M. Tech. (Mechanical Engineering) Curriculum Structure
Specialization: Design Engineering
(w. e. f. 2015-16)

List of Abbreviations

ILE- Institute level Open Elective Course
PSMC – Program Specific Mathematics Course
PCC- Program Core Course
DEC- Department Elective Course
LLC- Liberal Learning (Self learning) Course
MLC- Mandatory Learning Course (Non-credit course)
LC- Laboratory Course

Semester I

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	ILE	1. Finite Element method 2. Mechanics of composite materials [To be offered to other programs]	3	--	--	3
2.	PSMC	Mathematical Methods in Engineering	3		--	3
3.	PCC-I	Stress Analysis	3	--	--	3
4.	PCC-II	Computer Aided Design	3	--	--	3
5.	PCC-III	Advanced Vibrations and Acoustics	3		--	3
6.	DECI	**Departmental Elective** 1. Advance machine Design 2. Design for manufacturing and assembly 3. Advance Machine tool design 4. Advance Engineering Materials 5. Robotics	3	--	--	3
7.	LC-I	Lab course	--	--	4	2
8.	MLC-I	Research Methodology	1	--	--	--
9.	MLC-II	Humanities	1	--	--	--
		Total	**20**		**4**	**20**

Semester II

Sr. No.	Course Code/Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	PCC-IV	Finite Element-Boundary Element Methods	3		--	3
2.	PCC-V	Analysis and Synthesis of Mechanisms	3		--	3
3.	PCC-VI	Fracture Mechanics	3	--	--	3
4	PCC-VII	Optimization Techniques in Design	3			3
5	DEC II	Departmental Elective II 1. Tribology in Design 2. Advanced Tool Design 3. Mechanics of composite materials 4. Multibody dynamics 5. Condition based monitoring 6. Failure Analysis	3			3
6.	LC-II	Seminar	--	--	4	2
7.	LC-III	Lab course	--		4	2
8	MLC-III	Intellectual Property Rights	1	--	--	--
9.	LLC	Liberal Learning Course	1	--	--	1
		Total	**17**		**8**	**20**

Semester-III

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	Dissertation	Dissertation Phase – I	--	--	14	14
		Total	**--**	**--**	**14**	**14**

Semester-IV

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	Dissertation	Dissertation Phase - II	--	--	18	18
		Total	**--**	**--**	**18**	**18**

M Tech (Mechanical Engineering)

Specialization: Design Engineering
Semester I

(ILE-1) Finite Element Method

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. The student will be able to classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.

2. The students will be able to develop system level matrix equations from a given mathematical model of a problem following the Galerkin weighted residual method or principle of stationary potential.

3. While demonstrating the process mentioned in 2 above, he will be able to identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an element, implement Gauss-Legendre scheme of numerical integration to evaluate integrals at element level, and assemble the element level equations to get the system level matrix equations. He will also be able to substitute the essential boundary conditions correctly and obtain the solution to system level matrix equations to get the values of the field variable at the global nodes.

4. The student will be able to state three sources of errors in implementing FEM and suggest remedies to minimize the same for a given problem, viz. Modelling errors, Approximation errors, and numerical errors.

5. The student will be able to obtain consistent and lumped mass matrices for axial vibration of bars and transverse vibration of beams and obtain fundamental frequency of natural vibration using the methods mentioned in the curricula.

6. The students will be able use MATLAB for implementation of FEM to obtain elongations at nodes of a bar subjected to traction and concentrated loads and prescribed boundary conditions

7. The students will be able to use commercial software like ANSYS or ABAQUS for

implementation of FEM to obtain stress concentration due to a small hole in a rectangular plate subjected to traction on edges and concentrated loads at points on the edges and prescribed boundary conditions.

Syllabus Contents:

Unit 1: Introduction, Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear, etc,

Unit 2: Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions,

Unit 3: Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss-Legendre scheme of numerical integration, Nodal degrees of freedom,

Unit 4: Finite element formulation, variational, weighted residual and virtual work methods, 1-D and 2-D problems from Structural Mechanics – Bar and Beam problem,

Unit 5: Plane stress and plane strain problems, Axi-symmetric problems – Axi-symmetric forces and geometry, computer implementation, higher order elements, iso-parametric formulation,

Unit 6: Eigen-value problems, Natural axial vibration of bars and transverse vibration of beams, Methods to find eigen-values and eigen-vectors.

