ಬಿ. ಎಂ. ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರು

(ಸ್ವಾಯತ್ತ ವಿದ್ಯಾಸಂಸ್ಥೆ)

B. M. S. COLLEGE OF ENGINEERING, BENGALURU.

(Autonomous College under VTU)

DEPARTMENT OF MECHANICAL ENGINEERING

M. TECH. – MACHINE DESIGN

SCHEME & SYLLABUS

A. Y. 2020 – 21 ONWARDS

ಬಿ. ಎಂ. ಎಸ್. ತಾಂತ್ರಿಕ ಮಹಾವಿದ್ಯಾಲಯ

ಬಸವನ ಗುಡಿ ರಸ್ತೆ, ಬೆಂಗಳೂರು–೫೬೦ ೦೧೯.

B. M. S. COLLEGE OF ENGINEERING

Bull Temple Road, Bengaluru-560 019.

VISION

Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION

To become a center of excellence in educating students to become successful Mechanical Engineers

DEPARTMENT MISSION

- To empower the students with the fundamentals for a successful career in the field of Mechanical engineering.
- To continue their education through post-graduation, Research & Development.
- To provide service to the society.

Scheme and Syllabus for M. Tech. (Machine Design)

With effect from A. Y. 2020 – 21

M. Tech. (Machine Design)

Programme Educational Objectives

PEO1	Graduates will have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.
PEO2	Graduates shall be successful in their career as analysts and designers of structural components of conventional and advanced materials, participating in a team or individually in an industry, research or academia.
PEO3	Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.

Programme Outcomes

PO No.	Programme Outcomes (PO)
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document
PO3	An ability to demonstrate mastery in the domain of the specialization of the program

M. Tech. (Machine Design)

Scheme of Instruction for **First Semester M. Tech. in Machine Design** 2020-2021

Sl. No.	Course Code	Name of the Course	Credits				Total Credits
			L	T	P	S	
1	20MEMDPCAS	Advanced Mechanics of Solids	3	0	0	0	3
2	20MEMDPCDM	Dynamics and Mechanism Design	3	0	1	0	4
3	20MEMDPCAD	Advanced Machine Design	3	0	0	0	3
4	20MEMDPCFE	Finite Element Method	3	0	1	0	4
5	20MEMDPEXX	Elective–I	3	0	0	0	3
6	20MEMDPEXX	Elective–II	3	0	0	0	3
7	20ALLPICRM	Research Methodology	2	0	0	0	2
	Total		**20**	**0**	**2**	**0**	**22**

Note: Electives to be chosen one from each group.
Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

Elective I	
Course Code	**Course**
20MEMDPECM	Composite Materials Technology
20MEMDPEMD	Mechatronics Systems Design
20MEMDPERD	Robust Design

Elective II	
Course Code	**Course**
20MEMDPECA	Computer Applications in Design
20MEMDPESE	Statistical Modeling and Experimental Design
20MEMDPEOT	Optimization Techniques

M. Tech. (Machine Design)

Scheme of Instruction for **Second Semester M. Tech. in Machine Design** 2020-2021

Sl. No.	Course Code	Name of the Course	Credits				Total Credits
			L	T	P	S	
1	20MEMDPCVA	Vibration & Acoustics	3	1	0	0	4
2	20MEMDPCAF	Advanced Finite Element Method	3	0	1	0	4
3	20MEMDPEDF	Design for Manufacturing	3	0	0	0	3
4	20MEMDPEXX	Elective-III	3	0	0	0	3
5	20MEMDPEXX	Elective-IV	3	0	0	0	3
6	20XXXXIEXX	Elective-V (Institutional)	4	0	0	0	4
7	20MEMDPCSL	Simulation Laboratory	0	0	1	0	1
	Total		**19**	**1**	**2**	**0**	**22**

Note: Electives to be chosen one from each group.
Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

Elective III	
Course Code	Course
20MEMDPETR	Tribology
20MEMDPERT	Rotor Dynamics
20MEMDPEAC	Automatic Control Systems

Elective IV	
Course Code	Course
20MEMDPEEM	Experimental Mechanics
20MEMDPCFM	Fracture Mechanics
20MEMDPETS	Theory of Plates and Shells

Elective V (Institutional)	
Course Code	Course
20MEMDIECE	Computational Methods in Engineering Analysis
20MEMDIESS	Smart Materials and Structures

M. Tech. (Machine Design)

Scheme of Instruction for **Third Semester M. Tech. in Machine Design** 2020-2021

Sl. No.	Course Code	Name of the Course	Credits				Total Credits
			L	T	P	S	
1	20MEMDPCIN	Internship/Industrial training	0	0	10	0	10
2	20MEMDMEPL	Product Life Cycle Management	2	0	1	0	3
3	20MEMDPRP1	Project Work Phase: I	0	0	8	0	8
4	20MEMDPCTS	Technical Seminar	0	0	1	0	1
5	20MEMDNCXX	Non-credit Mandatory Course – 1	0	0	0	0	0
		Total	**2**	**0**	**20**	**0**	**22**

NOTE: III Semester:

- **Internship:** The student shall undergo Internship/Industrial training for 16 weeks.

  Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

  Final Report submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty of Department. Report Evaluation to be completed within two weeks of submission for 100 marks.

  Viva-Voce on Internship - To be conducted by the Internal Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HoD as chairman for 100 marks

- **Project Phase: I**

  Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HoD as Chairman.

  Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HoD as chairman for 50 marks.

M. Tech. (Machine Design)

Scheme of Instruction for **Fourth Semester M. Tech. in Machine Design** 2020-2021

Sl. No.	Course Code	Subject	Credits				Credits
			L	T	P	S	
1	20MEMDPRP2	Project Work Phase - II	0	0	20	0	20
2	20MEMDMEBA/ 20MEMDMECM	Business Analytics / Cost Management of Engineering Projects	2	0	0	0	2
3	20MEMDNCXX	Non-credit Mandatory Course – 2	0	0	0	0	0
		Total	**2**	**0**	**20**	**0**	**22**

IV Semester:

- **Project Work Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HoD as Chairman
- Internal Evaluation of Project Demonstration shall be evaluated after 15 weeks for 50 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation of Project Work and Viva-voce**.
  - ➢ Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4^{th} semester.
  - ➢ The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HoD as chairman will complete the final evaluation of Project.
- Internal and External Examiners shall carry out the evaluation of thesis for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce:** The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HoD as chairman for 100 Marks.

Course		Credits : 04				Marks	
Name	**ADVANCED MECHANICS OF SOLIDS**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	20MEMDPCAS	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I

Introduction to Stress: Definition and Notation for forces and stresses. Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses and shear stresses. Stress transformation, Stress components on an arbitrary plane, Stress invariants, Octahedral stresses.

7 Hours

UNIT - II

Introduction to Strain : Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, Strain transformation, Compatibility equations, Cubical dilatation.
Stress -Strain Relations and the General Equations of Elasticity: Generalized Hooke's; law in terms of engineering constants. Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem. **10 Hours**

UNIT – III

Energy Methods: Work done by forces and elastic strain energy stored, Begg's Deformeter, First theorem of Castigliano, Theorem of virtual work. **5 Hours**

UNIT – IV

Two Dimensional Problems in Cartesian Co-Ordinates: Airy's stress function, investigation for simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load. **5 Hours**

UNIT - V

Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, Thick cylinder, shrink fit, Strain components in polar co-ordinates, Rotating disk and cylinder, Thermo-elastic stress –strain relations ,Thermal stresses in thin discs.
Torsion of Prismatic Bars: Torsion of Circular and elliptical cross section bars, Membrane analogy, Torsion of thin walled closed tubes. **12 Hours**

Text Books:

1. Timoshenko and Goodier, **"Theory of Elasticity"** -'McGraw Hill Book Company.
2. L S Srinath **"Advanced Mechanics of Solids"** - Tata Mcgraw Hill Company.
3. Arthur P Boresi and Richard J Schmidt, Advanced Mechanics of Materials, 6th Ed 2002

References Books:

1. T. G. Sitharam, Applied Elasticity - Interline publishing.
2. Dym C. L and Shames. I. H, Solid Mechanics: A variation Approach – McGraw Hill New York-1973.
3. Sadhu Singh **,** Theory of Elasticity, Khanna publisher
4. Richard G Budynas, Advanced strength and applied stress analysis, Second Edition, McGraw Hill International, Edition 1999.
5. Martin H Sadd, Elasticity: Theory, Applications and Numerics, Academic Press, 2009.

