Curriculum of M. Tech Program in Machine Design

Semester wise distribution of the courses

Semester I (M1)

Slot	Course Type	Course	Marks		Hours L - T - P	Credits
			CIA	ESE		
A	DCC	Computational Methods for Engineers	40	60	3 – 0 - 0	3
B	PCC	Advanced Theory of Vibration	40	60	3 – 0 - 0	3
C	PCC	Continuum mechanics	40	60	3 – 0 - 0	3
D	PEC	Program Elective 1	40	60	3 – 0 - 0	3
E	PEC	Program Elective 2	40	60	3 – 0 - 0	3
S	RM	Research Methodology & IPR	40	60	2 – 0 - 0	2
T	LBC	Mechanical Design Lab	100	-	0 – 0 - 2	1
Total			**340**	**360**	**19**	**18**

Teaching Assistance:6 hours

Semester II (M2)

Slot	Course Type	Course	Marks		Hours L - T - P	Credits
			CIA	ESE		
A	DCC	Design of Experiments	40	60	3 – 0 - 0	3
B	PCC	Finite element analysis	40	60	3 – 0 - 0	3
C	PEC	Program Elective 3	40	60	3 – 0 - 0	3
D	PEC	Program Elective 4	40	60	3 – 0 - 0	3
E	IEC	Industry/Interdisciplinary Elective	40	60	3 – 0 - 0	3
S	PR	Mini project	100	-	0 – 0 - 4	2
T	LBC	Computational Analysis Lab	100	-	0 – 0 - 2	1
Total			**400**	**300**	**21**	**18**

Teaching Assistance:6 hours

Semester III (M3)

Slot	Course Type	Course	Marks		Hours L - T - P	Credits
			CIA	ESE		
TRACK 1						
A*	MOOC	MOOC	To be successfully completed		-	2

B	AC	Audit Course	40	60	3 – 0 - 0	-
C	PR	Internship	50	50	-	3
D	PR	Dissertation Phase I	100	-	0 – 0 - 17	11
TRACK 2						
A*	MOOC	MOOC	To be successfully completed		-	2
B	AC	Audit Course	40	60	3 – 0 - 0	-
C	PR	internship	50	50	-	3
D	PR	Research project Phase I	100	-	0 – 0 - 17	11
Total			**190**	**110**	**20**	**16**

Teaching Assistance:6 hours

*MOOC must be successfully completed before the commencement of fourth semester. This course can be carried out at any time from M1 to M3.

Semester IV (M4)

Slot	**Course Type**	**Course**	**Marks**		**Hours L - T - P**	**Credits**
			CIA	**ESE**		
TRACK 1						
D	PR	Dissertation Phase II	100	100	0 – 0 - 24	16
TRACK 2						
D	PR	Research project Phase II	100	100	0 – 0 - 24	16
Total			**100**	**100**	**24**	**16**

Teaching Assistance:5 hours

Syllabus for the theory courses

1) Core courses in M1

#	Course category	Course code	Course Name	Credits
	DCC	1ME160A	COMPUTATIONAL METHODS FOR ENGINEERS	3

Brief syllabus

Introduction to scientific computing and algorithms; iterative methods, systems of linear equations with applications; nonlinear algebraic equations; function interpolation and differentiation and optimal procedures; data fitting and least-squares; numerical solution of ordinary and partial differential equations.

*Focus should be on MATLAB implementation of the above methods

TEXT BOOKS/REFERENCES

1. Schilling R.J and Harris S L, "Applied Numerical Methods for Engineering using MatLab and C", Brooks/Cole Publishing Co., 2000.
2. Chapra S C and Canale R P, "Numerical Methods for Engineers", McGraw Hill, 1989.
3. Hines, W.W and Montrogmery, "Probability and Statistics in Engineering and Management Studies", John Willey, 1990.
4.Santhosh K.Gupta, "Numerical Methods for Engineers", New age international publishers, 2005.

#	Course category	Course code	Course Name	Credits
	PCC	1ME161B	CONTINUUM MECHANICS	3

Brief 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. 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. 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.

