning. Feature selection and extraction techniques such as decision trees and PCA, as well as classification and regression algorithms, are explored. The course emphasizes ML model development, hyperparameter tuning, and predictions. Advanced topics include reinforcement learning, deep learning, and neural networks. Real-world case studies in condition monitoring of turbines, bearings, and industrial pumps highlight practical applications.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Analyze the fundamentals of artificial intelligence and machine learning and their relevance to mechanical engineering applications.
2. Evaluate and implement feature extraction and selection techniques for data preprocessing in machine learning models.
3. Develop and optimize machine learning algorithms for solving classification and regression problems in engineering scenarios.
4. Design and construct machine learning models by following systematic steps, including data preprocessing, model selection, and evaluation.
5. Assess concepts of reinforcement and deep learning to interpret vibration signals for condition monitoring and predictive maintenance in mechanical systems.

Prerequisite: Engineering Mathematics, Programming Fundamentals, Signal Processing, Vibration.

Course Content

Unit No	Description	Hrs.
01	**Basics of Artificial Intelligence and Machine Learning** History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning,	06

	Reinforcement learning.	
02	**Feature Extraction and Selection Feature selection** Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering. Feature extraction: Statistical features, Principal Component Analysis	04
03	**Classification and Regression Classification** Decision tree, Random Forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K- Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.	04
04	**Development of ML Model Problem Identification** Classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, Kfold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions.	06
05	**Reinforced Learning Characteristic of Reinforced Learning, Algorithms** Value Based, Policy-Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Application of Reinforced Learning in Mechanical Engineering.	06
06	**Deep Learning** Characteristic of Deep Learning, Artificial Neural Network, Convolution Neural Network, Application of Deep Learning in Mechanical Engineering. **Applications of Condition Monitoring** Case studies related Balancing Problems in Turbines, Condition Monitoring in Sugar mills, Health Monitoring of Journal Bearing, Condition Monitoring of Industrial Pumps. (Aspects to be covered : Selection of sensors, recommended location of sensor, direction of measurement, selection of plot type, Data validation and Identification of Faults)	10

References:

Text Books:

- Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press
- A.R. Mohanty, "Machine Condition Monitoring: Principles and Practices", CRC Press
- Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global
- Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press
- B Joshi, Machine Learning and Artificial Intelligence, Springer

Reference Books:

- R.A. Collacott, "Mechanical Fault Diagnosis and Condition Monitoring", Chapman and Hall
- Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1247**	Course Name: **Research Methodology & IPR**

L	T	P	Credits
02	**01**	**--**	**03**

Course Description:
This course provides a first coverage of the main concepts of research process, literature review, experimental designs and the associated analysis of variance models. It introduces different types of experimental designs to students from all types of disciplines. Statistical methods useful in design and analysis of experiments in all fields of engineering. The basic idea behind introducing this course is to cultivate the research qualities within the post graduate students so that the knowledge gained in this course will prepare graduate for dissertation work. Course also covers basics about IPR which helps them to know about patents & copy rights etc.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Formulate a research problem.
2. Analyse research related information.
3. Prepare and present research proposal/paper by following research ethics.
4. Make effective use of computers and computing tools to search information, analyze information and prepare report.
5. Describe nature and processes involved in development of intellectual property rights.

Prerequisite: Engineering Mathematics and Statistics.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Research Characteristics** Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	**04**
02	**Effective Literature Studies Approaches** Plagiarism, Research Ethics Approaches of Investigation of solutions for Research Problems Data Collection and analysis.	**04**
03	**Technical Report Writing** Effective technical writing, how to write technical report and paper, Developing a Research Proposal, Format of research proposal, presentation and assessment by a review committee.	**04**
04	**IPR Nature of Intellectual Property** Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario:	**04**

	International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT.	
05	**Patent Rights** Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications New Developments in IPR: Administration of Patent System.	**04**
06	**New Developments in IPR** New developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.	**04**

References:

Text Books:

- Stuart Melville and Wayne Goddard. Research methodology: an introduction for science & engineering students. Juta & Co Ltd.
- Ranjit Kumar. Research Methodology: A Step by Step Guide for beginners. SAGE Publication.

Reference Books:

- Wayne Goddard and Stuart Melville. Research Methodology: An Introduction. Juta Academic.
- Halbert. Resisting Intellectual Property. Taylor & Francis Ltd.
- Mayall. Industrial Design. McGraw Hill.
- Niebel. Product Design. McGraw Hill.
- Asimov. Introduction to Design. Prentice Hall.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley. Intellectual Property in New Technological Age. Wolters Kluwar.
- T. Ramappa. Intellectual Property Rights under WTO.S. Chand.