References:

1. Chandrupatla and Belegundu "Introduction to finite elements in Engineering", Prentice Hall of India Pvt. Ltd. New Delhi, 2001.
2. Logan Deryl L., "A First Course in Finite Element Method", Thomson Brook/Cole, 3rd ed. 2002
3. Cook R.D. "Concepts and applications of finite element analysis" Wiley, New York, 1981.
4. Reddy J N, "Finite element Method", Tata McGraw Hill publishing Co Ltd, New Delhi, Ed. 2, 2003
5. Bathe K.J., Cliffs, N.J. "Finite Element Procedures in Engineering Analysis", Englewood. Prentice Hall, 1981.

(ILE-2)Mechanics Of Composite Materials

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

The student should be able to

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

Syllabus Contents:

Unit 1. Introduction

Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus

Unit 2. Basic Concepts and Characteristics

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials

Unit 3. Elastic Behavior of Unidirectional Lamina

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters

Unit 4. Strength of Unidirectional Lamina

Micromechanics of failure; failure mechanisms, Macromechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories

Unit 5. Elastic Behavior of Laminate

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

Unit 6. Hygrothermal Effects

Hygrothermal effects on mechanical behavior, Hygrothermal stress-strain relations, Hygro-thermoelastic stress analysis of laminates, Residual stresses, Warpage

Unit 7. Stress and Failure Analysis of Laminates

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials

References:

1. Isaac M. Daniels, Ori Ishai, “Engineering Mechaincs of Composite Materials”, Oxford University Press, 1994.
2. Bhagwan D. Agarwal, Lawrence J. Broutman, “Analysis and Performance of fiber composites”, John Wiley and Sons, Inc. 1990.
3. Mathews, F. L. and Rawlings, R. D., “Composite Materials: Engineering and Science”, CRC Press, Boca Raton, 2003.
4. Madhujit Mukhopadhyay, “Mechanics of Composite Materials and Structures”, University Press, 2004.
5. Mazumdar S. K., “Composaite Manufacturing – Materials, Product and Processing Engineering”, CRC Press, Boca Raton, 2002.

6. Robert M. Jones, “*Mechanics* of Composite Materials”, Taylor and Francis, Inc., 1999.

(PSMC) Mathematical Methods in Engineering

Teaching Scheme
Lectures: 3 hrs/week, Tutorial:1hr/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Students will be able to identify & solve engineering problems by applying the knowledge of differential equations.
2. Students will be able to apply statistical techniques to analyse multivariate functions.
3. To analyse and develop the mathematical model of Engineering systems.

Syllabus Contents:

Unit 1 : Introduction to Probability Theory

Probability Theory and Sampling Distributions. Basic probability theory along with examples. Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance. Some sampling distributions like $\chi 2$, t, F. **[9 Hrs]**

Unit 2 : Testing of Statistical Hypothesis

Testing a statistical hypothesis, tests on single sample and two samples concerning means and variances. ANOVA: One – way, Two – way with/without interactions. **[7 Hrs]**

Unit 3 : Ordinary and Partial Differential Equations and Concepts in Solution to Boundar Value Problems:

Ordinary linear differential equations solvable by direct solution methods; solvable nonlinea

ODE’s; First and second order partial differential equations; canonical forms; space o functions, projection of functions onto an orthogonal set; Fourier Series **[10 Hrs]**

Unit 4 : Major Equation Types Encountered in Engineering and Physical Sciences

Solution methods for wave equation, D’Alembert solution, potential equation, properties o harmonic functions, maximum principle, solution by variable separation method, hea (diffusion) equation, maximum principle for heat equation, methods for infinite and semi infinite media, Fourier and Laplace Transforms **[14 Hrs]**

Text Books :

1. Ronald E, Walpole, Sharon L. Myers, Keying Ye, *Probability and Statistics for Engineers and Scientists* (8th Edition), Pearson Prentice Hall, 2007 (for Units I & II)
2. J. B. Doshi, *Differential Equations for Scientists and Engineers*, Narosa, New Delhi, 2010 (for Units III & IV)

Reference Books :

1. Douglas C. Montgomery, *Design and Analysis of Experiments* (7th Edition), Wiley Student Edition, 2009.
2. S. P. Gupta, *Statistical Methods*, S. Chand & Sons, 37th revised edition, 2008
3. William W. Hines, Douglas C. Montgomery, David M. Goldsman, *Probability and Statistics for Engineering*, (4th Edition), Willey Student edition, 2006.
4. Advanced Engineering Mathematics (9th Edition), by Erwin Kreyszig, Wiley Indi (2013)

(PCC-I) Stress Analysis

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. Students will understand the tensorial approach of continuum mechanics and comprehend modern research material.
2. Student will learn basic field equations such as equilibrium equations, compatibility and constitutive relationship.
3. Students will be able to apply basic field equations to torsion, bending and two dimensional problems, energy methods and plastic hinges.
4. Students will be proficient in using FEM software packages with framing correct boundary conditions.

