Rajasthan Technical University (RTU)
Mechanical
(Machine Design)

M. Tech Program in Mechanical Engineering with specialization in
Machine Design

Courses

The theory subjects will be of maximum 125 Marks each having 25 Marks as course work and 100 Marks for University examination.

First Semester

S. No.	Code No.	***Subject***	L	T	P	Marks	Ex. Hrs.
1.	1MEMD1	Advanced Solid Mechanics	3	1	0	125	3
2.	1MEMD2	Advanced Vibrations	3	1	0	125	3
3.	1MEMD3	Numerical Methods	3	1	0	125	3
4.	1MEMD4	Computer Aided Graphics and Design	3	1	0	125	3
5.	1MEMD5	CAD Lab	0	0	3	100	3
Total			12	4	3	600	

Second Semester

S. No.	Code No.	***Subject***	L	T	P	Marks	Ex. Hrs.
6.	2MEMD6	Finite Element Analysis	3	1	0	125	3
7.	2MEMD7	Rotor Dynamics	3	1	0	125	3
8.	2MEMD8	Experimental Modal Analysis	3	1	0	125	3
9.	2MEMD9	Advanced Mechanisms and Manipulators	3	1	0	125	3
10.	2MEMD10	FEA lab	0	0	3	100	3
Total			12	4	3	600	

Rajasthan Technical University (RTU)
Mechanical
(Machine Design)

Third Semester

S. No.	Code No.	***Subject***	L	T	Marks	Ex. Hrs.
11.	3MEMD11	Elective 1	3	1	125	3
12.	3MEMD12	Elective 2	3	1	125	3
13.	3MEMD13	Seminar			150	
14.	3MEMD14	Dissertation –I			100	
Total			6	2	500	

Fourth Semester

S. No.	Code No.	***Subject***	L	T	Marks	Ex. Hrs.
15.	4MEMD15	Dissertation -II			500	
Total					500	

List of Electives: (For 3MEMD11 & 3MEMD12)

Choose any two out of six given below.

3MEMD11&12.1:Composite Materials

3MEMD11&12.2:Fracture Mechanics

3MEMD11&12.3:Micro-Electrical and Mechanical Systems (MEMS)

3MEMD11&12.4:Tribology

3MEMD11&12.5:Pipe and Pressure Vessel Design

3MEMD11&12.6:Selection of Engineering Materials

Rajasthan Technical University (RTU)
Mechanical
(Machine Design)

1MEMD1: ADVANCED SOLID MECHANICS

3L+1T **MM:125** **Ex.Hrs. 3**

Continuum concepts- Stress field (stress tensor, Cauchy's principle, equilibrium equation), Deformation (strain tensor, compatibility), Constitutive equations. Uniqueness and superposition- Boundary value problems in plane stress and plain strain. Torsion of non circular cross section (St. Venant's theory), Timoshenko beam theory and Kirchoff's plate theory. Failure theories, introduction to concepts of fracture mechanics. Numerical and Experimental methods, Introduction to Photo-elasticity and strain gauge techniques. Principle of virtual work, Energy theorems.

1MEMD2: ADVANCED VIBRATIONS

3L+1T **MM:125** **Ex.Hrs. 3**

Vibration of continuous systems: Hamilton's principle, Lagrange's equations. Longitudinal vibration of bars, lateral vibration beams, vibration of membranes and plates. Wave motion in continuous systems.

Nonlinear vibrations: Phase space, singular points, limit cycle; Analytical methods, perturbation techniques, equivalent linearization; Duffing's equation, jump phenomenon, Van der Pol's equation. Stability criterion; Floquet's theory, Hill's and Mathieu's equations, Bifurcation and chaos.

1MEMD3: NUMERICAL METHODS

3L+1T **MM:125** **Ex.Hrs. 3**

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation Algebraic equations : Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss - Siedel), convergence of iteration methods, eigen values and eigen vectors. Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials. Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration. Introduction to optimization methods: Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function.

