Visvesvaraya Technological University, Belagavi
Tentative Scheme of Teaching and Evaluation
PG Programmes
(w. e. f. Academic year 2018-19)
(Common to Design Engineering/Machine Design/ Engineering Analysis and Design)

28-07-2018

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination – 2018 - 19
M.Tech (MMD, MDE & MEA)
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Field work/Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	**18MDE11**	**Mathematical Methods in Engineering**	04	--	03	40	60	100	4
2	PCC	**18MDE12**	**Advanced Theory of Vibrations**	04	--	03	40	60	100	4
3	PCC	**18MDE13**	**Continuum Mechanics**	04	--	03	40	60	100	4
4	PCC	**18MDE14**	**Dynamics and Mechanism Design**	04	--	03	40	60	100	4
5	PEC	**18MDE15**	**Fracture Mechanics**	04	--	03	40	60	100	4
6	PCC	**18MDEL16**	**Design Laboratory 1**	-	04	03	40	60	100	2
7	PCC	**18RMI17**	**Research Methodology and IPR**	02	--	03	40	60	100	2
			TOTAL	**22**	**04**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/Fieldwork/Assignment	Duration inhours	CIE Marks	SEE Marks	Total Marks	
1	PCC	**18MEA21**	**Finite Element Methods**	04	--	03	40	60	100	4
2	PCC	**18MDE22**	**Advanced Machine design**	04	--	03	40	60	100	4
3	PCC	**18MDE23**	**Tribology and Bearing Design**	04	--	03	40	60	100	4
4	PEC	**18XXX24X**	**Professional elective 1**	04	--	03	40	60	100	4
5	PEC	**18XXX25X**	**Professional elective 2**	04	--	03	40	60	100	4
6	PCC	**18MDEL26**	**Design Laboratory 2**	--	04	03	40	60	100	2
7	PCC	**18MDE27**	**Technical Seminar**	--	02	--	100	--	100	2
TOTAL				**20**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		Professional Elective 2	
Course Code under 18XXX24X	**Course title**	**Course Code under 18XXX25X**	**Course title**
18MDE241	**Material Handling Equipment Design**	**18CAE251**	**Design Optimization**
18MEA242	**Computer Applications in Design**	**18MEA252**	**Automobile System Design**
18MDE243	**Rotor Dynamics**	**18MEA253**	**Computational Fluid Dynamics**

Note:

1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
					Practical/	uration in hours	E Marks	SEEMarks	TotalMarks	
1	PCC	**18MDE31**	**Design for manufacture and assembly**	04	--	03	40	60	100	4
2	PEC	**18XXX32X**	**Professional elective 3**	04	--	03	40	60	100	4
3	PEC	**18XXX33X**	**Professional elective 4**	04	--	03	40	60	100	4
4	Project	**18MDE34**	**Evaluation of Project phase -1**	--	02	--	100	--	100	2
5	Intenship	**18MDEI35**	**Internship**	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)		03	40	60	100	6
TOTAL				**12**	**02**	**12**	**260**	**240**	**500**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		**Professional elective 4**	
Course Code under 18XXX32X	**Course title**	**Course Code under 18XXX32X**	**Course title**
18CAE321	**Experimental Mechanics**	**18CAE331**	**Smart materials and Structures**
18MDE322	**Mechatronics System Design**	**18MDE332**	**Composite Materials Technology**
18MEA323	**Robust Design**	**18MDE333**	**Acoustics and Noise Control Engineering**

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.
SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent university examinations after satisfying the internship requirements.
Internship SEE (University examination) shall be as per the university norms.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAG AVI
Schem e of Teaching and Examination – 2018 - 19
M.Tech. (MMD, MDE & MEA)
Outcome Based E ducation(OBE) and Choice Based Credit System (CBCS)

IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/Fieldwork/Assignment	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
1	Project	**18MDE41**	**Project work phase -2**	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Phase-2:

CIE marks shall be awarded by a comm ittee comprising of HoD as Chairman, guide/co-guide, if any, and a senior faculty of the department. The CIE marks awarded for project work phase-2 shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examin ation (SEE), after satisfying the plagiarism check, shall be as per the un iversity norms.

I SEMESTER

ADVANCED THEORY OF VIBRATIONS

(Common toMDE, MEA, MMD, CAE)

Course Code	**18MDE12**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To understand the theoreticalprinciplesof vibration,andvibrationanalysistechniquesfor thepracticalsolutionof vibration problems.
CL02	To understand theimportanceofvibrations in design ofmachineparts subject to vibrations.
CL03	To understand the concepts of Transient and Non-linear vibrations.
CL04	To understand concepts of vibration measurements and its applications.
CL05	To understand the principles of Transient and Non linear vibrations.

Course Content:

Module 1:ReviewofMechanicalVibrations:Basicconcepts;freevibrationofsingledegreeoffreedomsystemswithandwithoutdamping,forced vibration ofsingleDOF-systems, Natural frequency. VibrationControl:Introduction,Vibrationisolationtheory,Vibrationisolationandmotionisolationforharmonicexcitation,practical aspects ofvibration analysis, vibration isolation, Dynamicvibration absorbers, and Vibration dampers **12 Hours**

Module 2: VibrationMeasurementandapplications: Introduction,Transducers,Vibrationpickups,Frequencymeasuringinstruments,Vibration exciters, Signal analysis.

Modal analysis &Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Conditionmonitoring anddiagnosis.

10 Hours

Module 3:TransientVibrationofsingleDegree-offreedomsystems:Impulseexcitation,arbitraryexcitation,Laplacetransformformulation,Pulse excitation and risetime, Shock responsespectrum, Shock isolation.
RandomVibrations:Randomphenomena,Timeaveragingandexpectedvalue,Frequencyresponsefunction,Probabilitydistribution, Correlation, Powerspectrum and powerspectral density,Fouriertransforms and response.

10 Hours

Module 4:NonLinearVibrations:Introduction,Sourcesofnonlinearity,Qualitativeanalysisofnonlinear systems.Phaseplane,Conservativesystems,Stabilityofequilibrium,Methodofisoclines,Perturbationmethod,Methodofiteration, Self-excited oscillations.

10 Hours

Module 5: Continuous Systems: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.

08 Hours

CourseOutcomes:

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

C01	Apply Newtons equation of motion and energy methods to model basic vibrating mechanical system, model undamped and damped mechanical systems and structures for free and harmonically forced vibrations.
C02	Model single-and multi-degree of freedom for free and forced vibrations and determine response to vibration, natural frequencies and modes of vibration.
C03	Apply the fundamentals of vibration to its measurement and analysis.
C04	Solverealisticvibrationproblems in mechanicalengineeringdesign that involves application ofmost ofthe coursesyllabus.

TextBooks

1. S. S. Rao, " MechanicalVibrations" , Pearson Education, 4th edition.
2. S. Graham Kelly," Fundamentals ofMechanicalVibration" -McGraw-Hill, 2000
3. Theoryof Vibration with Application, -William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition PearsonEducation.

ReferenceBooks

1. S. Graham Kelly," Mechanical Vibrations" , Schaum' s Outlines, TataMcGraw Hill, 2007.
2. C Sujatha," Vibrations and Acoustics – Measurements and signalanalysis" , Tata McGraw Hill, 2010.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

CONTINUUM MECHANICS
(Common to MDE, MEA, MMD)

Course Code	**18MDE13**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To expose the students to the field of Continuum Mechanics.
CL02	To understand elastic behavior of materials (hyper elasticity, linear elasticity) and plasticity (basic concepts of small strain and large strain plasticity).
CL03	Introduce student to basic notion and rules of tensor calculus as well as basic idea and laws of continuum mechanics.
CL04	To learn the fundamentals of analysis of stresses, deformation and strain, generalised Hooke's law, two dimensional problems, and viscoelastic equations.