Syllabus Contents:

Unit 1:

Continuum & Tensors, Stress tensor,

Unit 2:

Displacement and strains, compatibility,

Unit 3:

Conservation Laws, Constitutive relations and Linear Elasticity,

Unit 4:

Two dimensional problems, Torsion, Bending, Energy methods,

Unit 5:

Plasticity in structures,

Unit 6:

Thick cylinders and Disks, Contact stresses

References:

1. Sadd, Martin H., Elasticity: Theory, applications and Numerics, Academic Press 2005 (Text Book)
2. Boresi, A.P. and K. P. Chong, Elasticity in Engineering Mechanics, Second Edition, John Wiley & Sons, 2000
3. Budynas, R. G. Advance strength and Applied Stress Analysis, Second Edition, WCB/ McGraw Hill 1999
4. Dally, J. W. and W.F. Riley, Experimental Stress Analysis, McGraw Hill International, Third Edition, 1991

(PCC-II) Computer Aided Design

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
2. Understand 2D, 3D transformations and projection transformations
3. Get knowledge of various approaches of geometric modeling
4. Understand mathematical representation of 2D and 3D entities

5. Understand basic fundamentals of FEM

Syllabus Contents:

Unit 1: CAD Hardware and Software, Types of systems and system considerations, input and output devices, hardware integration and networking, hardware trends, Software modules,

Unit 2: Computer Communications, Principle of networking, classification networks, network wring, methods, transmission media and interfaces, network operating systems,

Unit 3: Computer Graphics Introduction, transformation of geometric models: translation, scaling, reflection, rotation, homogeneous representation, concatenated transformations; mappings of geometric models, translational mapping rotational mapping, general mapping, mappings as changes of coordinate system; inverse transformations and mapping;

Unit 4 : Projections of geometric models, orthographic projections, Geometric Modeling, curve representation: Parametric representation of analytic curves, parametric representation of synthetic curves, curve manipulations. Surface representation,

Unit 5 : Fundamentals of solid modeling, boundary representation (B-rep), Constructive Solid Geometry (CSF), sweep representation, Analytic Solid Modeling (ASM), other representations; solid manipulations, solid modeling based applications: mass properties calculations, mechanical tolerancing, etc.

Unit 6: Finite Element Modeling and Analysis, Finite Element Analysis, finite element modeling, mesh generation mesh requirements, semiautomatic methods, fully automatic methods, design and engineering applications, System Simulation, Need of simulation, areas of applications, when simulation is appropriate tool / not appropriate, concept of a system, components of a system, discrete and continuous systems, model of a system, types of models, types of simulation approaches

References:

1. Ibrahbim Zeid, “CAD / CAM Theory and Practice”.
2. Jim Browne, “Computer Aided Engineering and Design”.

3. P. Radhakrishnan / V. Raju / S. Subramanyam, "CAD / CAM / CIM".

4. P.N. Rao, "CAD / CAM principles and applications", Tata Mcraw-Hill, 2002.

5. Rogers / Adams, "Mathematical Elements for Computer Graphics".

6. Rooney and Steadman, "Principles of Computer Aided Design", Aug. 1993.

7. Jerry Banks / John Carson / Barry Nelson / David Nicol, "Discrete-Event System Simulation"

(PCC-III) Advanced Vibrations and Accoustics

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. The students will be able to model a given vibratory system as SDOF or MDOF system, with or without damping. He would also identify the type of given base or force excitation as periodic or aperiodic. He would be able to write, mathematically, the excitations of the types such as impulse, step, ramp, half sinusoidal, or such simple arbitrary excitations.

2. The student will be able to predict response of a SDOF system, damped or undamped, subjected to simple arbitrary base or force excitations mentioned above using convolution integral; They will be able to obtain Shock Response Spectrum of SDOF systems for such excitations and understand use of the SRS.

3. The students will be able to write differential equations of motion for MDOF systems, and through the technique of decoupling and orthogonal properties of

natural modes, should be able to obtain the eigen-values and mode shapes of natural vibrations and response to harmonic and arbitrary excitations.

4. The students will be able to obtain the eigen-values and mode shapes of natural vibrations and response to harmonic excitations using orthogonal properties of natural modes.

5. Student will be able to obtain natural frequencies and mode shapes of MDOF and continuous systems using computational methods such as Rayleigh-Ritz method, Holzer method, Dunckerley's method, and Stodola's method.

6. The student should be able to obtain natural frequencies and mode shapes of MDOF and continuous systems and their response to harmonic excitation using MATLAB

7. Student will know various terminologies used in acoustics and acoustic wave transmission.

8. The student will able to derive plane and spherical wave equations, and will be able to obtain sound pressure level at a given distance from a simple sound source of known strength.