TEXT BOOKS/REFERENCES:

1. G. Thomas Mase, George E. Mase, Ronald E. Smelser. "Continuum mechanics for engineers" 3rd edition CRC Press, 2009.

2. Lawrence E. Malvern. "Introduction to the Mechanics of a Continuous Medium" – Prentice Hall, 1977.

3. J.H. Heinbockel, "Introduction to Tensor Calculus and Continuum Mechanics" – Open Source, 2001

#	Course category	Course code	Course Name	Credits
	PCC	**1ME161C**	**ADVANCED THEORY OF VIBRATION**	**3**

Brief syllabus

Overview of vibration of single degree of freedom (sdof) systems. Free and forced vibrations, rotating unbalance, support motion, whirling of shafts, vibration isolation, and vibration measuring instruments. Types of damping and damping materials- Response of sdof systems to arbitrary excitation-convolution integral, method of Fourier transforms. Two dof systems – undamped free vibration – formulation and solution of matrix eigenvalue problem for natural frequencies and mode shapes. Elastic and inertial coupling, orthogonality of modes, natural coordinates - Response of two dof systems to harmonic excitation - damped and undamped vibration absorbers. Multi dof systems – formulation and solution of matrix eigenvalue problem -orthogonality of modal vectors - expansion theorem – decoupling of equations of motion - modal analysis. Vibration of continuous systems – transverse vibration of a string, axial vibration of a rod, torsional vibration of a shaft, bending vibration of beam – natural frequencies and mode shapes – orthogonality properties of the eigen functions. Lagrange's equation.

TEXT BOOKS/REFERENCES:

1. Leonard Meirovitch, “Principles & Techniques of Vibration”, Prentice Hall, 1996.

2. Thomson T., “Theory of Vibration with Applications”, Fifth Edition, Pearson Education, 2003.

3. Leonard Meirovitch, “Analytical Methods in Vibrations”, MacMillan, 1967.

4. Rao S. S., “Mechanical Vibrations”, Fifth Edition, Prentice Hall, 2010.

5. Graham S. Kelly, “Mechanical Vibrations”, Second Edition, McGraw Hill, 2000.

#	Course category	Course code	Course Name	Credits
	RM	**1MC161D**	**RESEARCH METHODOLOGY**	**2**

Brief syllabus

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations Effective literature studies approaches, analysis, Plagiarism, Research ethics Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

TEXT BOOKS/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.

#	Course category	Course code	Course Name	Credits
	PCC	1ME169E	MECHANICAL DESIGN LAB	3

Brief syllabus

Experimental determination of natural frequencies of systems. Determination of mode shapes using accelerometers, impact hammers and data acquisition system. Use of softwares to conduct modal analysis and harmonic analysis of structures

2) Core courses in M2

#	Course category	Course code	Course Name	Creidts
	DCC	1ME160F	DESIGN OF EXPERIMENTS	3

Brief syllabus

Introduction to Research, Review of linear estimation, basic designs and Design Principles, Completely Randomized Designs, Treatment Comparisons, Diagnostics and Remedial Measures, Experiments to Study Variances, Random Effects Models. Factorial Designs: General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2n and 3r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments. Complete Block Designs: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible design. Analysis of Covariance including a Measured Covariate Split-Plot Designs, Repeated Measures Designs, missing plot technique: - General theory and applications, Analysis of Co-variance for CRD and RBD. Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey's test for additivity.

TEXT BOOKS/REFERENCES:

1. Douglas C. Montgomery, "Design and Analysis of Experiments", Seventh Edition, Wiley, 2010.
2. Jiju Antony, "Design of Experiments for Engineers and Scientists", Elsevier, 2014.
3. Larry B. Barrentine, "An Introduction to Design of Experiments: A Simplified Approach", ASQ Quality Press, 1999.
4. Paul G. Mathews, "Design of Experiments with MINITAB", ASQ Quality Press, 2005.
5. Mark J. Anderson and Patrick J. Whitcomb, "DOE Simplified: Practice.