Course Outcomes:

Upon completion of this course, student will be able to:

CO 1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems
CO 2	Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	Use MATLAB or equivalent software to evaluate and plot particular solutions.
CO 4	Apply principles of continuum mechanics to design a structure or component to achieve desired performance under realistic constraints.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit I, III, IV and Two questions each from units II & V.

Course		Credits : 04				Marks	
Name	DYNAMICS AND MECHANISM DESIGN	L	T	P	S	CIE	SEE
Code	20MEMDPCDM	3	0	1	0	50	50

Course Content:

UNIT - I

Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, Unique mechanisms, Inversions of mechanism. **03 Hours**

UNIT - II

Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. **07 Hours**

UNIT - III

Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. **08 Hours**

Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. **06 Hours**

UNIT - IV

Generalized Principles of Dynamics: Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton's equations, Hamilton's principle, Lagrange's, equation from Hamilton's principle, Derivation of Hamilton's equations, Examples. **10 Hours**

UNIT – V

System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances.

05 Hours.

List of Practical's:

1. Kinematic analysis of four bar mechanism and slider bar mechanism using ADAMS Software.
2. Kinematic analysis of complex mechanisms using ADAMS Software.
3. Develop a code in MATLAB to for kinematic analysis of four bar mechanism and slider bar mechanism.

4. Write a MATLAB code to synthesize a four bar mechanism using Freudenstein's method for function generation.
5. Write a MATLAB code to generate phase plane plot.

Text Books:

1. Joseph Edward Shigley and John Joseph Uicker, "Theory of Machines and Mechanism" -McGraw-Hill, 1995.
2. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.

References Books:

1. K. J. Waldron& G. L. Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.
2. A. G. Ambekar, "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick, "Theory of Mechanism and Mechanism", East West press 2007.
4. David H. Myszka, "Machines and Mechanisms", Pearson Education, 2005.
5. G. K. Grover "Mechanical Vibrations" NemChad and Bros. 1996.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.
CO2	Synthesize mechanisms for function generation and path generation.
CO3	Analyze the Dynamics of Mechanical systems using D'Alembert's, Lagrange's, and Hamilton's Principles.
CO4	Demonstrate the skills to use software to analyze mechanisms

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit I, II, V and Two questions each from units III & IV.

Course		Credits : 04				Marks	
Name	ADVANCED MACHINE DESIGN	L	T	P	S	CIE	SEE
Code	20MEMDPCAD	3	0	0	0	50	50

Course Content:

UNIT - I

Introduction: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.

Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features. **10 Hours**

UNIT - II

Stress-Life (S-N) Approach: S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.

Strain-Life(ε-N)approach: Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.

10 Hours

UNIT - III

LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects. Cyclic Plastic zone, Crack Closure, Small Fatigue cracks and LEFM limitations. Plasticity extension and LEFM and Elastic Plastic Fracture Mechanics. **6 Hours**

UNIT - IV

Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach.

6 Hours

UNIT - V

Fatigue from Variable Amplitude Loading: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach and strain life approach. **7 Hours**

Text Books:

1. Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, "Metal Fatigue in engineering", John Wiley Newyork, Second edition. 2001.
2. Jack. A. Collins, "Failure of Materials in Mechanical Design", John Wiley, New York 1992.
3. Robert L. Norton , "Machine Design", Pearson Education India, 2000

Reference Books:

1. S. Suresh, "Fatigue of Materials", Cambridge University Press, -1998.
2. Julie. A. Benantine, "Fundamentals of Metal Fatigue Analysis", Prentice Hall, 1990.
3. Fatigue and Fracture, ASM Hand Book, Vol 19, 2002.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Predict failure of engineering components using appropriate failure theories.
CO2	Identify and explain the types of fractures of engineered materials and their characteristic features;
CO3	Estimate life of components using stress life, strain life and LEFM approach.
CO4	Analyze the machine members subjected to spectrum loads.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit III, IV, V and Two questions each from units I & II.

Course		Credits : 04				Marks	
Name	**FINITE ELEMENT METHOD**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPCFE**	**3**	**0**	**1**	**0**	**50**	**50**

Course Content:

UNIT - I

Introduction to Finite Element Method: Basic Steps in Finite Element Method to solve mechanical engineering Solid Mechanics problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements. Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions.

8 Hours

UNIT - II

Solid Mechanics : One-Dimensional Finite Element Formulations and Analysis – Bars- uniform, varying and stepped cross section-Basic(Linear) and Higher Order Elements Formulations for Axial and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation for uniform cross section for different loading and boundary conditions with problems. Trusses: Basic (Linear) Elements Formulations for different boundary and loading condition with problems. **9 Hours**

UNIT - III

Two Dimensional Finite Element Formulations for Solid Mechanics Problems: Triangular Membrane Element (CST), Four-noded Quadrilateral Membrane Element (QUAD 4) Formulations for in-plane loading with sample problems. Shape functions for Higher order Triangular and Quadrilateral membrane elements, Triangular Axis symmetric basic Element formulation for axis symmetric loading. Serendipity and Lagrange family Elements. **8 Hours**

UNIT - IV

Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of 4-noded Tetrahedral Element, 8-noded Hexahedral Element, Shape functions for Higher order elements. **6 Hours**

UNIT - V

Dynamic Analysis: Finite Element Formulation for point/lumped mass and distributed mass system, Finite Element Formulation for one dimensional dynamic analysis: bar and truss element.

08 Hours.

Text Books:

1. T. R. Chandrupatla and A. D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall, 3rd Ed, 2002.
2. Lakshminarayana H. V., "Finite Elements Analysis– Procedures in Engineering", Universities Press, 2004.

Reference Books:

1. Rao S. S, "Finite Elements Method in Engineering", 4th Edition, Elsevier, 2006.
2. P. Seshu, "Finite Element Analysis", PHI, 2004.

3. J. N. Reddy, "Introduction to Finite Element Method", McGraw -Hill, 2006.
4. Bathe K. J., "Finite Element Procedures", Prentice-Hall, 2006.
5. Cook R. D., "Finite Element Modeling for Stress Analysis", Wiley, 1995.

Laboratory Exercises:
FE analysis of machine members using reputed commercial software for stress distribution, stress concentration and report writing on results of analysis.

1. **Numerical Calculation using MATLAB:** Invariants, Principal stresses and strains with directions, Maximum shear stresses and strains and planes, von-Mises stress, Calculate and Plot Stresses in Thick-Walled Cylinder
2. **Finite element formulation and Simulation using MATLAB**: Formulation of 1D elements
3. **Stress analysis of Curved beam in 2D:** Static stress analysis and numerical simulation
4. **Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. Shear**
5. **Single edge notched beam in bending**: Modelling of single edge notched beam in four point bending, Numerical Studies using FEA, Parametric studies
6. **Torsion of Prismatic bar:** Elastic solutions, MATLAB Simulation, Finite Element Analysis of any chosen geometry.
7. **Nonlinear bending of beam:** Material nonlinearity
8. **Contact Stress Analysis of Circular Disc under diametrical compression**

Course Outcomes:
Upon completion of this course, the students will be able to

CO1	Develop governing equation for a mechanical system and apply principles of variation and integral formulation to formulate finite element equations.
CO2	Formulate one dimensional, two dimensional and axisymmetric elements.
CO3	Analyse problems related to 1D, 2D and solids of revolution.
CO4	Develop mass matrices and compute eigenvalues and eigenvectors for a 1D and 2D analysis of mechanical components.
CO5	Demonstrate the use of commercial FEA packages to solve complex problems.

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.

ELECTIVE - I

Course		Credits : 03				Marks	
Name	COMPOSITE MATERIALS TECHNOLOGY	L	T	P	S	CIE	SEE
Code	20MEMDPECM	3	0	0	0	50	50

Course Content:

UNIT - I

Introduction to Composite Materials: Definition, Classification, Types of matrix material and reinforcements, Characteristics & selection, Fiber composites, Laminated composites, Particulate composites, Prepegs, and sandwich construction. **5 Hours**

UNIT - II

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angled lamina, Engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **9 Hours**

UNIT – III

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixtures, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths

Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **9 Hours**

UNIT - IV

Macro Mechanical Analysis of Laminate: Introduction, Code, Kirchoff hypothesis, Classical Lamination Theory, Derivation of A, B, and D matrices, Hygroscopic effect, Special cases of laminates, Numerical problems. **8 Hours**

UNIT - V

Manufacturing, Testing and Applications:

Layup and curing - open and closed mold processing, Hand lay-up techniques, Bag molding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection molding, Cutting, Machining, joining and repair.

NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **8 Hours**

Text Books:

1. Autar K. Kaw, "Mechanics of Composite materials", CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, "Mechanics of Composite Materials & Structures", Universities Press, 2004.