9. Students will be able to understand the mechanism of hearing by human and principles of Psychoacoustics and noise control.

10. The student will be able to measure and analyze signals received from vibrating and/or noise radiating structure by use of accelerometers, microphones and signal analyzer. They should be able to carry out FFT analysis and know the dominant frequency components in the signal and their correlation with the vibration of the structure. They should be able to identify correlation between two signals being received from two sources.

Syllabus Contents:

Unit 1

Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function

Unit 2

Multi degree of freedom systems, Free, damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors, normal modes and their properties, mode summation method, use of Lagrange's equations to derive the equations of motion,

Unit 3

Continuous Systems, Vibrations of strings, bars, shafts and beams, discretised models of continuous systems and their solutions using Rayleigh – Ritz method, Mode summation method,

Unit 4

Vibration Control, Methods of vibration control, Non-linear vibrations, Systems with non-linear elastic properties, principle of superposition, Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Dunkerley's methods, matrix iteration method for eigen-value calculations, Holzer's method,

Unit 5

Plane and Spherical acoustic waves, Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns, transmission through three media, Resonators and filters, Absorption of sound waves in fluids : Phase log between pressure and condensation, viscous absorption of plane waves, heat conduction as a source of acoustic attenuation,

Unit 6

Speech, Hearing and Noise, The voice mechanism, acoustic power output of a speech, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre, beats, aural harmonics and combination tones, masking by pure tones, masking by noise.

References:

1. Thomson W.T., "Theory of Vibrations with applications", George Allen and Unwh Ltd. London, 1981.
2. S.S. Rao, Addison, "Mechanical Vibrations", Wesley Publishing Co., 1990.
3. Leonard Meirovitch, "Fundamentals of vibrations", McGraw Hill International Edition.

4. S. Timoshenko, “Vibration problems in Engineering”, Wiley, 1974.

5. Lawrence E. Kinsler and Austin R.Frey, “Fundamentals of acoustics”, Wiley Eastern Ltd., 1987.

6. Michael Rettinger, “Acoustic Design and Noise Control”, Vol. I & II. , Chemical Publishing Co., New York, 1977.

(DECI) Advance Machine Design

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. Students will realize that creativity, manufacturability, assembly, maintainability, emotions, reliability are also important aspects of design other than finding dimensions and stresses in the highly competitive, dynamic and customer centered market.

2. Students will demonstrate the ability to identify needs of the coustomer and convert them in to technical specifications of a product.

3. Students will be able to generate different ideas after identifying the need and determining the specifications and constraints of a product for a particular purpose.

4. Students will understand the principals used while designing for manufacture, assembly, emotions and maintenance.

5. Students will know various methods of rapid prototyping the products to test and modify the designs.

6. Students will be able to design the components considering strength based reliability.

Syllabus Contents:

Unit 1 :

Development processes and organizations, Product Planning

Unit 2 :

Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing

Unit 3 :

Design for manufacture, assembly, maintenance, casting, forging,

Unit4 :

Design for Reliability, strength based reliability, parallel and series systems, robust design,.

Unit 5 :

Industrial design: Design for Emotion and experience, Introduction to retrofit and Eco design, Human behavior in design

Unit 6 : Rapid Prototyping

References:

1. George E Dieter, "Engineering Design", McGraw Hill Company, 2000.
2. Prashant Kumar, "Product Design, Creativity, Concepts and Usability", Eastern Economy Edition, PHI New Delhi. 2012
3. Woodson T.T., "Introduction to Engineering Design", McGraw Hill Book Company, 1966.
4. John J.C. "Design Methods", Wiley Inter science, 1970.
5. Averill M. Law and W. David Kelton "Simulation, modelling and analysis", McGraw Hill Book Company, 1991.
6. Pahl, G.and W.Beitz, *Engineering Design–A Systematic Approach* – Springer, 2nd Ed., 1996.
7. Product Design and development Karl T. Ulrich, Steven Eppinger

(LC-I) Lab Course

Teaching Scheme | **Examination Scheme**
Lectures: 2 hrs/week | **End sem -100**

Course Outcomes: **At the end of the course:** 1. **Students will be able to use various experimental techniques relevant to the subject.** 2. **Students will acquire hands on experience on the various test-rigs, Experimental set up.** 3. **Students will be able to function as a team member** 4. **Students will develop communication skills.** 5. **Students will be able to write technical reports.** 6. **Students will be able to use different software's.** 7. **Students will develop attitude of lifelong learning.**
Syllabus Contents: The lab practice consists of experiments, tutorials and assignments decided by the course supervisors of the program core courses and program specific elective courses.
References:

Humanities Syllabus

Teaching Scheme:
Lecture: 1.0 hour per week

Examination Scheme:
T1: 20 marks, T2: 20 marks
ESE: 60 marks

Objectives:

To appreciate and understand, with special reference to the engineering profession:

1. The development of Civilization, Culture and Social Order over the Centuries
2. The development of Technology and its impact on the Society's Culture and vice-versa, as well as the concept of Globalization and its effects.
3. The process of Industrialization and Urbanization, their positive and negative effects, like social problems, etc.