Class: **F. Y. M. Tech**	Semester: **II**
Course Code: **MDE1267**	Course Name: **Vibration Lab**

L	T	P	Credits
--	--	02	01

Course Description:
This laboratory course focuses on the dynamic analysis of mechanical systems through vibration studies. Students will explore free and forced vibrations of cantilever, supported, and fixed beams to determine parameters such as logarithmic decrement, damping ratio, damping frequency, and natural frequency. Experiments include analyzing the effects of damping on forced vibration in single-degree-of-freedom (SDOF) systems subjected to harmonic and unbalanced forces. The course also covers two-degree-of-freedom (2DOF) spring-mass systems and dynamic vibration absorbers to study the influence of varying parameters like excitation frequency and mass. Vibration-based fault diagnostics are introduced for machine condition monitoring, and MATLAB is used for solving SDOF and MDOF problems.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Develop the equation of motion for single degree of freedom by using various methods.
2. Analyze the vibration effect of two degree of freedom mechanical systems.
3. Evaluate the vibration effect of multi-degrees of freedom system by using various methods.
4. Determine the natural frequency of mechanical system by using vibration instruments.

Prerequisite: Mechanical Vibrations.

Course Content

Experiment No.	List of Experiments	Hrs.
01	Determine the modal parameters of a cantilever beam under free vibration.	02
02	Determine modal parameters of simply supported beam under free vibration.	02
03	Determine the modal parameters of a fixed beam under free vibration.	02
04	Determine the effect of damping on the Forced Vibration of the single-degree-of-freedom system using a Harmonic Force.	02
05	Determine the effect of damping in forced vibration of a single degree of freedom due to the rotating of an unbalanced force.	02
06	Determine effect of viscoelastic material layer on damping of continuous system.	02
07	Determine the effect of force excitation on the Two DOF spring-mass system and observe its characteristics by varying its different parameters.	02

08	Determine the characteristics of different excitation frequencies and amplitude and masses of the dynamic vibration absorber system.	**02**
09	Machine fault diagnostic system based on vibration analysis.	**02**
10	Solve the SDOF and MDOF problems using MATLAB.	**02**
11	Mini Project.	**02**

References:

Text Books:

- Rao, S.S, Mechanical Vibrations, Addison Wesley Longman.
- Shriniwasan P, Mechanical Vibration Analysis, Tata McGraw Hill.
- W. T. Thomson, Theory of Vibrations with Applications, CBS Publishers, Delhi.
- Mechanical Vibrations, S. S. Rao, Addison-Wesley Publishing Co.

Reference Books:

- Ashok Kumar Mallik, Principles of Vibration Control, Affiliated East-West Press.
- Leonard Meirovitch, Fundamentals of Vibration, McGraw Hill International Edison.

Class: **F. Y. M. Tech**	Semester-**II**
Course Code: **MDE1271**	Course Name: **Engineering Computation Lab**

L	T	P	Credits
-	-	02	01

Course Description:
MATLAB is a popular language for numerical computation. This course introduces students to MATLAB programming, and demonstrate its use for scientific computations. The basis of computational techniques are expounded through various coding examples and problems, and practical ways to use MATLAB will be discussed. Numerical Computation in MATLAB includes use of MATLAB software to solve linear and nonlinear equations, ordinary differential equations, Linear regression and Numerical Integration problems.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Apply basics of MATLAB programming for Engineering applications.
2. Compute differentiation of single variable using MATLAB.
3. Solve Numerical Integration problems using MATLAB.
4. Solve Linear and Non-Linear equations using MATLAB.
5. Solve Linear Least Square Regression problems using MATLAB.
6. Solve Ordinary Differential Equation using MATLAB.

Prerequisite: Linear Algebra and Calculus, Numerical Methods / Computational Techniques

Course Content

Experiment No.	Description	Hrs.
01	Introduction to MATLAB Programming	02
02	Array Operation in MATLAB	02
03	Loops and Execution Control in MATLAB	02
04	Working with files -scripts, function, plotting and outputs in MATLAB	02
05	Differentiation in single variable	02
06	Numerical Integration (Trapezoidal /Simpson's 1/3rd rule)	02
07	Solve Linear Equations (Gauss Elimination and Back Substitution)	02
08	Non Linear Equations with single variable (Newton Raphson Method)	02
09	Linear Least square Regression	02
10	Ordinary Differential Equation (Euler's Method).	02

11	**Case Study:** Solve the problems of vibration using MATLAB	**02**

References:

Text Books:

- Rudra Pratap MATLAB Programming by, Oxford University Press.
- Fausett L.V. Applied Numerical Analysis Using MATLAB, Pearson Education

Reference Books:

- Chapra S.C. and Canale R.P. Numerical Methods for Engineers, McGraw Hill

Class: **F. Y. M. Tech.**	Semester-**II**
Course Code: **MDE1287**	Course Name: **Seminar**

L	T	P	Credits
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Course Description:

Seminar shall be delivered on one of the advanced topics chosen in consultation with the Supervisor after compiling the information from the latest literature. The concepts must be clearly understood and presented by the student. All modern methods of presentation should be used by the student. A hard copy of the report (25 to 30 pages A4 size, 12 fonts, Times New Roman, single spacing both side printed, preferably in IEEE format) should be submitted to the Department Post Graduate Committee (DPGC) before delivering the seminar. Seminar work will be assessed by Department Post Graduate Committee. A PDF copy of the report in soft form must be submitted to the Supervisor along with other details if any.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Survey the literature such as books, national/international refereed journals and contact resource persons for the selected topic of Seminar.
2. Learn to write technical reports.
3. Develop oral and written communication skills to present and defend their work in front of Department Post Graduate Committee.

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Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MDE2017**	Course Name: **Industry Internship**

L	T	P	Credits
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Course Description:

In the field training work, the student is expected to get training in the industry, related to subject specialization for duration of 15 days (minimum) for at least 6 hrs. per day. Student should write a report on the field training and submit to department for ISE evaluation at the beginning of third semester. Student should include the certificate from the company regarding satisfactory completion of the field training.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Identify the real applications and practices of courses studied, at industry level
2. Recognize various modeling, analysis and validation techniques adopted at industries
3. Demonstrate the issues at design, manufacturing and assembly levels
4. Summarize and present technical data in report format.

Open Elective

Class: **S. Y. M. Tech**	Semester- **III**
Course Code: **MOE2012**	Course Name: **Artificial Intelligence - Machine Learning**

L	T	P	Credits
03	--	--	03

Course Description:
Machine learning is a part of Artificial Intelligence. It uses interdisciplinary techniques such as statistics, linear algebra, optimization, and computer science to create automated systems that can sift through large volumes of data at high speed to make predictions or decisions without human intervention. Machine learning as a field is now incredibly pervasive, with applications spanning from business intelligence to homeland security, from analyzing biochemical interactions to structural monitoring of aging bridges, and from emissions to astrophysics, etc. This class will familiarize students with a broad cross-section of models and algorithms for machine learning and prepare students for research or industry application of machine learning techniques.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Describe central machine learning methods and techniques and how they relate to artificial intelligence.
2. Differentiate between supervised and unsupervised learning techniques.
3. Apply the ML algorithms to a real-world problem.
4. Optimize the models learned and report on the expected accuracy that can be achieved by applying the models.
5. Evaluate a given problem and apply appropriate machine learning technique.

Prerequisite: Statistics, Linear Algebra, Optimization Techniques, Programming Language

Course Content

Unit No	Description	Hrs.
01	**Introduction to Artificial Intelligence and Machine Learning** Introduction: What Is AI and ML? Examples of AI and ML, Applications, Supervised Learning, Un-Supervised Learning and Reinforcement Learning, Important Elements of Machine Learning- Data formats, Learnability, Statistical learning approaches, Elements of information theory.	06
02	**Feature Selection** Scikit- Learn Dataset, creating training and test sets, managing categorical data, Managing missing features, Data scaling and normalization, Feature selection and Filtering, Principle Component Analysis(PCA)- non-negative matrix factorization, Sparse PCA, Kernel PCA. Atom Extraction and Dictionary Learning.	06

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03	**Regression** Linear regression- Linear models, A bi-dimensional example, Linear Regression and higher dimensionality, Polynomial regression, Logistic regression-Linear classification, Logistic regression, Implementation and Optimizations, Stochastic gradient descendent algorithms.	06
04	**Naïve Bayes and Support Vector Machine** Bayes Theorom, Naïve Bayes Classifiers, Naïve Bayes in Scikit- learn- Bernoulli Naïve Bayes, Multinomial Naïve Bayes, and Gaussian Naïve Bayes. **Support Vector Machine(SVM)** Linear Support Vector Machines, Scikit- learn implementation, Linear Classification, Kernel based classification, Non- linear Examples. Controlled Support Vector Machines, Support Vector Regression.	06
05	**Decision Trees and Ensemble Learning** Decision Trees- Impurity measures, Feature Importance. Decision Tree Classification with Scikit learn, Ensemble Learning-Random Forest, AdaBoost, Gradient Tree Boosting, Voting Classifier. Clustering Fundamentals- Basics, K-means: Finding optimal number of clusters, DBSCAN, Spectral Clustering. Evaluation methods based on Ground Truth- Homogeneity, Completeness, Adjusted Rand Index.	04
06	**Clustering Techniques** Hierarchical Clustering, Expectation maximization clustering, Agglomerative Clustering Dendrograms, Agglomerative clustering in Scikit- learn, Connectivity Constraints. Introduction to Recommendation Systems Naïve User based systems, Content based Systems, Model free collaborative filtering-singular value decomposition, alternating least squares.	08