Reference Books:

1. Mein Schwartz, "Composite Materials", handbook, McGraw Hill, 1984.
2. P. K. Mallik, Marcel Decker, "Fiber Reinforced Composites", CRC Press, 3rd ed, 1993.
3. Robert M. Jones, "Mechanics of Composite Materials", Taylor & Francis, 1998.
4. J. N. Reddy, "Mechanics of Laminated Composite Plates & Shells", CRC Press, 2nd Ed, 2004.
5. Michael W Hyer, "Stress analysis of fiber Reinforced Composite Materials", McGraw Hill International, 2009.
6. Krishan K. Chawla, "Composite Material Science and Engineering", Springer, 3rd ed, 2012.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Identify the role of matrices and reinforcements used in practical composite structures.
CO2	Analyze problems on micro and macro mechanical behavior of lamina.
CO3	Assess the strength of laminated composite and predict its failure for given static loading conditions.
CO4	Develop understanding of different methods of manufacturing and testing of composites.
CO5	Make oral presentation on recent advancements in the field of composite materials and structures.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit I, IV, V and Two questions each from units II & III.

Course		Credits : 03				Marks	
Name	MECHATRONICS SYSTEM DESIGN	L	T	P	S	CIE	SEE
Code	20MEMDPEMD	3	0	0	0	50	50

Course Content:

UNIT - I

Introduction: Definition and Introduction to Mechatronic Systems. Modeling & Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. **8 Hours**

UNIT - II

Electrical Actuation Systems: Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. System Models: Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems. **9 Hours**

UNIT - III

Signal Conditioning: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. **10 Hours**

UNIT - IV

Data Presentation Systems: Basic System Models, System Models, Dynamic Responses of System. **6 Hours**

UNIT – V

Advanced Applications in Mechatronics: Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design. **6 Hours**

Text Books:

1. W. Bolton, "Mechatronics", Addison Wesley Longman Publication, 1999.
2. HSU "MEMS and Microsystems design and manufacture", Tata McGraw-Hill Education, 2002.

Reference Books:

1. Lawrence J. Kamm, "Understanding Electro-Mechanical Engineering an Introduction to Mechatronics", Wiley-IEEE Press, 1st edition, 1996.
2. Devdas Shetty and Richard A. Kolk, "Mechatronics System Design", Cengage Learning, 2nd ed, 2011.
3. Mahalik, Mechatronics, Tata McGraw-Hill Education, 2003.
4. HMT, "Mechatronics"- Tata McGraw-Hill Education, 1998.
5. Michel B. Histand and David. Alciatore, "Introduction to Mechatronics & Measurement Systems", McGraw Hill, 2002.
6. Fine Mechanics and Precision Instruments- Pergamon Press, 1971.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Appreciate multi-disciplinary nature of modern engineering systems.
CO2	Model and analyse mechanical and electrical systems and their connection.
CO3	Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.
CO4	Address issues of design, fabrication, and packaging issues of Microsystems.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.

Course		Credits : 03				Marks	
Name	ROBUST DESIGN	L	T	P	S	CIE	SEE
Code	20MEMDPERD	3	0	0	0	50	50

Course Content:

UNIT - I

Quality by Experimental Design: Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions.

Robust Design: Steps in robust design: parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.

Experimental Design: Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples. **9 Hours**

UNIT - II

Measures of Variability: Measures of variability, Concept of confidence level, Statistical distributions: normal, log normal and Weibull distributions. Hypothesis testing, Probability plots, choice of sample size illustration through numerical examples. Analysis and interpretation of experimental data: Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples.

10 Hours

UNIT - III

Taguchi's Orthogonal Arrays: Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, Branching design, Strategies for constructing orthogonal arrays. Signal to Noise ratio (S-N Ratios): Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the –better – type, larger – the- better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.

10 Hours

UNIT - IV

Parameter Design and Tolerance Design: Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples**.** **5 Hours**

UNIT - V

Reliability Improvement Through Robust Design: Role of S-N ratios in reliability improvement; Case study; illustrating the reliability improvement of routing process of a printed wiring board using robust design concepts. **5 Hours.**

Text Books:

1. Madhav S. Phadake, "Quality Engineering using Robust Design", Prentice Hall,1989.
2. Douglas Montgomery, "Design and analysis of experiment", Willey India Pvt. Ltd., 2007.
3. Phillip J. Ross, Taguchi, "Techniques for Quality Engineering", McGraw Hill Int. Ed., 1996.

Reference Books:

1. Thomas B. Barker, “Quality by Experimental Design” , Marcel Dekker Inc, ASQC Quality Press, 1985.
2. C. F. Jeff Wu, Michael Hamada, “Experiments planning, analysis and parameter design optimization”, John Wiley Ed., 2002.
3. W. L. Condra, Marcel Dekker, “Reliability improvement by Experiments”, Marcel Dekker Inc ASQC Quality Press, 1985.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Apply Design of Experiments (DOE) techniques to various methods of design.
CO2	Analyse and evaluate design parameters using different design strategies.
CO3	Illustrate through numerical examples improvements in design parameters.
CO4	Perform case studies involving identification of parameters, analysis of experimental data in a robust design.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.

ELECTIVE – II

Course		Credits : 03				Marks	
Name	**COMPUTER APPLICATIONS IN DESIGN**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPECA**	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I

Introduction to CAD/CAM/CAE Systems: Overview, Definitions of CAD, CAM and CAE, Integrating the Design and Manufacturing Processes through a Common Database-A Scenario, Using CAD/CAM/CAE Systems for Product Development-A Practical Example. Components of CAD/CAM/CAE Systems: Hardware Components, Vector-Refresh (Stroke-Refresh) Graphics Devices, Raster Graphics Devices, Hardware Configuration, Software Components, Windows-Based CAD Systems. **7 Hours**

UNIT - II

Basic Concepts of Graphics Programming: Graphics Libraries, Coordinate Systems, Window and Viewport, Output Primitives - Line, Polygon, Marker Text, Graphics Input, Display List, Transformation Matrix, Translation, Rotation, Mapping, Other Transformation Matrices, Hidden-Line and Hidden-Surface Removal, Back-Face Removal Algorithm, Depth-Sorting, or Painters, Algorithm, Hidden-Line Removal Algorithm, z-Buffer Method, Rendering, Shading, Ray Tracing, Graphical User Interface, X Window System. **7 Hours**

UNIT - III

Geometric Modeling Systems : Wireframe Modeling Systems, Surface Modeling Systems, Solid Modeling Systems, Modeling Functions, Data Structure, Euler Operators, Boolean Operations, Calculation of Volumetric Properties, Non manifold Modeling Systems, Assembly Modeling Capabilities, Basic Functions of Assembly Modeling, Browsing an Assembly, Features of Concurrent Design, Use of Assembly models, Simplification of Assemblies, Web-Based Modeling. Representation and Manipulation of Curves: Types of Curve Equations, Conic Sections, Circle or Circular Arc, Ellipse or Elliptic Arc, Hyperbola, Parabola, Hermit Curves, Bezier Curve, Differentiation of a Bezier Curve Equation, Evaluation of a Bezier Curve.

B-Spline Curve, Evaluation of a B-Spline Curve, Composition of B-Spline Curves, Differentiation of a B-Spline Curve, Non uniform Rational B-Spline (NURBS) Curve, Evaluation of a NURBS Curve, Differentiation of a NURBS Curve, Interpolation Curves, Interpolation Using a Hermite Curve, Interpolation Using a B-Spline Curve, Intersection of Curves. **10 Hours**

UNIT – IV

Representation and Manipulation of Surfaces: Types of Surface Equations, Bilinear Surface, Coon's Patch, Bicubic Patch, Bezier Surface, Evaluation of a Bezier Surface, Differentiation of a Bezier Surface, B-Spline Surface, Evaluation of a-B-Spline Surface, Differentiation of a B-Spline Surface, NURBS Surface, Interpolation Surface, Intersection of Surfaces. **8 Hours**

UNIT - V

CAD and CAM Integration Overview of the Discrete Part Production Cycle, Process Planning, Manual Approach, Variant Approach, Generative Approach, Computer-Aided Process Planning Systems, CAM-I CAPP, MIPLAN and Multi CAPP, Met CAPP, ICEM-PART, Group Technology, Classification and Coding, Existing Coding Systems, Product Data Management (PDM) Systems.

7 Hours

Text Books:

1. Kunwoo Lee, "Principles of CAD/CAM/CAE systems"-Addison Wesley, 1999.
2. Radhakrishnan P, "CAD/CAM/CIM"-New Age International, 2008.