Unit 1 **(1)**

Introduction

The meaning of Humanities and its scope. The importance of Humanities in Society in general and for Engineers in particular.

Unit 2 **(6)**

Social Science and Development

Development of Human Civilization over the centuries – Society and the place of man in society – Culture and its meaning -- Process of social and cultural change in modern India -- Development of technology, Industrialization and Urbanization -- Impact of development of Science and Technology on culture and civilization -- Urban Sociology and Industrial Sociology – the meaning of Social Responsibility and Corporate Social Responsibility – Engineers' role in value formation and their effects on society.

Unit 3 **(7)**

Introduction to Industrial Psychology

The inevitability of Social Change and its effects -- Social problems resulting from economic development and social change (e.g. overpopulated cities, no skilled farmers, unemployment, loss of skills due to automation, addictions and abuses, illiteracy, too much cash flow, stressful working schedules, nuclear families etc.) – Job Satisfaction -- The meaning of Motivation as a means to manage the effects of change – Various theories of Motivation and their applications at the workplace (e.g. Maslow's Hierarchy of Needs, McGregor's Theory X and Y, The Hawthorne Experiments, etc.) – The need to enrich jobs through skill and versatility enhancement – Ergonomics as a link between Engineering and Psychology

- **References:**

1. Jude paramjit S and Sharma Satish K Ed: dimensions of social change
2. Raman Sharma. Social Changes in India;
3. Singh Narendar. (2011). Industrial Psychology. Tata McGraw-Hill: New Delhi.
4. Ram Ahuja. Social Problems in India.

M Tech (Mechanical Engineering)

Specialization: Design Engineering
Semester II

(PCC-IV) Finite Element-Boundary Element Methods

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course,

For one and two dimensional, linear, static and dynamic problems in Structural Mechanics and Heat Transfer, the student will be able to demonstrate the learning outcomes as mentioned below:

1. The student will be able to classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.
2. The students will be able to develop system level matrix equations from a given mathematical model of a problem following the Galerkin weighted residual method or principle of stationary potential.
3. While demonstrating the process mentioned in 2 above, he will be able to identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an element, implement Gauss-Legendre scheme of numerical integration to evaluate integrals at element level, and assemble the element level equations to get the system level matrix equations. He will also be able to substitute the essential boundary conditions correctly and obtain the solution to system level matrix equations to get the values of the field variable at the global nodes.
4. The student will be able to state three sources of errors in implementing FEM and suggest remedies to minimize the same for a given problem, viz. Modeling errors, Approximation errors, and numerical errors.
5. The student will be able to obtain consistent and lumped mass matrices for axial vibration of bars and transverse vibration of beams and obtain fundamental frequency of natural vibration using the methods mentioned in the curricula.
6. The students will be able use MATLAB for implementation of FEM to obtain

elongations at nodes of a bar subjected to traction and concentrated loads and prescribed boundary conditions

7. The students will be able to use commercial software like ANSYS or ABAQUS for implementation of FEM to obtain stress concentration due to a small hole in a rectangular plate subjected to traction on edges and concentrated loads at points on the edges and prescribed boundary conditions

8. The student will be able to apply principles of boundary element method to solve field problems

Syllabus Contents:

Unit 1

Introduction, steps in finite element method, discretisation, types of elements used, Shape functions

Unit 2

Linear Elements, Local and Global coordinates, Nodal degrees of freedom, Finite element formulation - variational, weighted residual and virtual work methods

Unit 3

Field problems, conduction heat transfer, electromagnetic and electrostatic fields, Quasi harmonic equation, Axisymmetric field problems, computer implementation,

Unit 4

Higher order elements, isoparametric version, Serendipity elements – Derivation of shape functions, h and p methods of improvements of accuracy, Criteria of making a choice between them , error analysis

Unit 5

Application to non-linear problems, solution to Nervier Strokes equations, phase change, radiation, temperature dependant materials, stress analysis in simple cases, axisymmetric solids, stress concentration factors,

Unit 6

Boundary element approach, numerical implementation, analyzing time domain, boundary element formulation, discretisation and matrix formulation, adaptive mesh refinement.

