SYLLABUS
2020
(Autonomous)

M.Tech
Machine Design

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Mar IvaniosVidya Nagar, Nalanchira, Thiruvananthapuram – 695 015

November 2020

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY THIRUVANANTHAPURAM-695015

DEPARTMENT OF MECHANICAL ENGINEERING

M. Tech in Machine Design

CURRICULUM UNDER AUTONOMY STATUS

i) Knowledge Segments and Credits

Every course of M.TechProgramme is placed in one of the seven categories as listed in table below. No semester shall have more than five lecture-based courses and two laboratory courses, and/or drawing/seminar/project courses in the curriculum.

Sl. No.	Category	Category Code	Number of Courses	Total Credits
1	Programme Core Courses	PCC	8	27
2	Laboratory Courses		2	02
3	Programme Elective Courses	PEC	4	12
4	Mandatory Credit Courses (Research Methodology)	MCC	1	02
5	Seminar	PWS	2	04
6	Mini Project		1	02
7	Project		2	18
Total Mandatory Credits				**67**

Program Core: Special Functions Partial Differential Equations and Tensors, Advanced Theory of Vibration, Continuum Mechanics, Finite Element Method, Industrial Tribology, Advanced Theory of Mechanisms, Design of Pressure Vessels and Piping and Experimental Stress Analysis.

Lab Courses: Machine Dynamics Lab, Modelling and Analysis Lab.

ii) Semester-wise Credit Distribution

Semester	***I***	***II***	***III***	***IV***	***Total Credits***
Credits for Courses	*22*	*19*	*14*	*12*	***67***

Semester I							
Slot	**Category Code**	**Course Number**	**Course Name**	L	T	P	**Credit**
A	PCC	MA0P60D	Special Functions, Partial Differential Equations and Tensors	3	0	0	3
B	PCC	ME1P60A	Advanced Theory of Vibration	3	1	0	4
C	PCC	ME1P60B	Finite Element Method	3	1	0	4
D	PCC	ME1P60C	Continuum Mechanics	3	0	0	3
E	PCC	ME1P60D	Industrial Tribology	3	0	0	3
S	MCC	MC0P60A	Research Methodology	0	2	0	2
T	PCC	ME1P68A	Machine Dynamics Lab	0	0	2	1
U	PWS	ME1P69A	Seminar -1	0	0	2	2
			Total	**15**	**4**	**4**	22

Semester II							
Slot	**Category Code**	**Course Number**	**Course Name**	L	T	P	**Credit**
A	PCC	ME1P60E	Advanced Theory of Mechanisms	3	1	0	4
B	PCC	ME1P60F	Design of Pressure Vessels and Piping	3	0	0	3
C	PCC	ME1P60G	Experimental Stress Analysis	3	0	0	3
D	PEC	ME1PXXX	Elective I	3	0	0	3
E	PEC	ME1PXXX	Elective II	3	0	0	3
T	PCC	ME1P68B	Modelling & Analysis Lab	0	0	2	1
W	PWS	ME1P69B	Mini Project	0	0	4	2
			Total	**15**	**1**	**6**	**19**

PROGRAMME ELECTIVE I

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
D	PEC	ME1P61A	Design of Power Transmission Elements	3	0	0	3
		ME1P61B	Design & Analysis of Composite Structures	3	0	0	3
		ME1P61C	Advanced Computer Graphics	3	0	0	3
		ME1P61D	Condition Monitoring & Maintenance Engineering	3	0	0	3

PROGRAMME ELECTIVE II

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
E	PEC	ME1P62A	Optimization Techniques for Engineering	3	0	0	3
		ME1P62B	Acoustics and Noise Control	3	0	0	3
		ME1P62C	Advanced Finite Element Methods	3	0	0	3
		ME1P62D	Robotics	3	0	0	3

SEMESTER III							
Slot	**Category Code**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
A	PEC	ME1PXXX	Elective III	3	0	0	3
B	PEC	ME1PXXX	Elective IV	3	0	0	3
T	PWS	ME1P79A	Seminar II	0	0	2	2
W	PWS	ME1P79B	Project (Phase I)	0	0	12	6
		Total		**6**	**0**	**14**	**14**

PROGRAMME ELECTIVE III

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
A	PEC	ME1P71A	Advanced Numerical Methods	3	0	0	3
		ME1P71B	Advanced Non Destructive Evaluation	3	0	0	3
		ME1P71C	Advanced Design Synthesis	3	0	0	3
		ME1P71D	Mechatronics System Design	3	0	0	3
		ME1P71E	Computational Plasticity	3	0	0	3

PROGRAMME ELECTIVE IV

Slot	Category Code	Course Number	Course Name	L	T	P	Credit
B	PEC	ME1P72A	Theory of plates and shells	3	0	0	3
		ME1P72B	Mechanical Behaviour of Materials	3	0	0	3
		ME1P72C	Computational Methods in Design and Manufacturing	3	0	0	3
		ME1P72D	Advanced Vehicle Dynamics	3	0	0	3
		ME1P72E	Control System	3	0	0	3
		ME1P72F	Fracture Mechanics	3	0	0	3

SEMESTER IV							
Slot	**Category Code**	**Course Number**	**Course Name**	**L**	**T**	**P**	**Credit**
W	PWS	ME1P79C	Project (Phase II)	0	0	24	12
			Total	**0**	**0**	**24**	**12**

SEMESTER – 1

Syllabus and Course Plan

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
MA0P60D	SPECIAL FUNCTIONS, PARTIAL DIFFERENTIAL EQUATIONS AND TENSORS	PCC	3	0	0	3	2020

i) Course Objectives: The objective of this course is

1. To familiarize the students with integral equations, its formation and application
2. To introduce basic concepts of Tensors
3. Equip the Students with a thorough understanding of alternative methods of solving PDE's
4. To familiarize with methods of solution of special functions and its application to Engineering problems.
5. To equip with the different methods of numerical solution of partial differential equations

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO1	Solve integral equations by different methods
CO2	Apply properties of special functions in appropriate problems.
CO3	Classify and solve Partial differential equations
CO4	Apply numerical procedures to solve Partial Differential Equations in Design problems
CO5	Apply the concepts of tensors to solve engineering problems

iii) SYLLABUS

Vector calculus-Green's theorem- Stoke's Theorem and divergence Theorem. Tensor calculus-Eigen vectors of tensors-integral equations-transform method. Partial differential equations-D-Alembert's method-canonical form-PDE in polar coordinates-special functions. Bessel and Legendre functions. Numerical solution of partial differential equations.

iv) REFERENCES:

1. Erwin Kreyzig, Advanced Engineering Mathematics, Wiley publications 2014.
2. Rutherford Aris , Vector, Tensors and Basic Equations of Fluid Mechanics – (Dover Publications)
3. David Kay, Schaum's outline of Tensor Calculus, Schaum's outline series, 1988.
4. A. J. McConnell , Applications of Tensor Analysis , Dover Books on Mathematics, 2011.
5. John Henry, Introduction to Tensor Calculus and Continuum Mechanics, Heinbockel, Trafford Publishing 2001
6. Santhi swaroop, Integral equations, Krishna Prakash media

7. Dr. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2017.
8. K. Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India, 2011.

v) COURSE PLAN

Module	Contents	No. of hours
I	Vector calculus: An introduction to vector calculus -gradient, divergence, curl -green‘s theorem, Divergence theorem, Stokes theorem	**7**
II	Tensor calculus: Transformation of coordinates- Kronecker delta-contravariant tensor-tensor of high order-symmetric and skew symmetric tensors Metric tensor-contraction of a tensor- Christoffel symbols-transformation of Christoffel symbols	**7**
III	Integral Equations: Formation of Volterra and Fredhlom integral equations, solution of integral of equation of 2nd kind by transform methods, convolution type, method of successive approximation and iterative method.	**8**
IV	Partial differential equations: Classification of PDE-Parabolic, elliptic and hyperbolic equations. -reduction to Canonical form, Solution of partial differential equations using Laplace Transform Method.	**7**
V	Special functions: Beta, Gamma functions, Bessel functions-recurrence relation, generating functions, Legendre’s equations and Legendre’s Polynomials – recurrence relation and orthogonality property.	**8**
VI	Numerical solutions of PDE, derivations of finite difference approximations – Leibmann’s iterative method for the solution of Laplace’s and Poisson’s equation. Numerical solutions of parabolic PDE – Schmidt method, Bendre- Scmidt method, Crank- Nicolson method. Numerical solution of Hyperbolic PDE.	**8**
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60A	ADVANCED THEORY OF VIBRATIONS	PCC	3	1	0	4	2020

i) Course Objectives:

The objective of this course is

1. To understand the principles of vibration theory
2. To introduce techniques for solving vibration problems.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Develop differential equations of motion of a vibrating system.
CO2	Determine the natural frequencies and response to free vibrations and to external periodic forces in single degree of freedom systems.
CO3	Calculate the parameters of an undamped vibration absorber
CO 4	Conduct modal analysis in multi degree of freedom systems.
CO 5	Determine the free vibration response of continuous systems.

iii) SYLLABUS

Analysis of un-damped, damped, free and forced SDOF systems.

Transients, non-periodic excitation of Single DOF systems.

Two degree of freedom systems -dynamic vibration absorbers.

Multi-degree freedom system Matrix formulation. Lagrange's equation

Matrix Iteration, Holzer method.

Vibration of continuous system. Approximate numerical methods.

iv) REFERENCES:

1. Leonard Meirovitch, Elements of Vibrations Analysis, Tata McGraw Hill - 2007
2. Thomson W.T, Theory of Vibration with Applications, Pearson Education; 5 Edition, 2008.
3. S. Graham Kelly, Mechanical Vibrations, Schaum's Outline Series, Tata McGraw Hill 2011 Special Indian Edition
4. S.S Rao, Mechanical Vibrations, Pearson Education India; Sixth edition, 2018.
5. Den Hartog, J P, Mechanical Vibrations, McGrawHill, 1956.
6. V. P. Singh, Mechanical Vibrations, Dhanpat Rai & Company Pvt. Ltd. 2014 - 3rd Edition

v) COURSE PLAN

Module	Contents	No. of hours
I	Oscillatory motion – Periodic motion- Analysis of un-damped, damped, free vibration- Logarithmic decrement –Introduction to harmonically excited vibrations-Numerical problems Forced Vibration- magnification factor – Rotating and revolving unbalance – Base excitation – transmissibility – Vibration isolation-Structural damping- Numerical problems	10
II	Transients – non periodic excitation of Single DOF systems – Impulse excitation- Convolution Integral – Laplace Transform- Shock response spectrum Two degree of freedom systems – normal modes and natural frequencies – Principal co-ordinates –co-ordinate coupling - dynamic vibration absorbers – Vibration Damper- Numerical problems	9
III	Introduction to multi-degree freedom system- Matrix formulation- Influence coefficients- Flexibility and stiffness-Orthogonality of Eigen vectors Lagrange's equation – Generalized co-ordinates- Virtual work – Derivation of Lagrange's equation- Mode summation	9
IV	Eigen Value problem-– Eigen value and Eigen vectors. Frequency mode shape -Modal analysis. Matrix Iteration– Stodola–and Sweeping methods-Cholesky Decomposition. – Jacobi diagonalisation- Numerical problems	8
V	Vibration of continuous system-Transverse vibration of strings-Longitudinal vibration of Rods- Numerical problems Torsional vibration of Rods- Euler Equation for beams- Numerical problems	12
VI	Approximate numerical methods- Dunkerley's method - Rayleigh method – Rayleigh –Ritz method- Holzer procedure for lumped masses. Introduction to Transfer matrices.- MATLAB program for torsional systems.	12
	Total hours	**60**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60B	FINITE ELEMENT METHOD	PCC	3	1	0	4	2020

i) Course Objectives:

The objective of this course is

1. Basic understanding of FEA.
2. Preprocessing, solution and post processing
3. Discretization of solution domain into a finite element mesh
4. Assembly of element equations and boundary condition
5. Solution for nodal unknowns and derived quantities over each element
6. Finite element mesh refinement and convergence.
7. Implementation and application of FEM in 1-D, 2-D and 3D static and dynamic structural analysis and heat conduction

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain the fundamental ideas of the FEM like meshing, solution and post processing
CO 2	Develop suitable FE models for the analysis of structural problems
CO 3	Apply various numerical methods for solving FE models
CO 4	Use commercial FE software efficiently and effectively

iii) SYLLABUS

Matrix algebra in FEM, Methods of solution of simultaneous equations, Basic concepts of FEM, Virtual work and variational methods.

Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations (Stiffness matrix, load vectors).

Development of Euler beam equations, Frame and grid equations, Transformation of coordinates.

Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r).

Development of the Plane Stress and Plane Strain Stiffness Equations. Practical Considerations in Modeling, Interpreting Results and Examples of Plane Stress/Strain.

Axisymmetric Elements, Natural coordinates systems.