Reference Books:

1. Ibrahim Zeid, "CAD/CAM – Theory & Practice", McGraw Hill, 1998.
2. Bedworth, Mark Henderson & Philip Wolfe, "Computer Integrated Design and Manufacturing" - McGraw Hill Inc., 1991.
3. Pro-Engineer, Part modeling Users Guide, 1998.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Interpret the role of computers in various activities of product development.
CO2	Create and manipulate the geometric entities like lines, curves, surfaces and 3D objects.
CO3	Create an assembly of parts using software package as an engineering tool.
CO4	Connect the activities of CAD and CAM.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit I, IV, V and Two questions each from units II & III.

Course		Credits : 03				Marks	
Name	**STATISTICAL MODELING AND EXPERIMENTAL DESIGN**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPESE**	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I
Statistical Modeling and Data Analysis: Introduction, Review of basic statistical concepts: Concepts of random variable, Sample and population, Measure of Central tendency; Mean, median and mode. Illustration through Numerical examples, Normal, Log Normal & Weibull distributions. Illustration through Numerical examples. **9 Hours**

UNIT - II
Introduction to Designed Experiments: Strategy of experimentation, Some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Summary: Using statistical techniques in experimentation. **10 Hours**

UNIT - III
Factorial Experiments Basic definitions, The advantages of factorials, the two factorial design. Introduction, Factorial Experiments Terminology: factors, levels, interactions, Two-level experimental designs for two factors and three factors. Illustration through Numerical examples. **10 Hours**

UNIT - IV
Regression Analysis: linear and multiple Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples. **4 Hours**

UNIT - V
Signal to Noise Ratio: Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-batter type, Nominal the-better-type, Larger-the better type. Signal to Noise for Dynamic problems. Illustration through Numerical examples. **6 Hours**

Text Books:

1. Design and Analysis of Experiments, Douglas C. Montgomery, 5th Edition Wiley India Pvt. Ltd. 2007.
2. Quality engineering using robust design, Madhav S. Phadke, Prentice Hall PTR, Englewood Cliffs, New Jersey 07632, 1989.

Reference Book:

1. Thomas B. Barker, "Quality if experimental design", Marcel Dekker Inc ASQC Quality Press.1985.
2. C.F. Jeff Wu Michael Hamada, "Experiments Planning Analysis and Parameter Design Optimization", Wiley Editions. 2002.
3. L. W. Condra, "Reliability Improvement with design of Experiments", 2nd ed, CRC Press, 2001
4. Phillip j. Ross, "Taguchi Techniques for Quality Engineering", 2nd ed. McGraw Hill International Editions, 1996.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Statistically model a population and fit in a suitable distribution for the population for further analysis.
CO2	Analyse and apply statistical concept in the design of experiments.
CO3	Develop experimental models for 2 factors or 3 factors.
CO4	Establish a regression pattern for given mathematical model established for experiment and evaluate signal to noise ratio for sensitivity.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.

Course		Credits : 03				Marks	
Name	**OPTIMIZATION TECHNIQUES**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPEOT**	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I

Introduction: Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation, Engineering Optimization Problems. Calculus method. Linear Programming. Simplex method, Concept of Duality **9 Hours**

UNIT - II

Single Variable Optimization Problems: Optimality Criterion, Bracketing Methods, Region Elimination Methods, Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method. Application to Root finding. **10 Hours**

UNIT - III

Multivariable Optimization Algorithms: Optimality Criteria, Unidirectional Search, Direct Search Methods: Hooke-Jeeves pattern search method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method. **6 Hours**

UNIT - IV

Constrained Optimization Algorithms: Kuhn Tucker conditions, Transformation Methods: Penalty Function Method, Method of Multipliers, Sensitivity analysis. **4 Hours**

UNIT - V

Further Topics in Optimization Techniques: Quadratics Programming, sequential quadratic programming; Integer Programming, Penalty Function Method, Branch and Bound Method, Geometric Programming, Applications Design of experiments and Taguchi method – Application and problem solving; Dynamic programming, principle of optimality, recursive equation approach and applications; Genetic algorithm. **10 Hours**

Text Books

1. S. S. Rao, “Engineering Optimization: Theory and Practice”, John Wiley & Sons, 1996.
2. Kalyanmoy Deb, “Optimization for Engineering Design: Algorithms and Examples”, 2nd ed, Prentice Hall of India, 2004.

Reference Books

1. E. J. Haug and J. S. Arora, “Applied Optimal Design”, Wiley, New York.
2. G. V. Reklaites, A. Ravindran and K. M. Rogsdeth, “Optimization”, Wiley, New York.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Formulate engineering optimization problem and solve LPP by simplex method.
CO2	Solve single and multivariable optimization problem by various relevant method.
CO3	Develop algorithm for constrained optimization.
CO4	Examine various optimization techniques and demonstrate their applicability.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit I, III, IV and Two questions each from units II & V.

Course		Credits : 02				Marks	
Name	**RESEARCH METHODOLOGY**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20ALLPICRM**	**2**	**0**	**0**	**0**	**50**	**50**

Course Content:

Module 1:

Meaning and sources of research problem, , Objectives and Characteristics of research – Errors in selecting research problem, Research methods Vs Methodology - Types of research-Criteria of good research – Developing a research plan.

Module 2:

Investigations of a research problem - Selecting the problem - Necessity of defining the problem – Data collections-analysis- Importance of literature review in defining a problem - Survey of literature - Necessary instrumentations

Module 3:

How to write paper-conference articles-poster preparation, thesis report writing, inclusion of references, journal reviewing process, journal selection process, filling about journal template, developing effective research proposal-plagiarism-research ethics

Module 4:

Nature of Intellectual property, IPRs- Invention and Creativity - Importance and Protection of Intellectual Property Rights (IPRs) – procedure for grant of patents and patenting under PCT-types of patents-technological research and innovation- international cooperation on IP.

Module 5:

A brief summary of: Patents-Copyrights-Trademarks, patent rights-licensing and transfer of technology-patent databases-case studies on IPR-Geographical indications-new developments in IPR-protection of IPR rights

REFERENCE BOOKS:

1. Garg, B. L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S. C. and Dhiman, A. K., 2002. Research Methodology, Ess Ess Publications. 2
5. Subbarau NR-Handbook of Intellectual property law and practise- S Viswanathan Printers and Publishing Private Limited 1998.

COs and POs for Research Methodology

CO		PO
CO1	Ability to write and present a substantial technical report/document	PO2
CO2	Able to demonstrate a degree of mastery over the area of specialization	PO3

Examination patterns

Test 1	15 marks
Test 2	15 marks
Quiz 1	10 marks
Alternative Assessment (presentation)	10 marks
Final Exam	50 marks
Total marks	**100**

Course		Credits : 04				Marks	
Name	VIBRATION AND ACOUSTICS	L	T	P	S	CIE	SEE
Code	20MEMDPCVA	3	1	0	0	50	50

Course Content:

UNIT - I
Review of Mechanical Vibrations:
Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency. Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time. **12 Hours**

UNIT - II
Vibration Control:
Introduction, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, Vibration dampers. Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Vibration exciters. **08 Hours**

UNIT - III
Modal Analysis:
Experimental Modal analysis, Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **10 Hours**

UNIT – IV
Continuous Systems:
Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. **05 Hours**

UNIT - V
Fundamentals of Acoustics:
Human perception of sound, Sound wave propagation in 1-D, 3-D space. 3-D wave equation, Some important acoustic quantities and relations, Acoustic Transducers: Various types of microphones. **04 Hours**

Alternate Assessment:

Students are expected to undertake a literature review on specific topics as instructed and comprehend them, rework and make a presentation and report of the same using any general purpose FE software or using MATLAB programming.

Text Books:

1. William T. Thomson, Marie Dillon Dahleh and Chandramouli Padmanabhan, "Theory of Vibration with Application", 5th Ed, Pearson Education.
2. S. Graham Kelly, "Fundamentals of Mechanical Vibration"- McGraw-Hill, 2000.
3. S. S. Rao, "Mechanical Vibrations", Pearson Education, 4th Edition.

Course Outcomes:

Upon completion of this course, the student will be able to:

CO1	Model and analyse a free damped, undamped and forced response of a mechanical system.
CO2	Develop equation and analyse the transient response of a single degree freedom system.
CO3	Access the response characteristics of a continuous mechanical system.
CO4	Analyse and discuss the behavior of single degree freedom system for linear and non-linear behavior.
CO5	Undertake literature review on unfamiliar problems related to vibration, comprehend it and make presentation to the engineering community.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit II, IV, V and Two questions each from units I & III.