Course Content:

Module 1:Analysis of Stress: Definition and Notation for forces and stresses. Body force, surface force, components of stresses, equations of equilibrium, specification of stress at a point. Principal stresses, maximum and minimum shear stress, Mohr's diagram in three dimensions. Boundary conditions. Stress components on an arbitrary plane, stress invariants, octahedral stresses, decomposition of state of stress, deviator and spherical stress tensors, stress transformation.

10 Hours

Module 2:Deformation and Strain: Deformation, strain Displacement relations, strain components, The state of strain at a point, , Principal strain, strain invariants, Strain transformation, Compatibility equations, Cubical dilatation, spherical and deviator strains, plane strain, Mohr's circle, and compatibility equation

Relations and the General Equations of Elasticity: Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity Problems.

10 Hours

Module 3: Two Dimensional Problems in Cartesian Co-Ordinates: Airy's stress function, investigation of simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems.

Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem.

10 Hours

Module 4: Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate.

Thermal Stresses: Introduction, Thermo-elastic stress -strain relations, thin circular disc, long circular cylinder. **10 Hours**

Module 5: Torsion of Prismatic Bars: Introduction, Torsion of circular cross section bars, Torsion of elliptical cross section bars, Soap film analogy, Membrane analogy, Torsion of thin walled open tubes.

Elastic Stability: Axial compression of prismatic bars, Elastic stability, buckling load for column with constant cross section.

Viscoelasticity: Linear Viscoelastic behavior. Simple viscoelastic models-generalized models, linear differential operator equation. Creep and Relaxation- creep function, relaxation function, hereditary integrals. Complex modulii and compliances. (Note: No numericals)

10 Hours

Course Outcomes:

At the end of the course, students should be able to:

	Treat general stresses and deformations in continuous materials.
	Formulate and solve specific technical problems of displacement, strain and stress.
	Perform experiments with stresses and deformations.
	Model and analyse the stresses and deformations of simple geometries under an arbitrary load in solids.

C01
C02
C03
C04

Text Books:

1 Timoshenko and Goodier, "Theory of Elasticity"-'Tata McGraw Hill, New Delhi,3rd edition , 1970

2. L S Srinath “Advanced Mechanics of Solids”- Tata McGraw Hill, New Delhi, 3rd edition, 2010

3 G. Thomas Mase, Ronald E. Smelser, George. E. Mase, Continuum Mechanics for Engineers, 3rd Edition, CRC Press,Boca Raton, 2010

References:

1. Batra, R. C., Elements of Continuum Mechanics, Reston, 2006.
2. George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw-Hill, 1970
3. Dill, Ellis Harold, Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity, CRC Press , 2006.
4. Sadhu Singh," Theory of Elasticity"- Khanna publisher, 4th edition, 2013

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

DYNAMICS AND MECHANISM DESIGN

(Common to MDE, MEA, MMD)

Course Code	**18MDE14**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To provide a theoretical and practical foundation for analysis and design of articulated mechanical systems for desired applications.
CL02	evelop skills to analyze the displacement, velocity, and acceleration of mechanisms.
CL03	Improve understanding of the synthesis of mechanismsfor given tasks
CL04	To includedynamics considerations in thedesignofmechanisms forengineeringapplications.

Course Content:

Module

1:GeometryofMotion: Introduction,analysisandsynthesis,Mechanismterminology,planar,Sphericalan dspatialmechanisms,mobility, Grashoffslaw,Equivalentmechanisms,uniquemechanisms.
Kinematicanalysisofplanemechanisms: Auxiliarypointmethodusing rotated velocityvector, Hall - Ault auxiliarypoint method, Goodman's indirect method. Numerical examples.

08 Hours

Module

2:GeneralizedPrinciplesofDynamics: Fundamentallawsofmotion,generalizedcoordinates,configurati onspace,constraints, v irtual work,principleofvirtualwork,energy andmomentum, workandkineticenergy,andstability,kineticenergyofasystem, angular momentum,generalizedmomentum.

Lagrange'sEquation: Lagrange'sequationfromD'Alembert'sprinciples,examples, Hamiltonsequations,Hamiltonsprinciple,Lagrange'sequationfromHamiltonsprinciple,Derivationof Hamiltonsequations,numerical examples. **12 Hours**

Module 3: **SynthesisofLinkages:**Type,number,anddimensionalsynthesis, function generation,pathgenerationandbodyguidance,precisionpositions,structuralerror,Chebychevspacing.T wopositionsynthesisof slider crankmechanisms, crank-rocker mechanismswithoptimumtransmissionangle.

MotionGeneration: Polesandrelative poles, Location ofpoles andrelativepoles, polode, curvature,Inflection circle,numerical examples.

10 Hours

Module

4:GraphicalMethodsofDimensionalSynthesis: Twopositionsynthesisofcrankandrockermechanisms,t hreepositionsynthesis,four positionsynthesis(pointprecisionreduction),Overlaymethod,Couplercurvesynthesis,Cognatelinkages.
Ana1yticalMethodsof DimensionalSynthesis: Freudenstein'sequationforfourbarmechanismandslidercrankmechanism,exa

mples,Bloch'smethodof synthesis, analytical synthesis usingcomplexalgebra.

12 Hours

Module 5:

SystemDynamics: Gyroscopicactioninmachines,Euler'sequationofmotion,PhasePlanerepresentation,PhaseplaneAnalysis, Response ofLinear Systemstotransientdisturbances.

Spatial Mechanisms: Introduction, Positionanalysis problem, Velocity and acceleration analysis, Eulerian angles, numerical examples. **08 Hours**

Course Outcomes:

At the end of the course, students will be able to:

C01	Apply the tools of analytical dynamics with the main goal of developing mathematical models that describe the dynamics of systems of rigid bodies.
C02	Formulate equations of motion for complicated mechanical systems /linkages and hods for solving these equations.
C03	Understand multi body dynamics in mechanical engineering design.

Text Books:

1. K.J.Waldron&G.L.Kinzel , "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.
2. Greenwood , "Classical Dynamics", Prentice Hall of India, 1988.

References Books:

1. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
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.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

FRACTURE MECHANICS
(Common to MDE, MEA, MMD)

Course Code	**18MDE15**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To understand the design principle of materials and structures using fracture mechanics approaches.
CL02	To introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design.
CL03	To develop the ability in students to compute the stress intensity factor, strain energy release rateand the stress and strain fields around a crack tip for linear and non linear materials.
CL04	To prepare the students for broader applications of fracture mechanics in material testing,evaluation,characterization, and material selection.

Course Content:

Module 1: Fracture mechanics principles: Introduction and historical review, sources of micro and macro cracks. stress concentration due to elliptical hole, strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, numerical problems. The Airy stress function, complex stress function, solution to crack problems, effect of finite size, special cases, elliptical cracks, numerical problems.

10 Hours

Module 2: Plasticity effects, Irwin plastic zone correction, and Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, plastic constraint factor. The thickness effect, and numerical problems.

Determination of stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors.
Plane strain fracture toughness test; standard test, and specimen size requirements.

10 Hours

Module 3: The energy release rate, and criteria for crack growth. The crack resistance (R curve), compliance, J integral, tearing modulus and stability.

Elastic Plastic Fracture Mechanics (EPFM): Fracture beyond general yield. The crack-tip opening displacement, the use of CTOD criteria, and experimental determination of CTOD. Parameters affecting the critical CTOD, use of J integral, and limitation of J integral.

10 Hours

Module 4: Dynamics and crack arrest: 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**.**

10 Hours

Module 5: Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, mixed mode (combined) loading and design criteria.

10 Hours

Course Outcomes:

At the end of the course students will:

C01	Develop basic fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
C02	Be able to select appropriate materials for engineering structures to insure damage tolerance.
C03	Learn to employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.

C04	Understand the relationship between crack tip opening displacement, SIF and ERR and application of such parameters for ductile and brittle materials.
C05	Understanding of experimental techniques to determine the critical values of parameters at crack tip.
C06	Understand and appreciate of the status of academic research in field of fracture mechanics.