Structural Dynamics, Mass matrix computation, Evaluation of eigen values and eigen vectors.

iv) References:

1. David V Hutton, Fundamentals of FEM, Mc GrawHill, July 2003
2. Reddy J N, An introduction to the Finite Element Method, January 2005.
3. S S Rao, The Finite element methods in engineering, Butterworth-Heinemann; 3 Edition, 1998.
4. Zeinkiewicz O. C., The Finite Element Method, Butterworth-Heinemann Ltd. 2000.
5. Lary J Segerlind, Applied finite element analysis, Wiley publications, 1984.

v) COURSE PLAN

Module	Contents	No. of hours
I	Matrix algebra in FEM, Methods of solution of simultaneous equations, Basic concepts of FEM, Virtual work and variational methods. Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations (Stiffness matrix, load vectors)	**9**
II	Development of Euler beam equations, Frame and grid equations, Transformation of coordinates. Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r)	**9**
III	Development of the Plane Stress and Plane Strain Stiffness Equations Practical Considerations in Modelling, Interpreting Results and Examples of Plane Stress/Strain Analysis	**9**
IV	Development of the CST, Linear-Strain Triangle equations, Method of weighted residuals (Galerkin), Boundary conditions (Neumann, Dirichlet and Robin), Plate Bending Element	**9**
V	Axisymmetric Elements, Natural coordinates systems, Isoparametric Formulation Numerical integration, Full and reduced integration Three-Dimensional Stress Analysis, Lagrange and Serendipity Elements.	**12**
VI	Structural Dynamics, Mass matrix computation, Evaluation of eigen values and eigen vectors, Modal space, Transient analysis: Euler's method, Central difference technique, Critical time step, Rigid body modes. Newton Raphson method for solving nonlinear differential equations.	**12**
	Total hours	**60**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60C	CONTINUUM MECHANICS	PCC	3	0	0	3	2020

i) Course Objectives:

Goal of this course is to develop a systematic and in-depth understanding of the principles of continuum mechanics

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Apply the vector and tensor manipulations in Cartesian and curvilinear coordinate systems
CO 2	Explain the principles of continuum mechanics comprehensively.
CO 3	Solve continuum problems conversant with physical laws and analytical tools such as tensor calculus .
CO 4	Explain the application of continuum mechanics for viscoelastic materials and fluids.

iii) SYLLABUS:

Introduction to continuum Mechanics. Concept of tensors Algebra and calculus of tensors.

Traction and stress, Spherical and deviatoric stresses. Octahedral stress, Stress transformation.

Kinematics and strain - Lagrangian and Eulerian descriptions of motion; Material and spatial derivatives Strain Transformation Principal strains. Saint Venant strain compatibility equations.

Balance Laws, Reynold's transportation theorem. Lagrangian and Eulerian forms of equation for mass balance. Continuity equation; Balance of linear momentum equation; Equilibrium equations; Balance of angular momentum.

Constitutive relations - Invariance of constitutive equations; Generalized Hooke's law for isotropic materials in indicial and matrix forms.

Uni axial tension and pure bending of a beam. Torsion formulation. Continuum mechanics for viscoelastic materials and fluids.

iv) References:

1. G. Thomas Mase, George E. Mase, Ronald E. Smelser. Continuum mechanics for engineers 3rd ed CRCPress, 2009.

2. Lawrence E. Malvern. Introduction to the Mechanics of a Continuous Medium – PrenticeHall, 1977.
3. J.H. Heinbockel, Introduction to Tensor Calculus and Continuum Mechanics – OpenSource, 2001.
4. W. Michael Lai, David Ribin, Erhard Kaempl, Introduction to Continuum Mechanics 4th Ed., Butterworth-Heinemann, 2009.
5. J. N. Reddy, An Introduction to Continuum Mechanics with applications - Cambridge University Press, 2007.
6. Y. C. Fung, A First Course in Continuum Mechanics for Physical and Biological Engineersand scientists - PrenticeHall
7. Han-Chin W, Continuum mechanics and plasticity - CRCPress
8. Sudhakar Nair, Introduction to Continuum Mechanics – Cambridge Universitypress
9. Morton E. Gurtin, An introduction to continuum mechanics, AcademicPres
10. S.P. Timoshenko, J.N. Goodier, Theory of Elasticity, 3rd Edition, McGraw HillPublishing

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to continuum mechanics – concept of continua in solid- and fluid mechanics – evolution, relevance and scope of the subject. Mathematical preliminaries - Index notation, Einstein's summation convention, Kronecker delta and Levi-Civita symbols, Matrix algebra, Cayley Hamilton theorem. Concept of tensor - Vector space- Inner product space- Cartesian basis- Tensor as a linear transformation- Vector as a first order tensor- Second order tensor expressed as a dyad- Dyadic product- Components of a tensor- Coordinate transformation of vectors and tensors- Principal values, trace and invariants- Orthogonal and isotropic tensors- Symmetric and anti symmetric tensors- Spherical and deviatoric tensors Algebra and calculus of tensors - Dot and cross products, scalar triple product, tensor product, inverse, contraction - Gradient, divergence and curl of vector and tensor fields - Gauss' divergence and Stokes' theorems	9
II	Traction and stress - Surface tractions in reference and current configurations; Cauchy and first Piola-Kirchoff stress tensors; Cauchy stress components along orthonormal basis vectors; Components of Cauchy stress vector on any plane. Principal stress components- Principal planes; Principal coordinate system; Normal and shear stresses; Spherical and deviatoric stresses; Octahedral stress; Stress transformation; Mohr's circle for 3D and 2D stresses.	7

III	Kinematics and strain - Continuum body; Reference and current configurations; Lagrangian and Eulerian descriptions of motion; Material and spatial derivatives; Displacement, velocity and acceleration fields Extension of a line element; Deformation gradient tensor; Displacement gradient tensor; Nanson's formula Polar decomposition theorem; Right and left Cauchy Green tensors; Infinitesimal deformation theory; Linearized strain; Infinitesimal rotation; Rate of deformation gradient, velocity gradient and spin tensors; Determinant of deformation gradient Geometric interpretation of small deformation theory; Strain transformation; Principal strains; Saint Venant strain compatibility equations	7
IV	Balance Laws - Reynold's transportation theorem; Localization theorem; Deformation of a volume element; Lagrangian and Eulerian forms of equation for mass balance Continuity equation; Balance of linear momentum equation; Equilibrium equations; Balance of angular momentum; Symmetry of stress tensor; Law of conservation of energy; Principle of virtual work	6
V	Constitutive relations - Invariance of constitutive equations; Material frame indifference; Linear elasticity; Material symmetry; Independent constants in the 4th order elasticity tensor for anisotropic, monoclinic, orthotropic and transversely isotropic materials. Generalized Hooke's law for isotropic materials in indicial and matrix forms; Lame's constants, Young's modulus, Poisson's ratio and Bulk modulus, Beltrami-Michell compatibility equations; Navier's equations. 2D formulation of field equations; Airy's stress function; Biharmonic equation	8
VI	Uni axial tension and pure bending of a beam; End loaded cantilever; Polar coordinates; Axisymmetric formulation; Lame's thick cylinder problem; Quarter circle cantilevered beam with radial load; Uniaxially loaded large plate with a small circular hole. Torsion formulation; Torsion of a solid elliptical shaft; Torsion of a cylinder with equilateral triangular section; Overview about the application of continuum mechanics for viscoelastic materials and fluids.	8
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60D	INDUSTRIAL TRIBOLOGY	PCC	3	0	0	3	2020

i) Course Objectives:

Goal of this course is to develop the essential knowledge both practical and theoretical in the field of tribology.

ii) Course outcomes:

After the completion of the course, the student will be able to:

CO 1	Explain the principles of friction, wear and lubrication.
CO 2	Explain different methods of surface roughness and wear measurements
CO 3	Explain the mechanism of lubrication and criteria for selection for lubricants
CO 4	Design hydrodynamic, hydrostatic and antifriction bearings

iii) SYLLABUS

Introduction to Tribology: Origins and significance Nature of surfaces-Physico-chemical characteristics of surface layers- Analysis of surface roughness- Measurement of surface roughness.

Friction: Types of friction, dry-boundary and fluid laws of friction and friction theories. Variables in friction Surface cleanliness effect of pressure, velocity, temperature, vibration etc.

Wear, Classification Running in wear theories of wear, stages of wear. Types of wear mechanisms- adhesive and abrasive wear- factors affecting wear. Lubrication.

Bearings- classification and applications- Selection of bearings. Petroff's equation friction and power loss-ideal and real bearings – leakage factors, Sommerfield number and design charts

Hydrostatic bearings: Analysis of oil pads, hydrostatic step bearings- Rolling element bearings: Types - static and dynamic capacities-bearing life, Stribeck's equation, cyclic loading, Selection of bearings.

iv) References:

1. Radzimovsky, Theory of lubrication of bearings, The Donald Press Company, London 1959.
2. Fuller D.D: Theory and practice of lubrication for Engineers – John Willey& Sons, Inc.1966.

3. Bharat Bhusan, Introduction to Tribology- John Wiley & Sons,Inc. 2002.
4. Khonsari and Booser, Applied Tribology: Bearing Design and Lubrication,Wiley, 2017.
5. Principles of Lubrication – A Cameron, Longman's Green Co.Ltd, 1966.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Tribology- Origins and significance of Micro/Nanotribology – tribological parameters like friction, wear and lubrication. Nature of surfaces-Physico-chemical characteristics of surface layers- Analysis of surface roughness- Measurement of surface roughness- Measurement of real area of contact. Surface force apparatus (SFA) studies- Description of an SFA- Static, Dynamic and Shear properties of molecularly thin liquid films- Description of Atomic force microscope (AFM) and Friction force Microscope (FFM)-Friction and adhesion-Atomic scale friction- Microscale friction - Nanoscale wear - Microscale scratching - Microscale wear.	**8**
II	Friction: Types of friction-dry-boundary and fluid-laws of friction and friction theories-Tomlinson hypothesis, Bowden and Tabor theory. Friction of metals, ceramic materials and polymers-Variables in friction – Surface cleanliness – effect of pressure, velocity, temperature, vibration etc.	**7**
III	Wear – Classification – Running in wear-theories of wear- stages of wear-Types of wear mechanisms- adhesive and abrasive wear- factors affecting wear. Types of particles present in wear debris. Wear of materials. Tests and Instrumentation in Tribology. Sliding friction and wear abrasion test, rolling contact and fatigue test, solid particle and erosion test, Corrosion test.	**7**
IV	Lubrication: Role of lubrication- Lubricants-selection of lubricants-Importance of viscosity and methods for measuring viscosity- fundamentals of viscous flow through capillary tube–flow between parallel pates -radial flow between parallel circular plates Flow between parallel pates -radial flow between parallel circular plates, Squeeze film lubrication –Reynolds's equation	**7**
V	Bearings- classification and applications- Selection of bearings. Hydrodynamic bearings: Journal bearings eccentricity-pressure distribution–attitude angle, load carrying capacity, Petroff's equation-friction and power loss-ideal and real bearings – leakage factors-Sommerfield number and design charts Oil flow and heat dissipation in bearings- Analysis of hydro thrust bearings – Fixed and pivoted shoe bearings.	**8**

VI	Hydrostatic bearings: Analysis of oil pads-hydrostatic step bearings-hydrostatic thrust bearing with shoes. Role of restrictors- bearing materials and lubricants. Rolling element bearings: Types - static and dynamic capacities-bearing life–Stribeck's equation- cyclic loading Selection of bearings– lubrication, mounting of bearings.	**8**
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
MC0P60A	RESEARCH METHODOLOGY	MCC	0	2	0	2	2020

i) COURSE OBJECTIVES:

Goal of this course is to prepare the student to do the M. Tech project work with a research bias. The student will be able to formulate a viable research problem, do a critical analysis of publications in the area of research, and identify the appropriate research methodology. The student will be able to write a technical paper based on the project findings.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Discuss research ethics
CO 2	Explain Citation, Impact factor and Plagiarism.
CO 3	Explain the need for promoting IPR among students and engineers.
CO 4	Explain that IPR helps to foster research work, leading to creation of improved products, thus helping in economic growth and social benefits.
CO 5	Explain research problem formulation.
CO 6	Analyze research related information
CO 7	Explain how to write a technical paper

iii) SYLLABUS

Introduction to Research Methodology- Meaning of research, types of research, research problem- scope-objectives, data collection and analysis, literature review.

Ethical issues- Research ethics, Plagiarism, Effective technical writing.

Developing a Research Proposal, Format of research proposal-presentation-assessment by a review committee.

Copy right-royalty-Intellectual property rights and patent law, Patents, Designs, Process of Patenting and Development, Procedure for grant of patents.