References:

Text Books:

- Giuseppe Bonaccorso, Machine Learning Algorithms, Packt Publishing Limited.
- Josh Patterson, Adam Gibson, Deep Learning: A Practitioners Approach, O REILLY, SPD.

Reference Books:

- Ethem Alpaydin, Introduction to Machine Learning, PHI.
- Peter Flach, Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Cambridge University Press.

Open Elective

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE2022**	Course Name: **Creative Thinking: Techniques & Tools**

L	T	P	Credits
03	--	--	03

Course Description:
In today's ever-growing and changing world, being able to think creatively and innovatively are essential skills. It can sometimes be challenging to step back and reflect in an environment which is fast paced or when students required to assimilate large amounts of information. Making sense of or communicating new ideas in an innovative and engaging way, approaching problems from fresh angles, and producing novel solutions are all traits which are highly sought after by employers. This course will equip with a 'tool-box', introducing to a selection of behaviors and techniques that will augment innate creativity. Some of the tools are suited to use on own and others work well for a group, enabling you to leverage the power of several minds. People can pick and choose which of these tools or techniques suit needs and interests, focusing on some or all of the selected approaches and in the order that fits best.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Comprehend importance in tackling global challenges as well as in everyday problem-solving scenarios.
2. Apply different brainstorming techniques in group activities.
3. Be proficient in the application of the 6 thinking hats tool in different life scenarios.
4. Develop a systematic approach to idea generation through the use of morphological analysis.
5. Innovate on an existing product, service or situation applying the SCAMPER method.
6. Get confident with the theory of inventive problem solving, called TRIZ.

Prerequisite: There are no prerequisites to this course.

Course Content		
Unit No	**Description**	**Hrs.**
01	**Introduction to the Principles of Creativity** Basic principles of creativity and highlight its importance in tackling global challenges. Creativity is explored and applied at two different levels, lower and higher-level creativity.	**06**

02	**Creativity Tools** Augment our creativity using different methods of Brainstorming, a creativity approach that aids the generation of ideas in solving a stated problem. Particularly focus on the application of brainstorming tools in group activities, with the aim of enabling to understand, evaluate and apply different types of brainstorming techniques in own context.	**06**
03	**Six Thinking Hats** Principles as well as application of the 6 Hats thinking tool both at an individual level and in a group, under various professional and personal situations, allowing students to develop competency and accelerate proficiency on the use of technique.	**06**
04	**Clarifying the Problem** Organizing a process, turning problems into opportunities, facts, feelings & hunches, problem as question.	**06**
05	**Generating Ideas** Brainstorming, scamper, forced connections, portable think tank, case studies on generating ideas.	**06**
06	**Developing Ideas and Planning for Action** Organizing ideas, ideas to solutions, implementing solutions, case studies of development of ideas and plan of action.	**06**

References -

Text Books:

- Michael Michalko, Thinkertoys: A Handbook of Creative-Thinking Techniques, second edition, Ten Speed Press.
- Michael Michalko, Cracking Creativity: The Secrets of Creative Genius, revised edition, Ten Speed Press.
- Edward de Bono, Penguin, Lateral Thinking: A Textbook of Creativity.
- Edward de Bono, Penguin, Six Thinking Hats.

Reference Books:

- New World Library, Creative Thinkering: Putting Your Imagination to Work.
- Chris Griffiths, Kogan Page, The Creative Thinking Handbook: Your Step by Step Guide to Problem Solving in Business.

Open Elective

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE2032**	Course Name: **MOOC Course**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
Student can opt for online certification course and produce certificate.

- The students who are doing course on MOOC/NPTEL Course /Courses suggested by DPGC should select the course in consultation with supervisor and submit the details to Head of Program.
- The course should be minimum 25 hours duration and should have certification facility.
- Student should complete course and get certificate. The certificate copy should be submitted to head of program with supervisor signature.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Identify the real applications and practices of courses studied, at industry level
2. Recognize various modelling, analysis and validation techniques adopted at industries.
3. Demonstrate the issues at design, manufacturing and assembly levels.
4. Summarize and present technical data in report format.