#	Course category	Course code	Course Name	Creidts
	PCC	**1ME161G**	**FINITE ELEMENT ANALSYIS**	**3**

Brief syllabus

Fundamentals of governing equations in Solid Mechanics and Heat Transfer. Basic finite element procedures: Stiffness and Flexibility Approach, Direct Stiffness Method, Principle of Minimum Potential Energy, Strong form, Weak form, Variational formulation, Weighted Residual Method - Galerkin formulation, Formulation of the finite element equations - Element types - Basic and higher order elements –1D, 2D, 3D coordinate systems. Finite elements in Solid Mechanics: Analysis of trusses, beams and frames, Plane stress, Plane strain and Axisymmetric elements, Plate and shell elements. Isoparametric formulation. Finite elements in Heat Transfer: Formulations and solution procedures in 1D and 2D problems. Structural Dynamics: Formulation - Element mass matrices - Evaluation of Eigen values and Eigen vectors - Natural frequencies and mode shapes - Numerical time integration. Computer implementation of the Finite element method: Pre-processing, Element calculation, Equation assembly – Assembly Flowchart, ID, IEN, LM arrays, Solving – Numerical Integration – Gaussian Quadrature, Post processing – Primary and Secondary variables.

TEXT BOOKS/REFERENCES:

1. Thomas J. R. Hughes, "*The Finite Element Method – Linear Static and Dynamic Finite Element Analysis*", Dover Publications Inc, 2000.

2. Rao S. S., "*The Finite Element Method in Engineering*", Fourth Edition, Elsevier, 2007.

3. Daryl L. Logan, "*A First Course in the Finite Element Method*", Fourth Edition, Cengage Learning, 2007.

4. David V. Hutton, "*Fundamentals of Finite Element Analysis*", McGraw Hill, 2005.

5. Reddy J. N., "*An Introduction to the Mathematical Theory of Finite Elements*", Dover Publications, 2011.

6. Zienkiewicz O. C., "*The Finite Element Method for Solid and Structural Mechanics*", Sixth Edition, Butterworth-Heinemann, 2005.

7. Jacob Fish and Ted Belytschko, "*A First Course in Finite Elements*", Wiley Inter Science, 2007.

#	Course category	Course code	Course Name	Creidts
	LBC	**1ME169H**	**COMPUTATIONAL ANALYSIS LAB**	**1**

Brief syllabus

Introduction to Matlab and Simulink. Application of Matlab to solve various engineering problems. Modelling of 3D machine components and creating assemblies in modelling Software, Solving structural problems using finite element software, Modal analysis using MATLAB

3) Elective courses

a) Program Elective courses

List of Program Elective courses

#	Course code	Course Name
1	**PEC**	Fracture Mechanics
2	**PEC**	Acoustics and Noise Control
3	**PEC**	Robotics
4	**PEC**	Mechanical Behaviour of Materials
5	**PEC**	Design and Analysis of Composite Structures
6	**PEC**	Advanced Theory of Mechanisms
7	**PEC**	Rotor Dynamics
8	**PEC**	Mechatronic System Design
9	**PEC**	Optimization Methods for Engineers
10	**PEC**	Design of Power Transmission Elements

11	**PEC**	Theory of Plates and Shells
12	**PEC**	Advanced Vehicle Dynamics
13	**PEC**	Design of Pressure Vessel and Piping
14	**PEC**	Experimental Stress Analysis
15	**PEC**	Industrial Tribology
16	**PEC**	Modelling, Simulation and Analysis of Engineering Systems

Syllabus of Program Elective courses

#	Course code	Course Name
	1ME162I	**FRACTURE MECHANICS**

Brief syllabus

Introduction and review of solid mechanics, plane elasticity- In-plane and out-of-plane problems-Airy's stress function-plate with a circular hole, elliptic hole. Fatigue-Failure of uncracked solids, stress-life approach, strain-life approach, Effect of mean stress, Miner's rule, Damage rule for irregular loads. Linear Elastic Fracture mechanics: Energetics of fracture, Griffith's energy balance, strain energy release rate, stability of crack growth-R curve, Eigen expansion for wedges and notches, stress ,displacement field at the crack tip for Mode I and Mode II, Stress Intensity Factor (SIF), Mode III fields, Westergaards function, Relationship between K and G, direction of crack propagation, mixed mode fracture, SIF for various geometries, Crack-Tip plasticity, Correction factor for plasticity effects, Experimental determination of Kc. Elastic-Plastic Fracture mechanics: J- contour integral, Relation between J-integral and CTOD, crack growth resistance curves, constraint effect in fracture, Experimental measurement of J integral. Fatigue - Growth of an initial crack, Fatigue crack growth analysis, Paris law, fatigue life, variable amplitude loading. Fracture mechanics in metals: Ductile fracture, cleavage fracture, ductile-brittle transition.

