DEPARTMENT OF MECHANICAL ENGINEERING

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Syllabus and Scheme of Examination

M.Tech. inMachine Design

2017-18

Institution

Vision - Pursuing Excellence, Empowering people, Partnering in Community Development.

Mission - To develop NMAM Institute of Technology, Nitte, as Center of Excellence by imparting Quality Education to generate Competent, Skilled and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.

Department: Mechanical Engineering

Vision Statement: To produce Mechanical engineers of the highest quality who are professionally competent and highly qualified to suit the need for industries and organizations by promoting excellence in teaching, learning and research

Mission Statement: The Dept of Mechanical Engineering is committed to-

- Provide high quality education to the students, to fulfill the requirements of a 'Global Engineer'.
- Constantly strive to improve the teaching-learning methods, in order to deliver good academic programs.
- To respond to the fast evolving scientific and technological challenges in a highly competitive world.
- To inculcate, ethics, integrity, honesty, credibility, social and environmental consciousness

Programme Educational Objectives

PEO1: Graduates shall have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.

PEO2: Graduates shall be successful in their career as analysts and designers developing components made of conventional and advanced materials, participating in a team or individually in an industry, research or academia.

PEO3: Graduates shall be proficient in their communication, presentation and writing skills and will be prepared to engage in the process of self learning and life-long learning through professional development and research.

Programme Outcomes

PO 1: To acquire indepth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.

PO2: To analyze complex engineering problems critically, apply independent judgement for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

PO3: To think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

PO4: To extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

PO5: To create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

PO6: To possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

PO7: To demonstrate knowledge and understanding of engineering and management principles and apply the same to one’s own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

PO8: To communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions

PO9: To recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously

PO10: To acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

PO11: To observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Programme Specific Outcomes

PSO1: To work as a design engineer for designing products that require detailed analysis using tools that involves products having complex geometry, multi material composition and various working conditions.

PSO2: To review relevant literature, apply appropriate research methodologies, working individually or as a team on socially and technically relevant projects contributing to the advancement of domain knowledge

PSO3: To engage in collaborative multidisciplinary scientific research for decision making through rational analysis

NMAM INSTITUTE OF TECHNOLOGY, NITTE

SCHEME OF TEACHING AND EXAMINATION FOR M. TECH. MACHINE DESIGN (AUTONOMOUS SCHEME)

Revised at the BOS meeting on 20-05-2017

I SEMESTER

Sub. Code	Name of the Subject	Contact hours/week L/T/P/S	Duration of Sem. End Exam in hours	Marks for CIE	Marks for SEE	Total Credits
17MMD101	Dynamics & Mechanism Design	4/2/0/0	3	50	50	5
17MMD102	Finite Element Methods	4/2/0/0	3	50	50	5
17MMD103	Theory of Elasticity and plasticity	4/2/0/0	3	50	50	5
17MMD111	Elective - I	4/2/0/0	3	50	50	4
17MMD123	Elective -II	4/2/0/0	3	50	50	4
17MMD104	Research Experience through Practice-I	0/0/4/0	0	100	--	2
TOTAL			15	350	250	25

ELECTIVE –I		ELECTIVE-II	
17MMD111	Experimental Stress Analysis	17MMD121	Computer Graphics
17MMD112	Tribology & Bearing Design	17MMD122	Computer Applications in Design
17MMD113	Smart Materials & Structures	17MMD123	Mechatronics System Design
		17MMD124	Rotor Dynamics

M.TECH. MACHINE DESIGN
(AUTONOMOUS SCHEME)

II SEMESTER

Sub. Code	Name of the Subject	Teaching hours/week L/T/P/S	Duration of Sem. End Exam in hours	Marks for CIE	Marks for SEE	Total Credits
17MMD 201	Composite Materials Technology	4/2/0/0	3	50	50	5
17MMD 202	Advanced Machine Design	4/2/0/0	3	50	50	5
17MMD 203	Theory of Vibrations	4/2/0/0	3	50	50	5
17MMD21X	Elective - III	4/2/0/0	3	50	50	4
17MMD 22X	Elective -IV	4/2/0/0	3	50	50	4
17MMD 204	Research Experience through Practice-II	0/0/4/0	0	100	--	2
TOTAL			15	350	250	25

ELECTIVE –III		ELECTIVE - IV	
17MMD211	Fracture Mechanics	17MMD221	Optimum Design
17MMD212	Theory of Plates & Shells	17MMD222	Theory of Plasticity
17MMD213	Design for Manufacture	17MMD223	Robotics
17MMD214	Condition Monitoring and Conditionbased maintenance	17MMD224	Robust Design

List of Audit courses currently offered

- **Acoustic Emission Science and its Applications**

M.TECH. MACHINE DESIGN
(AUTONOMOUS SCHEME)

III SEMESTER

Revised at the BOS meeting on**20-05-2017**

Sub. Code	Name of the Subject	Duration	Marks for		Total Credits
		Practical/Field Work/Assignment	CIE	SEE	
17MMD 301	Industrial Training Mini-Project	Full time 8 weeks	50 (report) 50 (presentation)	--	8
17MMD 302	Seminar on special topics	----	100	--	2
17MMD303	Project-Part I	Full time 10 weeks	100 (report) 100(presentation)	--	10
TOTAL			400		20

IV SEMESTER

Sub. Code	Name of the Subject	Duration	Duration of Exam in Hrs.	Marks for		Total Credits
		Practical Field work		CIE	SEE	
17MMD 401	Project - Part II	Full time 20 weeks		200 [PPE*-I – 100 PPE-II – 100]	200	30
TOTAL				400		30
GRAND TOTAL From 1st to 4th semester: 100 credits (2000 marks)						

PPE – Project Progress Evaluation

DYNAMICS AND MECHANISM DESIGN

Sub Code: 17MMD 101 No. of Credits: 4
Hrs / week: 4 CIE: 50 marks
Total hrs: 52 SEE: 50 marks

Course Outcomes:

On completion of the course the student should be able to:

1. Understand the terminologies in kinematics and mechanism, Analyze the mechanisms for displacement.
2. Analyze the mechanisms for velocity and acceleration using different methods.
3. Design and Synthesis of four bar mechanisms for two positions.
4. Synthesis of four bar mechanisms for three and four positions using graphical and analytical methods.
5. Analyze mechanisms subjected to external forces and determine the pin forces and torque, and understand the terminologies and motion in spatial mechanisms.

Unit – I

Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grubblers rule, Grashoffs law, Equivalent mechanisms

Kinematic Analysis: Displacement Analysis, Transmission angle, Deviation angle, Range of motion.**10hours**

Unit – II

Velocity Analysis: Relative velocity method, Kennedy's theorem, Instantaneous center method, Auxillarymethod, Mechanical advantage.

Acceleration Analysis: Relative acceleration, Coriolis Acceleration, Mechanism with higher pair. **-10 hours**

Unit – III

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

Two position synthesis of Slider crank, crank and rocker mechanisms.**-10 hours**

Unit- IV

Graphical Methods of Dimensional Synthesis: different typesofthree position synthesis, Four position synthesis (point precision reduction), Overlay method, Coupler curve synthesis.

Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis. **-12 hours**

Unit - V

Dynamics of Mechanism: Introduction, static forces, dynamic forces, D'Alembert's principle, Inertia forces in linkages, Center of percussion, Kinetostatic Analysis, The superposition method, The matrix method.