Rajasthan Technical University (RTU)
Mechanical
(Machine Design)

1MEMD4: COMPUTER AIDED GRAPHICS AND DESIGN

3L+1T **MM:125** **Ex.Hrs. 3**

Brief introduction to solid modeling: Fundamentals of Solid Modeling, Half -spaces, Boundary Representation (B-rep), Constructive Solid Geometry (CSG), Sweep Representation, Analytical Solid Modeling. Solid Manipulations

Methodology of interactive, graphical, engineering design; Discretization, optimization, simulation in CAED. Design of curves and surfaces. Design of volumes. Intersection of surface and interference of volumes.

1MEMD5: CAD LAB

3P **MM:100** **Ex.Hrs. 3**

Computer aided drafting. Solid modeling: part creation, surface generation and assembly of parts. Exercise problems using software.

2MEMD6: FINITE ELEMENT ANALYSIS

3L+1T **Ex. Hrs: 3**

Method of weighted residuals and variational approach for solving differential equations. Galerkin and Rayleigh-Ritz methods. Finite element method and implementation. Convergence criterion. Finite element formulation for linear elastic continuum. Substructuring. C_0-elements including isoparametric elements. Plate bending and C_1 elements. Introduction to dynamic and non-linear problems.

2MEMD7: ROTOR DYNAMICS

3L+1T **Ex. Hrs: 3**

Torsional Vibration. Analysis of Rotating Machines including branched systems. Response to steady state and transient excitation. Bending critical speeds of simple shafts, Unbalance response, Orbital Analysis and Cascade Plots. Disc gyroscopics, synchronous and non-synchronous whirl, Review of fluid film bearings and seals, Analysis of rotors mounted on hydrodynamic bearings, Application to two spool and multispool rotors. Introduction to asymmetric shafts. Parametric excitation and instabilities.

2MEMD8: EXPERIMENTAL MODAL ANALYSIS

3L+1T **Ex. Hrs: 3**

Introduction to modal testing: Presentation and properties of FRF data for SDOF system, undamped multi degree of freedom system (MDOF), proportional damping, hysteretic damping, viscous damping, characteristics and presentation of MDOF FRF data.
Mobility measurement techniques: Basic measurement system, structure preparation, excitation of the structure, transducers and amplifiers, analyzers, digital signal processing, use of different excitation types, calibration, mass cancellation.
Modal parameter extraction methods: Preliminary checks of FRF data, SDOF modal analysis- Peak amplitude, circle-fit method, inverse method, residuals, introduction to MDOF curve-fitting procedure - extension of SDOF method.
Derivation of mathematical models: Modal models, display of modal model, response models, spatial models, mobility skeletons and system models.
Application: Comparison of experiment and predication, correction or adjustment of models, structural modification, response predication and force determination.

2MEMD9: ADVANCED MECHANISMS AND MANIPULATORS

3L+1T **Ex. Hrs: 3**

Classification of closed- and open-loop kinematic systems, Definition of mechanisms and manipulators, Kinematic constraints, Degree of freedom (DOF) and Mobility; DH parameters, Coordinate transformations, Matrix methods; Structural analysis and synthesis of mechanisms; Forward kinematics of robot manipulators with examples; Inverse kinematics; Jacobian and singularity; Alternative design solutions of mechanisms and manipulators; Evaluation and selection of optimum mechanism; Type and number synthesis, Design of mechanisms; Indexes of merit; Graphical, Algebraic and Optimization techniques.

2MEMD10: FEA LAB

3P **MM:100** **Ex.Hrs. 3**

Laboratory work for the solution of solid mechanics problems and free vibration problems using FE packages.

III SEMESTER M-Tech. (MACHINE DESIGN) SYLLABUS (FOR 3MEMD11 & 12)

3MEMD11&12.1:COMPOSITE MATERIALS

Lamina constitutive Relations

Definition – Need –General Characteristics, Applications. Fibers, Glass, Carbon, Ceramic and Aramid fibers. Matrices-polymer, Graphite, Ceramic and Metal Matrices- Characteristics of fibers and matrices.

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic viewpoint. Generalized Hook's Law. Reduction to Homogeneous Orthotropic Lamina –Isotropic limit case, orthotropic stiffness matrix (Q_{ij}), Typical Commercial material properties, Rule of Mixtures, Generally Orthotropic Lamina – Transformation Matrix, Transformed stiffness. Manufacturing: Bag Moulding- Compression Moulding- Pultrusion- Filament Winding – Other Manufacturing Processes.