Open Elective

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE2041**	Course Name: **Energy Audit and Management**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course provides basic understanding of energy audit and management. Essential theoretical and practical knowledge about the concept of energy conservation, energy management, and different approaches of energy conservation in industries, economic aspects of energy conservation project and energy audit and measuring instruments in commercial and industrial sector will be achieved through this course.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Identify the important of Energy Scenario.
2. Use energy audit knowledge to carry out energy audit of a given firm.
3. Examine different rolls in energy action planning
4. Apply project finance and management skills to carry out energy audit
5. Plan for energy monitoring and targeting.

Prerequisite: Electric Machines, Thermal Systems and Finance system

Course Content		
Unit No	**Description**	**Hrs.**
01	**Energy Scenario** Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment, Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features.	**06**
02	**Energy Management and Audit** Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments	**06**
03	**Energy Action Planning** Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing –location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability. Motivating-motivation of employees: Information system-	**06**

	designing barriers, Strategies; Marketing and communicating-training and planning.	
04	**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, Energy performance contracts and role of ESCOs	**06**
05	**Project Management** Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification	**06**
06	**Energy Monitoring and Targeting** Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Techniques -energy consumption, Production, Cumulative sum of differences (CUSUM).	**06**

References:

Text Books:

- Amit Kumar Tyagi,Handbook on Energy Audits and Management, TERI Publication
- Wayne C. Turner, Energy Management Handbook, Wiley Inter Science Publication

Reference Books:

- P. O'Callaghan, Energy Management, McGraw - Hill Book Company
- Bureau of Energy Efficiency Study material for Energy Managers and Auditors Examination: Paper I

Open Elective

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MOE2062**	Course Name: **Augmented Reality and Virtual Reality**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course presents an introduction to virtual and augmented reality technologies, with an emphasis on designing and developing interactive virtual and augmented reality experiences. The course will cover the history of the area, fundamental theory, and interaction techniques. Students are provided with hands-on experience developing applications for modern virtual and augmented reality systems. In the course, students will also explore libraries and tools for creating AR/VR experiences such as Vuforia and UNITY.

Course Outcomes:
After successful completion of the course, students will be able to:
1. Define the basic concepts of Virtual and Augmented Reality
2. Identify the differences in AR/VR concepts and technologies
3. Describe the fundamental concepts relating to Virtual Reality such as presence,immersion, and engagement
4. Evaluate usability of AR/VR applications and critique their use of AR/VR capabilities
5. Design and prototype effective AR/VR applications using UNITY platform for various application.

Prerequisites: Programming and Data Structures

Course Content		
Unit No	**Description**	**Hrs.**
01	**Introduction to Augmented Reality** Definition and Scope, Brief History of Augmented Reality, Displays (Multimodal Displays, Spatial Display Model, and Visual Displays), Strong vs Weak, AR Applications AR Challenges in AR.	**06**
02	**Introduction to Virtual Reality** Definition and Scope, Types of VR Characteristics, Basic VR environments, Limitations of VR environments, Immersion Vs Presence.	**06**
03	**Interaction Design for AR/VR Environments** Interaction design process Identifying user needs, AR/VR design considerations Typical AR/VR Interface Metaphors, User experience (UX) guidelines for AR/VR, UX challenges for AR/VR, Prototyping for AR/VR, Evaluation of the developed AR/VR prototype.	**06**

04	**Introduction to UNITY** Unity Overview: Windows, Interface, Navigation, Terminology, Game Objects, Hierarchy, Parenting Objects, Asset Store, Importing Plug-ins, Creating a Terrain, Materials, Colors, Transparency, Introduction to Mono behaviours: Awake, Start, Update.	**06**
05	**Introduction to Vuforia and Physics in UNITY** Vuforia Overview: Interface, Navigation, Terminology, Image Targeting, Custom Images, Overview of Physics in Unity, Introduction to Scripting: Terminology, Creating Objects, Accessing Components, Debugging, Lists, Loops.	**06**
06	**Expanding on Scripting and Interaction** Creating Trigger Events, Manipulating Components in Scripts, Programming Interactions between Objects and Tracked Images in AR, designing a simple User Interface in AR, Introduction to colliders and their use: On Collision Enter, On Collision Exit. On Collision Stay, On Trigger vs On Collision, Rigid bodies and how Colliders report to them.	**06**

References:

Text Books:

- Vince, Virtual Reality Systems, Pearson Education.
- Grigore Burdea, Philippe Coiffet, Virtual Reality Technology, Wiley.
- Schmalstieg, D., & Hollerer, T. Augmented reality: principles and practice.Addison-Wesley Professional.