Spatial Mechanisms: Introduction, Planar transformation, spatial transformation, Concatenation of displacements, Rotation about an axis, Problems.**-10 hours**

Mapping of POs & COs:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
1	H	H	L	L	M	M	L	M	M	L	M	M	M	M
2	H	H	L	M	H	M	L	H	M	L	M	H	H	M
3	H	H	H	M	H	M	M	H	H	L	L	H	H	M
4	H	H	H	M	H	M	M	H	H	L	L	H	H	H
5	H	H	M	M	H	M	M	H	H	L	L	H	H	H

L: Low M: Medium H: High

Text books:

1. Mechanism Design Anlysis and Synthesis by Arthur G Erdman and George N Sandor, Prentice Hall of India Pvt Ltd, New Delhi.
2.Kinematics,Dynamics and Design of machinery – K.J. Waldron &G.L.Kinzel, Willey India,2007
3.Classical Dynamics –Greenwood Prentice hall of india,1988

References Books:

1. Theory of Machines and Mechanism - E.Shigley&J.J.Jicker McGraw Hill company.
2. Mechanism and Machine Theory - A.G.Ambekar, PHI, 2007.
3. Theory of Mechanism and Mechanism - Ghosh and Mallick, East West press 2007.
4. Machines and Mechanisms - David H. Myszka, Pearson Education, 2005.

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

FINITEELEMENT METHODS

SubCode	**:**	**17MMD102**	**IAMarks**	**:**	**50**
Hrs/Week	**:**	**04**	**ExamHours**	**:**	**03**
TotalHrs.	**:**	**52**	**ExamMarks**	**:**	**100**

Course Outcomes:

Upon completion of this course, graduates will have the

1. Understand the concept of fem along with its applications and implement weighted residual methods for determining deformation and deflection of various structural systems.
2. Formulate and perform one dimensional structural analysis using line elements and truss elements.
3. Formulate and perform two dimensional structural analysis using triangular elements and quadrilateral elements. Students should be able to formulate and perform two dimensional structural analyses for axi symmetric bodies using axi symmetric triangular and quadrilateral ring elements.
4. Perform three dimensional analyses of mechanical systems using standard software. Students should be able to formulate and perform one dimensional structural analyses using beam element.
5. Formulate and perform one dimensional and two dimensional heat transfer analysis. Students should be able to formulate and perform one dimensional modal analysis using consistent mass matrix and lumped mass matrix and different forms of solution.

UNIT-I

1. **IntroductiontoFiniteElementMethod:**Definition of FEM, General Description of FEM, Engineering applications of FEM, Discretization process, Types of Elements – 1D, 2D, 3D and Axisymmetric elements, location of nodes, node numbering scheme, boundary conditions, half bandwidth, EngineeringAnalysis,History,Advantages,Classification, Basicsteps,Convergencecriteria,Roleoffiniteelementanalysisincomputer-aided design, Mathematical Preliminaries. **5Hours**

2. Differentialequationsformulations,Variationformulations,weightedresidualmethods **6 Hours**

UNIT-II

3. **One-Dimensional Elements-Analysis of Bars,** Basic Equations and Potential EnergyFunctional,1DBarElement,Admissible displacementfunction,Strainmatrix,Stressrecovery,Element equations,Stiffnessmatrix,Consistentnodalforcevector:Bodyforce,Initialstrain,Assembly Procedure, Boundary andConstraintConditions,Singlepointconstraint,Multi-pointconstraint,2-DBarElement,Shape functionsforHigherOrderElements. **6Hours**

4. **One-Dimensional Elements-Analysis ofTrusses,** Admissible displacementfunction,Strainmatrix,Stressrecovery,Element equations,Stiffnessmatrix,Consistentnodalforcevector of truss element. Numerical problems. **4Hours**

UNIT-III

5. **Two-DimensionalElements-AnalysisofPlaneElasticityProblems:**Three-NodedTriangularElement (TRIA 3),Four-NodedQuadrilateralElement (QUAD4),ShapefunctionsforHigherOrderElements (TRIA 6, QUAD8) **6Hours**
6. **Axi-symmetric Solid Elements-Analysis of Bodies of Revolution under axi-symmetric loading:** AxisymmetricTriangularandQuadrilateralRingElements.ShapefunctionsforHigherOrderElements. **4Hours**

UNIT-IV

7. **Three-DimensionalElements-Applications toSolidMechanicsProblems:**BasicEquationsandPotential EnergyFunctional,Four-NodedTetrahedralElement(TET4),Eight-NodedHexahedralElement(HEXA8), Tetrahedral elements,Hexahedral elements:Serendipityfamily,Hexahedral elements:Lagrangefamily.Shape functionsforHigherOrderElements **6 Hours**
8. **BeamElements-AnalysisofBeamsandFrames:**1–DBeamElement,2–DBeamElement,Problems. **5 Hours**

UNIT-V

9. **Heat Transfer/ FluidFlow:**Steadystateheattransfer,1Dheatconductiongoverningequation,boundary Conditions,Onedimensionalelement,Functionalapproach forheatconduction, Galerkin approach forheat conduction,heatfluxboundarycondition,1 Dheattransferinthin fins.Basicdifferentialequationforfluidflow inpipes,aroundsolidbodies,porousmedia.**6Hours**
10. **DynamicConsiderations:**Formulationforpointmassanddistributedmasses,Consistentelementmass matrix ofonedimensionalbarelement,trusselement,axisymmetrictriangular element,quadrilatateralelement, beamelement.Lumpedmassmatrix,Evaluationofeigenvaluesandeigenvectors,Applicationstobars,stepped bars,andbeams. **4Hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	H	M	H	L	M	M	L	M	H	M	M
2	H	H	H	H	M	M	L	L	M	L	M	H	M	M
3	H	H	H	H	H	L	L	L	M	L	M	H	M	M
4	H	H	H	M	H	H	L	L	M	L	M	H	M	M
5	H	H	H	M	H	H	L	L	M	L	M	H	M	M

L: Low M: Medium H: High

TextBooks:

1. ChandrupatlaT.R.“**FiniteElementsinengineering”-**2nd Edition,PHI,2007.
2. LakshminarayanaH.V.,“**FiniteElementsAnalysis”**– ProceduresinEngineering,UniversitiesPress, 2004

ReferenceBooks:

1. RaoS.S.“**FiniteElementsMethodinEngineering”-**4th Edition,Elsevier,2006
2. P.Seshu,“**TextbookofFiniteElementAnalysis”**-PHI,2004.
3. J.N.Reddy, “**Finite Element Method”-** McGraw -Hill International Edition. BatheK. J. Finite ElementsProcedures,PHI.
4. CookR.D.,etal.“**ConceptsandApplicationofFiniteElementsAnalysis”-** 4th Edition,Wiley& Sons,200

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

Theory of Elasticity and Plasticity

Sub Code: 17 MMD 103	No. of Credits: 4
Hrs / week: 4	CIE: 50 marks
Total hrs: 52	SEE: 50 marks

Course Outcomes

After the successful completion of this course, the student will be able to

1. Understand the components of stresses in structures subjected to different loads.
2. Understand the components of strains and analyze the stress-strain relations.
3. Carry out the analysis of two-dimensional problems in cartesian co-ordinates and understand the elastic stability of columns.
4. Arrive at the solution of two-dimensional problems in polar co-ordinates.
5. Understand the concepts of idealized plastic behaviour and viscoelasticity

Unit – I

Introduction to stress: Definitionandnotationforforces andstresses, body force, surface force, components ofstresses,equationsof equilibrium,specification ofstressatapoint- stress tensor, stress tensor symmetry, stress quadric of Cauchy and principalstresses.**Mohr'sdiagram**inthreedimensions, boundary conditions, stresscomponentsonanarbitrary plane,stressinvariants,deviator and spherical stress tensors and stresstransformation. **-10 hours**

Unit – II

Introductiontostrain: Deformation**,**straindisplacementrelations,straincomponents,stateof strainata point,principalstrains,strain invariants, strain transformation, cubicaldilatation, spherical and deviator strain tensors and compatibilityequations.