Scope of Patent rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications. Administration of Patent system- Biological systems- Computer software.

iv) REFERENCES:

1. Stuart Melville and Wayne Goddard, *Research methodology: an introduction for science & engineering students.*

2. Wayne Goddard and Stuart Melville, *Research Methodology: An Introduction*.
3. Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners*.
4. Halbert, *Resisting Intellectual Property*, Taylor & Francis Ltd, 2007.
5. Mayall, *Industrial Design*, McGraw Hill, 1992. Niebel, “Product Design”, McGraw Hill, 1974.
6. Asimov*, Introduction to Design*, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, *Intellectual Property in New Technological Age*, 2016.
8. Ramappa T.*, Intellectual Property Rights under WTO*, S. Chand, 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Research Methodology: Motivation towards research, Types of research. Professional ethics: Ethical issues -ethical committees. Copy right - royalty - Intellectual property rights and patent law - Reproduction of published material - Plagiarism. New developments in IPR of Biological Systems, Computer Software etc. Citation and acknowledgement, Impact factor. Identifying major conferences and important journals in the concerned area.	6
II	Defining and formulating the research problem -Literature Survey, Choose two papers in the area and analyze to understand how the authors have undertaken literature review, identified the research gaps, developed the objectives, formulated their problem and developed a hypothesis.	5
III	Research design and methods: Analyze the chosen papers to understand formulation of research methods, both analytical and experimental methods.	5
IV	Data Collection and analysis: Analyze the chosen papers and study the methods of data collection, data processing, analysis strategies, and tools used for analyzing the data.	5
V	Technical writing - Structure and components, contents of a typical technical paper, difference between abstract and conclusion, layout, illustrations and tables, bibliography, referencing and footnotes.	4
VI	Identification of a simple research problem, Literature survey - Research design, Methodology paper writing based on a hypothetical result.	5
	Total hours	**30**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P68A	MACHINE DYNAMICS LAB	PCC	0	0	2	1	2020

i) Course Objectives:

The goal of the course is to make the students

1. Aware of the experimental analysis of critical speed of shafts.
2. Aware of the MATLAB/ Pythonsoftware for vibration analysis.
3. Aware of the experimental modal analysis in structures.

ii) Course Outcomes

After the completion of the course, the student will be able to:

CO 1	Experimentally determine the critical speed of shafts under different end conditions.
CO 2	Conduct experimental modal and harmonic analysis in structures.
CO 3	Experimentally determine the sloshing frequency.
CO 4	Experimentally evaluate the effect of gyroscopic couple.
CO 5	Explain the role of Tribometer in the study of friction and wear
CO 6	Conduct modal analysis of discrete and continuous parameter systems using softwares

iii) SYLLABUS:

Experimental determination of critical speed and gyroscopic effect. Experimental determination of natural frequencies of systems. Determination of mode shapes using accelerometers, impact hammers and data acquisition system. Estimation of sloshing frequency. Use of softwares to conduct modal analysis and harmonic analysis of structures. Study of Tribometer.

iv) References:

1. Sujatha C, Vibrations and Acoustics: Measurement and Signal Analysis, Tata McGraw Hill Education Pvt. Ltd., 2009.
2. Anders Brandt, Noise and Vibration Analysis: Signal Analysis and Experimental Procedures, Wiley; 1st edition, 2011.
3. Sujatha C, Vibration, Acoustics and Strain Measurement - Theory and Experiments, AneBooks Pvt Ltd, 2020.
4. Rudra Pratap, Getting Started with MATLAB, Oxford University Press, Seventh edition, 2019.
5. Martin C. Brown, Python: The Complete Reference, McGraw Hill Education; Fourth edition, 2018.

v) COURSE PLAN:

	Experiment	Main equipment required
1	Determination of critical speed of a shaft under varying conditions	Whirling shaft apparatus
2	Determination of Velocity of precession and gyroscopic couple.	Motorized Gyroscope
3	Study of free and forced vibration using universal vibration machine	Speed controller, motor ,disc, tachometer, spring, damper, drum.etc.
4	Estimation of damping of beam specimen for different damping treatments.	Beam specimen of Steel, Viscoelastic material for attachments, Accelerometer, Charge amplifier, Oscilloscope
5	To find the natural frequencies and mode shapes of a free-free beam experimentally and verify the same analytically	Vibration exciter, free-free beam, Oscilloscope, Amplifier, laser displacement meter
6	Determination of natural frequencies and mode shapes of a free-free plate.	Accelerometer, Oscilloscope, Exciter, plate, Labview sound and vibration tool kit
7	Estimation of sloshing frequency in a liquid filled tank	Sloshing apparatus
8	Study of friction and wear	Pin on Disc Tribometer
9	Determine the frequency of a discrete vibration model under free and forced condition.	MATLAB/Python

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P69A	Seminar-I	PWS	0	0	2	2	2020

i) COURSE OBJECTIVES:

Goal of this course is to prepare the student to identify the current topics in the specific stream. The student will be able to collect recent publications related to identified topics, do a detailed study, present a seminar on the selected topic and submit a technical report.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Identify promising new directions of various cutting edge technologies
CO 2	Organise information after the study of research papers related to the branch of study
CO 3	Develop effective written and oral communication

SEMESTER – 2

Syllabus and Course Plan

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60E	ADVANCED THEORY OF MECHANISMS	PCC	3	1	0	4	2020

i) Course Objectives:

The goal of this course is to develop the problem solving skills in the area of kinematics of different mechanisms, synthesis and design of mechanisms and dynamic analysis.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Analyze the velocity and acceleration in mechanisms.
CO 2	Select and design mechanisms for specific motions and other Applications.
CO 3	Design cams and analyze its dynamic effects.
CO 4	Model the dynamics of moving members in the machinery and design appropriately.

iii) SYLLABUS:

Planar Kinematics of Rigid Bodies: Velocity and acceleration relationships for two points in a rigid link - Slider-crank mechanisms, four bar linkages. Graphical approach to velocity and acceleration in mechanisms. Brief introduction to complex Mechanisms.

Curvature Theory: Instantaneous centre or Pole, centrode or polode, polode curvature, collineation axis, radius of curvature. The Euler-Savary equation, the inflection circle, Hartmans construction, Bobillier constructions

Four-bar coupler-point curves; Equation of coupler curves, The Roberts-Chebychev Theorem and cognate linkages.

Synthesis of mechanisms: The four-bar linkage, Two and Three Position Design. Design of slider crank and double lever mechanisms

Cam Dynamics: Acceleration and Jerk. Analysis of eccentric cam, effect of sliding friction, Analysis of disc cam with reciprocating roller follower. Cam force analysis.

Dynamics: Plane motion of rigid bodies using the principle ofimpulse and momentum. Kinetics of rigid bodies in three dimensions.

Motion of a rigid body in three dimensions. Euler's equation of motion.

iv) References:

1. John J. Uicker, Gordon R. Pennock & Joseph E. Shigley, Theory of Machines and Mechanisms, Oxford University Press, 4th edition, 2014.
2. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education, 4th edition, 2012.
3. Richard S. Hartenberg, Jacques Denavit, Kinematic synthesis of Linkages, McGraw Hill book company 1964.
2. Allen S. Hall, Kinematics and linkage design, Prentice Hall of India, Ltd 1986.

v) COURSE PLAN

Module	Contents	No. of hours
I	Planar Kinematics of Rigid Bodies: Velocity and acceleration relationships for two points in a rigid link -Vector approach, two- coordinate system approach for velocity and acceleration, applied to planar mechanisms: Slider-crank mechanisms, four bar linkages. Graphical approach to velocity and acceleration in mechanisms. Brief introduction to complex mechanisms	9
II	Curvature Theory: Instantaneous centre or Pole, centrode or polode, polode curvature, collineation axis, radius of curvature. The Euler-Savary equation, the inflection circle, Hartmans construction, Bobillierconstructions,thecubicofstationarycurvature.Designbasedon the above.	9
III	Four-bar coupler-point curves: Equation of coupler curves, circle of foci, multiple points, imaginary points, asymptote. Singular foci, double points and symmetry, cusp, crunode, symmetry. The Roberts-Chebychev Theorem and cognate linkages.	9
IV	Cams:Polydyne cams: Cam Dynamics: Acceleration and Jerk. Analysis of eccentric cam, effect of sliding friction, Analysis of disc cam with reciprocating roller follower. Analysis of elastic cam systems, follower response: Phase-plane method, Johnson‘s numerical analysis .Position error, Jump and cross-over shock, unbalance, spring surge and wind-up. Cam force analysis.	9
V	Synthesis of mechanisms: The four-bar linkage, Two and Three position design. Design of slider crank and double lever mechanisms for specified input crank motion and output crank motion, Determination of minimum Transmission angle.	12

VI	Dynamics: Plane motion of rigid bodies using the principle ofimpulse and momentum. Kinetics of rigid bodies in three dimensions :-Angular momentum of a rigid body in three dimensions. Application of the principle of impulse and momentum to the three-dimensional motion of a rigid body Kinetic energy of a rigid body in three dimensions. Motion of a rigid body in three dimensions. Euler's equation of motion. Motion of a rigid body about a fixed axis. Motion of gyroscope: Eulerian angles Steady precession of a gyroscope. Motion of an axi-symmetrical body under no force	**12**
	Total hours	**60**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60F	DESIGN OF PRESSURE VESSELS AND PIPING	PCC	3	0	0	3	2020

i) COURSE OBJECTIVES:

Goal of this course is to gain knowledge of pressure vessel design, designing of piping and piping systems, and using of design codes in pressure vessel design.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO 1	Explain the various types of stress acting on pressure vessels.
CO 2	Design various types of pressure vessels using codes.
CO 3	Design support members for vessels.
CO 4	Design for buckling in pressure vessels.
CO 5	Design of pressurized fluid piping.

iii) SYLLABUS

Terminology of Pressure Vessels-

Stresses in pressure vessels

Stresses in Thick walled cylinders & Built up cylinders

Design of Tall Cylindrical Self supporting process column

Reinforcement theory

Buckling of Pressure Vessels, Design of Piping.

iv) REFERENCES:

1. John F. Harvey, Theory and Design of Pressure Vessels, CBS Publisher and Distributors
2. Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons
3. Somnath Chathopadhyay, Pressure Vessels Design and practice, C. R. C Press
4. Henry H. Bender, ‘Pressure Vessels Design hand book’
5. ASME Pressure Vessel Codes Section VIII, 2006.
6. Dennis Moss Pressure Vessel Design Manual Gulf publishing, 2003.

Design Data Book is to be permitted in the University examination.

1. P S G Data book by Faculty of Mechanical Engineering, P S G,
2. Design Data Handbook for Mechanical Engineering in SI and Metric Units by K. Mahadevan, K. Balaveera Reddy
3. Standard Pressure Vessel Design Data Handbook ref. ASME ISI IBR)

v) COURSE PLAN

Module	Contents	No. of hours
I	Pressure vessel – Terminology , Types of loads , Types of pressure Stresses in pressure vessels, Dilation of pressure vessels, Membrane stress analysis of vessel shell components Cylindrical shells, spherical shells, conical head, elliptical head, Discontinuity stresses in pressure vessels Thermal stresses	8
II	Stresses in thick walled cylinders Lame's equation, Shrinkfit stressesin Built up cylinders, autofrettage of thick cylinders, Thermal stresses and its significance	7
III	Design of vessels : Design of tall cylindrical vessels supports for short vessels, Support for horizontal vessels	8
IV	Design for wind load, design for seismic load and vibration, Theory of reinforcement, Familiarization of relevant ASME codes and standard practices	7
V	Buckling - buckling phenomenon , Elastic buckling of cylinders under external pressure Stiffeners buckling under combined compressive pressure and external load	8
VI	Piping - Pipe specification , Pipe classification Piping elements , Piping layout and piping stress Analysis , Flexibility Analysis.	7
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P60G	EXPERIMENTAL STRESS ANALYSIS	PCC	3	0	0	3	2020

i) Course Objectives:

Goal of this course is to impart to the students, the basic aspects of theory of elasticity and stress-strain relationship as well as experimental stress analysis techniques that includes the most versatile techniques like photoelasticity, strain gauges and non-destructive test (NDT) methods

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain various aspects of stress analysis and various methods employed to find out stress experimentally.
CO 2	Explain the working of various strain measurement devices.
CO 3	Compare various Non-destructive testing methods.
CO 4	Explain photoelastic methods of determining stress in materials.
CO 5	Explain the fundamentals of electrical strain measurements and the various configurations they can be used.

iii) SYLLABUS

Overview of stress analysis: Theory of Elasticity, Plane stress and plane Principal stresses and strains:– Analytical, Numerical and Experimental approaches.

Strain measurement: Strain gauges and Stress gauges.

Instrumentation: Principles of Measurement: Errors, Accuracy and Precision, Uncertainty analysis, Curve fitting

Oscillograph: Cathode Ray Oscilloscope, Transducers. Photoelasticity: The Polariscope, stress optic law Polariscope arrangements – Plane polariscope and Circular polariscope.