Reference Books:

- Azuma, R.T. A survey of augmented reality. Presence: Teleoperators & Virtual Environments.
- Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. Recent advances in augmented reality. IEEE computer graphics and applications.
- Bhagat, K. K., Liou, W.-K., & Chang, C.-Y.A cost-effective interactive 3D virtual reality system applied to military live firing training. Virtual Reality.
- Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. Augmented reality technologies, systems and applications. Multimedia tools and applications.
- Raisamo, R., Rakkolainen, I., Majaranta, P., Salminen, K., Rantala, J., & Farooq, A. Human augmentation: Past, present and future. International journal of human- computer studies.
- Schuemie, M. J., Van Der Straaten, P., Krijn, M., & Van Der Mast, C. A. Research on presence in virtual reality: A survey. Cyber Psychology & Behavior.

Open Elective

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE2072**	Course Name: **Industrial Instrumentation**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
This course is an overview of the principles, concepts, and applications of process transmitters found in an industrial plant. Continuous measurement and control of all the parameters will be emphasized. Also practical installation and calibration procedures of various types of sensors and transducers will be covered. Open and closed loop control systems will also be discussed, including such concepts as on/off control, set point, overshoot, undershoot, gain, feedback, PID loops, and reverse/direct acting systems.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Elaborate working principal of different transducers.
2. Select suitable transducer/sensor for specific application.
3. Justify the use of specific measurement technique for specific task.
4. Evaluate the Calibration and Interfacing of the transducers.

Prerequisite: Sensor And Measurement

Course Content		
Unit No	**Description**	**Hrs**
01	**Metrology** Measurement of length – Gauge blocks – Plainness – Area using Simpson's rule, Plain meter – Diameter – Roughness – Angle using Bevel protractor, sine bars and Clinometer – Mechanical, Electrical, Optical and Pneumatic Comparators. Optical Methods for length and distance measurements using Optical flats and Michelson Interferometer.	**06**
02	**Velocity and Acceleration Measurement** Relative velocity – Translational and Rotational velocity measurements – Revolution counters and Timers – Magnetic and Photoelectric pulse counting stroboscopic methods. Accelerometers-different types, Gyroscopes-applications.	**06**
03	**Force and Pressure Measurement** Force measurement – Different methods –Gyroscopic Force Measurement – Vibrating wire Force transducer. Basics of Pressure measurement –Manometer types – Force-Balance and Vibrating Cylinder Transducers – High and Low Pressure measurement – McLeod Gauge, Knudsen Gauge, Momentum Transfer Gauge,	**06**

	Thermal Conductivity Gauge, Ionization Gauge, Dual Gauge Techniques, Deadweight Gauges, Hydrostatic Pressure Measurement.	
04	**Flow Measurement and Level Measurement** Flow Meters- Head type, Area type (Rota meter), electromagnetic type, Positive displacement type, mass flow meter, ultrasonic type, vertex shedding type, Hotwire anemometer type, Laser Doppler Velocity-meter. Basic Level measurements – Direct, Indirect, Pressure, Buoyancy, Weight, Capacitive Probe methods.	**06**
05	**Density, Viscosity and Other Measurements** Density measurements – Strain Gauge load cell method – Buoyancy method – Air pressure balance method – Gamma ray method – Vibrating probe method. Units of Viscosity, specific gravity scales used in Petroleum Industries, Different Methods of measuring consistency and Viscosity –Two float viscorator –Industrial consistency meter. Sound-Level Meters, Microphones, Humidity Measurement.	**06**
06	**Calibration and Interfacing** Calibration using Master Sensors, Interfacing of Force, Pressure, Velocity, Acceleration, Flow, Density and Viscosity Sensors, Variable Frequency Drive. Open and closed loop control system with on/off control, setpoint, overshoot, undershoot, gain, feedback, PID loops, and reverse/direct acting systems.	**06**

References:

Text Books:

- Doeblin E.O., Measurement Systems – Applications and Design, McGraw Hill International.
- Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill.

Reference Books:

- Considine D. M., Process Instruments and Control Handbook, McGraw Hill International.
- Jain R.K., Mechanical and Industrial Measurements, Khanna Publications.