Stress-StrainrelationsandLinear Elasticity: GeneralizedHooke'slawintermsof engineering constants, formulation of elasticityproblems, existenceanduniquenessofsolution,Saint-Venant'sprinciple,principleofsuperpositionandreciprocaltheorem**.-10 hours**

Unit – III

Twodimensionalproblemsincartesianco-ordinates: Plane stress, plane strain,Airy'sstressfunction,investigationfor simple beamproblems, bendingofanarrowcantileverbeamunderendload,simplysupportedbeamwith uniform load and useofFourierseriestosolvetwodimensionalproblems.

Elasticstability: Axialcompressionofprismaticbars,elasticstability,bucklingloadforcolumn with constant cross section.**-10 hours**

Unit- IV

Twodimensionalproblemsinpolarco-ordinates: Generalequations,stressdistributionsymmetrical aboutanaxis and purebending ofcurvedbar.

Straincomponentsinpolarco-ordinates,rotatingdisk andcylinder, concentratedforceonsemi-infiniteplane and stressconcentrationarounda circularholeinan infiniteplate.**-12 hours**

Unit - V

Plasticity: Basic concept and definitions, idealized plastic behaviour, yield condition- Tresca and Von-Mises criteria, yield surface, post yield behaviour-isotropic and kinematic hardening, plastic stress-strain equations, plastic potential theory, equivalent stress, equivalent plastic strain increment, plastic work, strain hardening hypothesis, total deformation theory-elastoplastic problems and elementary slip line theory for plane plastic strain.

Viscoelasticity: Linear viscoelastic behaviour, simple viscoelastic models-generalized models, linear differential operator equation, creep and relaxation- creep function, relaxation function, hereditary integrals, complex moduli and compliances, three dimensional theory, viscoelastic stress analysis and corresponding principles **-10 hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	L	H	M	L	H	H	-	M	M	M	L
2	H	H	H	L	H	M	L	H	H	-	M	M	M	L
3	H	M	M	L	M	L	M	H	M	-	-	L	L	-
4	M	M	L	L	M	L	M	M	M	-	-	L	L	-
5	M	L	M	M	L	L	L	M	H	-	L	M	L	L

L: Low M: Medium H: High

Text books:

1. TimoshenkoandGoodier,"**Theoryof Elasticity",** Third Edition, TataMcGrawHillBookCompany, 2010.

2. DymC.LandShames.I.H,“**SolidMechanics:Avariationalapproach”**,Springer, 2013.

3. G. T. Mase, R.E. Smelser, R.M. Smelser, G.E. Mase, “**Continuum Mechanics for Engineers”**, Taylor and Francis, 2009.

4. Sadhu Singh, **“Theory of Plasticity and Metal forming Process**”, Khanna Publishers, Delhi, 1999.

References Books:

1. T.G.Sitharam, **“AppliedElasticity”**, Interlinepublishing, 2008.

2. LSSrinath, **“AdvancedMechanicsofSolids”,** Third Edition,TataMcGrawHillCompany, 2009.

3. SadhuSingh, **“Theoryof Elasticity”,** Khannapublishers, 2010..

4. Wang.C.T., **“AppliedElasticity”,** McGrawHill, 1953.

5. Haffman and Sachs, **“Introduction to the Theory of Plasticity for Engineers”,** Literary Licensing, LLC, 2012.

6. Dill, Ellis Harold, **“Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity”,** CRC Press , 2006.

E-books:

1. J.N. Goodier and P.G.Hodge, “ **Elasticity and Plasticity**”, Dover Publications, 2016.
2. E. Starovoitov, F.B.O Naghiyev, “**Foundations of the Theory of Elasticity, Plasticity, and Viscoelasticity**”, CRC Press, Taylor and Francis, 2013.

MOOC/NPTEL resources:

1. http://nptel.ac.in/courses/105108070
2. https://www.coursera.org/learn/mechanics-1

EXPERIMENTAL STRESS ANALYSIS

Sub Code: 17MMD 111	No. of Credits: 4
Hrs / week: 4	CIE: 50 marks
Total hrs: 52	SEE: 50 marks

Course Outcomes

On completion of the course the student should be able to:

1. Differentiate between stress and strain and between experimental stress analysis with other techniques and be aware about the latest developments in the field.
2. Use electric resistance strain gauges for strain measurement by identifying the types, their characteristics, performance, influence of the environment, the circuits used for measurement and the commonly used strain gauge arrangements.
3. Discuss about photoelasticity for stress measurements by recognizing the laws, effects, materials used, instrumentation required, data obtained and its analysis.
4. Discuss about photoelastic coatings for stress and strain measurements and differentiate its behaviour from photoelastic model materials.
5. Present information about Holography and Moire techniques for stress and strain measurements.

Unit – I

Overview of Experimental stress analysis – analytical, numerical and experimental approaches, specific domain of these approaches, advantages and disadvantages**2 hours**
Introduction to stress and strain **3 hours**

Recent developments in experimental stress analysis techniques - Shearography, Speckle Interferometry, Thermoelastic stress analysis and Digital Image Correlation **3hoursTotal - 8 hours**

Unit – II

Electrical resistance gauges - Introduction - physical principle, strain sensitivity of gage metals, gage construction, gage sensitivity and gage factor, transverse sensitivity factor performance characteristics, environmental effects, strain gage circuits – Potentiometer, Wheatstone bridge, constant current and voltage circuits. **6 hours**

Strain rosettes – introduction, two element, three element, rectangular and delta rosettes. **3 hours**

Strain gaugeconstruction - alloys, carriers and adhesives, strain gauge selection, bonding of srain gauges and temperature compensation. **3 hours**

Total -12 hours

Unit – III

Transmission photoelasticity – physical principle, historical development, birefringence, nature of light, Polarization, methods to get polarized light, plane and circular polariscope, stress-optic law, waveplates, Isoclinics and Isochromatics, Fringe order determination, Tardy's Compensation method and fringe multiplication techniques**Photoelastic model materials** – properties and types, calibration.**7 hours**

Two dimensional photoelasticity- 2 hours

Three dimensional photoelasticity – introduction, stress freezing, slicing, scattered light photoelasticity**.** **3 hours**

Total -12 hours

Unit- IV

Photoelastic coatings – introduction, strain-optic relation for coating, evaluation of coating and specimen stresses, correction factors for photoelastic coatings, coating materials, properties of coating materials, selection of coating thickness**5 hours**

Brittle coatings – introduction, brittle coating technique principles, crack patterns produced, steps in brittle coating tests, coating selection and surface preparation. **3 hours**

Digital photoelasticity – introduction and over view. – **2 hours**

Total -10 hours

Unit - V

Moire technique – introduction, geometrical approach, displacement approach, in-plane and out-plane moiré methods, moiré photography and moiré grid production. **5 hours**

Holography - introduction, difference between normal photography and holography, equation for plane and spherical waves, recording and reconstruction process, intensity and coherence, Holographic interferometry, Real time and Double exposure methods**5 hours**

Total -10 hours

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	M	L	M	H			M	M			H	H	M
2	H	M		L	M				M			H	M	M
3	H	M	L	H	L				M			M	M	M
4	H	M	L	H	L				M			M	M	M
5	H	M		M	L				M			M	M	M

L: Low M: Medium H: High

Text books:

1. K.Ramesh, e-book on Experimental Stress Analysis (DVD Media), IIT Madras, 2009.
2. J.W.Dally and W.F.Riley, Experimental Stress analysis, McGraw Hill, 1991.
3. L.S.Srinath, M.R.Raghavan, K.Lingaiah, G.Gargesa, B.Pant and K.Ramachandra, "Experimental Stress Analysis, Tata McGraw Hill, 1984.