References:

1. Cook R.D. “Concepts and applications of finite element analysis” Wiley, New York, 1981.
2. Bathe K.J., Cliffs, N.J. “Finite element procedures in Engineering Analysis”, Englewood. Prentice Hall, 1981.
3. Desai C.S. and J.F. Abel “Introduction to the finite element method.” New York, Van Nostrand Reinhold, 1972.
4. Chandrupatla and Belegundu “Introduction to finite elements in Engineering”, Prentice Hall of India Pvt. Ltd. New Delhi, 2001.
5. O. P. Gupta, “Finite and boundary element methods in Engineering”, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2000.

(PCC-V) Analysis and Synthesis of Mechanisms

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. To develop analytical equations describing the relative position, velocity and acceleration of all moving links.
2. To select, configure, and synthesize mechanical components into complete systems.
3. Use kinematic geometry to formulate and solve constraint equations to design linkages for specified tasks.
4. Formulate and solve four position synthesis problems for planar and spherical four-bar linkages by graphical and analytical methods.
5. Analyze and animate the movement of planar and spherical four-bar linkages.
6. students will be able to apply modern computer-based techniques in the selection, analysis, and synthesis of components and their integration into complete

mechanical systems.

7. Finally Students will demonstrate ability to think creatively, participate in design challenges, and present logical solutions.

Syllabus Contents:

Unit 1

Basic Concepts; Definitions and assumptions; planar and spatial mechanisms; kinematic pairs; degree of freedom; equivalent mechanisms; Kinematic Analysis of Planar Mechanisms. Review of graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanisms, velocity-acceleration, analysis of complex mechanisms by the normal acceleration and auxiliary-point methods.

Unit 2

Curvature Theory: Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature, Ball's point, Applications in dwell mechanisms.

Unit 3

Kinematic Synthesis of planar mechanisms, accuracy (precision) points, Chebesychev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre and circle point curves, Analytical synthesis of four-bar and slider-crank mechanisms.

Unit 4

Freudenstein's equation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, three accuracy point synthesis using complex numbers.

Unit 5

Coupler Curves : Equation of coupler curve, Robert-Chebychev theorem, double points and symmetry.

Unit 6

Kinematic Analysis of Spatial Mechanisms, Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

References:

1. R.S. Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill, New York, 1980.

2. Robert L.Nortan ,"Design of Machinery',Tata McGraw Hill Edition

3. Hamilton H.Mabie,"Mechanisms and Dynamics of Machinery",John Wiley and sons New York

4. S.B.Tuttle,"Mechanisms for Engineering Design" John Wiley and sons New York

5. A. Ghosh and A.K. Mallik, “Theory of Machines and Mechanisms”, Affiliated East-West Press, New Delhi, 1988.

6. A.G. Erdman and G.N. Sandor, “Mechanism Design – Analysis and Synthesis”, (Vol. 1 and 2), Prentice Hall India, 1988.

7. A.S. Hall, “Kinematics and Linkage Design”, Prentice Hall of India.

8. J.E. Shigley and J.J. Uicker, “Theory of Machines and Mechanisms”, 2^{nd} Edition, McGraw-Hill, 1995.

(PCC-VI) Fracture Mechanics

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. Students will be able to use any one of the four parameters for finding out damage tolerance: stress intensity factor, energy release rate, J integral, Crack tip opening displacement.
2. Students will be able to manage singularity at crack tip using complex variable.
3. Students will understand important role played by plastic zone at the crack tip.
4. Students will learn modern fatigue and will able to calculate the fatigue life of a component with or without crack in it.
5. Students will learn modern sophisticated experimental techniques to determine fracture toughness and stress intensity factor.

Syllabus Contents:

Unit 1:

Modes of fracture failure, Brittle and ductile fracture,

Unit 2:

Energy release rate: crack resistance, stable and unstable crack growth.

Unit 3

Stress intensity factor: Stress and displacement fields, edge cracks, embedded cracks.

Unit 4:

Crack tip plasticity: Shape and size of plastic zone, effective crack length, effect of plate thickness, J-Integral. Crack tip opening displacement.

Unit 5:

Test methods for determining critical energy release rate, critical stress intensity factor, J-Integral.

Unit 6:

Fatigue failure: Crack propagation, effect of an overload, crack closure, variable amplitude fatigue load. Environment-assisted cracking. Dynamic mode crack initiation and growth, various crack detection techniques.

References:

1. Brook D, "Elementary engineering fracture mechanics".
2. Liebowitz H., "Fracture" Volume I to VII.
3. A Nadai, W. S. Hemp, "Theory of flow and fracture of solids", McGraw Hill Book Company, 1950.

(PCC-VII) Optimization Techniques in Design

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week, Tutorial :1hr/week	**T1, T2 – 20 marks each, End-Sem Exam - 60**

Course Outcomes:

At the end of the course:

1. Students will know the principles of optimization.
2. Students will have knowledge of algorithms for design optimization
3. Students will be able to formulate an optimization problem.
4. Students should be able to find the optimum solution of their problems using optimization techniques.