Flat plates laminate constitutive relations

Definition of stress and Moment Resultants. Strain Displacement relations. Basic assumptions of Laminated anisotropic plates. Laminate Constitutive Equations- Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses with in Laminates.

Lamina strength analysis

Introduction – Maximum Stress and Strain Criteria. Von- Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.

Introduction of Failure mode of composite laminate, Hygrothermal behaviors of laminates

3MEMD11&12.2:FRACTURE MECHANICS

Elements of solid mechanics

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation Airy's function- field equation for stress intensity factor.

Stationary crack under loading

Two dimensional elastic field- Analytical solutions yielding near a crack front- Irwin's approximation- plastic zone size- Dugdaale model- determination of J integral and its relation to crack opening displacement.

Energy balance and crack growth

Griffith analysis- stable and unstable crack growth- Dynamic energy balance- crack arrest mechanism- K_{1c} test methods- R curves- determination of collapse load.

Fatigue crack growth curve

Empirical relation describing crack growth law-life calculations for a given load amplitude-effects of changing the load spectrum. Introduction to factors affecting fatigue crack propagation.
Detection of cracks: NDT methods.
Experimental determination of GIC, KIC, J-Integral and CTOD.
Introduction to crack propagation in composite materials.

3MEMD11&12.3:MICRO-ELECTRICAL AND MECHANICAL SYSTEMS (MEMS)

1. **Introduction:** Production Engineering; Precision Engineering and Ultra Precision Engineering; Integrated Circuits (IC); Micro Electromechanical Systems (MEMS); Micro-sensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS; MOEMS; Magnetic MEMS; RF MEMS; Micro fluidic Systems; Bio and Chemo – Devices; Nano-technology; Modeling and Simulation; MEMS Packaging and Design consideration; Micro instrumentation.
2. **Micromachining:** Introduction; Photolithography; Structural and Sacrificial Materials; other lithography Methods; Thin Film Deposition; Impurity Doping; Etching; Surface Micromachining; Bulk versus Surface Micromachining; Wafer Bonding; LIGA
3. **System Modeling and Properties of Material:** The need for Modeling; System Types; Basic Modeling Elements in Mechanical System; Basic Modeling Elements Electrical Systems; Basic Modeling Elements Fluid Systems; Basic Modeling Elements Thermal Systems; Translational Pure Mechanical System with Spring. Damper and Mass; Rotational Pure Mechanical System with spring, Damper and Mass; Modeling Hybrid Systems.
4. **Passive Components and Systems:** Introduction; System on a Chip (SOC); Passive Electronic Systems; Passive Mechanical Systems (PMS).
5. **Mechanical Sensors and Actuators:** Principal of Sensing and Actuation; Beam and Cantilever; Micro Plates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain measurements; Pressure Measurement; Flow Measurement; using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shear mode Piezo-actuator; Gripping Piezo-actuator; Inchworm technology.
6. **Thermal Sensors and Actuators:** Thermal Energy Basics and Heat Transfer Processes; Transistors; Thermistors; Thermo-devices; Thermo-couple; Micromachined Thermo-couple Probe; Peltier Effect Heat Pumps; Thermal Flow Sensors; Microhotplate Gas Sensors; MEMS Thermovessels; Pyroelectricity; Shape Memory Alloys (SMA); U Shaped Horizontal and Vertical Electro-thermal Actuator; Thermally Activated MEMS Relay; Microspring Thermal Actuator.
7. **Microfludic Systems:** Applications; Important Considerations on Microscale Fluid; Fluid Actuation Methods; Dielectrophoresis (DEP); Electro-wetting; Electro-thermal Flow; Thermo-capillary Effect; Electroosmosis Flow; Optoelectro-wetting (OEW); Tuning Using Micro-fluidcs; Typical Micro-fludic Channel; Micro-fluid Dispenser; Micro-needle; Molecular Gate; Micropumps; The Continous Flow System.
8. **Principal and introduction of Micro-Opto-Electromechanical system, Magnetic sensors and actuators and Radio frequency(RF) MEMS**