Reference books:

1. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 2009.

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

MECHATRONICSSYSTEMDESIGN

SubCode	**:**	**17MMD123**	**IAMarks**	**:**	**50**
Hrs/Week	**:**	**04**	**ExamHours**	**:**	**03**
TotalHrs.	**:**	**52**	**ExamMarks**	**:**	**100**

Course Outcomes-COs:

At the end of the course student will be able to:

(1) Design a mechatronics system for a specific application
(2) Select the sensors and actuators required for mechatronics system
(3) Design a signal conditioning circuit
(4) Understand dynamics and control of a mechatronics system
(5) Understand MEMS based systems and their fabrication methods

Unit-I

Introduction:DefinitionandIntroductiontoMechatronicSystems,OverviewofMechatronicproductsandtheirfunctioning, measurement systems, ControlSystems, simpleControllers, Integrated Design Issues in Mechatronics, Mechatronics Design Process, Key Elements of Mechatronics system.

System Models: Mathematical models, mechanical system building blocks, electrical system building blocks, thermal system building blocks, pneumatic systems build blocks. Electro-mechanical systems, hydro-mechanical systems.

Active learning of System Models using computer simulations **10Hours**

Unit-II

Sensors

Introduction, Sensors for Motion and Position Measurement, Proximity sensors, Electrical strain and stress measurement, Force measurement, Vibration—Acceleration Sensors, Time of flight sensors, Binary force sensors, Temperature measurement, Sensors for Flow Measurement, Pressure measurement, Problems, Laser Displacement Sensors,

Active Learning of sensors and their application.

Actuators

Introduction ,Electromagnetic Principles, Solenoids and Relays, Electric Motors, DC Motors, DC Motor Electrical Equation,Permanent Magnet DC Motor, Dynamic Equations, Electronic Control of a Permanent MagnetDC Motor, The servo motor, Stepper Motors, Stepper Motor Drive Circuits, Selecting a Motor, Hydraulics, Hydraulic Valves, Hydraulic Actuators, Pneumatics. Piezoelectric Actuators, Different types of Piezoelectric Actuators.

Active Learning of actuators and their actuation.**10Hours**

Unit-III

Signal Conditioning

Amplifiers, ideal operational amplifier model, inverting amplifier, non-inverting amplifier, unity-gain buffer summing amplifier, difference amplifier, instrumentation amplifier, integrator amplifier, differentiator amplifier, comparator, sample and hold amplifier, active filters, Problems, Data acquisition, Introduction, Sampling and aliasing, Quantization theory, Digital-to-analog conversion hardware, Analog-to-digital conversion hardware, Problems, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition

Active Learning of Data Acquisition Systems**10Hours**

Unit-IV

Interfacing

Interfacing microcontrollers with actuators Introduction Interfacing with general-purpose three-state transistors Interfacing relays Interfacing solenoids Interfacing stepper motors Interfacing permanent magnet motors, Interfacing sensors Interfacing with a DAC Interfacing power supplies Interfacing with RS 232 and RS 485 Compatibility at an interface, Problems

Control theory-Modeling: Introduction Modeling in the frequency domain Modeling in the time domain Converting a transfer function to state space Converting a state-space representation to a transfer function Block diagrams, Problems

Control theory-Analysis: Introduction System response Dynamic characteristics of a control system Zero-order systems First-order systems Second-order systems General second-order transfer function Systems modeling and interdisciplinary analogies Stability The Routh-Hurwitz stability criterion Steady-state errors, Problems.**12Hours**

Unit-V

Micro Electro Mechanical Systems (MEMS)

Working principles of MEMS and microsystems, micro sensors, acoustic wave sensors, biomedical sensor, chemical sensors, optical sensors, micro pressure sensors, micro thermal sensors,microactuators, microactuation using thermal forces, actuation using shape memory alloys (SMA), microactuation using electrostatic forces, applications of microactuations, micro-valves, micro-pumps and micro heatpipes, micro-accelerometers and microgyroscopes

Microfabrication Processes: Photolithography, Ion implantation, Diffusion, Oxidation Chemical vapor deposition, Physical vapor deposition (Sputtering), Deposition by expitaxy, Etching.

Micromanufacturing: Bulk micromanufacturing, Surface micromachining, LIGA process

Active learning of MEMS Sensors like Accelerometers, gyroscopes, and Pressure Sensors

10Hours

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	L	H	M					L	H	L	M
2	L	M	M	L	L	M	L				L	M		M
3	M	H	H	M	M	M					L	H	L	M
4	H	H	H	L	M	M		L	L			H	L	M
5	M	H	H	L	H	H			L		L	H	L	M

TextBooks:

1. **“IntroductiontoMechatronics&MeasurementSystems”**–Michel.B.Histand&David. Alciatore, McGrewHill
2. DevdasShettyandKolk“**MechatronicsSystemDesign**”-Thomson.
3. HSU“**MEMSandMicrosystemsdesignandmanufacture**”-TMH

ReferenceBooks:

1. **“Mechatronics”**–W. Bolton,2 Ed. AddisonWesleyLongman,Pub,1999
2. Mahalik“**Mechatronics**”-TMH.
3. **“Mechatronics”–**HMT,TMH.
4. Kamm,“**UnderstandingElectro-MechanicalEngineeringanIntroductiontoMechatronics”-**PHI.
5. **“FineMechanicsandPrecisionInstruments”**-PergamonPress,1971.

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

Research Experience through Practice -I

Course code: 17MMD104
Course credits:2

No. of contact hours / week – 4
CIE: 100 marks

Course Outcomes-COs:

At the end of the course student will be able to:

1. Know the significance of literature survey in research and understand how to carry out literature survey
2. Identify a research problem with clear objectives and methodologies backed by extensive literature review.
3. Know different software tools required to carry out research work
4. Understand how to communicate the results in the form of research paper
5. Know how to write a research report based on the research work carried outand how to submit a research proposal outlining the proposed area of research work done

Methodology:

Ist&IIIrd week	The PG students should conduct detailed literature survey and identify the problem statement
IVth week	The students should define objectiverelated to the problem statement.
Vth week	Develop methodologies with expected outcome related to the identified problem statement.
VIth - VIIIthweek	The students should learn software toolsfor system/device simulation and analysis, software/ hardware tools for signal acquisition, data processing, control simulation, Testing/measuring equipment, related to the given problem statement.
IXth -week	The students should write the research proposal.