Dark Field and Light field, Isochromatics and Isoclinics, Introduction to three dimensional photoelasticity, Failure theories,

Crack detection, Non-destructive testing (NDT) methods. Introduction to lasers in NDT – Ultrasonic flaw detection.

iv) References:

1. J. W. Dally and W. F. Riley, Experimental Stress Analysis - McGraw Hill, 1991
2. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Experimental Stress Analysis, Tata McGraw Hill, 1984.
3. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 1996.
4. Jayamangal Prasad, C. G. Krishnadas Nair, Non-Destructive Test and Evaluation Of Materials, Tata McGraw-Hill, 2008.
5. J. P. Holman, Experimental methods for engineers, McGraw-Hill Mechanical Engineering, 2009.

v) COURSE PLAN

Module	Contents	No. of hours
I	Overview of stress analysis: Theory of Elasticity, Plane stress and plane strainconditions,compatibilityconditions,problemusingplanestress and plane strain conditions, three-dimensional stress strain relations. Principal stresses and strains. Mohr's circle-measurement of strains and stresses. Stress analysis – Analytical, Numerical and Experimental approaches.	7
II	Strain measurement: Strain gauges and Stress gauges.Mechanical, Optical and Electrical gauges- construction and applications. Variable resistance strain gauges, Gauge characteristics, Gauge sensitivity, static and dynamic strains- reduction of strain gauge data- compensation- strain measurement over long period at high and low temperature. Strain rosettes- Rectangular rosette, Delta rosette. Residual stresses: Beneficial and harmful effects. Principle of residual stress measurement- methods only. Moire Method of Strain Analysis	7
III	Instrumentation : Strain Circuits, Potentiometer Circuits ,Range and sensitivity, The Wheatstone Bridge , Sensitivity, Galvanometer, Transient response, Principles of Measurement: Errors, Accuracy and Precision, Uncertainity analysis, Curve fitting Oscillograph, Cathode Ray Oscilloscope, Transducers- Displacement, Force, Pressure, Velocity, Acceleration	7
IV	Photoelasticity : The Polariscope, stress optic law, Photo elastic model materials, Polariscope arrangements – Plane polariscope and Circular polariscope. Dark Field and Light field, Isochromatics and Isoclinics, Jones Calculus, Partial fringe value and compensation techniques. Introduction to three dimensional photoelasticity, Use of photo elastic coatings.	8
V	Brittle coatings : Coating stresses, Failure theories, Brittle coating crack patterns produced by direct loading, refrigeration, load release, Crack detection, Types of coatings, Steps in brittle coating tests, Coating selection, Surface preparation.	8

VI	Non destructive testing (NDT) methods : Types –dye penetrate methods, Radiography-X-ray and Gamma ray-X-ray fluoroscopy-Penetrameter-Magnetic particle method. Introduction to lasers in NDT – Ultrasonic flaw detection	**8**
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P61A	DESIGN OF POWER TRANSMISSION ELEMENTS	PEC	3	0	0	3	2020

i) Course Objectives:

The goal of this course is to

- To understand the various elements involved in a transmission system.
- To analyse the various forces acting on the elements of a transmission system.
- To design the system based on the input and the output parameters.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Design different power transmitting elements like Belt drives and Chain drives.
CO 2	Design different clutches and brakes.
CO 3	Design shafts subjected to different loading.
CO 4	Design different types of gears.
CO 5	Design different types of gear boxes.

iii) SYLLABUS:

Flexible Transmission Elements: Introduction to transmission systems, factors, materials selection stresses. Design of flat and V- belts, Design of chain drives.
Design of Clutches: single and multi-plate clutches and cone clutch.

Design of Brakes: Internal and external shoe brakes disk brakes-self actuating brakes fixed, link and sliding anchor drum brakes. Design of Shafts:

Design of Spur Gear: Design of Helical & Bevel Gears: Design of Worm Gear: Definitions, Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Design of Gear Boxes: Introduction, Types, Components, Progression ratio , Kinematic arrangement Ray diagram, Design of multi speed gear boxes.

Design of sliding mesh gear box, Constant mesh gear box. Synthesis of multi speed gear boxes.

iv) References:

1. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", Tata McGraw-Hill, 8th Edition, 2008.

2. R. L. Norton, Machine Design – An Integrated Approach, Pearson Education, 5th edition, 2018.
3. Robert C. Juvinall and Kurt M. Marshek, "Fundamentals of Machine Design", Wiley, 4th Edition, 2005.
4. Bernard Hamrock, Steven Schmid, Bo Jacobson, "Fundamentals of Machine Elements", 2nd Edition, Tata McGraw-Hill Book Co., 2006.
5. V. B. Bhandari, Design of Machine elements, McGraw Hill, 4th edition, 2017.

Data Book

1.Design Data Hand Book, K. Mahadevan, Balaveera Reddy, CBS publishers, 4th Revised edition, 2019.

2. Design Data – PSG College of Technology, DPV Printers, Coimbatore, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	Selection of V belts and pulleys, selection of Flat belts and pulleys Selection of Wire ropes and pulleys, Selection of Transmission chains and Sprockets. Design of pulleys and sprockets.	7
II	Design of plate clutches, axial clutches, cone clutches, internal expanding rim clutches. Brakes, internal and external shoe brakes disk brakes-self actuating brakes fixed, link and sliding anchor drum brakes.	8
III	Shafts: Design of shafts subjected to twisting moment, bending moment, combined twisting and bending moments Design of shafts subjected to fluctuating loads, design of shafts based on rigidity.	7
IV	Gear Terminology, Speed ratios and number of teeth, Force analysis, Tooth stresses, Dynamic effects, Fatigue strength, Factor of safety, Gear materials, Module and Face width-power rating calculations based on strength and wear considerations, Parallel axis Helical Gears, Pressure angle in the normal and transverse plane- Equivalent number of teeth-forces and stresses. Estimating the size of the helical gears.	7

V	Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears. Worm Gear: Merits and demerits- terminology. Thermal capacity, materials-forces and stresses, efficiency, estimating the size of the worm gear pair.	**8**
VI	Geometric progression, Standard step ratio, Ray diagram, Structural diagram, kinematics layout Design of sliding mesh gear box, Constant mesh gear box. Synthesis of multi speed gear boxes.	**8**
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P61B	DESIGN & ANALYSIS OF COMPOSITE STRUCTURES	PEC	3	0	0	3	2020

i) Course Objectives:

The goal of this course is to gain knowledge of

1. Different types of engineering materials, anisotropy, orthotropic and composite materials.
2. Composites - types, applications and mechanics .
3. Stress analysis and failure analysis of composites.
4. Basic design principles of composite structures

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain the different types of composite materials.
CO 2	Explain the mechanical behavior of layered composites compared to isotropic materials
CO 3	Apply constitutive equations to study the mechanical behavior at micro and macro levels of composite materials
CO 4	Explain the failure mechanism in composites.
CO 5	Make use of FE methods for the analysis of composite structures.

iii)SYLLABUS:

Design Classifications of Composites, Micro mechanics, Macro mechanics of laminates, Analysis based on classical laminate theory, Failure theory of laminated composites, Testing of composite materials.

iv) REFERENCES:

1. R. M. Jones, Mechanics of Composite Materials, Taylor & Francis, 2nd Edition, 2015.
2. Autar Kaw, Mechanics of Composite Materials, Taylor & Francis-India, 2nd Edition, 2006.
3. Krishan K. Chawla, Composite Materials, Science & Engg., 3rd Edition, Springer publication, 2013.
4. S.S. W. Tsai, Introduction to Composite Materials, Technomic Publication, 1986.

Data Book

1. Design Data Hand Book, K. Mahadevan, Balaveera Reddy, CBS publishers, 4^{th} Revised edition, 2019.
2. Design Data – PSG College of Technology, DPV Printers, Coimbatore, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Composite materials. Classical laminate theory - Hooke‘s law for anisotropic, monoclinic, orthotropic and transversely isotropic material. Macro mechanical behavior of a lamina. Determination of laminate mechanical properties for laminates.	8
II	Strength failure criteria- maximum stress, maximum strain criteria, Tsai Hill and Tsai-Wu theories for an angle laminate. Micromechanical behavior of a lamina- volume and mass fractions, density and void content, evaluation of elastic moduli.	8
III	Kirchhoff’s assumption, Equilibrium equations for laminated plates, buckling equations for laminated plates ,vibration equations for laminated plates Solution techniques- symmetric, antisymmeric cross ply laminates. Impact and fatigue characteristics	8
IV	Differences in fracture behviour of isotropic and composites. Type of fracture in composites- interlaminar and intralaminar fracture. Modified crack closure approach - assess the failure strength. Evaluation of fracture toughness.	7
V	Basic principles of sandwich structures, manufacturing process, sandwich local instabilities like, dimpling, wrinkling, shear crimpling, crushing. Stringer stiffened structures. Design of a sandwich plate. Design of stiffened plates.	7
VI	Types of textile weaving, 3D composite and inflatable structures, stitched composites and nano-composites. Finite element analysis of composite beam, plate/ shell type composite structures.	7
	Total hours	**45**

Course Number	Course Name	Category Code	L	T	P	Credit	Year of Introduction
ME1P61C	ADVANCED COMPUTER GRAPHICS	PEC	3	0	0	3	2020

i) Course Objectives:

Goal of the course is to make students to familiarize the mathematical concepts of advanced computer graphics techniques. It is also aimed to make students to write simple programs and simulations using C++ programming or any software tools like MATLAB.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO No	Course Outcomes
CO 1	Develop programs for simulating engineering concepts.
CO 2	Apply their aptitude in developing graphics.
CO 3	Make use of visualizing techniques for industry needs.
CO 4	Explain the background of programming softwares.

iii) SYLLABUS

Introduction to Computer Graphics; Input output devices; Geometric Transformations Coordinate Systems and Frames; Affine Transformations

Geometric Objectsand Transformations; Transformation inHomogeneous Coordinates; Concatenation ofTransformations; OpenGL Transformation Matrices; Interfaces to three dimensional applications.

Clipping; Line-segment clipping; Polygon clipping; Rasterization; Bresenham's algorithm; Polygon Rasterization; Hidden- surface removal; Antialiasing.

Interactive Mesh Displays; Parallel-projection matrices; Perspective-projection matrices; Projections and Shadows.

3D modeling techniques C++ programming,Mathematical formulation of space curves C++ programming.

iv) References:

1. Rogers, Mathematical elements of ComputerGraphics, McGraw Hill Education, July 2017.
2. Rogers, Procedural element of computerGraphics. William C Brown Pub, 1997.

3. Veera B Anand, Computer Graphics and geometric modelling for Engineers, John Wiley & Sons 1993.
4. Rudra Pratap, Getting started with MATLAB, OUP 2010.
5. StevenHarringtonComputerGraphics–AProgrammingApproach-Stev,McGraw Hill Publication 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Computer Graphics; Input output devices; Clients and Servers; Display Lists; Display Lists and Modeling. Programming Event Driven Input; Menus; Picking; A simple CAD program; Building Interactive Models; Animating Interactive Programs.	7
II	Geometric Transformations Scalars, Points, and Vectors. Three-dimensional Primitives, Coordinate Systems and Frames, Modeling a Colored Cube, Affine Transformations; Rotation, Translation and Scaling.	7
III	Geometric Objects and Transformation, Transformation in homogeneous Coordinates; Concatenation of Transformations. OpenGL Transformation Matrices; Interfaces to three dimensional applications.	7
IV	Clipping; Line-segment clipping; Polygon clipping; Clipping of other primitives; Clipping in three dimensions. I Rasterization, Bresenham's algorithm; Polygon Rasterization; Hidden- surface removal, Antialiasing.	7
V	Interactive Mesh Displays; Parallel-projection matrices; Perspective-projection matrices; Projections and Shadows.	8
VI	3D modeling techniques (Wire frame, solid modeling and surface modeling). C++ programming or Matlab coding to represent simple 3D geometric models. Mathematical formulation of space curves.(Cubic spline, and Bezier curves) C++ programming or Matlab coding to generate space curves.	9
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P61D	CONDITION MONITORING & MAINTENANCE ENGINEERING	PEC	3	0	0	3	2020

i) Course Objectives:

1. To introduce various predictive maintenance techniques
2. To familiarize the Destructive and Nondestructive testing techniques
3. Analysis and remedial of condition monitoring and maintenance of various machinery in plants

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain the causes of machinery vibration.
CO 2	Apply predictive maintenance techniques
CO 3	Analyze different condition monitoring techniques
CO 4	Plan the maintenance of industrial machinery in plants.

iii) SYLLABUS:

Introduction to condition monitoring and fault diagnosis. Machinery Failure Type and cause, Experimental modal analysis,

Vibration monitoring- Misalignment and eccentricity detection. Cavitations induced vibration in fluid machines Noise measurement,

Introduction Classification of signals Basic Measuring Equipments for Vibration, Force, Rotational speed.

Radiography Ultrasound Testing, Thermography Wear Debris Analysis, Eddy current Testing, Acoustic Emission.

Case studies of condition monitoring in Process & Manufacturing industry. Bend Pull ey Failure Analysis, Vibration measurement on a multi-stage gearbox drive set.

iv) References:

1) Amiya R. Mohanty, Machinery Condition Monitoring, Principles & Practices, CRC Press,2015.
2) Robert Bond Randall, Vibration Based Condition Monitoring, John Wile yPublication-2010.