Text Books:

1. David Broek, “Elementary Engineering Fracture Mechanics”, Springer Netherlands,2011
2. Anderson , “Fracture Mechanics-Fundamental and Application”, T.L CRC press1998.

Reference Books:

1. Karen Hellan , “Introduction to fracture mechanics”, McGraw Hill, 2nd Edition
2. S.A. Meguid , “Engineering fracture mechanics” Elsevier Applied Science, 1989
3. Jayatilaka, “Fracture of Engineering Brittle Materials”, Applied Science Publishers, 1979
4. Rolfe and Barsom , “Fracture and Fatigue Control in Structures” , Prentice Hall, 1977
5. Knott , “Fundamentals of fracture mechanisms”, Butterworths, 1973

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

DESIGN LABORATORY-I
(Common to MDE, MEA, MMD)

Course Code	**18MDEL16**	**CIE Marks**	**40**
Number of Practical Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Hours	**50**	**Exam Hours**	**03**

Note:

1. These are independent laboratory exercises.
2. Student must submit a comprehensive report on the problems solved and give a presentation on the same for Internal Evaluation.
3. Any one of the experiments done from the following list has to be set in the examination for conduction and evaluation.

Experiment #1
Experimental and Numerical Analysis of Tensile Test
Part A: Experimental study of Tensile Test
Part B: Numerical Analysis of Tensile Test.

Experiment #2
Experimental and Numerical Analysis of Flexural Test

Part A: Experimental study of Flexural Test
Part B: Numerical Analysis of Flexural Test.

Experiment #3
Numerically Calculation and MATLAB Simulation
Part A: Invariants, Principal stresses and strains with directions
Part A: Maximum shear stresses and strains and planes, Von-Mises stress
Part C: Calculate and Plot Stresses in Thick-Walled Cylinder

Experiment #4
Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. shear Part A: Matlab simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate

Part B: Modeling of plate geometry under chosen load conditions and study the effect of plate geometry.
Part C: Numerical Analysis using FEA package.

Experiment #5
Single edge notched beam in four point bending.
Part A: Modeling of single edge notched beam in four point bending.
Part B: Numerical Studies using FEA.
Part C: Correlation Studies.

Experimental #6
Torsion of Prismatic bar with Rectangular cross-section.
Part A: Elastic solutions, MATLAB Simulation
Part B: Finite Element Analysis of any chosen geometry. Part C: Correlation studies.

Experiment #7
Contact Stress Analysis of Circular Disc under diametrical compression

Part A: 3-D Modeling of Circular Discs with valid literature background, supported with experimental results on contact stress.
Part B: Numerical Analysis using any FEA package.
Part C: 2D Photo Elastic Investigation.

Experiment #8
Vibration Characteristics of a Spring Mass Damper System.
Part A: Analytical Solutions.
Part B: MATLAB Simulation. Part C: Correlation Studies.

II Semester

FINITE ELEMENT METHOD

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MEA21**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures.
CL02	To present Finite element formulation using variational and weighted residual approaches.
CL03	To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.
CL04	Learn to model complex geometry problems and technique of solutions.

Course Content:

Module 1: Introduction to finite element method: basic steps in finite element method to solve mechanical engineering problems (solid, fluid and heat transfer). Functional approach and Galerkin approach. Displacement approach: admissible functions. Convergence criteria: conforming and nonconforming elements, C0, C1 and Cn continuity elements. Basic equations, element characteristic equations, assembly procedure, boundary and constraint conditions.

10 Hours.

Module 2: 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, torsional and temperature loads with problems.

Beams- basic (linear) element formulation-for uniform, varying and stepped cross section-for different loading and boundary conditions, numericals.

Trusses, Plane frames and Space frame – basic (Linear) elements formulations for different boundary conditions -axial, bending, torsional, and temperature loads, numericals.

10 Hours.

Module 3: Two dimensional finite element formulations for solid mechanics problems: triangular membrane (tria 3, tria 6, tria 10) element, fournoded quadrilateral membrane (quad 4, quad 8) element formulations for in-plane loading with simple problems.

Triangular and quadrilateral axi-symmetric basic and higher order elements formulation for axi-symmetric loading with simple numericals.

Three dimensional finite element formulations for solid mechanics problems: finite element formulation of tetrahedral element (tet 4, tet 10), hexahedral element (hexa 8, hexa 20), for different loading conditions. Serendipity and Lagrange family elements.

10 Hours.

Module 4: Finite element formulations for structural mechanics problems: Basics of plates and shell theories: classical thin plate theory, shear deformation theory and thick plate theory. Finite element formulations for triangular and quadrilateral plate elements. Finite element formulation of flat, curved, cylindrical and conical shell elements.

10 Hours.

Module 5: Dynamic analysis: finite element formulation for point/lumped mass and distributed masses system, finite element formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite element formulation of two dimensional dynamic analysis: triangular membrane and axi-symmetric element, quadrilateral membrane and axi-symmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

10 Hours.

Course Outcomes:
At the end of this course, students should be able to:

C01	Understand the concepts of Variational methods and Weighted residual methods.
C02	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3D element.
C03	Develop element characteristic equations and generate global stiffness equations.
C04	Apply suitable boundary conditions to a global structural equation, and reduce it to a solvable form.
C05	Identify how the finite element method expands beyond the structural domain, for problems involving dynamics and heat transfer.

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, Textbook of 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.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

ADVANCED MACHINE DESIGN
(Common toMDE, MEA, MMD, CAE)

Course Code	**18MDE22**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To identify failure modes and evolve design by analysis methodology.
CL02	To understand the theories of failure relating to different ductile and brittle materials.
CL03	To understand the concept of fatigue testing of materials including criteria for fatigue design and different fatigue life models.
CL04	To understand the concepts of the stress life behavior, strain life behavior and factors influencing stress life behavior and strain life behavior.
CL05	To understand the concept of crack nucleation, crack growth and fracture of materials using fundamentals of linear elastic fracture mechanics.
CL06	To gain the knowledge of various cumulative damage theories and different cycle counting methods relating to fatigue from variable amplitude loading.
CL07	To understand the different surface failure mechanisms with stress distribution of various contact surfaces.
CL08	To learn fundamental approaches to failure prevention for static and repeated loading.

Course Content:

Module 1:
Introduction: Roleoffailurepreventionanalysisinmechanicaldesign,Modesofmechanicalfailure,Reviewoffailuretheoriesfor ductile and brittlematerials includingMohr’s theoryand modified Mohr’ stheory.Numerical examples.
FatigueofMaterials:Introductory concepts,Highcycleandlowcyclefatigue,Fatiguedesignmodels,Fatiguedesignmethods,Fatigue designcriteria,Fatiguetesting,Testmethodsandstandardtestspecimens,Fatigue fracture surfacesandmacroscopic features,Fatiguemechanisms and microscopic features.

10 Hours

Module 2: Stress-Life(S-N)Approach:S-Ncurves,Statisticalnatureoffatiguetestdata,GeneralS-Nbehavior,Meanstresseffects,Different factorsinfluencing S-N behaviour,S-Ncurve representationandapproximations,Constantlifediagrams,Fatiguelifeestimationusing S- N approach.
Strain-Life(ε-N)approach:Monotonic stress-strainbehavior

,Straincontrolledtestmethods,Cyclicstress-strainbehavior,Strainbased approachtolife estimation,Determinationofstrainlife fatigue properties,Meanstresseffects,Effectofsurface finish,Life estimationby ε-N approach.

10 Hours

Module 3:LEFMApproach:LEFMconcepts,Cracktipplasticzone,Fracturetoughness,Fatiguecrackgrowth,Meanstresseffects,Crackgrowth lifeestimation.

Notchesandtheireffects:Concentrationsandgradientsinstressandstrain,S-Napproachfornotchedmembranes,mean StresseffectsandHaighdiagrams,Numerical examples.