TEXT BOOKS/REFERENCES:

1. Anderson T. L., “Fracture Mechanics: Fundamentals and Applications”, Third Edition, CRC Press, 2005.
2. Suresh S., “Fatigue of Materials”, Second Edition, Cambridge University Press, 2012.
3. Barsom J. M. and Roffe S. T., “Fracture and Fatigue Control in Structures”, Third Edition, Englewoods Cliffs, Prentice Hall, 1999.

4. Broek D., “Elementary Engineering Fracture Mechanics”, Fourth Edition, Martinus Nijhoff, 1987. Knott J. K., “Fundamentals of Fracture Mechanics”, Third Edition, Butterworth Heinemann, 2011.

#	Course code	Course Name
	1ME163J	**ACOUSTICS AND NOISE CONTROL**

Brief 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.

TEXT BOOKS/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.
   Petrusowicz and Longmore, Noise and Vibration control for industrialists, Elsevier, 1974

#	Course code	Course Name
	1ME163K	**MECHANICAL BEHAVIOUR OF MATERIALS**

Brief syllabus

Introduction, Types of Fracture in Metals, Griffith Theory of Brittle Fracture, Fracture of Single Crystals, Ductile Fracture, Concept of the Fracture Curve. Strain Energy Release rate, Fracture Toughness and Design, Crack Opening Displacement, J-Integral, R Curve, Introduction, Stress Cycles, S-N Curve, Effect of Mean Stress on Fatigue, Cyclic Stress strain curve, Low Cycle Fatigue, Strain Life Equation, Structural Features of Fatigue, Fatigue Crack Propagation, Effect of Metallurgical Variables on Fatigue. Effect of stress concentration on Fatigue, Size Effect, Surface effects on Fatigue, Fatigue under Combined stresses, Design for Fatigue, Machine Design Approach-Infinite life design, Local strain approach, Corrosion Fatigue, Effect of Temperature on fatigue. The evolution of creep damage, primary, secondary and tertiary creep, Micro-mechanisms of creep in materials and the role of diffusion, Ashby creep deformation maps. Stress dependence

of creep – power law dependence. Comparison of creep performance under different conditions – extrapolation and the use of Larson-Miller parameters, Creep-fatigue interactions.

TEXT BOOKS/REFERENCES:

1. Fracture Mechanics Fundamentals and Applications by T.L. Anderson, 2nd Ed. CRC press, (1995)
2. Fracture of Brittle Solids by B. Lawn, Cambridge Solid State Science Series 2nd ed 1993.
3. Fundamentals of Fracture Mechanics by J. F. Knott, Butter worths (1973)

#	Course code	Course Name
	1ME162L	**DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES**

Brief syllabus

Composite materials and its characteristics-Analysis of an orthotropic lamina-Analysis of laminated composites-Fracture mechanics-Determination of strain energy release rateManufacturing Processes-Testing of Composites-Stress analysis - interlaminar stresses and free edge effects-Failure Criteria-Whitnessnuismer failure criteria-Vibration and stability analysis- Introduction to Design of Composite Structures –Introduction to Structural -Design and Analysis of mechanically fastened joints- Optimization Concepts –Fatigue in Composites-Effects of holes in Laminates –Transverse shear effects-Post curing shapes of Unsymmetric Laminates-Environmental Effects on Composite Materials-Study of Hygrothermic effects on laminates-Quality control and Characterization of Composite-Non Destructive testing on Composites-Recycling of Composites –Primary and Secondary Recycling of Composites.

TEXT BOOKS/REFERENCES:

1. Mallick P. K., “Fiber Reinforced Composite Materials - Manufacturing and Design”, Marcel Dekker, 2008. Robert M. Jones, “Mechanics of Composite Materials”, Second Edition, Taylor and Francis, 1999.
2. Halpin J. C., “Primer on Composite Materials Analysis”, Techomic, 1992.
3. Mallick P. K. and Newman S., “Composite Materials Technology - Processes and Properties”, Hansen, 1991.
4. Agarwal B. D. and Broutmen L. J., “Analysis and Performance of Fibre Composites”, John Wiley & Sons, 2017.