Open Elective

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE2082**	Course Name: **Advanced Mechatronics Systems**

L	T	P	Credits
03	**--**	**--**	**03**

Course Description:
The course will be helpful to provide overview of mechanical and electronic systems used in industrial atmosphere. This will be helpful for upcoming automation in industry. Mechatronics is a multidisciplinary field of science that includes a combination of Mechanical Engineering, Electronics, Computer Engineering, Telecommunications Engineering and Control Engineering. Mechatronics is a multi-disciplinary study dealing with the integration of mechanical devices, actuators, sensors, electronics, intelligent controllers and computers. Mechatronics generally involves

(i) implementing electronics control in a mechanical system
(ii) enhancing existing mechanical design with intelligent control and
(iii) replacing mechanical component with an electronic solution.

This course will cover all aspects related with mechatronics such as sensors and transducers, actuators and mechanisms, signal conditioning, microprocessors and microcontrollers, modeling & system response and design of mechatronics systems.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Explain Mechatronics System.
2. Analyze the Mechatronics Based System.
3. Model, simulate, and verify the mechatronics systems.
4. Identify Electrical, Hydraulic and Pneumatic Components.

Prerequisite: Basic knowledge of research related activities.

Course Content		
Unit No.	**Description**	**Hrs.**
01	**Introduction** What is Mechatronics, Integrated Design Issues in mechatronics, Mechatronics Design Process, Mechatronics Key elements, applications in mechatronics.	**06**
02	**Modelling and Analysis of Mechatronics Systems** Block Diagram Modelling, Analogy approach, Impedance Diagrams, Electrical Systems, Mechanical systems and electromechanical systems. Mass-Spring-Oscillation and Damping system, Dynamic response of systems, Transfer function and frequency response. Labview, MATLAB, Scilab.	**06**

03	**Sensors and Actuators** Performance terminology of sensors, Displacement, Position & Proximity Sensors, Displacement, Position sensors, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Electrical and Mechanical Actuation Systems.	06
04	**Signal Conditioning** Introduction to signal processing, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Signal processing devices, relays, contactors and timers. Microcontrollers, PID controllers and PLCs.	06
05	**Hydraulic System and Pneumatic System** Flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, and pumps, Pneumatic system components and graphic representations, Advantages and limitations of pneumatic systems.	06
06	**Case Study** List of various mechatronics systems, Case study of pick and place mechanism of robotic arm using pneumatic power, Hydraulic circuit for CNC Lathe machine, 3D Printer, Auto-control system for Green House Temperature and Auto-focusing in Digital Cameras.	06

References:

Text Books:

- Bradley, D. Dawson, N. C. Burd and A.J. Loader, Mechatronics: Electronics in product and process, Chapman and Hall, London.
- Devadas Shetty, Richard A. Kolkm, Mechatronics system design, PWS publishing company.
- David G. Alciatore, Michael B. Histand, Introduction to mechatronics and measurement systems Mc Graw Hill Education.

References Books:

- Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, R. Merzouki, A. K. Samantaray, P. M. Pathak, B. Ould Bouamama, Springer, London.
- Technical website: https://onlinecourses.nptel.ac.in/noc21_me27/course

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Open Elective

Class: **S. Y. M. Tech**	Semester: **III**
Course Code: **MOE2091**	Course Name: **Disaster Management**

L	T	P	Credits
03	--	--	03

Course Description:
This course provides a holistic understanding of disaster management, covering both natural and manmade disasters. Students will delve into the meaning, nature, and various types of disasters, exploring their effects on individuals, communities, and the environment. The course encompasses a global perspective while focusing on the disaster profile of India, considering regional and seasonal variations

Course Outcomes:
After successful completion of the course, students will be able to,

1. Outline disaster and disaster management cycle.
2. Summarize disaster preparedness and response activities for various types of disaster.
3. Apply various advanced techniques for disaster management.
4. Examine role of various agencies in disaster management.
5. Dissect the disaster management scenario in India.

Prerequisite: Environmental Science

Course Content		
Unit No.	**Description**	**Hrs.**
01	**Natural Disaster** Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic, eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion.	06
02	**Manmade Disasters** Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents. Disasters -A Global View, Disaster Profile of India- Regional, and Seasonal.	06
03	**Disaster Management Cycle** Introduction to Disaster Management Cycle: Mitigation, Preparedness, Response and Recovery. Disaster Mitigation, Hazard identification and vulnerability analysis, Mitigation strategies or measures	06

04	**Disaster Preparedness, Response and Recovery** Introduction to Disaster Preparedness, Disaster Risk Reduction (DRR), The Emergency Operation Plan (EOP). Introduction to Disaster Response, Aims of disaster response, Disaster Response Activities, Modern and traditional responses to disasters, Modern methods of disaster response, Disaster Recovery, The Recovery Plan, Disasters as opportunities for development initiatives.	06
05	**Role of Technology in Disaster Management** Geographic Information System (GIS) and Disaster Management. GIS applications. Global Positioning System (GPS) and Disaster Management, Applications of GPS to Disaster management. Remote Sensing and its significance in Disaster Management.	06
06	**Role of Multiple Stakeholders In Disaster Management** Role of NGO's, Community based organizations, media, Central, State, District and Local Administration, armed forces, Police and other organizations.	06

References:

Codes of Practice:

- National Disaster Management Authority (NDMA). National Disaster Management Plan 2019.
- National Disaster Management Authority (NDMA). National Disaster Management Act 2005.