10 Hours

Module 4: FatiguefromVariableAmplitudeLoading: Spectrumloadsandcumulativedamage,Damagequantificationandtheconceptsofdamage fractionandaccumulation,Cumulativedamagetheories,Loadinteractionandsequence effects,Cyclecounting methods,Lifeestimation usingstress lifeapproach. Numerical examples.

Notchstrainanalysis: Strain– lifeapproach,Neuber' srule,Glinka' srule,applicationsof fracturemechanics to crack growth at notches. Numerical examples. **10 Hours**

Module 5:SurfaceFailure: Introduction,Surfacegeometry,Matingsurface,Friction,Adhesivewear,Abrasivewear,Corrosionwear.

Surface fatigue: spherical contact, Cylindrical contact, General contact, Dynamiccontact stresses, Surfacefatiguestrength, Surface fatigue failure modes, Design to avoid Surface failures. **10 Hours**

CourseOutcomes:

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

C01	Apply stateofthe art design methodologynamelydesign byanalysisand damagetolerant design to mechanical components.
C02	Distinguish different design criteria and their procedure to carry out the design of mechanical components.
C03	Design machine components which are subjected to fluctuating loads.
C04	Design machine components using techniques like stress life approach, Strain life approach and Fracture mechanics approach.
C05	Define the various statistical aspects of fatigue using different probability distribution plots.
C06	Explain the contact stresses and implementation of Hertz contact phenomenon to the real field problem.
C07	Explain surface failure mechanisms.

TextBooks:

1. RalphI. Stephens,Ali Fatemi, Robert, Henryo. Fuchs, " MetalFatiguein engineering" , John WileyNew York, Second edition. 2001.
2. FailureofMaterials in Mechanical Design, Jack.A. Collins,John Wiley,New York 1992.

3. RobertL.Norton , “ Machine Design” , Pearson EducationIndia, 2000.

ReferenceBooks:

1. S.Suresh , “ FatigueofMaterials” , Cambridge UniversityPress, -1998
2. Julie.A.Benantine, “ Fundamentals ofMetalFatigue Analysis” , PrenticeHall,1990
3. Fatigue andFracture, ASM Hand Book, Vol 19,2002.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

TRIBOLOGY AND BEARING DESIGN
(Common to MDE, MEA, MMD)

Course Code	**18MDE23**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To understand the fundamental principles of lubrication for reduction of friction and wear.
CL02	To understand the principles for selecting compatible materials for minimizing friction and wear in machinery.
CL03	To understand the principles of hydrodynamic and hydrostatic lubrication and their design and applications.
CL04	To Understand the principles of bearing selection and bearing arrangement in machines.
CL05	To learn the computations required for selecting and designing bearings in machines.
CL06	To understand the fundamental principles of high contact stresses (Hertz stresses), fatigue-failure, and Elasto- hydrodynamic (EHD) lubrication in rolling bearings and gears.
CL07	To understand the factors influencing the design and selection of Porous and Magnetic bearings.

Course Content:

Module 1: 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's Poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. **8 Hours Module 2: Hydrodynamic Lubrication:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynold's equation in two dimensions

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

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.

12 Hours

Module 3: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.

EHL Contacts: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution.

10 Hours

Module 4:Antifriction bearings: Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing Mountings.

Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings,Equations for porous bearings and working principal, Fretting phenomenon and its stages.

10 Hours

Module 5: 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.

10 Hours

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

C01	Design or choose efficient tribological systems such as rolling element bearings, hydrodynamic bearings, and dry sliding bearings, for the needs of a specific application.
C02	Select compatible materials for minimizing friction and wear in machinery.
C03	Explain the concepts advanced bearings like magnetic bearings, porous bearings and gas lubricated bearings.

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.Fulier " Theory and practice of Lubrication for Engineers", New York Company.1998
2. Moore "Principles and applications of Tribology", Pergamon press, 1975.
3. Oscar Pinkus, BenoSternlicht, ‘‘Theory of hydrodynamic lubrication’’, McGraw-Hill, 1961.
4. G W Stachowiak, A W Batchelor , ‘‘Engineering Tribology’’, Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 1

MATERIAL HANDLING EQUIPMENT DESIGN
(Common to MDE, MEA, MMD)

Course Code	**18MDE241**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

This subject provides students with:

A basic understanding of material handling facilities and the fundamental principles of material handling;

A quantitative techniques for designing material handling systems and an understandingof their limitations;

An understanding of safety issues and regulations in material handling.

Module 1: Introduction: Elements of Material Handling System,Importance, Terminology, Objectives and benefits of better Material Handling; Principles and features of Material Handling System; Interrelationships between material handling and plant layout, physical facilities and other organizational functions; Classification of Material Handling Equipment.

Selection of Material Handling Equipment: Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications ; Activity cost data and economic analysis for design of components of

Material Handling Systems; functions and parameters affecting service; packing and storage of materials. **10 Hours**

Module 2: Conveyor Design: Introduction to apron conveyors, Pneumatic conveyors, Belt Conveyors, Screw conveyors and vibratory conveyors and theirapplications, Design of Belt conveyor-Belt selection procedure and calculation of drop energy, Idler design.

10 Hours

Module 3: Design of hoisting elements: Welded and roller chains -Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs-lifting magnets - Grabbing attachments -Design of arresting gear -Brakes: shoe, band and cone types

10 Hours

Module 4: Design of cranes: Hand-propelled and electrically driven E.O.T overhead Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes. **10 Hours**

Module 5: Design of Bucket Elevators: Introduction, Types of Bucket Elevator, Design of Bucket Elevator - loading and bucket arrangements, Cage elevators , shaft way, guides, counter weights.

Packaging and storage of bulk materials: Steps for design of packages, protective packaging, testing the physical characteristics of packaging, container testing, types of storage and industrial containers, Automatic guided vehicles, Automatic storage and retrieval system. **10 Hours**

Course Outcomes:
At the end of the course, students will be able to:

C01	Select appropriate equipment for material handling and understand the basic roles of the different equipment.
C02	Apply appropriate techniques for improving existing material handling systems; recognize the importance of safety and applicatons of optimization techniques to material handling.

Reference Books:

1. Conveyor Equipment Manufacturer' s Association, " Belt conveyors for bulk materials" 6th edition,The New CEMA Book
2. Rudenko N., " Materials handling equipment " , Elnvee Publishers, 1970
3. Ishwar G Mulani and Mrs.Madhu I Mulani, " Engineering Science and application design for belt conveyor" , Madhu I. Mulani, 2002.
4. Spivakovsy A.O. and Dyachkov V.K., " Conveying Machines, Volumes I and II" , MIR Publishers, 1985.
5. Alexandrov, M., " Materials Handling Equipments " , MIR Publishers, 1981.
6. Boltzharol, A., " Materials Handling Handbook" , The Ronald press company 1958.
7. Kulwiac R. A., 'Material Handling Hand Book' , 2^{nd} edition, JohnWilly Publication, NewYork.
8. James M. Apple, ' Material Handling System Design' , John-Willlwy and Sons Publication, NewYork.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 1

COMPUTER APPLICATIONS IN DESIGN

(Common to MDE,MEA,MMD)

Course Code	**18MEA242**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To understand the concepts and tools of computer applications as used in the engineering profession.
CL02	To learn the principles of CAD/CAM/CAE Systems, Graphics programming, Geometric Modeling Systems, CAD, CAM and CAE Integration, and standards for Communicating between Systems.
CL03	To learn to create technically correct surface and solid models that are common to and useful for visualization and problem solving mechanical engineering.

Course Content:

Module 1 : 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. **10 Hours**

Module 2: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. Standards for communicating Between Systems: Exchange Methods of Product Definition

Data, Initial Graphics Exchange Specification, Drawing Interchange Format, Standard for the Exchange of Product Data. Tutorials, Computational exercises involving Geometric Modeling of components and their assemblies. **10 Hours**

Module 3: 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, Hermite Curves, Bezier Curve, Differentiation of a Bezier Curve Equation, Evaluation of a Bezier Curve.