Course		Credits : 04				Marks	
Name	**ADVANCED FINITE ELEMENT METHOD**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPCAF**	**3**	**0**	**1**	**0**	**50**	**50**

Pre-requisites: Theory of elasticity, Linear Finite Element Methods or equivalent

Course Content:

UNIT - I

Fundamentals of elasticity and overview of linear finite element methods

Concept of stress and strain. Stress and strain invariants. Spherical, deviatoric, octahedral, effective and representative components. Principal and von-Mises stresses and strains. Generalized Hooke's law. Numerical problems.

Linear finite element method. Library of elements. Handing of boundary conditions. Summary of formulations of bar, truss and beam elements. Numerical problems. **8 Hours**

UNIT - II

Yield Criteria and Stress-Strain relations

Mises and Tresca yield criteria. Numerical problems. Types of materials. Empirical relations. Theories of plastic flow. Experimental verification of St. Venant's and Prandtl Reuss theory of plastic flows.

8 Hours

UNIT - III

Bending of Beams and Torsion of Bars

Stages of plastic yielding, Analyses of stresses, Nonlinear stress-strain curve, Shear stress distribution, residual stresses in plastic bending.

Introduction to Torsion, Plastic torsion of a circular bar, elastic perfectly plastic material. Elastic work hardening of materials, residual stresses. **10 Hours**

UNIT - IV

Nonlinear solid mechanics and solution procedures

Introduction to nonlinear systems in solid mechanics, geometric nonlinearity, material nonlinearity. Kinematic nonlinearity, force nonlinearity. Solution procedures for nonlinear algebraic equations. Newton–Raphson method, modified Newton–Raphson method. **8 Hours**

UNIT - V

Nonlinear Finite Element Analysis

Steps in the solution of nonlinear finite element analysis. State determination, residual calculation, convergence check, linearization and solution. Nonlinear solution controls using commercial finite element programs. **7 Hours**

Laboratory exercises

Modelling of orthotropic materials. Study of plasticity behaviour in simple plate structures with discontinuities. Use of spring elements, rigid elements and joints. Modelling of nonlinear materials, contact problems, metal forming processes, rolling and extrusion processes. **13 Hours**

Text books:

- Sadhu Singh, "Theory of Plasticity and Metal forming Process", Khanna Publishers, Delhi, 1999.
- Nam-Ho Kim, "Introduction to Nonlinear Finite Element Analysis", Springer (2015).

Reference books:

- J Chakrabarty, "Theory of Plasticity", Butterworth, 2006.
- J. N. Reddy, "An Introduction to Nonlinear Finite Element Analysis", Oxford University Press, USA (2004).
- Javier Bonet, Richard D. Wood, "Nonlinear Continuum Mechanics for Finite Element Analysis", Cambridge University Press (2008).

Course Outcomes:

Upon completion of this course, the student will be able to,

CO1	Synthesize and determine the structural response of deformable bodies subjected to various types of loads.
CO2	Examine the failure and interpret the yielding behaviour in metallic materials using suitable yield criteria.
CO3	Develop mathematical models for the nonlinear behaviour and solve the same using suitable solution techniques.
CO4	Model and analyse the nonlinear behaviour of different mechanical systems using advanced software tools.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit II, IV, V and Two questions each from units I & III.

Course		Credits : 03				Marks	
Name	DESIGN FOR MANUFACTURING	L	T	P	S	CIE	SEE
Code	20MEMDPEDF	3	0	0	0	50	50

Course Content:

Unit – I
Design process overview: Conceptual and configuration design of products and assemblies, criteria and concepts in design, Dimensional management & tolerance analysis: GD & T, Datum features, stack-up analysis **7 Hours**

Unit – II
Selection of Materials and Shapes: Overview of engineering materials, standards for materials selection, Selection of shapes, Co-selection of materials and shapes, Effect of composition, processing and structure on material properties **7 Hours**

Unit – III
Performance of materials: Design of static structures, design for fatigue resistance, corrosion resistance, wear resistance, and other properties, Design with metals, plastics and composites **7 Hours**

Unit – IV
Manufacturing aspects of design: Design for manufacture and assembly, Manufacturing processes and their selection, Modeling of manufacturing process, Manufacturing cost estimation **9 Hours**

Unit – V
Case studies: Design for casting, Design for machining, injection molding, design for automation, Printed circuit board design **9 Hours**

Text Books:

1. Materials Selection and Design, Vol. 20, ASM Hand book, 1997.
2. Geoffrey Boothroyd, Peter Dewhurst, Winston Knight, "Product design for manufacture and assembly", Marcel Dekker. Inc. CRC Press, Third Edition, 2002.
3. Goerge Dieter & Linda Schmidt, "Engineering Design" - McGraw-Hill Higher Education, 5e, 2013.

Reference Books:

1. James D. Meadows, Geometric Dimensioning & Tolerancing: Applications and Techniques for Use in Design, Manufacturing and Inspection, Marcel Dekker, NY, 1995.

Course Outcomes:
Upon completion of this course, the student will be able to

CO1	Identify the role of manufacturing and assembly in product development
CO2	Apply manufacturing considerations in the design and development of components and processes
CO3	Apply geometrical dimensioning and tolerances issues in mechanical design.
CO4	Analyze effect of material, process and design on manufacturability of product

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, II, III and Two questions each from units IV & V.

ELECTIVE – III

Course		Credits : 04				Marks	
Name	**TRIBOLOGY**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPCTR**	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I

Introduction to Tribology: Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen Poiseuille theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. **7 Hours**

UNIT - II

Hydrodynamic Lubrication: Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems. **9 Hours**

UNIT - III

Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.

Hydrostatic Bearings: Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings. **10 Hours**

UNIT - IV

Antifriction bearings: Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings. Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal. **08 Hours**

UNIT - V

Magnetic Bearings: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings. **5 Hours**

Text Books

1. Mujamdar B. C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001.
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford Press Company, 2000.

Reference Books

1. Dudley D. Fuller " Theory and practice of Lubrication for Engineers", New YorkCompany.1998
2. Moore "Principles and applications of Tribology", Pergamon press, 1975.

3. Oscar Pinkus, Beno Sternlicht, “Theory of hydrodynamic lubrication”, McGraw-Hill, 1961.
4. G W Stachowiak, A W Batchelor, “Engineering Tribology”, Elsevier, 1993.
5. William Brian Rowe, “Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Comprehend basics of tribology and related sciences, theoretical background about processes in tribological system, mechanisms and forms of interaction of friction surfaces.
CO2	Analyze hydrodynamic, hydrostatic bearing.
CO3	Select bearings based on various tribological factors to be considered in moving and rotating parts.
CO4	Understand the application and limitations Magnetic and porous bearings.
CO5	Undertake literature survey on unfamiliar problems related to Tribology, comprehend it and make presentation to the engineering community.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit I, IV, V and Two questions each from units II and III.

Course		Credits : 04				Marks	
Name	ROTOR DYNAMICS	L	T	P	S	CIE	SEE
Code	20MEMDPERT	3	0	0	0	50	50

Course Content:

UNIT - I

Fluid Film Lubrication: Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.

Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field. **9 Hours**

UNIT - II

Critical Speed: Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center. **5 Hours**

UNIT - III

Turborotor System Stability by Transfer Matrix Formulation: General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **7 Hours**

UNIT - IV

Turborotor System Stability by Finite Element Formulation: General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis.
12 Hours

UNIT - V

Blade Vibration: Centrifugal effect, Transfer matrix and Finite element, approaches. **6 Hours**

Text Books:

1. Cameron, "Principles of Lubrication", Longman Publishing Group, 1986.
2. J S Rao, "Rotor Dynamics", New Age International, 1996.

Reference Books:

1. Donald E Bently and Charles T. Hatch, "Fundamentals of Rotating Machinery Diagnostics", Bently Pressurized Bearing Co; 1 edition 2003.
2. Agnieszka Muszynska, "Rotordynamics", CRC Press, 2005.
3. Bolotin, "Nonconservative problems of the Theory of elastic stability", Macmillan, 1963.
4. Peztel, Lockie, "Matrix Methods in Elasto Mechanics", McGraw-Hill, 1963.
5. Timoshenko, "Vibration Problems in Engineering", Ox ford City Press, 2011.
6. Zienkiewicz, "The finite element method in engineering science", McGraw-Hill, 1971.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Model a rotating machine element theoretically for rotor dynamic analysis.
CO2	Analyse Free and Forced lateral response of simple rotor models and of more complex systems including shafts, bearings, seals and stators.
CO3	Formulate Finite element and carry out analysis for Turborotor System Stability.
CO4	Apply Finite element approach to blade vibration.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit II, III, V and Two questions each from units I & IV.