Xth week	Write the detailed report which includes (Introduction, literature survey, objectives and problem statement, methodology with expected outcome) **(50 marks)**
XIth-XIIth week	Presentation **(50 marks)**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	M	H	M	H	M	M	H	H	H	H	H	H
2	H	H	M	H	M	H	M	M	H	H	H	H	H	H
3	H	H	M	H	H	H	M	M	H	H	H	H	H	H
4	H	H	M	H	M	H	M	M	H	H	H	H	H	H
5	H	H	M	H	M	H	M	M	H	H	H	H	H	H

COMPOSITEMATERIALSTECHNOLOGY

SubCode	:	**17MMD201**	**IAMarks**	:	**50**
Hrs/Week	:	**04**	**ExamHours**	:	**03**
TotalHrs.	:	**52**	**ExamMarks**	:	**100**

Course Outcomes:

At the end of the course the student should be able to

1. Student should be able to identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
2. Student should apply constitutive equations of composite materials and understand mechanical behavior at micro, macro and meso level.
3. Student should apply the different failure theories during the failure analysis of composite materials.
4. Student should be able to describe fundamental fabrication processes for polymer matrix, metal matrix, and ceramic matrix composites.
5. Student should be able to use the ideas developed in the analysis of composites towards using composites in Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment .

UNIT-I

1. **Introduction toCompositeMaterials:**Definition,Classification, Typesofmatricesmaterialand reinforcements,Characteristics&selection,Fibercomposites,laminatedcomposites,Particulatecomposites, Prepegs,andsandwichconstruction. **6Hours**

2. **MicroMechanicalAnalysisofaLamina:**Introduction,Evaluationofthefourelastic moduli, Rule of mixture, Numerical Problems **4 Hours**

UNIT-II

3. **MacroMechanics ofaLamina:**Hooke'slawfordifferenttypesofmaterials,Numberofelasticconstants, Derivationof nine independentconstantsfororthotropicmaterial,Two-dimensionalrelationshipofcompliance and stiffnessmatrix. Hooke's law for two-dimensional angle lamina, engineering constants – Numericalproblems.Invariantproperties.Stress-Strainrelationsforlaminaofarbitraryorientation,Numerical Problems. **8 Hours**

UNIT-III

4. **BiaxialStrengthTheories:**Maximumstresstheory,Maximumstraintheory,Tsa-Hilltheory,Tsai,Wutensortheory,Numericalproblems. **6 Hours**

5. **MacroMechanicalAnalysisofLaminate:**Introduction,code,Kirchoffhypothesis,CLT, A,B,andDmatrices(Detailedderivation)Engineeringconstants,Specialcasesof laminates. Numerical problems **6 Hours**

UNIT-IV

6. **Manufacturing:**Layupandcuring-openandclosedmouldprocessing,Handlayuptechniques,Bag mouldingandfilamentwinding.Pultrusion,Pulforming,Thermoforming, Injectionmoulding**6 Hours**
7. **Fabrication of Composite Structures:** Cutting, machining, drilling, mechanical fasteners and adhesive bonding, joining, tooling, fabrication equipments. Introduction,materialqualification, Typesofdefects,NDT methods **6 Hours**

UNIT-V

8. **ApplicationDevelopments:**Aircrafts,missiles,Spacehardware,automobile,Electricaland Electronics, Marine,Recreationalandsportsequipment-futurepotentialofcomposites. **5 Hours**
9. **MetalMatrixComposites:**Re-inforcementmaterials,Types,Characteristicsandselection,Basemetals, Selection,Applications. **5Hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	M	M	M	M	H	L	L	M	M	M	H	H	M
2	H	H	H	M	M	M	L	L	M	M	M	H	H	M
3	H	H	H	M	M	L	L	L	M	M	M	H	H	M
4	H	M	M	M	H	H	L	L	M	M	M	H	H	M
5	H	H	H	M	M	H	L	L	M	M	M	H	H	M

L : Low M: Medium H : High

TextBooks:

1. **CompositeMaterialshandbook,**MeinSchwartzMcGrawHillBookCompany,1984.
2. **Mechanicsofcompositematerials,**AutarK.KawCRCPressNewYork.

ReferenceBooks:

1. **Mechanicsof CompositeMaterials,**RoberM.JonessMc-GrawHillKogakushaLtd.
2. **Stress analysis of fiber Reinforced Composite Materials,** Michael W, HyerMcGrawHill International.
3. **CompositeMaterialScienceandEngineering,**KrishanK.ChawlaSpringer.
4. **FibreReinforcedComposites,**P.C.MallikMarcelDecker.

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

ADVANCED MACHINE DESIGN

SubCode	**:**	**17MMD202**	**Credits**	**:**	**04**
Hrs/Week	**:**	**04**	**CIE Marks**	**:**	**50**
TotalHrs.	**:**	**52**	**SEE Marks**	**:**	**50**

Course Outcomes:

On completion of the course the student should be able to:

1. Understand the theories of failure relating to different ductile and brittle materials. Students should be able to develop the concept of fatigue testing of materials including criteria for fatigue design and different fatigue life models.
2. Determine the stress life behavior using stress life curves and representation of these curves including different factors influencing stress life behavior. Students should be able to understand the strain life behavior with different test methods and factors influencing strain life behavior.
3. Understand the concept of crack nucleation, crack growth and fracture of materials using fundamentals of linear elastic fracture mechanics.
4. Understand the various cumulative damage theories and different cycle counting methods relating to fatigue from variable amplitude loading. Students should be able to define the various statistical aspects of fatigue using different probability distribution plots.
5. Understand the different surface failure mechanisms with stress distribution of various contact surfaces. Students should be able to define the weldment nomenclature and fatigue behavior of various weldments.

UNIT I

1. **Introduction:** Role of failure prevention analysis in mechanical design,Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.**06 Hours**

2. **Fatigue of Materials:** Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods Fatigue design criteria, Fatigue testing, Test methods and standard test specimens.**04 Hours**

UNIT II

3. **Stress-Life (S-N) Approach:** S- **N** curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams.**05 Hours**

4. **Strain-Life(-N)approach**: Monotonic stress-strain behavior ,Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surfacefinish. **05 Hours**

UNIT III

5. **LEFM Approach:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation **05 Hours**

6.**Notches and their effects:** Concentration and gradients in stress and strain, S-N approach for notched members, mean stress effects and Haigh diagrams, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches **05 Hours**

UNIT 1V

7. **Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle Counting methods **05 Hours**

8.**Statistical Aspects of Fatigue:** Definitions and quantification of data scatter, Probability distributions, Tolerance limits, Regression analysis of fatigue data, Reliability analysis, Problems using the Weibull distribution. **05 Hours**

UNIT V

9. **Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength. **07 Hours**

10.**Fatigue of Weldments:** Weldment Nomenclature and Discontinuities, Constant amplitude fatigue behavior of weldments, Improving weldment fatigue resistance, Weldment fatigue life estimation. **05 Hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	M	L	L	L	L	M	L	M	M	M	M
2	H	H	H	M	L	M	M	L	M	L	M	M	M	H
3	H	H	H	H	M	H	L	M	H	L	L	H	M	H
4	H	H	M	H	M	H	L	M	H	L	M	M	H	M
5	H	M	H	M	M	H	L	L	H	L	M	H	H	H

L: Low M: Medium H: High

Text Books:

1. Metal Fatigue in engineering, Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry o. Fuchs, John wileyNewyork, Second edition. 2001.

2. Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, Newyork 1992.