10 Hours

Module 4: 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. 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. **10 Hours**

Module 5: 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-ICAPP, MIPLAN and Multi CAPP, Met CAPP, ICEM-PART, Group Technology, Classification and Coding, existing Coding Systems, Product Data Management (PDM) Systems. **10 Hours**

Course Outcomes:

At the end of the course, students should be able to:

C01	Develop expertise in generation of various curves, surfaces and volumes used in geometric modeling systems.
C02	Design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
C03	Analyze a problem, and identify and define the computing requirements appropriate to its solution.

Text Books:

1. Kunwoo Lee, ‘‘Principles of CAD/CAM/CAE systems’’-Addison Wesley, 1999
2. Radhakrishnan. P., etal.,‘‘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

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 1

ROTOR DYNAMICS

(Common to MDE, MEA, MMD)

Course Code	**18MDE243**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To understand the rotor dynamics phenomena with the help of simple rotor models and subsequently the modern analysis methods for real life rotor systems.
CL02	To understandmodelingofbearings,shaftsandrotorstages(compressors,turbines includingblades)to predict instabilitylike whirlingincluding gyroscopicand Corialis effect.

Course Content:

Module 1:

FluidFilmLubrication: Basictheoryoffluidfilmlubrication,derivationofgeneralizedReynoldsequations,boundaryconditions,fluid film stiffness and dampingcoefficients, stabilityand dynamic response forhydrodynamicjournal bearing, and two lobejournalbearings.

Stability ofFlexibleShafts: Introduction,equationofmotionofaflexibleshaftwithrigidsupport,radialelasticfrictionforces,rotary friction, friction Independent of velocity, friction dependent on frequency, different shaft stiffness constants, gyroscopic effects, nonlinearproblems oflargedeformation applied forces, instabilityofrotors in magneticfield.

12 Hours

Module 2:CriticalSpeed: Dunkerley'smethod,Rayleigh'smethod,Stodola'smethod.RotorBearing System:Instabilityofrotorsduetotheeffectof hydrodynamicoil layerin thebearings, support

flexibility, simplemodelwith one concentrated mass at the center.
08 Hours

Module **3:**

mentofelementtransfermatrices,the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.

Module 4: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**

Module 5:Blade Vibration: Centrifugal effect, Transfer matrix and finite element approaches. **08 Hours**

Course Outcomes:

C01	Provides the student understanding of modeling rotating machine elements theoretically.
C02	Upon completion of this course, students will have gained an understanding of the design, application, and reliability evaluation of bearings in rotating machinery applications.

Reference Books:

1. Cameron, “Principles of Lubrication”, Longman Publishing Group, 1986
2. Bolotin , “Nonconservative problems of the Theory of elastic stability”, Macmillan, 1963
3. Peztel, Lockie , “Matrix Methods in Elasto Mechanics”, McGraw-Hill, 1963.
4. Timosenko , “Vibration Problems in Engineering”, Oxford City Press, 2011
5. Zienkiewicz, “The finite element method in engineering science”, McGraw-Hill, 1971

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 2

DESIGN OPTIMIZATION

(Common to MDE, MEA, MMD,CAE)

Course Code	**18CAE251**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

CourseLearning Objectives:

CL01	To understand the fundamentals of optimisation methods and their applications to manufacturing process and product design.
CL02	To learn optimisation models including design objectives, constraints and variables.
CL03	To learn appropriate optimisation techniques and programs.
CL04	To understand the limitations of solutions obtained from optimisation, and to use optimal design tools/software.

Course Content:

Module 1:EngineeringDesignPractice: EvolutionofDesignTechnology,IntroductiontoDesignandtheDesignProcess,DesignversusAnalysis, RoleofComputers in Design Cycle,Impact ofCAE on Design, Numerical Modelingwith FEAand Correlation with Physical Tests.

Applications ofOptimizationinEngineering Design: Automotive, Aerospaceand GeneralIndustryApplications, Optimization ofMetallic and CompositeStructures, Minimization and MaximizationProblems, MDO and MOO. **10 Hours**

Module 2: OptimumDesignProblemFormulation:TypesofOptimizationProblems,TheMathematicsofOptimization,DesignVariablesand DesignConstraints,FeasibleandinfeasibleDesigns,Equality andInequality Constraints,DiscreteandContinuousOptimization,Linearand NonLinear Optimization.

OptimizationTheory–FundamentalConcepts,GlobalandLocalMinimum,GradientVectorandHessianMatrix,Concept ofNecessary and Sufficient Conditions, Constrained and Unconstrained Problems,LagrangeMultipliers and Kuhn TuckerConditions. **10 Hours**

Module 3:SensitivityAnalysis: Linear andNonLinear Approximations. Gradient Based Optimization Methods– Dual and Direct.

OptimizationDisciplines: Conceptual DesignOptimizationandDesignFine Tuning, CombinedOptimization,Optimizationof Multiple Static andDynamicLoads,Transient Simulations,Equivalent StaticLoadMethods.InternalandExternal Responses,DesignVariablesin Each Discipline. **10 Hours**

Module 4:ManufacturabilityinOptimizationProblems: DesignForManufacturing,ManufacturingMethodsandRules,ApplyingManufacturingConstraints to Optimization Problems.

DesignInterpretation: UnboundProblems,OverConstrainedProblems,ProblemswithNoofMultipleSolutions,ActiveandInactiveConstraints, Constraint Violations and Constraint Screening, Design MoveLimits,Local and Global Optimum. **10 Hours**

Module 5:Dynamic Programming: Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming,Initial valueproblem, Examples. **10 Hours**

CourseOutcomes:

At the end of the course, students will be able to:

C01	Identify and apply relevant problem solving methodologies.
C02	Design components, systems and/ or processes to meet required specification.
C03	Optimizeanexistingdesignwithsingleormultipleobjectivefunctions.
C04	Apply decision-making methodologies to evaluate solutions for efficiency, effectiveness and sustainability.

TextBooks:

1. S.S.Rao, Engineering Optimization: Theoryand Practice, John Wiley, 2009
2. JasbirArora,Introduction to Optimum Design, McGrawHill, 2011.

ReferenceBooks:

1. Optimisation and Probabilityin System Engg-Ram, Van Nostrand.
2. Optimization methods -K. V. Mital and C. Mohan, New ageInternationalPublishers,

1999.
3. Optimization methods forEngg.Design -R.LFox, Addison – Wesley, 1971.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 2

AUTOMOBILE SYSTEMDESIGN

(Commonto MDE, MMD, MEA,CAE)

Course Code	**18MEA252**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Objective:

CL01	To understand of the stages involved in automobile system design.
CL02	To expose the to industrialpractices in design of various systems of an tomobile.
CL03	To study importance and features of different systems like axle, differential, brakes, Steering, suspension, and balancing etc.
CL04	To study working of various Automobile Systems.
CL05	To know some modern trends in Automotive Vehicles.

Course Content:

Module 1: Body Shapes: Aerodynamic Shapes, drag forces for small family cars.

Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit.

12 Hours

Module 2: Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.

08 Hours

Module 3: Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders).

10 Hours

Module 4: Transmission System: Design of transmission systems – gearbox (max of 4-speeds), differential.

Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.

10 Hours

Module 5:Cooling System: Heat exchangers,application todesign ofcoolingsystem(watercooled).

EmissionControl: Common emission control systems, measurement ofmissions, exhaust gas emission testing.

10 Hours

CourseOutcomes:
Upon completion of this course, students will be able to:

C01	Gain an insight into aspects of vehicle design, operation and maintenance, which will be useful for taking up a position in the automotive industry.
C02	Applytheknowledgeincreatingapreliminarydesign of automobilesub systems.
C03	Identify construction, working, preventive maintenance, trouble shooting and diagnosis of various Automobile Systems.
C04	Identify Modern technology and safety measures used in Automotive Vehicles.