Text Books:

- Coppola, D. P., Introduction to International Disaster Management, Elsevier USA.
- Singh R. B., Disaster Management, Rawat Publication.

Reference Books:

- Reiter L., Earthquake Hazard Analysis: Issues and Insight, Colombia University Press.
- Mileti D. S. Disaster by Design: A Reassessment of National Hazards in United States, The National Academic Press.

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MDE2027**	Course Name: **Dissertation Phase – I**

L	T	P	Credits
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Course Description:

Dissertation Phase I and Synopsis Approval Presentation:

Under the guidance of faculty called as Supervisor, PG student from second year is required to do innovative and research oriented work related to various theory and laboratory courses he/she studied during previous semesters. Dissertation work should not be limited to analytical formulation, experimentation or survey based project. Student can undertake an interdisciplinary type project with the prior permission of DPGC from both departments.

Synopsis:

Student need to carry out exhaustive literature survey with consultation of his/her Supervisor for not less than 25 reputed national international journal and conference papers. Student should make the Synopsis Submission Presentation (SSP) with literature survey report to DPGC and justify about the innovativeness, applicability relevance and significance of the work. At the time of presentation, student shall also prepare Synopsis of the work and submit to department for approval. Student shall submit synopsis of dissertation as per the prescribed format in 02 copies to department.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Explain the contributions of various researchers in the field of design engg. after carrying out literature survey from reputed journals.
2. Recognize the gap in the research and define a problem statement.
3. Explain significance and applicability of problem statement.
4. Summarize and present technical data in report format.

Class: **S. Y. M. Tech.**	Semester: **III**
Course Code: **MDE2037**	Course Name: **Dissertation Phase – II**

L	T	P	Credits
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Course Description:

Phase II evaluation is based on End Semester Examination (ESE) which is based on the work during the semester. It is expected that student shall present preliminary results from his/her work during the semester with report as per prescribed format. DPGC including external examiner as expert will approve the report and progress of student. ISE will be evaluated by DPGC and ESE will be evaluated by DPGC and one external expert. Student will submit a report (soft bound before 1 week of date of presentation) as per prescribed format and present to DPGC for ISE and ESE. If student is not showing satisfactory performance, then he /she will be given grace period of 2 week. After 2 weeks, student will again evaluated with grade penalty.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Outline the work plan for problem statement.
2. Identify the proper modelling and analysis tool.
3. Reproduce the preliminary results of problem statement.
4. Summarize and present technical data in report format.

Class: **S. Y. M. Tech.**	Semester: **IV**
Course Code: **MDE2047**	Course Name: **Dissertation Phase – III**

L	T	P	Credits
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Course Description:
Student is required to make a presentation on the progress of his/her dissertation work in front of supervisor and DPGC. It is expected that up to this stage almost 90% of the dissertation work is completed. Student will make the presentation and seek the suggestions from the supervisor and DPGC. Supervisor and DPGC will ensure that work carried out by the students till this stage is satisfactory and in compliance with synopsis of the dissertation submitted by the student. This is In Semester Evaluation (ISE).

Course Outcomes:
After successful completion of the course, students will be able to,

1. Explain the issues related to method adopted in solving the problem
2. Select proper technique in solving the problem
3. Compare the results with available literature

Class: **S. Y. M. Tech.**	Semester: **IV**
Course Code: **MDE2057**	Course Name: **Dissertation Phase – IV**

L	T	P	Credits
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Course Description:
This is the final presentation i.e., viva voce of the dissertation. Student will be allowed to make this presentation only if he has submitted duly completed and certified dissertation report. Students will make the presentation in front of supervisor, DPGC and external supervisor. Examiners will check whether the dissertation work is in full compliance with synopsis of dissertation or not. Dissertation will assess on the bases quality of dissertation work, efforts taken by the student, quality of the paper(s) published on the dissertation work etc.

Course Outcomes:
After successful completion of the course, students will be able to,

1. Design new methodology to address the problem.
2. Justify the results obtained from new methodology.
3. Write technical report and de end work.

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