3. Machine Design, Robert L. Norton, Pearson.

Reference Books:

1. Fatigue of Materials, S.Suresh, Cambridge university press, Cambridge, U.K.

2. Fundamentals of Metal Fatigue Analysis, Julie.A.Benantine Prentice Hall,1990

3. Fatigue and Fracture, ASM Hand Book, Vol 19,2002.

THEORY OF VIBRATIONS

Sub Code : 17MMD203 **Credits : 04**

Hrs. /Week : 4 **Total Hours: 52**

Course Outcomes:

At the end of this course the student shall be able to:

1. Recall the basic theory and concepts of mechanical vibrations with regard to single degree of freedom systems considering free, damped and forced vibrations and analyze two degree of freedom systems and use these concepts to solve problems.
2. Learn the significance of transient vibrations and apply mathematical concepts to solve problems related to it and get familiarized with vibration control and know about the different methods of achieving the same.
3. Know about the concepts of nonlinear vibrations and its applications and how vibration measurements are important and solve problems related to the same.
4. Apply mathematical techniques to analyze random vibrations and appreciate the use of modal analysis and condition monitoring in vibration signal analysis.
5. Learn the mathematical techniques to determine the equations of motion and natural frequencies of continuous systems and study their free/ forced vibration behavior and know how to solve Eigen value problems in vibrations.

UNIT – I

Review of Mechanical Vibrations - Basic concepts, free vibration of single dof systems with and without damping, forced vibration of single dof systems, Force and motion isolation, Twodof systems – natural frequency determination and mode shapes.**10 hours**

UNIT – II

Transient vibrations of single degree-of freedom systems – Impulse excitation, Laplace transforms formulation, step input, pulse excitation, shock response spectrum, Finite difference numerical computation. **- 6 hours**

Vibration Control – Introduction, vibration isolation theory, vibration isolation for harmonic excitation for different types of foundations, undamped dynamic vibration absorbers, types of vibration absorbers, types of vibration dampers**-6 hours**

UNIT - III

Non linear vibrations – Introduction, sources of nonlinearity, qualitative analysis of non linear systems, phase plane, conservative systems, Stability of equilibrium, Method of Isoclinics, Perturbation method, Method of Iteration, Self-excited oscillations**- 6 hours**

Vibration measurement and applications – Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis**- 6 hours**

UNIT – IV

Random vibrations – Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier Transforms and response **-5 hours**

Modal analysis and Condition Monitoring - Introduction, Dynamic testing of Machines and Structures, Experimental Modal analysis, Machine Condition Monitoring & Diagnosis.

-5 hours

UNIT – V

Continuous systems –Transverse vibration of a string or cable, Lateral vibration of beams, Longitudinal vibration of rods, vibration of membranes. **5 hours**

Eigen value problems – solution of the eigen value problem, solution of the characteristic equation, orthogonality of normal modes, repeated eigen values, expansion theorem, unrestrained systems, free vibration of damped systems**-5 hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	**H**	**M**	**L**	**L**	**L**				**M**				**L**	**L**
2	**H**	**M**	**M**	**M**	**M**				**M**				**M**	**M**
3	**H**	**H**	**H**	**H**	**L**				**M**				**M**	**M**
4	**H**	**H**	**H**	**H**	**M**				**M**				**H**	**H**
5	**H**	**H**	**L**	**L**	**L**								**L**	**L**

L: Low M: Medium H: High

Text books:

1. William T. Thomson, Marie Dillon Dahleh and ChandramouliPadmanabhan- Theory of Vibrations with Applications, 5th Edition, Pearson Education, 2008.
2. S.S.Rao - Mechanical Vibrations, 4th Edition, Prentice Hall, 2004.
3. J.S.Mehta and A.S.Kailey - Mechanical Vibrations, S.Chand& Company Ltd., New Delhi, 2012.
4. G.K.Grover – Mechanical Vibrations, Nem Chand & Brothers, 2009.

Reference books:

1. S. Graham Kelly – Fundamentals of Mechanical Vibration, 2nd Edition, Mcgraw Hill.
2. S. Graham Kelly – Mechanical Vibrations, Schaum's Outlines, Tata Mcgraw Hill, 2007.
3. ThammaiahGowda, Jagadeesha T. and D.V.Girish – Mechanical Vibrations, McGraw Hill, New Delhi, 2013

Research Experience through Practice -II

Course code: 17MMD205
No. of contact hours / week – 4

Course credits:2
CIE: 100 marks

Course Outcomes-COs:

At the end of the course student will be able to:

1. Carry out mathematical modelling/ Design calculations/ Computer simulations related to their problem statement
2. Able to conduct experiments, collect data, simulate / develop model, prototype etc. and analyze and interpret the results obtained.
3. Use different tools, techniques, literature etc. to solve the problem
4. Produce a technical paper related to the identified problem statement
5. Know the importance of research at PG level

Methodology:

Ist&IVth week	The students are expected to carry out Mathematical modelling/Design calculations/computer simulations.
Vth-VIIIth week week	The students are expected to carry outPreliminary experimentation/testing of the research problems identified during **Research Experience through Practice-I** carried out in the first semester
IXth - Xth week	Write technical paper related to the identified problem statement. **(50 marks)**
XIth-XIIth week	Final presentation of the research work carried out during **Research Experience**

	through Practice –I and II in front of the panel of examiners **(50 marks)**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	H	H	H	H	H	H	H	H	H	H	H
2	H	H	H	H	H	H	H	H	H	H	H	H	H	H
3	H	H	H	H	H	H	H	H	H	H	H	H	H	H
4	H	H	H	H	H	H	H	H	H	H	H	H	H	H
5	H	H	H	H	H	H	H	H	H	H	H	H	H	H

References

1. Research Methodology – Methods and Techniques (Second Revised Edition) – C.R.Kothari, New Age International Publishers, 2004.
2. Any other Research Methodology Text book
3. Resources from the Internet

FRACTURE MECHANICS

Sub Code: **17MMD 211** No. of Credits: **4**
Hrs / week: **4** CIE: **50 marks**
Total hrs: **52** SEE: **50 marks**

Course Outcomes:

On completion of the course the student should be able to:

1. Understand material failure for any combination of applied stresses & estimate failure conditions of a structure.

2. Define the near field equations to determine the stress-strain and load-displacement fields around a crack tip.
3. Identify and formulate stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear and non linear materials.
4. Calculate and predict fracture toughness of materials and be familiar with the experimental methods to determine the fracture toughness.
5. Analyze the fatigue life of structures using fracture mechanics approach and crack arrest techniques.

Unit – I

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.**-6 hours**

The Airy stress function: Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems.**-6 hours**

Unit – II

LEFM: Plasicity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Different forms of Dugdale model. Plastic constraint factor. The Thickness effect, Residual stress effect on plastic zone, Numerical problems.**-10 hours**

Unit – III

Elastic plastic fracture mechanics : Fracture beyond general yield, The energy release rate, Criteria for crack growth. The crack resistance(R curve). Compliance, J integral, Tearing modulus, Stability.

The Crack-tip opening displacement. The Use of CTOD criteria.Parameters affecting the critical CTOD.Use of J integral. Limitation of J integral.**-10 hours**

Unit- IV

Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods,experimental methods, estimation of stress intensity factors.

Experimental determination of CTOD. Plane strain fracture toughness test, The Standard test, numerical problems. Size requirements. Non-linearity. Applicability. Numerical problems.**-10 hours**

Unit – V

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.