TextBooks:

1. DesignofAutomotiveEngines, -A.Kolchin&V. Demidov, MIR Publishers, Moscow.
2. Themotorvehicle, Newtonsteeds &Garratte-Iliffee&sonsLtd.,London.
3. I.C. Engines -Edward FObert,International text book company.

ReferenceBooks:

1. Introductionto combustion-Turns.
2. AutomobileMechanic-, N.K.Giri, KhannaPublications, 1994
3. I.C. Engines -Maleev, McGrawHill book company, 1976
4. Diesel enginedesign- HeldtP.M.,Chilton companyNew York.
5. Problems on designofmachine elements- V.M. Faires&Wingreen, McMillan Company.,

1965
6. DesignofI.C.Engines -John Heywood, TMH.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 2

COMPUTATIONAL FLUID DYNAMICS

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MEA253**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	This course would create awareness about the theory behind fluid dynamics computations as applied in analysis tools.
CL02	This course provides core knowledge of the fundamentals of CFD, and an introduction to the methods and analysis techniques used in CFD.

Course Content:

Module 1: Basic Concepts: Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy). **10 Hours**

Module 2: Finite Difference Methods: Discretisation; Boundary conditions; error propagation; Introduction to spectral methods; examples. **10 Hours**

Module 3: Finite volume method: Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples. **10 Hours**

Module 4: Gausian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods.
Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions & under relaxation.Non linear systems. **10 Hours Module 5:** Initial value problem & Boundary value problems; Implicit & Explicit schemes;

2D and 3D examples.Heat and Mass transfer Problems; Multi Phase Flows. **10 Hours**

Course Outcomes:

At the end of the course,students will be able to:

C01	Understand the process of developing a geometrical model of the flow, applying appropriate boundary conditions, specifying solution parameters, and visualising and analysing the results.
C02	Apply CFD analysis to real engineering designs.

Text Books:

1. Computational Methods for Fluid Dynamics, 3rd edition - J.H. Ferziger& M. Peric, Springer,
2002.

2. Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., G.D. Smith, Oxford University Press. 1986.

Reference Books:

1. Computational Fluid Dynamics - T. J. Chung, Cambridge Univ. Press, 2002.
2. Partial Differential Equations for Scientists and Engineers - Farlow, John Wiley, 1982.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Design Laboratory -Lab2

(Common to MDE, MEA, MMD)

Course Code	**18MDEL26**	**CIE Marks**	**40**
Number of Practical Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Hours	**50**	**Exam Hours**	**03**

Note:

1. These are independent laboratory exercises.
2. Student must submit a comprehensive report on the problems solved and give a presentation on the same for Internal Evaluation.
3. Any one of the experiments done from the following list has to be set in the examination for conduction and evaluation.

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: Comparison of predicted Pressure and Velocity distributions with Target solutions.
Part C: Experimental Investigations using a Journal Bearing Test Rig.
Part D: Correlation Studies.

Experiment #6
Welded Joints.
Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #7
Bolted Joints.
Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #8
Adhesive Bonded Joints.
Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

III Semester

DESIGN FOR MANUFACTURE AND ASSEMBLY
(Common to MDE, MEA, MMD)

Course Code	**18MDE31**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

CourseLearning Objectives:

CL01	To understand various general design rules for manufacturability and criteria for material selection
CL02	To study various machining process and tolerance aspects in machining.
CL03	To know the design considerations for casting, forging and welding process.
CL04	To study the general design guidelines for manual assembly and development of DFA Methodology.

CourseContent:

Module 1: EffectofMaterials AndManufacturing ProcessOnDesign:Majorphasesofdesign.Effectofmaterial properties ondesignEffectof manufacturing processesondesign.Materialselectionprocess-

costperunitproperty,Weightedpropertiesandlimitsonproperties methods. TolerenceAnalysis:Processcapability,mean,varience,skewness,kurtosis,Processcapabilitymetrics,Cp, Cpk,Costaspects,Feature tolerances relevant to manufacturing and assembly, tolerance stacks,effects on assembly,methods of eliminating tolerance stacks, Geometriestolerances,Geometrictolerances,Surfacefinish,Reviewof relationshipbetweenattainabletolerancegradesand differentmachiningprocess.Cumulativeeffectoftolerance-Surefitlawandtruncatednormallaw **10Hours**

Module 2: Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group toleranceof matingpartsequal,Modeltotalandgrouptolerancesof shaftequal.Controlofaxialplay-Introducingsecondarymachining operations,Laminatedshims,examples. DatumFeatures:Functionaldatum,Datumformanufacturing,Changingthedatum.Examples. **10Hours**

Module 3: DesignConsiderations:Designofcomponentswithcastingconsideration.Pattern,Mould, andPartingline.CoredholesandMachined holes.Identifyingthepossibleandprobablepartingline.Castingrequiringspecialsandcores.Designingtoobviatesandcores.Welding considerations: requirements and rules, redesign of components for welding; case studies.

Component Design:Component designwithmachining considerations linkdesignforturningcomponents-milling, Drillingandother relatedprocessesincludingfinish-machiningoperations **12Hours**

Module 4: Forging considerations -Requirements and rules -Redesign of components for forging and Case studies.

True positional theory :Comparison between co-ordinate and convention method offeature location. Tolerance and true position tolerancing,virtualsize concept,floatingandfixedfasteners.Projectedtolerancezone.Assemblywith gasket,zeropositiontolerance. Functionalgauges, and Paperlayoutgauging **10Hours**

Module 5: Approaches to design for assembly-Qualitative evaluation procedures, knowledge based approach, Computer aided DFA methods. Assemblability measures. Boothroyd-Dewhurst DFA method -Redesign of a simple product-Case studies. **08 Hours**

CourseOutcomes:
At the end of the course, students will be able to:

C01	Describe the different types of manufacturing systems and comparetheir suitability foreconomic production of various components and products.
C02	Identify factors and causing mechanisms of the defects likely to occur with different manufacturing processes in producing mechanical products and the relevant design approaches to rectify them.
C03	Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic

	production.

Reference Books:

1. HarryPeck,“ DesigningforManufacturing” ,PitmanPublications,1983.
2. Dieter,“ MachineDesign” - McGraw-HillHigherEducation, -2008
3. R.K.Jain, "EngineeringMetrology",KhannaPublishers,1986
4. Productdesignformanufacture andassembly-GeoffreyBoothroyd, Peterdewhurst, WinstonKnight,Merceldekker. Inc.CRCPress, ThirdEdition
5. MaterialselectionandDesign,Vol.20-ASMHandbook.
6. Alan Redford and Chal, (1994) Design for Assembly-Principles and Procedures. McGraw Hill International.
7. James G. Bralla, (1986) Hand Book of Product Design for Manufacturing. McGraw Hill Co

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 3

EXPERIMENTAL MECHANICS

(Common to MDE, MEA, MMD, CAE)

Course Code	**18CAE321**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To introduce the concepts of dynamic measurements and analysis of experimental data.
CL02	To expose them to the techniques of Data Acquisition, Signal conditioning and processing.
CL03	To introduce students to different aspects of measuring deformation, strains, and stresses for developing a mechanistic understanding of both the material and the structure behavior.
CL04	Tofamiliarizethestudentwithstateoftheartexperimentaltechniquesemployingstraingauges,photoelasticity, Moiréinteroferometry,brittlecoating,Moiréfringesandholography.

CourseContent:

Module 1:Introduction:Definitionofterms,calibration,standards,dimensionandunits,generalizedmeas urementsystem,Basicconceptsindynamic measurements,systemresponse,distortion,impedancematching,experimentplanning.