3) R.A.Collacott, Mechanical Fault diagnosis and condition monitoring, springer 2011.
4) Condition Monitoring Manual- National Productivity Council, NewDelhi

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to condition monitoring and fault diagnosis Machinery failure, Type and cause , Frequency of failure, Bath-tub curve- Basic Maintenance strategies	7
II	Characteristics of Vibrating systems- Vibration of continuous systems, Mode shape and operational deflection shapes. Experimental modal analysis-Simple rotor disc systems and critical speed-Condition monitoring of large rotor systems	7
III	Vibration monitoring- Misalignment and eccentricity detection- Bearing fault, Gear fault, Cavitations induced vibration in fluid machines Noise measurement :Decibel scale–relationship between pressure, intensity and power – Noise source	7
IV	Introduction- Classification of signals-Frequency domain- Signal Analysis-Fourier series-Discrete Fourier Transforms Fundamentals of FFT, Auto power spectrum Frequency Response Spectrum – Basic Measuring Equipments for Vibration, Force, Rotational speed	8
V	Introduction- Radiography, Ultrasound Testing, Thermography- Wear Debris Analysis, Eddy current Testing , Acoustic Emission	8
VI	Introduction- Case studies of condition monitoring in Process & Manufacturing industry. Bend Pulley Failure Analysis, Vibration measurement on a multi-stage gearbox drive set.	8
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P62A	OPTIMIZATION TECHNIQUES FOR ENGINEERING	PEC	3	0	0	3	2020

i) Course Objectives:

The goal of this course is to

1. Appreciate the application of optimization problems in varied disciplines.
2. Model a real-world decision problem as an optimization problem.
3. Perform a critical evaluation and interpretation of analysis and optimization results.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Formulate the given problem in a mathematical format which is acceptable to an optimization algorithm.
CO 2	Explain the techniques and applications of engineering optimization.
CO 3	Apply the appropriate optimization method that is more efficient to the problem at hand.
CO4	Apply the linear and nonlinear programming methods of optimization.

iii) SYLLABUS

Introduction to Optimization: Engineering application of Optimization, Optimal Problem formulation Optimum design concepts:

Linear programming methods for optimum design, Application of LPP models in design and manufacturing.

Optimization algorithms for solving unconstrained optimization problems – Gradient based method:

Optimization algorithms for solving constrained optimization problems

iv) References:

1. S.S. Rao - Engineering Optimization, Theory and Practice - New Age International Publishers - 2012 - 4th Edition.
2. Kalyanmoy Deb, Optimization for Engineering Design Algorithms and Examples PHI – 2000.
3. Arora J. - Introduction to Optimization Design - 2nd Ed., Elsevier Academic Press, New Delhi – 2004
4. Bazarra M.S, Sherali H.D., Shetty C.M., Nonlinear Programming Theory and Algorithms, 3rd Ed., John Wiley, 2017.

5.Saravanan R. - Manufacturing Optimization through Intelligent Techniques - Taylor & Francis (CRC Press), 2017.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Formulation of optimization problems, examples Classification of optimization problems, Properties of objective function	5
II	Maxima, minima and points of inflection , Concavity and convexity of one and two variable functions, Taylor's theorem: single variable and multi variable function. Hessian matrix, Unconstrained Optimization of multi variable functions, Lagrange multiplier method	7
III	Single variable optimization: optimality criteria, Exhaustive search and dichotomous search. Region elimination methods- Fibonacci search and Golden section search, Gradient based methods- Newton Raphson method, Secant method	7
IV	Multivariable optimization: optimality criteria, Unidirectional Search, Direct search method-Simplex search method, Powell's conjugate direction method. Gradient based methods- Method of steepest ascent/ steepest descent, conjugate gradient method	7
V	Constrained optimization: Kuhn Tucker conditions, Transformation method- Penalty function method. Linearized search-Frank-Wolfe method.	7
VI	Geometric programming; Dynamic programming; Integer programming. Goal programming. Stochastic programming	12
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P62B	ACOUSTICS AND NOISE CONTROL	PEC	3	0	0	3	2020

i) Course Objectives:

The goal of this course is to

1. Understand the basic principles of acoustics
2. Understand the use and application of acoustic analysis instruments.
3. Provide detailed information on engineering noise control options and applications for specific equipment to address a variety of noise control challenges.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Illustrate sound propagation in different environments
CO 2	Analyze acoustical problems to determine the need for noise-control measures
CO 3	Design noise-control measures to solve basic noise problem
CO 4	Assess the results of acoustical measurements or calculations.
CO 5	Evaluate acoustic enclosures, barriers and walls for effective noise control

iii) SYLLABUS

Introduction: Basic Acoustic Principles - Acoustic terminology and definitions

Transmission through pipes branched and unbranched-resonators-Transmission losses

Noise measurement: Decibel scale-relationship between pressure intensity and power-sound level meter Noise analyser and graphic level recorder.

Human reaction to sound-definitions of speech interference level.

Acoustic insulation-acoustic materials acoustic filter and mufflers.

Principles of noise control in Machinery.

iv) References:

1. Harris, C.K., Handbook of Noise Control , McGraw Hill, 1979.

2. Berenek, L.L., Noise and Vibration Control , McGraw Hill, 1971.
3. Kinsler and Frey, Fundamentals of Acoustics , Wiley, 1950.
4. Petrusowicz and Longmore, Noise and Vibration control for industrialists, Elsevier, 1974.
5. Thumann and Miller, Secrets of noise control, Fairmont press, 1974.
6. Graf, Industrial noise and vibration, Prentice Hall, 1979.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Basic acoustic principles- acoustic terminology and definitions Plane wave harmonic solution. Velocity of sound in inviscid fluids relationship between wavelength-particle velocity, acceleration Energy density acoustic intensity reference standards	7
II	Transmission through one, two and three media Transmission through pipes branched and unbranched resonators Transmission loss reflection at plane surface spherical waves radiations simple source hemispherical source radiating piston pressure intensity distribution Beam width and directivity index sound absorbing materials	7
III	Noise measurement: Decibel scale relationship between pressure, intensity and power sound level meter, noise analyzer and graphic level recorder Measurement in anechoic and reverberation chambers Standing waves standing wave apparatus.	7
IV	Environmental noise control : Human reaction to sound definitions of speechinterferencelevel,perceivednoiselevel,phonandsoneetc,hearing loss principles of noise control, control at source, during transmission and at receiver- protection of receiver	7
V	Acoustic insulation acoustic materials acoustic filter and mufflers plenum chamber noise criteria and standards noise and number index guide lines for designing quieter equipments- Methods of controlling noise using baffles, coverings, perforations etc. transmission through structures control, vibration damping and other methods	9
VI	Principles of noise control in machinery such as pumps, rotating machines, reciprocating machines etc. Introduction sound design requirements of an auditorium	8
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P62C	ADVANCED FINITE ELEMENT METHODS	PEC	3	0	0	3	2020

i) Course Objectives:

The goal of this course is to summarize modern and effective finite element procedures for the nonlinear analysis of static and dynamic problems. The modelling of geometric and material nonlinear problems is discussed. Students will learn advanced topics and techniques in finite element methods and how to implement and apply these techniques to solve nonlinear systems of ordinary and partial differential equations.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Analyze Static and dynamic problems with Geometric and material nonlinearities.
CO 2	Analyse the limitations of the nonlinear FEM to avoid GIGO (Garbage In Garbage Out)
CO 3	Make use of commercial softwares for nonlinear FE programming.
CO 4	Explain the solution control options like load step, substep, time step, restart, stability of solution at bifurcation etc in commercial FE softwares.

iii) SYLLABUS

Introduction to Nonlinear Analysis, nonlinear differential equations, Basic Considerations in Nonlinear Analysis. Lagrangian Continuum Mechanics Variables for General Nonlinear Analysis, Virtual work principle and variational methods.

Formulation of Finite Element Matrices from the principles of continuum mechanics: General Nonlinear Analysis from the principles of continuum mechanics.

Two and Three-Dimensional Solid Elements; Plane Stress, Plane Strain, and Axisymmetric Conditions, Constitutive relations.

Formulation of Finite Element Matrices for Beam and Plate elements, Kirchhoff's and Mindlin's beam/plate theory, nodal coordinate system, surface normal, transformation matrices.

Linearization and Directional derivatives, Directional derivatives of different strain measures. Solution of Nonlinear Dynamic Response.

Solution of the Nonlinear Finite Element Equations in Static Analysis, Force and displacement control, residual calculation, convergence criterion.

iv) References:

1. Finite element procedures K. J. Bathe, PHI. 1996.
2. An Introduction to Nonlinear Finite Element Analysis, J.N Reddy, Oxford University Press, 2005.
3. Nonlinear Finite elements for continua and structures, Ted Belytschko, Wiley 2001.
4. Continuum Mechanics and plasticity, Han Chin Wu, CRC, 2001.
5. An introduction to continuum mechanics with applications, J.N Reddy, Cambridge University Press, 2008.
6. Nonlinear Finite Element Analysis of Solids and Structures: Volume 1 essentials - M.A. Crisfield, Wiley.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Nonlinear Analysis, nonlinear differential equations, Basic Considerations in Nonlinear Analysis Lagrangian Continuum Mechanics Variables for General Nonlinear Analysis, Virtual work principle and variational methods,	7
II	Continuum Mechanics Variables for General Nonlinear Analysis. Total Lagrangian formulation for Incremental General Nonlinear Analysis from the principles of continuum mechanics. Formulation of Finite Element Matrices from the principles of continuum mechanics: Two-Noded Truss Element	7
III	Updated Lagrangian formulation for Incremental General Nonlinear Analysis from the principles of continuum mechanics. Formulation of Finite Element Matrices from the principles ofcontinuum mechanics: Two-Noded Truss Element Formulation of the Nonlinear Finite ElementEquations.	7
IV	Two and Three-Dimensional Solid Elements; Plane Stress, Plane Strain, and Axisymmetric Conditions, Constitutive relations Formulation of Finite Element Matrices for Beam and Plate elements, Kirchhoff's and Mindlin's beam/plate theory, nodal coordinate system, surface normal, transformation matrices.	7
V	Linearization and Directional derivatives, Directional derivatives of different strain measures. Linearization of weak form in terms of second Piola Kirchoff stresses and the Green Lagrange strains, Solution of Nonlinear Dynamic Response,	8
VI	Solution of the Nonlinear Finite Element Equations in Static Analysis, Newton Raphson, Modified Newton Raphson, Secant method, Arc length method, Force and displacement control, residual calculation, convergence criterion.	9
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P62D	ROBOTICS	PEC	3	0	0	3	2020

i) Course Objectives:

Goal of this course is to

1. To introduce the basic concepts, parts of robots and types of robots.
2. To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
3. To discuss about the various applications of robots, justification and implementation of robot.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO No	Course Outcomes	Level
CO 1	Apply the basics of Kinematics and Dynamics in Robotics.	Apply
CO 2	Explain different Robot Drives And Power Transmission Systems	Understand
CO 3	Design automatic manufacturing cells with robotic control	Apply
CO 4	Explain the principle behind robotic drive system, end effectors, sensor, machine vision robot kinematics and programming.	Understand
CO 5	Explain the industrial applications of robots.	Understand

iii) SYLLABUS

Specifications of Robots, Classifications of robots, Work envelope. Flexible automation versus Robotic technology, Applications of Robots.

Robot kinematics and dynamics: Translations, Rotations and Transformations

Transformation Arithmetic, D-H Representation, Forward and inverse Kinematics of Six Degree of Freedom Robot Arm, Robot Arm dynamics.

Robot drives and power transmission systems

Robot end effectors Hooks & scoops. Gripper force analysis and gripper design. Active and passive grippers.