-6 Hours

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 loading and design criteria.**-4 hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	M	L	L	L	L	M	L	M	M	M	M
2	H	H	H	M	L	M	L	L	M	L	M	M	M	H
3	H	H	H	H	L	H	L	M	H	L	M	H	H	H
4	H	H	H	H	M	H	L	M	H	L	M	H	H	H
5	H	H	H	M	M	H	L	L	H	L	M	H	H	H

L: Low M: Medium H: High

Text books:

1. Elementary Engineering Fracture Mechanics - David Brock, Noordhoff.
2. Fracture Mechanics-Fundamental and Application - Anderson, T.L CRC press1998.

Reference Books:

1. Engineering fracture mechanics - S.A. Meguid Elsevier.
2. Fracture of Engineering Brittle Materials, Applied Science - Jayatilake, London.
3. Fracture and Fatigue Control in Structures - Rolfe and Barsom, , Prentice Hall.
4. Introduction to fracture mechanics - Karen Hellan, McGraw Hill.
5. Fundamentals of V fracture mechanisms - Knott, Butterworths.
6. Fracture –LiefbowitzVolime II.

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

CONDITION MONITORING AND CONDITION BASED MAINTENANCE

Sub Code : 17MMD214 **Credits : 04**

Hrs. /Week : 4 **Total Hours: 52**

Course Outcomes:

At the end of this course the student shall be able to:

1. Understand the types of maintenance used and its significance, role of condition based maintenance in industries, familiarize with different condition monitoring techniques and its advantages in industries.
2. Implement the basic signal processing techniques.
3. Understand the role of vibration monitoring, its methodology and its use in condition monitoring of rotating and reciprocating machines.
4. Understand the significance of mechanical fault diagnosis and non-destructive testing techniques in monitoring and maintenance.
5. Study condition monitoring of rolling element bearing, gears and tool condition monitoring techniques in machining.

UNIT – I

Chapter 1 - Introduction to maintenance and condition based maintenance

Definition, system approach, objectives, responsibilities of maintenance department, maintenance strategies, principles of maintenance, concepts of maintainability, availability and reliability, implementation of CBM, comparison of CBM with other maintenance techniques and case studies (overview).**4 hours**

Chapter 2 – Introduction to condition monitoring

Basic concept, techniques - visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring. **6 Hours**

UNIT – II

Chapter 3 – Basic signal processing techniques

Probability distribution and density, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Deterministic / random signal separation, Time-frequency analysis.**6 Hours**

Chapter 4 –WaveletTransform

Introduction to Wavelets, Continuous Wavelet Transform (CWT), Discrete WaveletTransform (DWT), Wavelet Packet Transform (WPT),types of wavelets – Haarwavelets,Shannon wavelets, Meyer wavelets, Daubechies wavelets, Coifmann wavelets and applications of wavelets. **6 Hours**

UNIT - III

Chapter 5 - Vibration Monitoring

Introduction, vibration data collection, techniques, instruments, transducers, selection, measurement location, time domain analysis, frequency domain analysis, time-frequency domain analysis and commonly witnessed machinery faults diagnosed by vibration analysis.

7 hours

Chapter 6 – Rotating and reciprocating machines

Vibration signals from rotating and reciprocating machines – signal classification, signals generated by rotating machines, signals generated by reciprocating machines. **5 Hours**

UNIT – IV

Chapter 7–Mechanical fault diagnosis

Wear monitoring and lubricant analysis - sources of contamination, techniques, Spectrometric Oil Analysis Procedure (SOAP) and ferrography. **5 hours**

Chapter 8 -Nondestructive testing techniques

Measurement of surface and subsurface flaws – liquid penetrant inspection, eddy current inspection, radiographic inspection, ultrasonic inspection. **5 hours**

UNIT – V

Chapter 9 - Condition monitoring of rolling element bearings and gear

Introduction, construction, types of faults, rolling element bearing diagnostics and gear diagnostics. **6 hours**

Chapter 10 - Tool wear monitoring

Introduction, techniques and case studies. **2 hours**

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	M	L	L	L	L	M	L	M	M	M	M
2	H	H	H	M	L	M	L	L	M	L	M	M	M	H
3	H	H	H	H	L	H	L	M	H	L	M	H	H	H

4	H	H	H	H	M	H	L	M	H	L	M	H	H	H
5	H	H	H	M	M	H	L	L	H	L	M	H	H	H

L: Low M: Medium H: High

TEXT BOOKS:

1. Robert Bond Randall – Vibration-Based Condition Monitoring – Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011
2. R.A.Collacot – Mechanical Fault Diagnosis – Chapman and Hall Ltd., 1977.
3. ISTE Course material on Condition Monitoring.
4. R.C.Mishra, K.Pathak – Maintenance Engineering and Management, Prentice Hall ofIndia Pvt. Ltd., 2002.
5. K. P. Soman, K. I. Ramachandran, N. G. Resmi – Insight into wavelet from theory to practice, Third Edition, Prentice Hall of India, ISBN: 978-81-203-4053-4

REFERENCES MATERIALS / BOOKS:

1. Dr. K.Balaveera Reddy, ISTE Summer School on Machinery Diagnostics and Preventive Maintenance, KREC, Surathkal, June 19-25, 1995.
2. Dr. A.Ramachandra, ISTE-STTP on Maintenance of Machinery, SJCE, Mysore, June 18-31, 2000.
3. John S.Mitchell, Introduction to Machinery Analysis and Monitoring, PennWell Books,1993.

ROBOTICS

SubCode	**:**	**17MMD22**	**IAMarks**	**:**	**50**
Hrs/Week	**:**	**04**	**ExamHours**	**:**	**03**
TotalHrs.	**:**	**52**	**ExamMarks**	**:**	**100**

Course Outcomes:

At the end of the course student will be able to:

(1) Understand 3D Homogeneous vector transformations with reference to the robotic applications
(2) Formulate the direct and inverse kinematics solution for Robotic manipulators
(3) Understand the robot differential motions and manipulator Jacobian
(4) Formulate the equation of motion for robot manipulators
(5) Understand robot trajectory planning and control

UNIT- I

Introduction to robotics, Robot anatomy, Links and joints, Degree Of Freedom, arm configuration, Wrist configuration, End effectors, Coordinate frames, Mapping, Mapping between rotated frames, Mapping between translated frames, Mapping between rotated and translated frames, Description of object in space, Transformation of vectors, rotation of vectors, Translation of vectors, Combined rotation and translation of vectors, Composite transformation, fundamental rotation matrices, Principal axes rotation, Fixed angle representation, Euler angle representation, Equivalent angle axis representation, Problems
Active Learning of 3D homogeneous Transformations.**10 Hours**

UNIT-II

Direct Kinematics and Inverse kinematics

Mechanical structure and Notations, Description of links and joints, Kinematic Modeling of the manipulator, Denavit – Hartenberg notation, Kinematic relationship between adjacent links, Manipulator transformation matrix, Problems, Manipulator workspace, Solvability of inverse kinematic model, Existence of solution, Multiple solutions, Solution technique, Closed form solution, Guidelines to obtain closed form solutions, Problems.
Active Learning of Direct and inverse kinematics.**12 Hours**

