

**MAHATMA GANDHI UNIVERSITY**



**SCHEME AND SYLLABI**  
**FOR**  
**M. Tech. DEGREE PROGRAMME**  
**IN**  
**MECHANICAL ENGINEERING**  
**WITH SPECIALIZATION IN**  
**MACHINE DESIGN**  
**(2011 ADMISSION ONWARDS)**

**SCHEME AND SYLLABI FOR M. Tech. DEGREE  
PROGRAMME IN MECHANICAL ENGINEERING  
WITH SPECIALIZATION IN  
MACHINE DESIGN**

**SEMESTER-I**

Sl. No.	Course Number	Subject	Hrs/Week			Evaluation Scheme (Marks)						Credits
						Sessional Exam (internal)			ESE (Theory / Practical)	Total		
			L	T	P	TA	CT	Sub Total				
1	MMEMD 101 <sup>\$1</sup>	Advanced Engineering Mathematics	3	1	0	25	25	50	100	150	4	
2	MMEMD 102	Theory of Vibrations	3	1	0	25	25	50	100	150	4	
3	MMEMD 103	Advanced Mechanics of Solids	3	1	0	25	25	50	100	150	4	
4	MMEMD 104	Advanced Theory of Mechanisms	3	1	0	25	25	50	100	150	4	
5	MMEMD 105	Professional Elective – I	3	0	0	25	25	50	100	150	3	
6	MMEMD 106	Professional Elective – II	3	0	0	25	25	50	100	150	3	
7	MMEMD 107	Seminar - I	0	0	2	50	-	50	0	50	1	
8	MMEMD 108	Advanced Measurements Laboratory	0	0	3	25	25	50	100	150	2	
			<b>18</b>	<b>4</b>	<b>5</b>			<b>400</b>	<b>700</b>	<b>1100</b>	<b>25</b>	

Elective – I (MMEMD 105)		Elective – II (MMEMD 106)	
MMEMD 105-1	Design of Pressure Vessels and Piping	MMEMD 106-1	Experimental Stress Analysis
MMEMD 105-2	Oil Hydraulics and Pneumatics	MMEMD 106-2	Composite Materials and Mechanics
MMEMD 105-3	Engineering Optimization	MMEMD 106-3	Vibration Control and Condition Monitoring
MMEMD 105-4	Industrial Tribology	MMEMD 106-4	Industrial Instrumentation

TA – Teachers Assessment (Quizzes, attendance, group discussion, tutorials, seminar, field visit etc)

CT – Class Test; Minimum two tests conducted by the institute

ESE – University End Semester Exam will be conducted by the institute through concerned affiliating University.

L - Lecture, T - Tutorial, P - Practical

MMEMD 101<sup>\$1</sup> Common to MMEMP 106-4

## SEMESTER-II

Sl. No.	Course Number	Subject	Hrs/Week			Evaluation Scheme (Marks)						Credits
						Sessional Exam (internal)			ESE (Theory / Practical)	Total		
			L	T	P	TA	CT	Sub Total				
1	MMEMD 201 <sup>\$2</sup>	Finite Element Method	3	1	0	25	25	50	100	150	4	
2	MMEMD 202	Design Engineering	3	1	0	25	25	50	100	150	4	
3	MMEMD 203	Design of Power Transmission Elements	3	1	0	25	25	50	100	150	4	
4	MMEMD 204 <sup>\$3</sup>	Computer Aided Design in Manufacturing	3	1	0	25	25	50	100	150	4	
5	MMEMD 205	Professional Elective – III	3	0	0	25	25	50	100	150	3	
6	MMEMD 206	Professional Elective – IV	3	0	0	25	25	50	100	150	3	
7	MMEMD 207	Seminar - II	0	0	2	50	0	50	0	50	1	
8	MMEMD 208	Computer Aided Engineering Design Laboratory	0	0	3	25	25	50	100	150	2	
			<b>18</b>	<b>4</b>	<b>5</b>			<b>400</b>	<b>700</b>	<b>1100</b>	<b>25</b>	