#	Course code	Course Name
	1ME164M	**ADVANCED THEORY OF MECHANISM**

Brief syllabus

Introduction to plane motion. Euler – Savary Equation, the Inflection circle, Analytical and graphical determination of di, Bobillier's Construction, Collineation axis, Hartmann's Construction, Inflection circle for the relative motion of two moving planes, Application of the Inflection circle to kinematic analysis. Polode curvature, Hall's Equation, Polode curvature in the four-bar mechanism, coupler motion, relative motion of the output and input links, Freudenstein's collineation – axis theorem, Carter –Hall circle. The Four bar linkage, guiding a body through Two distinct positions, guiding a body through Three distinct positions, The Roto center triangle, Guiding a body through Four distinct positions: Burmester's curve Function generation- General discussion, Function generation: Overlay's method, Function generation- Velocity – pole method, Path generation: Hrones's and Nelson's motion Atlas, Roberts's theorem. Function Generation: Freudenstien's equation, Precision point approximation. Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition, Method of components, Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link, Method of components.

TEXT BOOKS/REFERENCES:

1. Kinematics and Linkage Design by Allen S.Hall Jr., PHI, 1964.
2. Theory of Machines and Mechanisms by J.E Shigley and J.J. Uicker Jr., McGraw-Hill, 1995.
3. A Robot Engineering Text book, Mohsen Shahinpoor, Harper & Row Publishers, New York, 1987. Analysis of mechanisms and Robot manipulators by Joseph Duffy, Edward Arnold, 1980

#	Course code	Course Name
	1ME164N	MECHATRONIC SYSTEM DESIGN

Brief syllabus

Mechatronic systems, Mechatronic design process, Traditional and Mechatronics designs, Advanced approaches in Mechatronics system, Industrial design and ergonomics. Real-time interfacing, Elements of data acquisition and control, Overview of I/O process, Analog signals, discrete signals and Frequency signals. Simulation basics, Probability concepts in simulation, Discrete event simulation, Simulation Methodology, Queuing system model components, Continuous system modelling, Monte Carlo simulation, Analysis of simulation results, Simulation life cycle. Case studies of design of mechatronic products: Motion control using D.C.Motor & Solenoids, Car engine management systems. Applications in Mechatronics: Sensors for condition-based maintenance, Mechatronic Control in IoT based system, Artificial intelligence in Mechatronics, Machine Learning Applications in Mechatronics.

TEXT BOOKS/REFERENCES:

1. Bolton, "Mechatronics – Electronic control systems in mechanical and electrical engineering, 2nd edition, Addison Wesley Longman Ltd., 2009.
2. Brian morriss, "Automated manufacturing Systems – Actuators Controls, sensors and Robotics", McGraw Hill International Edition, 2000.
3. Bradley, D. Dawson, N.C.Burd and A.J. Loader, "Mechatronics: Electronics in product and process", Chapman and Hall, London, 1999.
   Klaus Janschek, "Mechatronic Systems Design", Springer publisher, 2012.

#	Course code	Course Name
	1ME164O	OPTIMIZATION METHODS IN ENGINEERING

Brief syllabus

Introduction to Optimization Engineering applications Statement of an optimization problem Classification Optimal problem formulation: Problems involving design and manufacturing -

Optimality criteria Classical optimization techniques Kuhn-Tucker (KT) optimality conditions. Non-linear programming: One dimensional minimization method - Unconstrained optimization techniques - Constrained optimization techniques - Transformation methods - Interior and exterior penalty function method - Convergence and divergence of optimization algorithms - Complexity of algorithms. Modern Methods in Optimization: Genetic Algorithm Simulated Annealing - Particle Swarm Optimization Neural Network based optimization - Optimization of Fuzzy systems MultiObjective optimization - Design of experiment-based optimization - Data Analytics and optimization using Machine learning approach. Implementing optimization algorithm using Matlab / Programming: Design optimization Robust design - Optimization in manufacturing / machining Multi objective optimization Structural optimization Shape optimization Optimization in production planning and control.

TEXT BOOKS/REFERENCES:

1. S.S. Rao, Engineering optimization: Theory and Practice, New age international, 3rd edition, 2013.

2. K. Deb., Optimization for Engineering Design: Algorithms and Examples, PHI, 2nd Edition, 2012.

3. J. S. Arora, Introduction to Optimum Design, Academic press, 4th Edition, 2017.

4. Saravanan. R., "Manufacturing Optimization through Intelligent Techniques", Taylor & Francis, CRC Press, 2006.

#	Course code	Course Name
	1ME162P	**DESIGN OF POWER TRANSMISSION ELEMENTS**

Brief 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.