Course		Credits : 03				Marks	
Name	**AUTOMATIC CONTROL SYSTEMS**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPEAC**	**3**	**0**	**0**	**0**	**50**	**50**

PRE-REQUISITES: Ordinary Differential Equations, Linear Algebra

Course Content:

UNIT - 1

Introduction & Mathematical Foundation: Introduction, Feedback & its effects, Types of Feedback Control Systems.

Complex variable concept, Frequency-domain plots, Differential equations, Laplace transform & its application to the solution of linear ODEs, Impulse-response & transfer functions of linear systems, Stability of linear control systems, BIBO stability – Continuous-data systems, Relationship between characteristics equation roots & stability, Zero input and asymptotic stability of continuous-data systems, Methods of determining stability, Routh-Hurwitz criterion, MATLAB tools & case studies. **10 Hours**

UNIT - 2

Modeling of Dynamic Systems: Introduction to Modeling of Mechanical Systems, Introduction to Modeling of Simple Electrical Systems, Modeling of Active Electrical Elements: Operational Amplifiers, Introduction to Modeling of Thermal Systems, Introduction to Modeling of Fluid Systems, Sensors and Encoders in Control Systems, DC Motors in Control Systems, Systems with Transportation Lags (Time Delays), Linearization of Nonlinear Systems, Analogies, MATLAB tools. **7 Hours**

UNIT - 3

Time-Domain Analysis of Control Systems: Time Response of Continuous-Data Systems: Introduction, The Unit-Step Response and Time-Domain Specifications, Steady-State Error, Time Response of a Prototype First-Order System, Transient Response of a Prototype Second-Order System, Speed and Position Control of a DC Motor, Time-Domain Analysis of a Position-Control System, Basic Control Systems and Effects of Adding Poles and Zeros to Transfer Functions, Dominant Poles and Zeros of Transfer Functions, Basic Control Systems Utilizing Addition of Poles and Zeros **8 Hours**

UNIT - 4

Root Locus Analysis: Introduction, Basic Properties of the Root Loci, Properties of the Root Loci, Design Aspects of the Root Loci, Root Contours (RC): Multiple-Parameter Variation **5 Hours**

Frequency-Domain Analysis: Introduction, Resonant Peak, Resonant Frequency and Bandwidth of the Prototype Second-Order System, Effects of Adding a Zero & Pole to the Forward-Path Transfer Function, Relative Stability: Cain Margin and Phase Margin, Stability Analysis with the Bode Plot, Relative Stability Related to the Slope of the Magnitude Curve of the Bode Plot **4 Hours**

UNIT - 5

Design of Control Systems: Introduction, Design with the PD Controller, Design with the PI Controller, Design with the PID Controller, A Hydraulic Control System, Controller Design **5 Hours**

Text Books

1. Automatic Control Systems, B C Kuo, F Golnaraghi, John Wiley & Sons, 2014.
2. Control Systems Engineering, 6th Edition, Norman S Nise, Wiley India - 2011

Reference Books:

1. Modern Control Engineering, Katsuhiko Ogata, Pearson Education, 2004.
2. Modern Control Systems, Richard C Dorf & Robert H Bishop, Prentice Hall, 2008

E-Books:

1. Feedback Systems: An Introduction for Scientists & Engineers, Karl J Astrom & Richard M Murray, Version v2.10b, Princeton University Press - http://www.cds.caltech.edu/~murray/books/AM05/pdf/am08-complete_22Feb09.pdf

MOOCs:

1. Dynamics and Control – **edX**: https://www.edx.org/course/dynamics-control-upvalenciax-dc201x-0

Course Outcomes

Upon completion of this course, student will be able to:

CO 1	Identify the components of control systems given real life situation
CO 2	Develop transfer function models and state-space models of single input single output, linear time invariant systems
CO 3	Analyse the time response of first and second order systems
CO 4	Evaluate the stability of systems using various methods
CO 5	Design PID controllers

Scheme of Examination: (SEE)

Answer five full questions selecting one from each unit.

To set one question each from Unit 2, 3 & 5 and two questions each from units 1 & 4.

ELECTIVE – IV

Course		Credits : 03				Marks	
Name	**EXPERIMENTAL MECHANICS**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPEEM**	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I

Introduction: Definition of terms, calibration, standards, dimensions and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning. General data acquisition system, Basic components, data transmission

Analysis of Experimental Data: Statistical analysis of experimental data- Probability distribution, Gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting **8 Hours**

UNIT - II

Force, Torque and Strain Measurement: Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects **8 Hours**

UNIT - III

Stress Analysis: Two Dimensional Photo elasticity **-** Nature of light, - wave theory of light,- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, Isoclinics, Iso-chromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials.

Three Dimensional Photo elasticity: Shear difference method, Oblique incidence method, Secondary principals stresses, Scattered light photo elasticity. **9 Hours**

UNIT - IV

Coating Methods: a) Photoelastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach **7 Hours**

UNIT - V

Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holograpic interferometry, Realtime and double exposure methods, Displacement measurement, Isopachics. **7 Hours**

Text Books:

1. Holman, "Experimental Methods for Engineers" 7th Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. R. S. Sirohi, H. C. Radha Krishna, "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 2004.

3. Ramesh K, "Experimental Stress Analysis", e book, online solutions, 2012.

4. Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, "Experimental Stress Analysis", Tata McGraw Hill, 1984.
5. B C Nakra K K Chaudhry, "Instrumentation, Measurement and Analysis", Tata McGraw-Hill, New York, Seventh Edition, 2006.

Reference Books:

1. Doeblin E. A., "Measurement Systems Application and Design", 4^{th} (SI) Edition, McGraw Hill, New York. 1989.
2. Montgomery D.C., "Design and Analysis of Experiments", John Wiley & Sons, 1997.
3. Dally and Riley, "Experimental Stress Analysis", McGraw Hill, 1991.
4. Sadhu Singh, "Experimental Stress Analysis", Khanna publisher, 1990.
5. M. M. Frocht, "Photoelasticity Vol I and Vol II", John Wiley and sons, 1969.
6. Perry and Lissner, "Strain Gauge Primer", McGraw Hill, 1962.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand functional requirements of a generalized measurement system and identify suitable components for an application.
CO2	Use concepts of Data Acquisition, Processing and apply the same for interpretation and analysis of experimental data.
CO3	Determine stresses and strains in a structure using different methods such as strain gages, photo-elasticity, brittle coating and holography.
CO4	Identify and apply suitable experimental stress analysis to practical problems.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit I, IV, V and Two questions each from units II & III.

Course		Credits : 04				Marks	
Name	FRACTURE MECHANICS	L	T	P	S	CIE	SEE
Code	20MEMDPCFM	3	0	0	0	50	50

Course Content:

UNIT - I

Fracture mechanics fundamentals: Introduction and historical review, ductile and brittle fracture, Modes of fracture, Fracture mechanics approach to design, NDT methods used in fracture mechanics, Stress concentration due to elliptical hole, Linear elastic fracture mechanics, Airy stress function, Stress intensity factor, Solution to crack problems, Determination of Stress intensity factors and plane strain fracture toughness, K_{1c} test technique, numerical method, Effect of finite size, Special cases, Numerical problems. **12 Hours.**

UNIT - II

Plasticity effects: Plastic zone, effective crack length, Irwin plastic zone correction. Dugdale approach, size and shape of the plastic zone for plane stress and plane strain cases, Thickness effect, numerical problems.

Energy release rate, Griffith's criteria, Energy release rate, compliance approach, crack resistance, R-curve, Compliance, stable and unstable crack growth, equivalence. **10 Hours**

UNIT - III

Elastic-plastic fracture mechanics: J-integral, path independence, features and limitations, equivalence, J_{1c} test method, engineering approach, Tearing modulus, Crack-tip opening displacement, experimental determination of CTOD, equivalence. **6 Hours**

UNIT - IV

Fatigue failure: Crack growth, crack propagation laws, crack propagation life, effect of overload, crack closure, variable amplitude service loading, environment-assisted fracture, factors influencing, liquid metal embrittlement, design considerations **6 Hours**

UNIT - V

Dynamics of crack: Crack speed and kinetic energy, dynamic stress intensity and elastic energy release rate, crack branching, principles of crack arrest, crack arrest in practice, dynamic fracture toughness.

5 Hours

Alternate Assessment:

Students are expected to carry out literature review on fracture mechanics analysis of components, evaluate fracture mechanics parameters for specimen with different crack configurations using a commercial finite element analysis software, prepare a term paper, and make presentations.