Syllabus Contents:

Unit 1:

Introduction to optimization, classification of optimisation problems, classical optimisation techniques,

Unit 2:

Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,

Unit 3:

Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods,

Unit 4:

Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.

Unit 5:

Introduction to Genetic Algorithms, Operators, applications to engineering optimization problems.

References:

1. S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York, 1985.
2. R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
3. J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
4. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2005
5. L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.
6. R.J. Duffin, E.L. Peterson and C.Zener "Geometric Programming-Theory and Applications", Willey, New York, 1967.
7. G.B. Dantzig "Linear Programming and Extensions Princeton University Press", Princeton, N. J., 1963.
8. R. Bellman "Dynamic Programming-Princeton" University Press, Princeton, N.J. 1957.

(DEC II) Tribology in Design

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	**T1, T2 – 20 marks each, End-Sem Exam - 60**

Course Outcomes:

At the end of the course:

1. The students will be able to apply theories of friction and wear to various practical situations by analysing the physics of the process.

2. They will understand the various surface measurement techniques and effect of surface texture on Tribological behaviour of a surface.
3. They will be able to select materials and lubricants to suggest a tribological solution to a particular situation.
4. The students will be able to design a hydrodynamic bearing using various bearing charts.
5. The students will be able to understand the recent developments in the field and understand modern research material.

Syllabus Contents:

Unit 1:

Friction, theories of friction, Friction control, Surface texture and measurement, genesis of friction, instabilities and stick-slip motion.

Unit 2:

Wear, types of wear, theories of wear, wear prevention.

Unit 3:

Tribological properties of bearing materials and lubricants.

Unit 4:

Lubrication, Reynolds's equation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders, infinitely long and infinitely short (narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff's solution),Finite Bearings , Design of hydrodynamic journal bearings

Unit 5:

Hydrostatic, squeeze film Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, application to journal bearings.

Unit 6:

Elasto-hydrodynamic lubrication – pressure viscosity term in Reynolds's equation, Hertz' theory, Ertel-Grubin equation, lubrication of spheres, gear teeth and rolling element bearings, Air lubricated bearings, Tilting pad bearings,

References:

1. Cameron, "Basic Lubrication Theory", Ellis Horwood Ltd, 1981.
2. Principles in Tribology, Edited by J. Halling, 1975
3. Fundamentals of Fluid Film Lubrication – B. J. Hamrock, McGraw Hill International,1994
4. D.D. Fuller, "Theory and Practice of Lubrication for Engineers", John Wiley and Sons, 1984.
5. "Fundamentals of Friction and wear of Materials" American Society of Metals.
6. Introduction to Tribology of Bearings –B. C. Majumdar, A. H. Wheeler & co. pvt. ltd 1985.
7. T.A. Stolarski, "Tribology in Machine Design".

(DEC III)Mechanics Of Composite Materials

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	**T1, T2 – 20 marks each, End-Sem Exam - 60**

Course Outcomes:

The student should be able to

1. Student will be able to understand the basic concepts and difference between composite materials with conventional materials.
2. Students will be able to understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3. Students will be able to apply knowledge for finding failure envelopes and stress-strain plots of laminates.
4. Students will be able to develop a clear understanding to utilize subject knowledge using computer programs to solve

problems at structural level.

Syllabus Contents:

Unit 1. Introduction
Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus

Unit 2. Basic Concepts and Characteristics

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials

Unit 3. Elastic Behavior of Unidirectional Lamina

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters

Unit 4. Strength of Unidirectional Lamina

Micromechanics of failure; failure mechanisms, Macromechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories

Unit 5. Elastic Behavior of Laminate

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

Unit 6. Hygrothermal Effects

Hygrothermal effects on mechanical behavior, Hygrothermal stress-strain relations, Hygro-thermoelastic stress analysis of laminates, Residual stresses, Warpage

Unit 7. Stress and Failure Analysis of Laminates

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials

References:

1. Isaac M. Daniels, Ori Ishai, "Engineering Mechaincs of Composite Materials", Oxford University Press, 1994.

2. Bhagwan D. Agarwal, Lawrence J. Broutman, “Analysis and Performance of fiber composites”, John Wiley and Sons, Inc. 1990.

3. Mathews, F. L. and Rawlings, R. D., “Composite Materials: Engineering and Science”, CRC Press, Boca Raton, 2003.

4. Madhujit Mukhopadhyay, “Mechanics of Composite Materials and Structures”, University Press, 2004.

5. Mazumdar S. K., “Composaite Manufacturing – Materials, Product and Processing Engineering”, CRC Press, Boca Raton, 2002.