Drive system for grippers. Mechanical adhesive vacuum-magnetic grippers. Hooks &scoops. Gripper force analysis and gripper design. Active and passive grippers

Robot languages computer control and Robot software Industrial Application of robots.

iv) References:

1. Deb S. R. and Deb S., Robotics Technology and Flexible Automation, Tata McGraw Hill Education Pvt. Ltd, 2010.
2. John J.Craig, Introduction to Robotics, Pearson, 2009.
3. Mikell P. Groover et. al., Industrial Robots - Technology, Programming and Applications, McGraw Hill, New York, 2008.
4. Richard D Klafter, Thomas A Chmielewski, Michael Negin, Robotics Engineering – An Integrated Approach, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
5. Fu K S, Gonzalez R C, Lee C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987

v) COURSE PLAN

Module	Contents	No. of hours
I	Specifications of Robots- Classifications of robots – Work envelope Flexible automation versus Robotic technology – Applications of Robots	7
II	Robot kinematics and dynamics : Positions, Orientations and frames, Mappings: Changing descriptions from frame to frame, Operators: Translations, Rotations and Transformations Transformation Arithmetic - D-H Representation - Forward and inverse Kinematics Of Six Degree of Freedom Robot Arm–Robot Arm dynamics	8
III	Robot drives and power transmission systems: Robot drive mechanisms, hydraulic, electric, servomotor, stepper motor Pneumatic drives, Mechanical transmission method . Gear transmission, Belt drives, cables, Roller chains, Link Rod systems. Rotary-to-Rotary motionconversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws	7
IV	Robot end effectors : Classification of End effectors, Tools as end effectors. Drive system for grippers- Mechanical adhesive, vacuum, magnetic grippers. Hooks & scoops. Gripper force analysis and gripper design. Active and passive grippers.	7
V	Drive systemfor grippers-Mechanical adhesive-vacuum-magnetic-grippers. Hooks &scoops. Gripper force analysis and gripper design. Active and passive grippers.	8
VI	Robot languages .computer control and Robot software. Industrial Application of robots.	8
	Total hours	**45**

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P68B	MODELLING AND ANALYSIS LAB	PCC	0	0	2	1	2020

i) COURSE OBJECTIVES:

This course helps the students to apply the conceptual theories in design, analysis of mechanical systems using simulation software platforms.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to:

CO1	Create 3D components in modelling software
CO2	Create 3D assembly in modelling software
CO3	Solve structural problems using finite element software
CO4	Develop computer programing code for solving design problems involving different types of mathematical models and equations

iii) SYLLABUS:

Modelling of 3D machine components and creating assemblies in modelling Software, Solving structural problems using finite element software, Modal analysis using MATLAB.

iv) REFERENCES:

1. Leonard Meirovitch, Elements of Vibration Analysis, McGraw Hill, 1995.
2. G. Thomas Mase, George E. Mase.. Ronald E. Smelser. Continuum mechanics for engineers 3rd ed CRC Press 2005.
3. ShigleyJ.E and Mischke C. R., Mechanical Engineering Design, Sixth Edition, Tata McGraw-Hill, 2003.

v) COURSE PLAN

	Experiment	Main equipments/Software required
1	3D Modelling of Universal Coupling	Any Three Modelling Package
2	3D modeling of Clutch Assembly	Any Three Modelling Package
3	3D Modelling of a 4 speed Gear box	Any Three Modelling Package

4	Modal analysis of a beam – by using impact hammer, and by using shaker	Accelerometers, oscilloscope, charge amplifier, impact hammer, electrodynamic exciter, beam and its fixer etc.
5	Modal analysis of plate – by using impact hammer, and by using shaker	Accelerometers, oscilloscope, charge amplifier, impact hammer, electrodynamic exciter, plate and its fixer etc.
6	Modal analysis of beam by modeling in CAD software and exporting the same to finite element analysis software.	Any FEM Software package, (ANSYS/NASTRAN/ABACUS/ADINA/COMSOL) Any 3D modeling CAD package (Pro-E, Inventor, Solidworks, Catia)
7	Modal analysis of plate using to finite element analysis software.	Any FEM Software package, (ANSYS/NASTRAN/ABACUS/ADINA/COMSOL) Any 3D modeling CAD package (Pro-E, Inventor, Solidworks, Catia)
8	Modal analysis of beam using computer program code	Software – MATLAB/FORTRAN/C++
9	Modal analysis of plate using computer program code	Software – MATLAB/FORTRAN/C++

Course Number	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P69B	MINI PROJECT	PWS	0	0	4	2	2020

i) Course Objectives:

The goal of this course is to make students

1. Collect the recent publications related to the identified Mini project.
2. Do a detailed study of the Mini project based on current journals, published papers and books.
3. Present a seminar based on the Mini project.
4. Improve the writing and presentation skills.
5. Design and develop a system or application in the area of their specialization.

ii) Approach:

1. Students shall make a presentation for 20-25 minutes based on the detailed study on the project and submit a report of the study.
2. There will be two interim progress review of the Mini project work. The first review will focus on the topic, objectives, methodology, design and expected results.
3. The second review shall focus on the work/ Implementation and results obtained.

iii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Solve various problems associated with designing and implementing a system or application
CO 2	Evaluate the designed system or application
CO 3	Develop effective written and oral communication

SEMESTER – 3

Syllabus and Course Plan

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P71A	ADVANCED NUMERICAL METHODS	PEC	3	0	0	3	2020

i) Course Overview: The goal of this course is to provide students with a solid foundation of the theory of Numerical Techniques thus equipping them to solve mathematical models of engineering systems. This course also prepare students with good scientific and mathematical principles to model and solve engineering problems met with in engineering design so as to innovate or improve existing designs in view of the purpose of improvement of standard of life.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO1	Apply numerical methods to find out solution of algebraic equations using different methods.	Apply
CO2	Apply various interpolation methods and finite difference concepts.	Apply
CO3	Perform numerical differentiation and integration to solve engineering problems.	Apply
CO4	Solve ordinary differential equations numerically using different methods.	Apply
CO5	Solve partial differential equations numerically using different methods through the theory of finite differences.	Apply

iii) Syllabus

Solution of algebraic and transcendental equation, Solution of simultaneous Equations. Direct & indirect methods, Interpolation & Curve Fitting. Numerical Differentiation & Integration Solution to ordinary Differential Equations Solution to partial differential Equations- FEM

iv) References:

1. B.S. Grewal and J.S. Grewal, Numerical Methods in Engineering and Science, 6th edition, Khanna Publishers, New Delhi, 2004.
2. John H. Mathews and Kurtis D. Fink, Numerical Methods using MATLAB, 4th edition, PHI Learning Private Limited, New Delhi, 2007.
3. S.S. Sastry, Introductory Methods of Numerical Analysis, 4th edition, PHI Learning Private Limited, New Delhi, 2007.

v) COURSE PLAN

Module	Contents	No. of hours
I	Solution of algebraic and transcendental equations, Review and comparison of various iterative methods, convergence. Generalised Newton-Raphson method for multiple roots. Solution of simultaneous equations-Direct & indirect methods, , Eigen value problems-Vector iteration method	7
II	Solution of simultaneous equations- Direct & indirect methods, Gauss elimination and Gauss Jordan methods, ill conditioning, pivoting. Jacobi, Gauss-Seidel and Relaxation methods-convergence-Eigen value problems-Vector iteration method	7
III	Interpolation & Curve Fitting-Newton's Divided difference, Lagrange, Aitken, Hermite and Spline techniques, Inverse interpolation -Double Interpolation, Trigonometric interpolation. Curve fitting, method of least squares, non-linear relationships, Correlation and Regression, Linear Correlation , Measures of correlation, Standard error of estimate, Coefficient of correlation, Multiple linear regressions.	7
IV	Numerical differentiation – Derivative using forward, backward and central difference scheme, Maxima and minima of tabulated functions. Numerical integration-Newton-Cote's Integration formula-Gauss Quadrature- Simson rule, Double integration. Error estimates-	7
V	Solution of ordinary differential equations-Single step & multi step methods-stability of solution Simultaneous first order differential equations- higher order different equations. Numerical solution of integral equations.	8
VI	Partial differential equations, classification–Laplace equation, ID wave equation, ID heat equation – Finite difference methods – Relaxation methods. Stability and convergence of solution. FEM for ordinary Differential equation and partial differential equations.	9
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P71B	ADVANCED NON DESTRUCTIVE EVALUATION	PEC	3	0	0	3	2020

i) **Course overview:** The goal of this course is to familiarize the various non-destructive evaluation techniques and identification of suitable technique for a particular requirement.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain various surface and volumetric non-destructive evaluation techniques and its sensitivity towards various types of defects	Understand
CO 2	Explain various advanced NDE techniques.	Understand
CO 3	Explain the principle of ultrasonic NDE and mechanics of elastic wave propagation	Understand
CO 4	Explain different advanced ultrasonic testing methods.	Understand
CO 5	Explain different radiographic methods.	Understand

iii) SYLLABUS:

Introduction to Non Destructive evaluation, Electro-Magnetic Methods
Principles of Thermography. Adiographic Methods-Overview of advance ultrasonic techniques.

iv) References:

1. P.J. Shull, Nondestructive evaluation, theory techniques and application, Marcell Decker Inc, New York2002.
2. D.E. Bray and R.K.Stanley, Nondestructive evaluation, a tool in design manufacturing and service, CRC Press,1996.
3. Paul E. Mix, Introduction to nondestructive testing- a training guide, Wiley International, USA,2005.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to non destructive evaluation, Visual inspection, Liquid Penetrant Testing– principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods. Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials. Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.	7
II	Electro-Magnetic Methods - Maxwell's Equations, Magnetic Flux Leakage. Eddy Current, Low Frequency Eddy Current, Remote Field Eddy Current, Pulsed Eddy Current.	7
III	Principles of Thermography, Contact and non-contact inspection methods Heat sensitive paints - Heat sensitive papers - thermally quenched phosphors liquid crystals – techniques for applying liquid crystals calibration and sensitivity Other temperature sensitive coatings non-contact thermographic inspection - Advantages and limitation -infrared radiation and infrared detectors, Instrumentations and methods, applications.	7
IV	Radiographic Methods Principles of X-ray NDT, Equipment, Calibration, Image Collection, Quantification, and Interpretation. High power sources and high quality films. Digital Radiography. Introduction to Tomography and Laminography.	7
V	Nature of sound waves, wave propagation, modes of Sound wave generation longitudinal waves, transverse waves, surface waves, lamb waves, Velocity, frequency and wavelength of ultrasonic waves. Ultrasonic pressure, intensity and impedance, Attenuation of ultrasonic waves - reflection, refraction and mode convection, Snell'slaw and critical angles, Fressnel and Faunhofer effects ultrasonic beam split. Various methods of ultrasonic wave generation, Piezoelectric effect, Piezoelectric materials and their properties, contact testing, Pulse echo method and through transmission method, immersion testing, couplants, Data presentation A, B and C scan displays	9
VI	Formulation of elastic wave equation, Elastic wave propagation in isotropic and anisotropic materials, Cristoffel equation. Overview of advance ultrasonic techniques-Phased array technique, Time of flight diffraction technique, Ultrasonic guided waves, EMAT, laser ultrasonics, nonlinear ultrasonics, acoustic emission technique.	8
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P71C	ADVANCED DESIGN SYNTHESIS	PEC	3	0	0	3	2020

i) **Course overview**: The goal of the course is to familiarize the graphical and analytical techniques commonly used in the synthesis of mechanisms and provide sufficient theoretical background to understand contemporary mechanism design techniques. This course also helps students to Identify mechanisms by type of motion, Select the best type of mechanism for a specific application and apply the fundamental synthesis technique to properly dimension the mechanism

ii) **Course Outcomes:**

After the completion of the course the student will be able to:

CO 1	Create and analyse different types of mechanisms.	Analyse
CO 2	Perform Kinematic analysis of common mechanisms used in machinery.	Apply
CO 3	Apply the analysis and synthesis methods to design a mechanism.	Analyse
CO 4	Explain the kinematics of robots.	Understand
CO 5	Explain the concept of spatial mechanisms.	Understand

iii) **Syllabus**

Floating Link, Overlay method, Coupler curves Inflection circle, Transmission angle. Two point synthesis and Three point synthesis of Mechanisms. Synthesis with Four accuracy points. Synthesis using Displacement Equations. Synthesis using Complex numbers, Spatial mechanisms.

iv) **References:**

1. Richard.S .Hartenberg, Jacques Denavit, Kinematic synthesis of Linkages McGrawHill Book Company, 1964.
2. Allen.S.Hall. Kinematics and linkage design by Prentice Hall of India,Ltd. 1986.
3. Shigley, Theory of Mechanisms and Machines, McGraw Hill International Edition. 1995.
4. A.R.Holowenko. Dynamics of Machinery John Wiley & Sons Inc, 1955.

v) **COURSE PLAN**

Module	Contents	No. of hours
I	Floating Link, Special methods of Velocity and Acceleration Analysis using auxiliary points. Overlay method for conditioned crank mechanisms, coupler curves. Roberts – Chebyshev theorem	7
II	Inflection circle, Euler Savery equation, Hartman construction, Bobillier construction, Synthesis using Optimum transmission angle	7
III	Geometric methods of synthesis with three accuracy points:-poles of four bar linkages, Relative poles of four bar linkages, Function generators, poles of slider crank mechanisms, Relative poles of slider crank mechanisms, Rectilinear recorder mechanisms. Synthesis of slider crank mechanism with three accuracy points.	7
IV	Geometricmethodsofsynthesiswithfouraccuracypoints:-poletriangles, center point curves, Circle point curves, Construction of circle points, Cardinal points, opposite poles, Pole quadrilaterals, Function Generators, Synthesis of slider crank mechanism with four accuracy points.	7
V	Algebraic methods of synthesis using displacement equations:-Crank and follower synthesis- three accuracy points, Crank and follower synthesis-angular velocities and accelerations.	8
VI	Rectilinear mechanisms, Algebraic methods of synthesis using complex numbers. Spatial motion and spatial linkages Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Simple mechanisms in Robots.	9
	Total hours	**45**

Cours e Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P71D	MECHATRONICS SYSTEM DESIGN	PEC	3	0	0	3	2020

i) Course overview: The goal of this course is to equip students with state of the art techniques and skills in the fields of automation and robotics and make the students aware of the latest trends in sensors, actuators, pneumatic and hydraulic systems, PLC etc.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Develop complicated pneumatic and hydraulic circuits to automate various equipment's.	Apply
CO 2	Explain about latest cutting edge technologies like MEMS, Robotics	Understand
CO 3	Explain about microprocessors and microcontrollers which are an essential part of modern automated devices	Understand
CO 4	Develop the case studies of various mechatronic devices.	Create

iii) SYLLABUS:

Introduction to mechatronics sensors and transducers, Automation system design, Modelling and simulation of mechatronics systems. Microprocessors & microcontrollers Real time interfacing, Robotic vision and case studies.

iv) References:

1. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, 2015.
2. HMT, Mechatronics, McGraw Hill Education. 2017.
3. K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram. Mechatronics: Integrated Mechanical Electronic Systems. Wiley India Pvt. Ltd., 2008.
4. David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw Hill Higher Education, 2003.

v) COURSE PLAN

Module	Contents	No. of hour
I	Characteristics. Displacement and position sensors. Resolvers and synchros. Velocity and motion sensors. Principle and types of force, temperature, vibration and acoustic emission sensors. ACTUATORS: Pneumatic, hydraulic and mechanical actuation systems used for Mechatronics devices	7
II	AUTOMATION SYSTEM DESIGN: Design of fluid power circuits cascade, KV-map and step counter method. PLC ladder logicdiagram, Programming of PLC, fringe condition modules, sizing of components in pneumatic and hydraulic systems. Analysis of hydraulic circuits.	7
III	Modeling And Simulation: Definition, key elements, mechatronics approach for design process, modeling of engineering systems, modeling system with spring, damper and mass. Modeling chamber filled with fluid, modeling pneumatic actuator. Transfer functions, frequency response of systems, bode plot. Software and hardware in loop simulation.	7
IV	Microprocessors & Microcontrollers: Microprocessors - introduction, 8085 architecture, types of memory, machine cycles and timing diagram, addressing modes, instruction set, development of simple programs. 8051 microcontroller architecture, registers, addressing modes, interrupts, port structure, timer blocks and applications- stepper motor speed control.	7
V	Real Time Interfacing: Introduction to data acquisition and control systems, overview of I/O process. Virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems.	8
VI	Real Time Interfacing: Introduction to data acquisition and control systems, overview of I/O process. Virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems. Case Studies Of Mechatronics Systems: Pick and place robot, Automatic Bottle filling unit, Automobile engine management system.	9
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P71E	COMPUTATIONAL PLASTICITY	PEC	3	0	0	3	2020

i) **Course overview:** The goal of the course is to gain insight into the behavior of metals under loading and heating conditions. This course also equips the students To use elementary theory of plasticity to formulate bulk forming processes and sheet forming Processes.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO1	Analyse the changes in mechanical behavior of materials due to thermo-mechanical processing based finite element modelling.	Apply
CO2	Determine the elastoplastic behavior of metals.	Apply
CO3	Explain the program structure of FEM for plasticity	Apply
CO4	Explain numerical integration algorithm for elastoplastic constitutive equations	Apply

iii) Syllabus

The principle of virtual work. Displacement - based finite elements. Large strain formulation. The mathematical theory of plasticity. Finite elements in small-strain plasticity problems. Application: integration algorithm for the isotropically hardening Von Mises model. Numerical examples with the Von Mises model - Further application: the von Mises model with nonlinear mixed hardening

iv) References:

1. Eduardo de Souza Neto, DjordjePeric, David Owens, Computational methods for plasticity: theory and applications - 2008 John Wiley & SonsLtd.
2. Han-Chin Wu, Continuum mechanics and plasticity - CRCPress.
3. D R J Owen, E Hinton, Finite Elements in Plasticity Theory and Practice – 1980 PeneridgePress Ltd.. Jacob Lubliner, Plasticity theory –2006
4. Introduction to Nonlinear Finite Element Analysis, , Nam-HoKim,Spinger

v) COURSE PLAN

Module	Contents	No. of hour
I	Elements of continuum mechanics and thermodynamics – Kinematics of deformation - Infinitesimal deformations - Forces. Stress Measures, Fundamental laws of thermodynamics - Constitutive theory - Weak equilibrium.	7
II	The principle of virtual work - The quasi-static initial boundary value problem The finite element method in quasi-static nonlinear solid mechanics - Displacement - based finite elements - Path-dependent materials. The incremental finite element procedure – Large strain formulation - Unstable equilibrium. The arc-length method.	7
III	The mathematical theory of plasticity. Overview of the program structure of FEM for plasticity	8
IV	Phenomenological aspects - One-dimensional constitutive model General elastoplastic constitutive model - Classical yield criteria – Plastic flow rules - Hardening laws	7
V	Finite elements in small-strain plasticity problems – Preliminary implementationaspects. General numerical integration algorithm for elastoplastic constitutive equations	8
VI	Application: integration algorithm for the isotropically hardening Von Mises model - The consistent tangent modulus Numerical examples with the von Mises model - Further application: the Von Mises model with nonlinear mixed hardening	8
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P72A	THEORY OF PLATES AND SHELLS	PEC	3	0	0	3	2020

i) Course overview: The goal of this course is to enable students to Identify the various thin walled structures in the form of plates and shells suitable for use in different structural systems and study the behaviour of the plates and shells with variable geometry under the action of different types of loads.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO1	Identify various thin walled structures such as plates and shells that are suitable for different structural systems	Apply
CO2	Analyse the behaviour of plates and shells of different geometry under the action of various types of load.	Apply
CO 3	Explain Classical Plate theory and Shell theory	Apply
CO 4	Determine the deformation in cylindrical shells	Apply

iii) Syllabus:

Introduction to plates and shells - Assumptions in the theory of thin plates; Bending of long rectangular plates; Pure bending of plates; Small deflections of laterally loaded plates – Navier solution and Levy's solution for simply supported rectangular plates; Symmetrical bending of circular plates - Classical Plate theory; Mindlin's plate theory. Theory of folded plates; Introduction to shell theory; cylindrical shells; hyperbolic shells, Hyperbolic paraboloid shells and Conoids.

iv) References:

1) Timoshenko S.P. and Krieger S. W., Theory of Plates and Shells, Tata McGraw Hill,
2) Chandrashekhara K., Theory of Shells, Universities (India) Press Ltd, 2000.
3) Bairagi N. K., Plate Analysis, Khanna Publishers, 1986.
4) Kelkar V. S. and Sewell R.T., Fundamentals of the Analysis and Design of Shell Strutures, Prentice Hall Inc, 1987.

v) Course Plan

Module	Contents	No. of hours
I	Introduction to plates and shells –Classifications, Assumptions in the theory of thin plates; Differential equation to Bending of long rectangular plates to a cylindrical surface. Pure bending of plates – Relation between slope and curvature, bending moments and curvature; Particular cases of pure bending	7
II	Small deflections of laterally loaded plates -Differential equation; Navier solution and Levy's solution for simply supported rectangular plates-Effect of transverse shear deformation.	7
III	Symmetrical bending of circular plates -Differential equations; Uniformly loaded circular plates with simply supported and fixed boundary conditions. Annular plate with uniform moments and shear forces along the boundaries.	7
IV	Classical Plate theory for Orthotropic plates and layered plates; Mindlin's plate theory-Navier solution and Levy's solution for orthotropic plates-Theory of folded plates.	7
V	Introduction to shell theory. Classification of shells, Membrane theory of shells, Application to spherical, conical and cylindrical shells, Deformation of shells without bending -definitions and notations. Shells in the form of a surface of revolution and loaded symmetrically with respect to their axis. Membrane and General theories of cylindrical shells -Circular cylindrical shell loaded symmetrically with respect to its axis; stresses in cylindrical shell under dead and snow loads, symmetrical deformation	9
VI	General case of deformation of cylindrical shells with supported edges; Hyperbolic shells, hyperbolic paraboloid shells and Conoids. Analysis of cylindrical shells.	8
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P72B	MECHANICAL BEHAVIOUR OF MATERIALS	PEC	3	0	0	3	2020

i) Course overview: The goal of this course is to provide information about the structure of crystalline materials, imperfections in crystals, its implications in the strength of materials, elastic and plastic behaviour of crystalline materials to applied forces.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain the structure of crystalline solids and the various imperfections in it.	Understand
CO 2	Explain the dislocation theory and the various strengthening mechanisms	Understand
CO 3	Analyse the composition of various alloys and its properties.	Apply
CO 4	Explain the basic concepts of fracture mechanics and failure mechanisms like fatigue and creep	Understand
CO 5	Explain the mechanical behaviour of polymers, ceramics and composites.	Understand

iii) Syllabus:

Structure and imperfections in crystals, Mechanical behaviour of metals, Strengthening mechanisms, recovery, recrystallisation and grain growth, Alloying Fracture, Fatigue and creep Mechanical behaviour of composites, polymers and ceramics. Advanced materials

iv) References:

1. Marc Andre Meyers, Mechanical Behaviour Materials, PHI, 2013.
2. Thomas H. Courtney, Mechanical Behaviour Materials, Waveland Pr Inc, 2nd edition 2010.
3. Callister W. D., Materials Science and Engineering: An Introduction, John Wiley & Sons, 8th Edition 2010.

v) Course Plan

Module	Contents	No. of hours
I	Elements of crystal structure, Imperfections in crystals, dislocation motion and dislocation theory. Slip in crystalline solids, Deformation twinning and kink bands, Grain boundaries and poly crystalline aggregates, Plasticity and the theoretical strength of materials.	7
II	States of stress and strain, Elasticity: origins, isotropic materials, anisotropic material . Stress-strain curves; plasticity; empirical relations for stress and strain, criteria for necking, Yield Criteria, strength coefficient and strain hardening exponent, Effect of strain rate and temperature on tensile properties and torsion, Mechanical testing methods	7
III	Strengthening mechanisms: solid solution, grain refinement, strain hardening, precipitation hardening, Recovery, recrystallisation and grain growth, Principles of Alloying - Solid solutions and intermediate phases. Gibbs phase rule and equilibrium diagram Types of binary phase diagrams , Isomorphous - Eutectic - Peritectic and Peritectoid reactions, Iron-iron carbide equilibrium diagram, TTT diagram, martensitic transformation	7
IV	Ceramics, polymers and composites. Advances and modern materials. Mechanical behavior of ceramics, Polymers and Composites.	7
V	Types of fractures - Ductile and brittle fractures - features of fracture , surface for ductile, brittle and mixed modes. The history of failure of engineering structures and parts, high strain rate, stress concentration and low temperature effects, impact tests and results, transition temperature and factors affecting transition temperature.	8
VI	Stress cycle, fatigue curve, fatigue fracture characteristics. Fatigue testing and testing machines, determination of fatigue strength. Factors affecting fatigue- size, surface, stress concentration, Creep, Creep curve, Creep mechanisms, Low temperature and high temperature creep theories, Fracture at elevated temperature. Stress rupture, Deformation mechanism maps, Material	9
	Total hours	**45**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P72C	COMPUTATIONAL METHODS IN DESIGN & MANUFACTURING	PEC	3	0	0	3	2020

i) Course overview: The goal of this course is to prepare the students for the professional practice of analysis of mechanical engineering manufacturing and to design through the application of engineering fundamentals.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Apply the concept of continuum mechanics in different manufacturing process.	Apply
CO 2	Explain the basic concepts in nonlinear analysis.	Understand
CO 3	Solve Nonlinear Finite Element Equations in Static Analysis	Apply
CO 4	Apply knowledge of finite element method in engineering design.	Apply
CO 5	Apply the concepts of Lagrangian formulation.	Apply

iii) Syllabus

Metal Forming and Machining Processes Index Notation and Summation Convention, Stress, Stress at a Point, Analysis of Stress at a Point, Equation of Motion, Deformation, Linear Strain Tensor, Analysis of Strain at a Point, Compatibility Conditions, Material Behavior, Elastic Stress-Strain Relations for Small Deformations, Elastoplasticity ,viscoplasticity. Finite element method – general procedure, elements and shape function, stiffness matrix, isoparametric simulations, assembly and solutions Basic Considerations in Nonlinear Analysis, Linearization and Directional derivatives. Solution of the Nonlinear Finite Element Equations in Static Analysis

iv) References:

1. An Introduction to Nonlinear Finite Element Analysis, J.N Reddy, Oxford UniversityPress, 2005.
2. Nonlinear Finite elements for continua and structures, Ted Belytschko, Wiley2001.
3. Continuum Mechanics and plasticity, Han Chin Wu,CRC,2001.