TEXT BOOKS/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.

#	Course code	Course Name
	1ME164Q	**THEORY OF PLATES AND SHELLS**

Brief syllabus

Introduction - Formulation of governing equations and associated boundary conditions by equilibrium and energy methods, rectangular plates - Solution of equation by double and single series, Circular plates - symmetric and un-symmetric loading cases, Continuous Plates, Plates with various plan forms, Plates with variable flexural rigidity, Plates on elastic foundation. Numerical and approximate methods - finite difference method - finite element method, energy methods and other variational methods. Introduction, Theory of Surfaces - first and second fundamental forms - principal curvatures, Formulation of governing equations in general orthogonal curvilinear coordinates based on classical assumptions - various shell theories, Membrane theory - governing equations - shells of revolution - application to specific geometric shapes - axisymmetric and non-axisymmetric loading cases. General theory of shells - governing equations and associated boundary conditions for specific geometry of shells (cylindrical, conical and spherical shells) - classical solutions - finite difference and finite element methods applied to shell problems.

TEXT BOOKS/REFERENCES:

1. Vardhan T. K. and Bhaskar K., "Analysis of Plates: Theory and Problems", John Wiley & Sons, 1999.
2. Timoshenko S. and Woinowsky Krieger S., "Theory of Plates and Shells", McGraw-Hill, 2017.
3. Chandrashekhara K., "Theory of Plates", Universities Press, 2001.

#	Course code	Course Name
	1ME163R	**ADVANCED VEHICLE DYNAMICS**

Brief syllabus

Introduction Motion and constraints degrees of freedom kinematic and dynamic analysis dynamical equations in different forms planar and spatial dynamics. Kinematics of rigid bodies velocity and acceleration equations constrained kinematics formulation of driving and joint constraints computational methods in kinematics. Forms of dynamic equations D'Alembert's principle Newton Euler equations constrained dynamics augmented formulation embedding techniques amalgamated formulation. Virtual work and Lagrangian dynamics constrained dynamics elimination of constrained forces. Lagrangian multipliers state space representation algorithm and sparse matrix implementation. Spatial dynamics Euler angles Dynamic equations of motion constrained dynamics Newton Euler equations linear and angular momentum.

TEXT BOOKS/REFERENCES:

1. Shabana A. A., "Computational Dynamics", Third Edition, John Wiley, 2010.
2. Shabana A. A., "Dynamics of Multibody Systems", Fourth Edition, Cambridge University Publications, 2013.
3. Nikravesh P. E., "Planar Multibody Dynamics-formulation, Programming and Applications", CRC Press, 2007.
4. Nikravesh P. E., "Computer Aided Analysis of Mechanical Systems", Prentice Hall, 1988.

#	Course code	Course Name
	1ME162S	**PIPING AND PRESSURE VESSEL DESIGN**

Brief syllabus

Piping - Introduction to piping Codes and Standards - Flow diagram - Basic Design of Piping Systems (material selection, pressure class, pipe size and thickness) and the components - Head losses due to pipes, valves & fittings – Darcy Weisbach and Hazen Williams equations and its applications - Piping layout and piping stress analysis – Allowable stresses - Flexibility factor and stress intensification factor – Two phase flow – Water hammer – Steam hammer – Piping Vibrations - Types of piping supports and their behavior. Pressure Vessel Design – Classification - Factors influencing the design of vessels - Material selection - Introduction to ASME cods for pressure vessel design, Pressure vessel and related components' design using ASME codes - Membrane stresses in pressure vessel under internal pressure and its application to shells (cylindrical, conical and spherical) and end closures - Thermal stresses - Buckling phenomenon - Elastic Buckling of circular ring and cylinders under external pressure - collapse of thick walled cylinders or tubes under external pressure - Effect of supports on Elastic Buckling of Cylinders - Design of circumferential stiffeners - Buckling under combined External pressure and axial loading - Design of saddle supports – Allowable nozzle loads and moments - Reinforcement requirements.