Text Books:

1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, 2011.
2. David Broek, Elementary Engineering Fracture Mechanics, Springer Netherlands, 2011.

Reference Books:

1. Anderson T. L., Fracture Mechanics-Fundamentals and Application, CRC Press, 1995.
2. Ramesh K, Engineering Fracture Mechanics, Online Solutions Publishing, 2007.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Develop governing equations based on theory, concepts and principles of fracture mechanics
CO2	Apply principles to characterize status of crack in a structure under different loads and perform failure analysis of engineering structures
CO3	Solve theoretical and practical problems to acquire judgment and skills
CO4	Evaluate fracture mechanics parameters, predict crack propagation and provide alternate solutions
CO5	Simulate and analyze behavior of cracked structure using a commercial analysis tool to perform fracture mechanics analysis.
CO6	Prepare a technical report/term paper and make oral presentation.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit III, IV, V and Two questions each from units I & II.

Course		Credits : 04				Marks	
Name	THEORY OF PLATES AND SHELLS	L	T	P	S	CIE	SEE
Code	20MEMDPETS	3	0	0	0	50	50

Course Content:

UNIT - I
Bending of long rectangular plate into a cylindrical surface: Differential equation - Bending of plates with different boundary conditions - Long plate on elastic foundation.
Pure Bending: Moment and curvature relations problems of simply supported plates-Strain energy impure bending. **8 Hours**

UNIT - II
Symmetrical Bending of Circular Plates: Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center. **5 Hours**

UNIT - III
Rectangular Plates: Differential equations - Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as non-central, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed.
Bending of plate under combined action of lateral and transverse loads derivation of differential equation, simply supported rectangular plate. **12 Hours**

UNIT - IV
Introduction to Shell Structures - General description of various types. Membrane Theory of thin shells (Stress Analysis): Cylindrical shells - Spherical Shells- Shells of double curvature, Viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid. **6 Hours**

UNIT - V
Membrane Deformation of Shells: Symmetrical 'loaded shell, symmetrically loaded spherical shell. General Theory of cylindrical shells: Circular; Cylindrical shell loaded symmetrically.
General equation of circular cylindrical shells. Approximate investigation of: bending of circular cylindrical shell. **8 Hours**

Text Books:

1. Timoshenko, Woinowsky and Krieger," Theory of Plates and Shells", McGraw Hill, New York.
2. Ansel C Ugural, "Stresses in Plates and Shells", McGraw Hill, 3rd ed, 1985.

Reference Books

1. Wilhelm Flugge, "Stresses in Shells", Springer Verlag, Berlin, 1990.
2. Goldnvizer, "Theory of Elastic Thin Shells", Pergamon Press, New York.
3. R. Szilard, "Theory and Analysis of Plates", Prentice Hall, 2004.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand and develop basic equations for thin plates.
CO2	Develop pure bending equations for circular and rectangular plates.
CO3	Analyze the rectangular plates using Navier and Levy approach.
CO4	Develop equations for combined loading on plates.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit I, II, IV and Two questions each from units III & V.

Course		Credits : 01				Marks	
Name	**SIMULATION LABORATORY**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	20MEMDPCSL	**0**	**0**	**1**	**0**	**50**	**50**

Course Content:

Experiment #1
Structural Analysis
Part A: FE modeling of a stiffened Panel using a commercial preprocessor.
Part B: Buckling, Bending and Modal analysis of stiffened Panels.
Part C: Parametric Studies.

Experiment #2
Design Optimization
Part A: Shape Optimization of a rotating annular disk.
Part B: Weight Minimization of a Rail Car Suspension Spring.
Part C: Topology Optimization of a Bracket.

Experiment #3
Thermal analysis
Part A: Square Plate with Temperature Prescribed on one edge and opposite edge insulated.
Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4
Thermal Stress Analysis
Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment #5
CFD Analysis
Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
Part B: Pressure and Velocity distributions in fluid flow

Experiment #6
Analysis of Welded Joints.
Part A: FE Modeling and Failure Analysis.
Part B: Parametric Studies.

Experiment #7
Analysis of Bolted Joints.
Part A: FE Modeling and Failure Analysis.
Part B: Parametric Studies.

Experiment #8

Adhesive Bonded Joints.

Part A: FE Modeling and Failure Analysis.

Part B: Parametric Studies.

Experiment #9

Fatigue Analysis

Part A: FE Modeling and Failure Analysis of specimen under cyclic loads.

Part B: Life estimation, Damage assessment, Parametric Studies.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Develop finite element models for static and dynamic analysis
CO2	Apply boundary conditions and analyze the problems to evaluate primary variables.
CO3	Solve and simulate real-time problems for stress and failure in different domains like structures, thermal, fluid flow, fatigue, etc.
CO4	Demonstrate skills in use of reputed commercial finite element analysis package.
CO5	Present the results in the form of a technical report.
CO6	Carry out independent investigation/development work in solving a real-time problem.

INSTITUTIONAL ELECTIVE

Course		Credits : 03				Marks	
Name	**COMPUTATIONAL METHODS IN ENGINEERING ANALYSIS**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPECE**	**3**	**0**	**0**	**0**	**50**	**50**

Course Content:

UNIT - I

Approximations and Round off Errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving, simple mathematical model, Conservation Laws of Engineering. **7 Hours**

UNIT - II

Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed point iteration.

Roots of Polynomial: Polynomials in Engineering and Science, Muller's method, Bairstow's Method. **9 Hours**

UNIT - III

Numerical Differentiation and Numerical Integration: Newton –Cotes and Gauss Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae. **6 Hours**

UNIT - IV

System of Linear Algebraic Equations: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, Error Analysis for direct methods, Iteration Methods.

Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method. **9 Hours**

UNIT - V

Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering

Orthogonality and Least Squares: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, Least Square problems, Inner product spaces. **8 Hours**

Text Books:

1. Steven C. Chapra, Raymond P. Canale "Numerical Methods for Engineers"- 5th Edition, Tata McGraw Hill, 2007.
2. S. S. Sastry "Introductory Method of Numerical Analysis", PHI, 2009.
3. M K. Jain, SRK Iyengar, R K. Jain "Numerical Methods for Scientific and Engg. Computation". New Age International, 2003.

Reference Books:

4. Perviz Moin "Fundamentals of Engineering Numerical Analysis", Cambridge, 2010.
5. David. C. Lay, "Linear Algebra and its applications" -3rd edition, Pearson Education, 2005.
6. Laurence V Fausett, "Applied Numerical Analysis using Matlab", Pearson, 2008.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Construct mathematical models of physical systems.
CO2	Develop algorithms to analyze mathematical models.
CO3	Apply numerical techniques to provide solutions to engineering problems.
CO4	Solve system of equations and matrices for problems of limited complexity.
CO5	Demonstrate use of computational tools (like MATLAB) to obtain solution to complex mathematical models.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit I, III, V and Two questions each from units II & IV.

Course		Credits : 21				Marks	
Name	**INTERNSHIP / INDUSTRIAL TRAINING**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	20MEMDNTIN	**0**	**0**	**10**	**0**	**100**	**100**

Course Objectives:

To satisfy the requirements for the internship, students will:

- explain the operation of the industrial facility in which they worked
- describe the professional skills they developed during their internship
- demonstrate communication skills (written and oral)

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Design/ appraise the working of a system/organization, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
CO2	Function in multi-disciplinary teams
CO3	Identify, formulate, and solve engineering problems
CO4	Understand professional and ethical responsibility
CO5	Gain knowledge of contemporary issues
CO6	Use the techniques, skills, and modern engineering tools necessary for engineering practice

Course		Credits : 02				Marks	
Name	**TECHNICAL SEMINAR**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	20MEMDSRTS	**0**	**0**	**1**	**0**	**100**	**100**

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Identify and understand current trends and real-world issues related to topics in Machine Design.
CO2	Classify appropriate content and sources, through literature survey, that can be summarised and integrated into presentation
CO3	Review, analyse, and interpret data & results using critical thinking skills
CO4	Revise and present scientific case studies in presentation
CO5	Collaborate effectively with other students in analysing results and preparing oral presentations
CO6	Prepare a technical seminar report and communicate effectively through oral presentation using multimedia tools

Course		Credits : 03				Marks	
Name	PRODUCT LIFECYCLE MANAGEMENT	L	T	P	S	CIE	SEE
Code	20MEMDPCPL	2	0	1	0	50	50

Course Content:

UNIT-1

Introduction to PLM, Definition, Corporate Challenges, System Architecture, Information models and product structures, Reasons for deployment of PLM Systems **02 Hours**

UNIT-2

Product Lifecycle Management Systems, Product development and Engineering, Production, After Sales, sales and marketing, Sub-contracting, Sourcing and Procurement. Product Structure case studies, with examples of ship, cellular phones, structure of customizable products.