v) **Course Plan**

Module	Contents	No. of hours
I	Metal Forming and Machining Processes , Introduction to Metal Forming, Bulk Metal Forming, Sheet Metal Forming Processes, Machining, Turning, Milling etc. Index Notation and Summation Convention, Stress, Stress at a Point, Analysis of Stress at a Point, Equation of Motion,	7
II	Deformation, Linear Strain Tensor, Analysis of Strain at a Point, Compatibility Conditions, Material Behavior, Elastic Stress-Strain Relations for Small Deformations,	7
III	Elastoplasticity, yield criteria, incremental and deformation plasticity, flow rule, viscoplasticity. Finite element method, general procedure, elements and shape function, stiffness matrix, isoparametric simulations, assembly and solutions. Examples of applications in mechanical design.	7
IV	Basic Considerations in Nonlinear Analysis, Lagrangian Continuum Mechanics Variables for General Nonlinear Analysis, Virtual work-Linearization and Directional derivatives, Directional derivatives of different strain measures, Linearization of weak form in terms of second PiolaKirchoff stresses and the Green Lagrange strains principle and variational methods	8
V	Nonlinear analysis, Total and Updated Lagrangian formulations, geometric nonlinearity and material nonlinearity-formulations and procedures for static analysis.	8
VI	Solution of the Nonlinear Finite Element Equations in Static Analysis Newton Raphson, Modified Newton Raphson, Secant method, Arc length method.	8
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P72D	ADVANCED VEHICLE DYNAMICS	PEC	3	0	0	3	2020

i) Course overview: The goal of the program is to develop an essential knowledge about dynamic behavior and mathematical modeling and simulation of vehicles.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO1	Analyse the different parameters that affect the static and dynamic behaviour of vehicles.	Apply
CO2	Determine the braking performance of automobiles.	Apply
CO3	Explain the tyre mechanics and modelling of tyre system.	Understand
CO4	Explain the mechanism tocontrol the vibrations of the vehicle	Apply

iii) Syllabus

Introduction to dynamics, Stability of Vehicles, Vehicle kinematics, Dynamic stability of vehicles, Tire dynamics and modeling, Driveline dynamics, Steering dynamics, Vehicle vibrations

iv) References:

1. Vehicle dynamics-Theory and applications - Reza.N.Jazar–Springer-2008
2. Fundamentals of Vehicle Dynamics - Gillespie T.D, SAE USA1992.
3. Vehicle Dynamics and Control,- Rajesh RajamaniSpringer-2008
4. Mechanics of road vehicles, W. Steeds- Wildlife book Ltd, London,1990
5. Automobile mechanics N.K. Giri-, Khanna Publishers, Delhi,1986

v) Course Plan

Module	Contents	No. of hours
I	Introduction to dynamics Stability of Vehicles- load distribution weight transfer during acceleration and braking, optimum braking, wheel locking and vehicle skidding, antilock braking system. Over steer, under steer, steady state cornering. Effect of braking, driving torques on steering. Effect of camber, transient effects in cornering. Directional stability of vehicles.	7

II	Vehicle kinematics Coordinate transformations, Euler angles, time derivative and coordinate frames, rigid body dynamics. Dynamic stability of vehicles -Vehicle planar dynamics Longitudinal vehicle dynamics-Lateral vehicle dynamics -Vehicle roll dynamics	7
III	Tire dynamics and modelling -Tire and rim fundamentals, Tire components, Tire coordinate frame and tire force systems, Tire Stiffness-linear and non-linear tire stiffness, hysteresis effect, Static tire stresses Effective radius Rolling resistance. Effect of speed on rolling resistance Effect of inflation pressure, load camber angle and side slip angle on rolling resistance, Forces on the tire- linear force, lateral force and camber force, Stresses and deformation of a rolling tire. Mathematical model of rolling tire-damping structure and Spring Structure.	7
IV	Driveline dynamics- Basic engine dynamics - power, speed and torque Characteristics. Driveline components -Gear box and clutch dynamics, gear box	7
V	Steering dynamics-Analysis of steering mechanisms, Steering of multi- axle vehicles, vehicles with trailer. Four wheel steering, optimization of steering mechanisms, Suspension mechanisms- Suspension optimization	8
VI	Vehicle vibrations Fundamentals of vibrations- single degree freedom and multi degree freedom vibrations. Passenger comfort and vibrations Numerical modelling of vehicle vibrations-Quarter car model Half car model, full car model	9
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P72E	CONTROL SYSTEM	PEC	3	0	0	3	2020

i) **Course overview:** The goal of the course is to introduce the elements of control system and their modelling using various techniques. This course also introduces methods for analyzing the time response, the frequency response and the stability of systems

ii) **Course Outcomes:**

After the completion of the course the student will be able to:

CO1	Explain the elements of control system and their modelling using various Techniques	Understand
CO2	Apply methods for analysing the time response and the frequency response	Apply
CO3	Explain the concept of stability of systems	Apply
CO4	Explain state variable analysis method.	Apply

iii) **Syllabus**

Basic Elements of Control System –- Transfer function, - characteristics equation Time response analysis P, PI, PD and PID Compensation, Analysis using MATLAB Frequency Response– Nichol's Chart - Compensators - Analysis using MATLAB. Stability, Routh-Hurwitz Criterion, Root Locus Technique, Analysis using MATLAB State space representation of Continuous Time systems – State equations – Transfer function from State Variable State space representation for Discrete time systems. Sampled Data control systems – Sampling Theorem

iv) **Reference**

1. Dorf R. C. and Bishop.R.H., *Modern Control Systems*, Pearson Education, 2011.
2. Nagarath I. J. and Gopal M., *Control System Engineering*, New Age International Pvt Ltd, 6th Edition, 2018.
3. Nise N. S., *Control Systems Engineering*, Wiley Eastern, 6th Edition, 2010.
4. Ogata K., *Modern Control Engineering*, Prentice Hall of India, New Delhi, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	Basic Elements of Control System – Open loop and Closed loop systems - Differential equation - Transfer function, Translational and rotational mechanical systems - Block diagram reduction. Techniques - Signal flow graph Mason's gain formula - characteristics equation	7
II	Time response analysis - First Order Systems - Impulse and Step Response analysis of second order systems - Steady state errors – P, PI, PD and PID Compensation, Analysis using MATLAB	7
III	Frequency Response - Bode Plot, Polar Plot, Nyquist Plot - Frequency Domain specifications from the plots - Constant M and N Circles – Nichol's Chart - Use of Nichol's Chart in Control System Analysis. Series, Parallel, series-parallel Compensators - Lead, Lag, and Lead Lag Compensators, Analysis using MATLAB	7
IV	Stability, Routh-Hurwitz Criterion, Root Locus Technique, Construction of Root Locus, Stability, Dominant Poles, Application of Root Locus Diagram - Nyquist Stability Criterion – Relative Stability, Analysis using MATLAB	8
V	State space representation of Continuous Time systems – State equations Transfer function from State Variable Representation – Solutions of the state equations	8
VI	Concepts of Controllability and Observability – State space representation for Discrete time systems Sampled Data control systems – Sampling Theorem – Sampler & Hold – Open loop & Closed loop sampled data systems	8
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P72F	FRACTURE MECHANICS	PEC	3	0	0	3	2020

i) Course overview: The goal of this course is to expose the student to fundamentals of linear elastic fracture mechanics, nonlinear (Elastic-Plastic) fracture mechanics and fatigue crack growth.

ii) Course Outcomes:

After the completion of the course the student will be able to:

CO 1	Explain mechanics of crack tip fields, stress intensity factor and J-integral or nonlinear energy release rate.	Understand
CO 2	Explain failure of structures by fatigue crack growth.	Understand
CO 3	Develop an engineering approach to elastic-plastic fracture mechanics and evaluate important fracture characterizing parameters.	Apply
CO 4	Apply the concepts learnt to design of structural components taking into account presence of flaws, nature of loading and constitutive behavior of the material.	Apply
CO 5	Explain standard test procedures to determine the fracture toughness of materials.	Understand

iii) Syllabus:

Basic stress analysis and mechanical properties, Linear Elastic Fracture Mechanics (LEFM), LEFM approach to crack-tip plasticity, Elastic-Plastic Fracture Mechanics (EPFM), Fatigue crack growth, Fracture toughness testing.

iv) References:

1. Janssen, J. Zuidema and R. J. H. Wanhill., Fracture Mechanics, Taylor & Francis, 2nd ed., 2002.
2. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986.
3. T.L. Anderson, Fracture Mechanics Fundamentals and Applications, CRC PRESS, 3rd ed., 2005.
4. E.E. Gdowan, Fracture Mechanism: An Introduction, Springer, 2005.

v) Course Plan

Module	Contents	No. of hours
I	Basic stress analysis and mechanical properties: Elasticity, General 3-D relations, Plane stress and plane strain. Mohr's circle-principal stresses, Yield in materials, Tresca and Von Mises criteria, Ideal and actual strength of materials. Typical stress/strain curves for different classes of materials.	7
II	Significance of fracture mechanics, Linear elastic fracture mechanics (LEFM)-Griffith energy balance approach, Irwin's modification to the Griffiththeory-instabilityandRcurve-Stressanalysisofcracks-fracture toughness - modes I, II &III - mixed mode problems-Expressionsforstressesandstrainsinthecracktipregion-finitespecimen width -superposition of stress intensity factors (SIF) – SIF of centre cracked plate, single edge notched plate, and embedded elliptical cracks R- curve concept-	7
III	Crack tip plasticity: Irwin plastic zone size - Dugdale approach – shape of plastic zone - state of stress in the crack tip region - influence of stress state on fracture behavior. Elastic plastic fracture mechanics (EPFM): Development of EPFM - J- integral – Definition-Path independence	7
IV	Application to engineering problems-crack opening displacement (COD) approach - COD design curve - relation between J and COD - tearing modulus concept. Fatigue crack growth: Mechanisms of fracture and crack growth- Description of fatigue crack growth using stress intensity factor	8
V	Effects of stress ratio - crack closure - prediction of fatigue crack growth under constant amplitude and variable amplitude loading. Fatigue Crack Initiation—Basic Aspects of Dynamic Crack Growth-Basic Principles of Crack Arrest-Fracture Mechanics Analysis of fast fracture and Crack Arrest.	8
VI	KIC test technique, various test specimens, load-displacement test, JIC testing, Test methods to determine GIC and GIIC, Determination of CTOD/COD, Time-to-failure (TTF) tests - crack growth rate testing - practical significance of sustained load fracture testing	8
	Total hours	45

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P79A	Seminar -II	PWS	0	0	2	2	2020

i. **Course overview:** Goal of this course is to prepare the student to identify the current topics in the specific stream, to collect recent publications related to identified topics, do a detailed study, present a seminar on the selected topic and submit a technical report.

ii. Course Outcomes

After the completion of the course the student will be able to:

CO 1	Select the current topics in the specific stream	Understand
CO 2	Improve the writing and presentation skills.	Apply
CO 3	Dissect domains of interest so as to pursue the course project	Apply

iii. Continuous Internal Evaluation Pattern

Internal Marks: 100 marks

Distribution of marks for the seminar shall be as follows

Seminar Report :30 marks
Seminar Presentation :40 marks

Ability to answer questions on the topic :30 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P79B	PROJECT (PHASE – I)	PWS	0	0	12	6	2020

i) **Course overview:** The goal of this course is to make students do an original and independent study on the area of specialization by exploring a subject in depth of his/her own choice. This course also serves to start the preliminary background studies towards the project by conducting literature survey in the relevant field, broadly identify the area of the project work, familiarize with the tools required for the design and analysis of the project and plan the experimental platform, if any, required for project work.

ii) **Approach:**

1) There will be three interim progress review of the Project (Phase I). The first review shall focus on the topic, and objectives. This review will be conducted within one month of the commencement of third semester classes.
2) The second review shall focus on the methodology. This review will be conducted within two months of the commencement of third semester classes.
3) The third review shall focus on the design and expected results, and scope of the work which has to be accomplished in the fourth semester. This review will be conducted towards the close of the third semester.

iii) **Course Outcomes:**

After the completion of the course the student will be able to:

1	Identify the topic, objectives and methodology to carry out the project.	Apply
2	Finalize the project plan for their course project.	Apply

iv) **Continuous Internal evaluation Pattern**

Internal Marks : 50 marks

Distribution of marks for the project shall be as follows:

Midterm Evaluation

Marks by Guide : 10 marks

Marks by Evaluation Committee : 10 marks

Final Evaluation

Marks by Guide : 10 marks

Marks by Evaluation Committee :20 marks

SEMESTER –4

Syllabus and Course Plan

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
ME1P79C	PROJECT (PHASE – II)	PWS	0	0	24	12	2020

i) Course overview:

The goal of this course is to make students apply computational and analytical tools, carry out the investigation and analyse the observations, communicate the findings orally as well as in writing and to familiarize with project management.

ii) Approach:

1) There will be three interim progress review of the Project (Phase II). The first review shall focus on the progress of the implementation of the design made in Project (Phase I). This review will be conducted within one month of the commencement of third semester classes.
2) The second review shall focus on the quality and quantum of the work completed. This review will be conducted within two months of the commencement of third semester classes.
3) The third review shall focus on the completed implementation and the results. This review will be conducted towards the close of the third semester.
4) At least one technical paper has to be prepared and published in journals / conferences based on their project work.

iii) Course Outcomes:

After the completion of the course the student will be able to:

1	Get a good exposure to a domain of interest	Apply
2	Get a good domain and experience to pursue future research activities.	Create

iv) Continuous Internal evaluation Pattern

Internal Marks : 70 marks

Distribution of marks for the project shall be as follows

Midterm Evaluation

Marks by Guide : 10marks

Marks by Evaluation Committee : 10 marks

Final Evaluation

Marks by Guide	: 20 marks
Marks by Evaluation Committee	: 30 marks

End semester examination : 30 marks

TOTAL MARKS FOR PROJECT(PHASE-II)	**: 100 marks**
TOTAL MARKS FOR PROJECT (PHASE-1 AND II)	**: 150 marks**