7. Robert M. Jones, “Mechanics of Composite Materials”, Taylor and Francis, Inc., 1999.

(LC-II) Seminar

Teaching Scheme	**Examination Scheme**
Lectures: 1 hrs/week	**End Sem : 100**

Course Outcomes:

At the end of the course,:

1. Student should develop thought process of their own liking subject
2. Students will develop skills to present and defend their work in front of technically qualified audience.
3. Develop self learning attitude.
4. Interact with various libraries, resource persons to get information about a selected topic.
5. Be familiar with various refereed national/international journals.
6. Improve their oral and written communication skills and will be conversant with technical writing.

Syllabus Contents:

Seminar shall consists of the in depth study of a topic, related to the field of Design engineering and should have research orientation. The student should know recent developments and applications in the chosen field of study. The topic of study/research is mutually decided by the student and the supervisor and a detailed technical report will be prepared. The study is to be presented in front of the committee of examiners, faculty and students of the department. The committee of examiners is decided by the PG coordinator and the Head of the department of Mechanical engineering.

References:

(LC-III) Lab course

Teaching Scheme **Examination Scheme**

Lectures: 2 hrs/week **End-Sem Exam - 100**

Course Outcomes:

At the end of the course:

1. **Students will be able to use various experimental techniques relevant to the subject.**
2. **Students will be able to function as a team member**
3. **Students will develop communication skills.**
4. **Students will be able to write technical reports.**
5. **Students will be able to use different software's.**
6. **Students will develop attitude of lifelong learning.**
7. **Students will acquire hands on experience on the various test-rigs, Experimental set up.**

Syllabus Contents:

The lab practice consists of experiments, tutorials and assignments decided by the course supervisors of the program core courses and program specific elective courses.

References:

(MLC-III) Intellectual Property Rights

Teaching Scheme | **Examination Scheme**

Lectures: 1 hrs/week | **End-Sem Exam - 100**

Course Outcomes:

At the end of the course:

1. **Students will understand the rights of an individual towards intellectual property.**
2. **Students will know the procedure to file a national/international patent.**

Syllabus Contents:

Patent as an intellectual property right; Patent act and patent rules, patent for process, product, product-process together; jurisdiction of patent, Invention as an intellectual property, Patent offices, Submission of application for patents, Patent of addition, granted on convention application, applicants for patents, application for ordinary patents, applicant working in government, Patentable invention, Term of patent, procedure to obtain patent in India, Overview of patenting abroad.

References:

1. Manual of Patent (Practice and Procedure) Patent office, India
2. Patent law, P Narayanan, Eastern Law House Pvt Ltd, Third Edition 1998
3. Terrel on law of patents, Douglas Falconer & William Aldous & David Young

(LLC) Liberal Learning Course

Examination Scheme
End-Sem Exam – 100

Course Outcomes:

At the end of the course:

1. Improve the Students' personality.
2. Student will learn to interact with people to get inputs for the topic of their study. Student will learn to convince his point of view on a particular topic to a non cohesive group of people

Syllabus Contents:

- Student will find a topic of his interest from following broad category:
  - Music
  - Defense studies
  - Performing arts
  - Philosophy
  - Agriculture
  - Literature

M Tech (Mechanical Engineering)

Specialization: Design Engineering
Semester III

(Dissertation) Dissertation Phase-1

Teaching Scheme
Lectures: 14 hr/week

Examination Scheme
End-Sem Exam 100

Course Outcomes:

At the end of the course:

1. Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.
1. Students will be able to use different experimental techniques.
2. Students will be able to use different software/ computational/analytical tools.
3. Students will be able to design and develop an experimental set up/ equipment/test rig.
4. Students will be able to conduct tests on existing set ups/equipments and draw logical conclusions from the results after analyzing them.
5. Students will be able to either work in a research environment or in an industrial environment.

Syllabus Contents:

The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. Seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

M Tech (Mechanical Engineering)

Specialization: Design Engineering

Semester IV

(Dissertation) Dissertation Phase- II

Teaching Scheme	**Examination Scheme**
Lectures: 18 hr/week	End-Sem Exam 100

Course Outcomes:

At the end of the course:

1. Students will develop attitude of lifelong learning and will develop interpersonal skills to deal with people working in diversified field will.
2. Students will learn to write technical reports and research papers to publish at national and international level.
3. Students will develop strong communication skills to defend their work in front of technically qualified audience.

Syllabus Contents:

It is a continuation of Project work started in semester III. He has to submit the report in prescribed format and also present a seminar. The dissertation should be presented in standard format as provided by the department. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. . The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the Head and PG coordinator. The candidate has to be in regular contact with his guide.