UNIT-III

Manipulator Differential Motion and Statics

Linear and angular velocity of rigid body, Linear velocity, Angular velocity, Linear velocity due to angular motion, Combined linear and angular motion, Relationship between transformation matrix and angular velocity, Mapping velocity vector, Velocity propagation of a link, Angular velocity of a link, Manipulator Jacobian, Jacobian computation, The prismatic joint Jacobian, The rotary joint Jacobian, Jacobian inverse , Jacobian singularity, Computation of singularities, Wrist singularities, Arm singularities, static analysis, Force and Moment balance, The Jacobian in statics, Problems.
Active Learning of Robot Jacobian and robot singularities.**10 Hours**

UNIT-IV

Robot Dynamics

Lagrangian mechanics, Two degree of freedom manipulator – dynamic model, Lagrange – Euler formulation, Velocity of a point on the manipulator, The inertia tensor, the kinetic energy, The potential energy, Equation of motion, The LE dynamic model algorithm
Derivation of Dynamic equation of motion for 2DOF and 3DOF robot configurations
10 Hours

UNIT V

Robot Trajectory Planning and Control

Definitions and planning tasks, Terminology, joint space techniques, Use of a p- Degree polynomial as interpolation function, Cubical polynomial trajectories, Linear function with parabolic blends, Cartesian space techniques, A straight –line path, A circular path, Position path, Orientation path, Joint-space versus Cartesian space, trajectory planning, problems, Open and closed loop control, The manipulator control problems, Linear control schemes, Characteristic of the second order linear system, Linear second order SISO model of a manipulator joint, Model of a DC motor, Partitioned PD control scheme, Effect of an external disturbance, PID control scheme, Computed Torque Control, Force control of Robotic Manipulator,

10 Hours

Mapping of POs & COs:

POs / Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
1	H	H	H	L	M	M			L			H	L	M
2	H	H	H	L	H	M			L		L	H	L	H
3	H	H	H	L	M	M			L		L	H	M	M
4	H	H	H	L	M	L			L		L	H	L	M
5	H	H	H	M	M	M			L		L	H	L	M

L: Low M: Medium H: High

Text books

1. Robotics and Control , R K Mithal and I J Nagrath , McGraw Hill
2. IntroductiontoRoboticsAnalysis-Niku,S.B.,Systems,Applications,PearsonEducation,2008.

Reference books

1. **IntroductiontoRobotics: MechanicaandControl-2ndEdition-**Craig,J.J.,Addison-Welsey,2nd edition1989.
2. **FundamentalsofRobotics,AnalysisandControl-** SchillingR.J.,PHI,2006.
3. **RoboticsControl,Sensing,VisionandIntelligence-** Fu, K,S.,GonzalezR.C.,LeeC.S.G.,McGraw Hill,1987.

Scheme of Examination:

Two questions to be set from each unit and Students shall answer FIVE full questions choosing at least ONE question from each unit.

Audit Course Title: **Acoustic Emission Science and its Applications**
Total Number of hours: **26**

Unit-1

Acoustic emission fundamentals

Acoustic emission phenomenon and principle, types of acoustic emission– burst and continuous, sources of AE, **Wave propagation theory** – modes and propagation effects, AE effects and models, **AE knowledge base** – history, terminology, codes and standards, AE community and organizations, **Mechanical fundamentals** – stress, strain, material behaviour and properties. **6 Hours**

Unit-2

Acoustic emission apparatus

AE sensors – sensing materials and their properties, piezo-electricity, mounting techniques, selection for specific applications, **AE measuring devices** – types of AE systems, data analysis and displays. **5 Hours**

Unit-3

Acoustic emission examination procedure

Examination approach, sensor placement methodologies, selection of AE examination scheme, loading procedures and test types, managing background noise, results interpretation and evaluation. **5 Hours**

Unit-4

AE general applications and basic signal processing tools

AE applications - AE for real time and continuous monitoring, condition monitoring of machines, machine elements, medical implants, prosthesis, structures and industrial applications. **Basic Signal Processing techniques -** probability distribution and density, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Deterministic/random signal separation, Time-frequency analysis and Wavelet transform **5 Hours**

Unit-5

Acoustic emission case studies

Case study 1 – Analysis of Acoustic Emission Data for Bearings subject to Unbalance, **Case study 2** – Measurement of Valve Leakage Rate using Acoustic Emission, **Case study 3** – an acoustic emission technique for measuring surface roughness, **Case study 4** – Acoustic Emission Monitoring of Total Hip ArthroplastyImplants**Case study 5** – Acoustic Emission in Condition Monitoring and Diagnosis of Diesel Engine Condition.**5 Hours**

Text Books:

1. **NDE and Quality Control**, Vo.17, ASM Hand book, 9th Edition, 1989
2. **Practical Non-Destructive Testing**, Baldev Raj, T. Jayakumar, M. Thavasimuthu, Narosa Publishers.
3. **Mechanical Vibration and Shock Measurements**, Volume 2nd edition and 3rd impression, by **Jens TrampeBroch**, April 1984**Bsruel and Kjaer**, ISBN 8787355345.
4. **Robert Bond Randall Vibration-Based Condition Monitoring** – Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011.

Reference text books:

1. **Training guidelines in non-destructive Testing Techniques: Leak Testing at Level 2**, International Atomic Energy Agency, Vienna, 2012, Training Course Series 52.
2. **Acoustic Emission: Standards and Technology Update**, Issue 1353, ASTM STP 1353, Volume 1353 of ASTM special technical publication, ISSN 0066-0558, **Sotirios J. Vahaviolos**, Publisher-ASTM, 1999, ISBN 0803124988, 9780803124981.
3. **Acoustic Emission, by American Society of Testing and Materials 1972**, Publisher: ASTM International, Library of Congress Catalog Card Number: 72-75896, Printed in Baltimore, 1972.
4. **Acoustic Emission-beyond the Millennium**, by **T. Kishi, MotoichiOhtsu, Shigenori Yuyama**, Publisher: Elsevier, 2000, ISBN 0080438512, 9780080438511.

Other reference materials:

1. **Erosion-Corrosion Characterisation for Pipeline Materials Using Combined Acoustic Emission and Electrochemical Monitoring,** by Jonathan Item Ukpai,

Doctoral Thesis, The University of Leeds School of Mechanical Engineering, July 2014.

2. **Analysis of Acoustic Emission Data for Bearings subject to Unbalance**, Seyed A. Niknam, Tomcy Thomas, J. Wesley Hines, RapinderSawhney,International Journal of Prognostics and Health Management, ISSN 2153-2648, 2013 015.
3. **Measurement of Valve Leakage Rate using Acoustic Emission**, WatitKaewwaewnoi, AsaPrateepasen, PakornKaewtrakulpong, Article.
4. **An Acoustic Emission Technique for Measuring Surface Roughness**,H.L. Dunegan, December 1998, Article.
5. **Acoustic Emission Monitoring of Total Hip Arthroplasty Implants**, Geoffrey W. Rodgers, Jade L. Young, Anna V. Fields, Riki Z. Shearer, Tim. B.F. Woodfield, Gary J. Hooper, and J. Geoffrey Chase, Preprints of the 19th World Congress, The International Federation of Automatic Control, Cape Town, South Africa. August 24-29, 2014.
6. Tan ACC (2016),**How can Acoustic Emission Signals be Used inCondition Monitoring and Diagnosis of Diesel Engine Condition?** Adv AutomobEngS1: 002. doi:10.4172/2167-7670.S1-002.
7. http://www.astm.org/SNEWS/OCTOBER_2003/carlos_oct03.html
8. http://www.idinspections.com/?page_id=126