Analysisof ExperimentalData: Causeandtypesof experimentalerrors,erroranalysis.Statisticalanalysisof experimentaldata-probability distribution, Gaussian, Normaldistribution. Chi-square test, method of least square, correlation coefficient, multivariable regression, standarddeviationofmean,graphicalanalysisandcurvefitting,generalconsiderationindataanalysis. **10Hours**

Module 2: DataAcquisition andProcessing: Generaldataacquisition system,signalconditioning revisited,datatransmission, Analog-to-Digital and Digital-to-Analogconversion. Basiccomponents (storageanddisplay)ofdataacquisition system.Computerprogramasasubstitute for wiredlogic.

Force,TorqueandStrainMeasurement: Massbalancemeasurement,elasticelementfor forcemeasurement,torquemeasurement.Strain gages-strainsensitivityofgagemetals,gageconstruction,gagesensitivityandgagefactor,performance characteristics,environmental effects,Straingagecircuits,Potentiometer, WheatStone'sbridges,Constantcurrentcircuits.Strainanalysismethods-two element and threeelement,rectangularanddeltarosettes,correctionfortransversestraineffects,stressgage - planesheargage,stressintensityfactor gage.

10Hours

Module 3: StressAnalysis: TwoDimensionalPhotoelasticity-natureoflight,-wavetheoryoflight,-opticalinterference-Polariscopesstressopticlaw effect ofstressed modelinplaneandcircularpolariscopes, Isoclinics, Isochromatics fringeorder determination -Fringe multiplicationtechniques-Calibrationphotoelasticmodelmaterials.Separationmethodssheardifferencemethod,Analyticalseparationmethods,Model toprototypescaling

10Hours

Module 4: ThreeDimensionalPhotoelasticity: Stressfreezingmethod,Generalslice,Effectivestresses,Stressesseparation,Shear deferencemethod, Obliqueincidencemethod,secondaryprincipalsstresses,scatteredlightphotoelasticity,Polariscopeandstressdataanalyses**.** **10 Hours**

Module 5: Coating Methods: a)Photoelastic Coating Method-Birefringence coating techniques,Sensitivity Reinforcing and thickness effects -data reduction-Stressseparation techniques,Photoelastic straingauges.

b)BrittleCoatingsMethod:Brittle coatingtechniquePrinciplesdata analysis-coatingmaterials,Coatingtechniques.

c)MoireTechnique-Geometricalapproach,Displacementapproach-sensitivityofMoire datareduction,InplaneandoutplaneMoiremethods,Moirephotography,Moiregridproduction.

Holography: Introduction, Equation forplane waves andspherical waves, Intensity, Coherence, Spherical radiator asanobject (record process),Hurter,Driffeldcurves,Reconstructionprocess,Holograpicinterferomerty, Realtimeanddoubleexposuremethods,Displacement measurement,Isopachics.

10Hours

CourseOutcomes:

At the end of this course, students should be able to:

	Mount strain gages, take measurements and analyze the obtained data.
	Design strain gage-based transducers for measuring specific loads.
	Describe the different methods photo elasticity for strain measurement viz, stress freezing , and Moirés method.
	Undertakeexperimentalinvestigationstoverifypredictionsbyothermethods.
	Apply the principles and techniques of brittle coating analysis.
	Apply the principles and techniques of holographic interferometry.

C01
C02
C03
C04
C05
C06

TextBooks:

1 . Holman,“ ExperimentalMethodsforEngineers” 7th Edition,TataMcGraw-Hill Companies,Inc,NewYork,2007.

2 . R.S.Sirohi,H.C.RadhaKrishna,“ Mechanicalmeasurements” NewAgeInternational Pvt.Ltd.,NewDelhi,2004

3. ExperimentalStressAnalysis-Srinath,Lingaiah,Raghavan,Gargesa,Ramachandraand Pant,TataMcGrawHill,1984.

4. Instrumentation,MeasurementAndAnalysis-Nakra&Chaudhry,BCNakraKKChaudhry, TataMcGraw-HillCompanies,Inc,NewYork, SeventhEdition,2006.

ReferenceBooks:

1. MeasurementSystemsApplicationandDesign-DoeblinE.A.,4th(S.I.)Edition,McGrawHill,NewYork.1989
2. DesignandAnalysisofExperiments- MontgomeryD.C.,JohnWiley&Sons,1997.
3. ExperimentalStressAnalysis-DallyandRiley,McGrawHill,1991.
4. ExperimentalStressAnalysis-SadhuSingh,Khannapublisher,1990.
5. PhotoelasticityVolIandVolII- M.M.Frocht,.JohnWileyandsons,1969.
6. StrainGaugePrimer-PerryandLissner,McGrawHill,1962.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 3

Mechatronics System Design

(Common to MDE, MEA, MMD,CAE)

Course Code	**18MEA322**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01 To educate the student regarding integration of mechanical, electronics, electrical and computer systems in the design of CNC machine tools, Robots etc.

CL02 To provide students with an understanding of the Mechatronic design process, actuators, sensors, transducers, signal conditioning, MEMS and Microsystems and also the advance applications in Mechatronics.

Course Content:

Module 1: 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 systems, Electrical actuation systems, Real time interfacing and hardware components for Mechatronics.

10 Hours

Module 2: 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, electro-mechanical systems, hydro-mechanical systems, pneumatic systems.

10 Hours

Module 3: 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 Micro systems: Introduction, working principle, materials for MEMS and Micro systems, Micro system fabrication process, overview of Micro Manufacturing, Micro system Design, and Micro system packaging.

10 Hours

Module 4: Data Presentation Systems: Basic System Models, System Models, Dynamic Responses of System.

10 Hours

Module 5: Advanced Applications in Mechatronics: Fault Finding, Design arrangements and practical case studies, Design for manufacturing, User- friendly design.

10 Hours

Course Outcomes:
At the end of the course,students will be able to:

C01	Describe mechatronic systems and overview of control systems & actuators.
C02	Identify and describe the different types of actuators used in mechatronic systems
C03	Differentiate between various sensors, transducers and actuators and their applications.
C04	Identify and describe the different types of speed- and position-feedbackdevices.
C05	Relate various signal conditioning units, amplifiers, logic gates and their role in programmable logic controllers.
C06	cuss the importance of feedback in controlling physical systems with the use of examples.
C07	lain the principle of operation of ac induction motor, dc motor, servomotor,

	and stepper motor.
C08	ntify and describe the types of controllers used in mechatronic systems.

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. Kamm, " Understanding Electro-Mechanical Engineering an Introduction to Mechatronics" - IEEE Press, 1 edition ,1996
2. Shetty and Kolk " Mechatronics System Design" - Cengage Learning, 2010
3. Mahalik " Mechatronics" - Tata McGraw-Hill Education, 2003
4. HMT " Mechatronics" - Tata McGraw-Hill Education, 1998
5. Michel .B. Histand& David. Alciatore, " Introduction to Mechatronics & Measurement Systems"– . Mc Grew Hill, 2002
6. " Fine Mechanics and Precision Instruments" - Pergamon Press, 1971.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 3

Robust Design

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MEA323**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

	CL01 To impart a holistic view of the fundamentals of experimental designs, analysis tools and techniques, interpretation and applications.
CL02	To cover the statistical design of experiments for systematically examining functioning of the system.
CL03	To understandTaguchi' s orthogonal array techniques which are predominantly

	used in optimization of parameters.
CL04	To understand the applications of statistical models in analysing experimental data.

Course Content:

Module 1: 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, factor levels, interactions, treatment combination, randomization, 2-levelexperimental 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, and illustration through numerical examples.
10 Hours

Module 2: 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

Module 3: 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

Module 4: 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.

10 Hours

Module 5: Reliability Improvement Through Robust Design : Role of S-N ratios inreliability improvement ; Case study; Illustrating the reliability improvement ofrouting process of a printed wiring boards using robust design concepts.

10 Hours

Course Outcome:

At the end of this course, students will be able to:

C01	Apply methods to analyze and identify opportunities to improve design processes for robustness.
C02	Set up full and fraction Factorial experiment design.
C03	Perform ANOVA and Hypothesis Testing.
C04	Apply statistical models in analysing experimental data.
C05	Lead product development activities that include robust design techniques.