Integration of PLM with other applications, Database integration, System Roles, ERP, CAD, Configurators, EAI. **07 Hours**

UNIT-3

Deployment of PLM system, Stages of deployment, Leading a PLM project, Need for change understanding, PLM Maturity model, Choosing system, Realization stage of project, Accomplishing change in organization. Business benefits, Costs of Quality, PLM Software licenses, Database licenses, Maintenance of Equipment, licenses. **04 Hours**

UNIT-4

Challenges of PLM in manufacturing and Engineering industry, Life cycle thinking, Value added services and after sales, Traceablility, Case studies of High tech and Engineering product, Product Management, Capital goods manufacturing customer specific variable product.

Role of Product management in Collaborative business development, CIM, Concurrent engineering, Tools for collaboration, International Standardization organizations, CPC, cPDM. **07 Hours**

UNIT-5

Basic behavior of product and lifecycles, metrics for performance review, Data management view, PLM as business strategy tool, Time to Market, time to react, Time to volume, time to service, Significance of product management, collaboration and electronic business for manufacturing industry. **06 Hours**

Textbooks:

1. Product Lifecycle Management, Antti Saaksvuori, Anselmi Immonen, 2nd Edition, Springer, Berlin.
2. Product Lifecycle Management, 21st Century paradigm for product realization, 2nd Edition, Springer, Berlin.

Reference Books:

1. Product Lifecycle Management driving the next generation, Michael Grieves, Tata Mc Graw Hill
2. Configuration management metrics, Frank B Watts, Elsevier
3. Product Lifecycle Management Geometric Variations, Max Giordano, Luc Mathieu, Francois Villeneuve, Wiley publications USA

MOOCS:

1. https://academy.3ds.com/en/learn-online

E-Books:

1. https://s3-eu-west-1.amazonaws.com/gxmedia.galileo-press.de/leseproben/3030/sappress_product_lifecycle_management.pdf

Course Outcomes: At the end of the course the student is expected to:

CO1	Analyze product lifecycle management systems for new product development and give a detailed technical report on current research
CO2	Evaluate and make use of the best tools and practices for product development make use of current software tools and evaluation models
CO3	Give a detail presentation of current PLM based systems and architecture for manufacturing and allied industries with some case studies
CO4	Compare various PLM approaches during decision making in industries and use cases
CO5	Demonstrate the use of PLM concepts in new product design and development processes.

Lab Component: 1 Hour /week (13 classes)

Module 1: Development of conceptual model using Sketching and idea presentation
Module2: Use of CAD tools such as CATIA/Solidworks to develop the model
Module 3: Analysis of the CAD model for developing engineering connections
Module 4: Use of Analysis software for analyzing the developed model
Module 5: 3D printing the model for realization of the concept into prototypes for form and fit conformance
Module 6: Use of Product Lifecycle Management Tool to create manuals and product service manuals.
Module 7: e-commerce platforms for product launch and tracking.

Scheme of Examination:

Answer five full questions selecting one from each unit. To set one question each from units 1, 3 and 5 and two questions each from units 2 and 4.

Course		Credits : 02				Marks	
Name	**BUSINESS ANALYTICS**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	**20MEMDPCBA**	2	**0**	**0**	**0**	**50**	**50**

Pre-requisites:
Statistics, Operations Research

Course Content:
UNIT-1
Introduction to Business Analytics (BA): Definition, Importance, Evolution, Impact and challenges, Scope of BA, Data and Data Types, Models, Problem solving using BA.
Prescriptive Analytics: Statistical methods for data summary, Frequency Distribution, Histograms, Cumulative relative frequency distribution, Percentiles and quartiles, Cross tabulation and pivot tables, Pivot chart, Simple problems.
Descriptive Statistical Measures: Population and Population Samples, Arithmetic Mean and Median and Mode of data, measures of Dispersion- range, Interquartile range, Variance, Standard deviation, Chebyshev's theorem, Standardized values, calculating Z, Co-efficient of Variation, Correlation, Simple problems. **07 hours**

UNIT-2
Probability distribution and data modeling: Basic concepts of probability, classical and relative frequency, Rules and Formulae, conditional probability, Expected value of discrete random variable, Expected value in decision making. Binomial Distribution, Poisson's distribution, Uniform Distribution, Normal Distribution, Exponential Distribution, Continuous distribution. Statistical Inference: Hypothesis testing, One Sample Test Hypothesis, Two tailed test of Hypothesis for mean, ANOVA, Chi-square test Simple Problems **07 hours**

UNIT-3
Predictive Analysis: Trendlines, Simple Linear regression, Multiple Linear regression, Qualitative and Judgemental Forecasting, Regression based seasonal Forecasting models, Moving Averages models, Introduction to Monte Carlo techniques. Simple Problems **04 hours**

UNIT-4
Prescriptive Analysis: Linear Optimization- LPP formulation **04 hours**

UNIT-5
Multi period production planning models, Decision strategies with and without outcome probabilities, Decision Trees **04 hours**

Textbooks:
1. Business Analytics James Evans, 2nd Edition, Pearson Learning, 2017
2. Business Analytics for Mangers, Wolfgang Jank, Springer 2011

Reference Books:
1. Business Intelligence Guidebook, From Data Integration to Analytics, Rick Sherman, Elsevier, 2015
2. Business Analytics: Data Analysis and Decision Making, S. Christian Albright, Wayne L Winston, sixth edition, Cengage Learning 2017
3. Data Analytics Basics for Managers, Harvard Business Review Press, 2018

MOOCS:

1. https://nptel.ac.in/courses/110/107/110107092/
2. https://nptel.ac.in/courses/110/105/110105089/
3. https://nptel.ac.in/courses/110/106/110106050/

E-Books:

1. https://www.researchgate.net/publication/327669859_Business_Analytics_Concept_and_Applications
2. https://www.cgma.org/Resources/DownloadableDocuments/business-analytics-briefing.pdf
3. https://informationashvins.files.wordpress.com/2012/04/varshney_icassp2012.pdf

Course Outcomes: At the end of the course the student is expected to:

CO1	Analyze data in real time environments for meaningful decision making in industries.
CO2	Evaluate probabilities of events and develop plans for the eventual probabilities in the real world scenarios
CO3	Improve processes through optimization techniques for quick decision making.
CO4	Develop and test hypothesis for new methods and processes
CO5	Generate meaningful data and analysis to help make and take decisions in the design and manufacturing setups

Scheme of Examination:

Answer five full questions selecting one from each unit. To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.

Course		Credits : 27				Marks	
Name	**PROJECT WORK**	**L**	**T**	**P**	**S**	**CIE**	**SEE**
Code	20MEMDPRP1 & 20MEMDPRP2	**0**	**0**	**28**	**0**	**200**	**200**

Course Outcomes:
Upon completion of this course, the student will be able to

CO1	Apply relevant knowledge and skills acquired during the course in the domain to the problem on hand
CO2	Formulate the specifications of the project work, identify a set of feasible solutions and prepare and execute project plan considering professional, cultural and societal factors
CO3	Extract information pertinent to problem using literature survey
CO4	Analyze independently and discuss complex issues
CO5	Use appropriate techniques and tools to conduct experiments, analyze data
CO6	Evaluate and critically examine the outcomes of one's own work and others' work
CO7	Draw suitable conclusions based on the results and identify relevant applications
CO8	Document the findings and prepare a report in the prescribed format
CO9	Demonstrate working knowledge of ethics and professional responsibility at different stages such as formulation, design, implementation, and presentation
CO10	Publish the outcomes of the project work in a reputed journal, make effective presentation of the work and communicate confidently in defending the work

ASSESSMENT:

Continuous Internal Evaluation (CIE) includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE) - A written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce).

Both CIE and SEE have equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Breakup of CIE Components for Courses in General:

Component	Test-1	Test-2	AAT	Total Marks
Maximum Marks	15	15	20	50

Breakup of CIE Components for Integrated Courses:

Component	Theory			Practical		Total Marks
	Test-1	Test-2	AAT	Records & Performance	Lab Test Viva-Voce	
Maximum Marks	10	10	05	10	15	50

<u>Note</u>:

Alternate Assessment Tools, if any, will be announced by concerned Faculty at the beginning of the semester.
In case of Alternative Assessment Tools (such as term papers, assignments, problem solving, micro-projects, seminars, MOOCs, etc.) being used by a faculty for a particular course, a maximum of 40% of the total CIE marks can be utilized.