TEXT BOOKS/REFERENCES:

1. Mohinder L. Nayyar, "*Piping Handbook*", McGraw Hill Handbook, Seventh Edition, 1999.
2. M. W. Kellogg Company, "*Design of Piping Systems*", 2009.
3. Crane Co., "*Flow of Fluids Through Valves, Fittings and Pipe*", Crane Technical Paper No. 410.
4. John F. Harvey, "*Theory and Design of Pressure Vessels*", CBS Publishers and Distributors, 1991.
5. Somnath Chattopadhyay, "*Pressure Vessel Design and Practice*", CRC press, 2007.
6. Henry H. Bednar, "*Pressure Vessel Design Hand Book*", CBS Publishers and Distributors, 1990.

7. ASME Boiler and Pressure Vessel Code, Section II (Part D) and Section VIII (Division 1 &2).
8. ASME Code for Pressure Piping, Power Piping ASME B31.1 & Process Piping ASME B31.3.
9. ASME B36.10M Welded and Seamless Wrought Steel Pipe.
10. Indian Boiler Regulations – 1950.

#	Course code	Course Name
	1ME163T	**EXPERIMENTAL STRESS ANALYSIS**

Brief syllabus

Strain gauges - mechanical, optical, acoustic, pneumatic and electrical strain gauges- strain measurement-Electrical resistance strain gauges-Wheat stone bridge, Strain gauge rosettesSemiconductor strain gauges-Photo-elasticity, stress optic law, stress freezing technique-Fringe sharpening-Methods of slicing-Separation of principle stresses-Scattered light photo-elasticity-Moire fringe method-Separation of isochromatic and isopachic fringe pattern-Theory of photo elastic coating, -crack detection methods-Brittle coating method – Isostatics and isoentacties.

TEXT BOOKS/REFERENCES:

1. J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New York, 1988.
2. Srinath, L.S., Raghava,M.R., Lingaiah,K. Gargesha,G.,Pant B. and Ramachandra,K. – Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984
3. P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.
4. M. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.
5. G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.

#	Course code	Course Name
	1ME162U	INDUSTRIAL TRIBOLOGY

Brief syllabus

Engineering Surfaces - surface topography-Analysis of surface roughness-Conformal and non-conformal surfaces-Greenwood and Williamson Model-Contact mechanics, Dry contactsFriction, Modern theories of friction-Stick-Slip Phenomenon-Liquid-Mediated contacts-Wear, Effect of surface roughness, friction, and sliding speed on wear-Ferrography - Oil Analysis Program - Basic equations of Flow, Navier-Stokes equation, Generalized Reynolds's equation-Hydrodynamic lubrication-Boundary lubrication-Bearing materials-Hydrodynamic real (finite) bearings-Design considerations in journal and thrust bearings-Hydrodynamic instability-Hydrodynamic and hydrostatic gas bearings-Idealized slider and journal bearingsOil flow and Thermal analysis of bearings-Bearing selection and design-Dynamically loaded bearings-Squeeze film bearings.

TEXT BOOKS/REFERENCES:

1. Majumdar B. C., "Tribology of Bearings", S. Chand & Company Ltd., 2008.

2. Bharat Bhushan, "Introduction to Tribology", John Wiley & Sons, 2013.

3. Moore and Desmond. F., "Principles and Applications of Tribology", Pergamom Press, 1975.

4. Dudley D. Fuller, "Theory and Practice of Lubrication for Engineers", John Wiley & Sons, 1984.

5. Johnson K. L., "Contact Mechanics", Cambridge University Press, 1987.

#	Course code	Course Name
	1ME163V	MODELLING, SIMULATION AND ANALYSIS OF ENGINEERING SYSTEMS

Brief syllabus

Introduction to linear systems, principle of super position-Modelling of engineering systems-mechanical, electrical, fluid, thermal and mixed discipline systems-Free, forced and transient response of first and second order systems-Solution of differential equation using Laplace

Transforms-Time domain and Frequency domain analysis-State space representation -System characteristics from state space representation-Solving the state equations-Stability criterion through the state transition matrix-Control system design in state space-Linear optimal control.