Text Books:

1.Madhav S. Phadake , " Quality Engineering using Robust Design" , Prentice Hall,1989.
2. Douglas Montgomery, " Design and analysis of experiments" , 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 Willey Ed., 2002
3. W.L. Condra, Marcel Dekker , " Reliability improvement by Experiments" , MarcelDekkerInc, ASQC Quality Press, 1985

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 4

Smart Materials and Structures

(Common to MDE, MEA, MMD,CAE)

Course Code	**18CAE331**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To understand the concepts of functional material, smart material and smart systems.
CL02	To expose the students to design smart structures for advanced engineering applications.

CL03	To introduce the concepts of shape memory alloys, ER and MR fluids, and MEMS.

Course Content:

Module 1: Smart Structures: Types of smart structures, potential feasibility of smart structures, key elements of smart structures, applications of smart structures. Piezoelectric materials, properties, piezoelectric constitutive relations, depoling and coersive field, field strain relation. Hysteresis, creep and strain rate effects, inchworm linear motor. Beam modeling: Beam modeling with induced strain rate effects, inchworm linear motor beam modeling with induced strain actuation-single actuators, dual actuators, pure extension, pure bending harmonic excitation, Bernoulli-Euler beam model, problems, piezo-electrical applications.

10 Hours

Module 2: Shape memory Alloy: Experimental phenomenology, shape memory effect, phase transformation, Tanaka' s constitutive model, testing of SMA wires, vibration control through SMA, multiplexing. Applications of SMA and problems. ER and MR fluids: Mechanisms and properties, fluid composition and behavior, the Bingham plastic and related models, pre-yield response, post-yield flow applications in clutches, dampers and others.

08 Hours

Module 3:Vibration absorbers: Series and parallel damped vibrations (overview), active vibration absorbers, fiber optics, physical phenomena,characteristics, sensors, fiber optics in crack detection, applications. Control of structures: Modeling, control strategies and limitations, active structures in practice.

10 Hours

Module 4: MEMS: Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

10 Hours

Module 5: Devices: Sensors and Actuators, conductivity of Semiconductors, crystal planes and orientation, Stress and Strain Relations, Flexural Beam Bending Analysis under simple loading conditions, polymers in MEMS, optical MEMS applications.

10 Hours

Course Outcomes:

At the end of this course, students will be able to:

C01	Understand the behavior and applicability of various smart materials.
C02	Design simple models for smart structures & materials.
C03	Devise experiments to verify the predictions.
C04	Judge the appropriate application of smart materials with respect to the feasibility of their fabrication and implementation, and to the economic aspects.

Text Books:

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, ArtechHouse, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

Reference Books:

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin;New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN:052144487X).

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 4

COMPOSITE MATERIALS TECHNOLOGY
(Common to MDE, MEA, MMD)

Course Code	**18MDE332**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To impart a basic understanding of micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.
CL02	To understand the principles, matrix and reinforcement material options,

	advantages and disadvantages of different manufacturing techniques of composites.
CL03	To comprehend recent developments in composites, including metal, ceramic and polymer matrix composites.
CL04	To know the use of composites in engineering applications.

Course Content:

Module 1: Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.

Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications. Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants fororthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law fortwo-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

10 Hours

Module 2: Micro Mechanical Analysis of aLamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, 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, Tsa-Hill theory, Tsai, Wu tensortheory, Numerical problem, practical recommendations.

10 Hours

Module 3:Macro Mechanical Analysis of Laminate: Introduction, code, Kirchhoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation).

10 Hours

Module 4:Analysis of Composite Structures: Optimization of Laminates, composite laminates of uniform strength, application of optimal compositestructures, composite pressure vessels, spinning compositedisks, composite lattice structures.

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

10 Hours

Module 5:Manufacturing and Testing: Layup and curing - open and closed mould processing,Hand lay-up techniques, Bag moulding and filamentwinding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair.

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

10 Hours

CourseOutcomes:

At the end of the course, students should be able to:

C01	Understand the use of fibre -reinforced composites in structural applications.
C02	Develop a basic understanding of the use of composite materials, micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.
C03	Apply the basic micro-mechanics theories in the design of fibre reinforced composites.
C04	Analyze the performance of composites in engineering applications.

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.

2.Madhijit Mukhopadhay, Mechanics of Composite Material s & Structures, Universities Press,2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.
7. Hand Book of Composites, P.C. Mallik, Marcel Decker, 1993

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

PROFESSIONAL ELECTIVE 4

Acoustics and Noise Control Engineering

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MDE333**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

CL01	To provide introduction to students the fundamentals of acoustics related to generation, transmission and control techniques.
CL02	To provide basic knowledge and understanding of noise and vibration control

	necessary for professional practice as a noise control engineer.
CL03	To expose them to acoustic instrumentation and techniques of sound measurement.
CL04	To understand Noise reduction and control techniques in Machinery, auditorium, and HVAC systems.

Course content:

Module 1: Introduction to Acoustics: Basics of acoustics - speed of sound, wavelength, frequency, and wave number, acoustic pressure and particle velocity, acoustic intensity and acoustic energy density, spherical wave, directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels. Sound sources and Propagation – Plane and spherical waves, near and far field, free and reverberant field - Anechoic and Reverberant chambers.

10 Hours

Module 2: Acoustics Evaluation Techniques: Room Acoustics ,Reverberation time, Acoustic materials, Absorption and Absorption Coefficient, Evaluation techniques.

10 Hours

Module 3:Noise and physiological effects: Noise and physiological effects , Acoustic criteria, the human ear, hearing loss, industrial noise criteria, speech interference level,

noise criteria for interior spaces , Loudness, hearing, hearing loss, hearing protectors, Mechanism -Weighted Networks -Noise standards for traffic - Community noise -Aircraft - Environmental noise, Articulation index, and Machinery acoustics.

10 Hours

Module 4: Acoustic Instrumentation: Sound level and intensity meters - Octave analyzers, octave band filters, acoustic analysers, dosimeter, measurement of sound power, sound power measurement in a reverberant room, sound power measurement in an anechoic chamber, sound power survey measurements, measurement of the directivity factor, calibration, noise measurement procedures.

Sound power estimation - Instruments for building acoustics -Speech Interference - Sound systems and Auditorium acoustics.

10 Hours

Module 5: Noise control techniques: At source and transmission path-Barriers and Enclosures- HVAC system noise, Machinery acoustics and levels- Near field monitoring and diagnostics - Active noise control techniques. Noise control in rooms, sound absorption.

10 Hours

Course Outcomes:

After studying this course, students will:

C01	Distinguish among different sound generation and propagation mechanisms and their representations, understand different categories of noise effects on

	humans.
C02	Understand how to use pressure wave expressions to describe sound transmission in different media.
C03	Analyze complex noise environments and predict sound levels in desired locations.
C04	Evaluate acoustic enclosures, barriers and walls for effective noise control.
C05	Become familiar with sound measurement instrumentation.
C06	Select appropriate noise control techniques for the solution of practical noise problems and evaluate their performance.
C07	Apply the noise control techniques considered in an integrated way to a practical design case.

Text Books:

1. J.D. Irwin and E.R.Graf, (2001), Industrial Noise and Vibration control, Prentice Hall Inc.

Reference books:

1. Bies and Colin. H. Hanson, (2001): Engg. Noise Control, E &FN SPON.
2. Noise Control Hand Book of Principles and Practices, David M.Lipsdomls Van Nostrand Reinhold Company.
3. Acoustic and Noise Control, (2000), B.J. Smith, R.J.Peters, Stephanie Owen.
4. Harris, C.K.—Handbook of Noise Control.
5. Petrusowicz and Longmore —Noise and Vibration control for industrialists
6. Thumann and Miller- Secrets of Noise control
7. R. D. Ford—Introduction to Acoustics.
8. Douglas P. Reynolds —Engineering Principles of Acoustics.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.