TEXT BOOKS/REFERENCES:

1. Philip D. Cha, James J. Rosenberg, and Clive L. Dym, "*Fundamentals of Modelling and Analysis of Engineering Systems*", Cambridge University Press, 2000.
2. Woods Robert L. and Lawrence Kent L., "*Modelling and Simulation of Dynamic Systems*", Prentice Hall, 1997.
3. Ashish Tiwari, "*Modern Control Design with MATLAB and SIMULINK*", John Wiley, 2002.

b) Interdisciplinary courses

List of Interdisciplinary courses

#	Course code	Course Name	Offering Department
	1ME165W	Digital Product Design and Manufacturing	Mechanical Engineering
	1ME165X	Advanced Non-Destructive Evaluation	Mechanical Engineering
	1ME165Z	Introduction to 3D Printing Technology	Mechanical Engineering

#	Course code	Course Name
	1ME165A	**DIGITAL PRODUCT DESIGN AND MANUFACTURING**

Brief syllabus

Need for developing products the importance of engineering design types of design the design process relevance of product lifecycle issues in design designing to codes and standards-societal considerations in engineering design generic product development process various phases of product development planning for products establishing markets market segments-

relevance of market research. Identifying customer needs voice of customer. Concept generation testing of concepts customer populations hierarchy of human needs need gathering methods affinity diagrams needs importance establishing engineering characteristics-competitive benchmarking product design specification-case studies Creative thinking creativity and problem solving creative thinking methods generating design concepts systematic methods for designing functional decomposition physical decomposition functional representation morphological methods. Decision making Psychology of colors Visual balancing case studies Quality Aspects of Design -Objectives and functions Targets Dimensions of Quality quality function deployment house of quality GD&T Measures and Matrices.Design of Experiments design process Identification of control factors, noise factors, and performance metrics Quality tools .Case studies Industrial design human factors design user friendly design. Design for manufacturability design for serviceability design for environment prototyping and testing cost evaluation categories of cost overhead costs activity based costing methods of developing cost estimates manufacturing cost value analysis in costing case studies & project Design for reliability basic concept of reliability failure distributions MTTF-MTBF reliability of systems redundancy derating maintainability availability reliability testing.

TEXT BOOKS/REFERENCES:

1. George E.Dieter, Linda C.Schmidt, "Engineering Design", McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9

2. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development ", 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9

3. Kevin Otto, Kristin Wood, "Product Design", Indian Reprint 2004, Pearson Education,ISBN 9788177588217

#	Course code	Course Name
	1ME165B	**ADVANCED NON-DESTRUCTIVE EVALUATION**

Brief syllabus

Die penetrate test (liquid penetrate inspection), Principle, scope. Equipment & techniques, Tests stations, Advantages, types of penetrants and developers, Zyglo test, Illustrative examples and interpretation of defects. Magnetic particle Inspection-scope and working principle, Ferro Magnetic and Non ferro magnetic materials, equipment & testing. Advantages,

limitations Interpretation of results, DC & AC magnetization, Skin Effect, use of dye & wet powders for magna glow testing, different methods to generate magnetic fields, Applications. Radiographic methods: Introduction to electromagnetic waves and radioactivity, various decays, Attenuation of electromagnetic radiations, Photo electric effect, Rayleigh's scattering (coherent scattering), Compton's scattering (Incoherent scattering), Pair production, Beam geometry and Scattering factor-ray radiography: principle, equipment & methodology, applications, types of radiations and limitations. Y-ray radiography-principle, equipment., source of radioactive materials & technique, advantages of Y-ray radiography over X-ray Radiography Precautions against radiation hazards. Case Study-casting and forging

TEXT BOOKS/REFERENCES:

1. Non-Destructive Testing and Evaluation of Materials, by-Prasad, McGraw Hill Education.
2. Practical Non-destructive Testing, by-Baldev Raj, T. Jayakumar, M. Thavasimuthu, Woodhead Publishing.
3. Non-Destructive Testing Techniques, by-Ravi Prakash, New Age International

#	Course code	Course Name
	1ME165C	**INTRODUCTION TO 3D PRINTING**

Brief syllabus

Introduction to Design, Prototyping fundamentals. Introduction to 3D printing, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of 3D printing process, Applications to various fields. Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, case studies. Solid ground curing (SGC): Models and specifications, case studies. Laminated object manufacturing(LOM): Models and specifications, Process, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Case studies, practical demonstration

TEXT BOOKS/REFERENCES:

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010

2. D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer, 2001

3. Terry Wohlers, "Wholers Report 2000", Wohlers Associates, 2000

4. Paul F. Jacobs, "Rapid Prototyping and Manufacturing"–, ASME Press, 1996

5. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.