Elective – III (MMEMD 205)		Elective – IV (MMEMD 206)	
MMEMD 205-1 <sup>\$4</sup>	Principles of Robotics and Applications	MMEMD 206-1 <sup>\$6</sup>	Research Methodology
MMEMD 205-2 <sup>\$5</sup>	Computer Integrated Manufacturing	MMEMD 206-2	Computational Fluid Dynamics
MMEMD 205-3	Advanced Theory of Vibrations	MMEMD 206-3	Acoustics and Noise Control for Engineers
MMEMD 205-4	Fracture Mechanics and Design	MMEMD 206-4	Advanced Machine Tool Design

TA – Teachers Assessment (Quizzes, attendance, group discussion, tutorials, seminar, field visit etc)

CT – Class Test; Minimum two tests conducted by the institute

ESE – University End Semester Exam will be conducted by the institute through concerned affiliating University.

L - Lecture, T - Tutorial, P - Practical

MMEMD 201<sup>\$2</sup> common to MMEMP 105.4

MMEMD 204<sup>\$3</sup> common to MMEPI 103

MMEMD 205-1<sup>\$4</sup> common to MMEPI 205

MMEMD 205-2<sup>\$5</sup> common to MMEMP 103

MMEMD 206-1<sup>\$6</sup> common to MMEPI 206.3

## SEMESTER-III

Sl. No.	Course Number	Subject	Hrs/Week			Evaluation Scheme (Marks)					Credits
						Sessional Exam (internal)			ESE (ORAL**)	Total	
			L	T	P	TA	CT	Sub Total			
1	MMEMD 301	Industrial Training	0	0	20	50*	0	50	100	150	10
2	MMEMD 302	Thesis – Phase I	0	0	10	100***	0	100	0	100	5
					<b>30</b>			<b>150</b>	<b>100</b>	<b>250</b>	<b>15</b>

- \* TA - based on technical report submitted together with presentation at the end of the industrial training.
- \*\* Industrial training evaluation will be conducted at end of the third semester by a panel of examiners, with at least one external examiner, constituted by the university.
- \*\*\* 50% of the marks to be awarded by the project guide and the remaining 50% to be awarded by a panel of examiners, including project guide, constituted by the department.

## SEMESTER-IV

Sl. No	Course Number	Subject	Hrs/Week			Evaluation Scheme (Marks)					Credits
						Sessional Exam (Internal)			ESE Thesis Evaluation and Viva****	Total	
			L	T	P	TA***	CT	Sub Total			
1	MMEMD 401	Thesis – Phase II	0	0	30	100	0	100	100	200	15
2	MMEMD 402	Master's Comprehensive Viva							100	100	
										<b>300</b>	<b>15</b>
<b>Grand total marks of all four semesters</b>										<b>2750</b>	<b>Total Credits = 80</b>

- \*\*\* 50% of the marks to be awarded by the project guide and the remaining 50% to be awarded by a panel of examiners, including project guide, constituted by the department.
- \*\*\*\* Thesis evaluation and viva-voce will be conducted at end of the fourth semester by a panel of examiners with at least one external examiner, constituted by the university.

L	T	P	C
3	1	0	4

### Module 1

**Special functions:** Power series solutions of ODE – Legendre’s equation – Legendre’s polynomial – Frobenius method – generating function – Bessel’s equation – Bessel’s function – Recurrence relations and orthogonality property.

### Module 2

**Applications partial differential equations:** Linear partial differential equation of second order – elliptic, parabolic, hyperbolic equations – solution of Laplace, one-dimensional heat & wave equations.

**Numerical solution of partial differential equation:** Finite difference method – solution of Laplace equation – solution of one-dimensional heat equation – Crank Nicholson method – solution of one-dimensional wave equation.

### Module 3

**Tensor analysis:** Range and summation conventions – transformation of co-ordinates contra variant, covariant, mixed, metric and conjugate tensors, fundamental operations with Tensors – Christopher’s symbols.

### Module 4

**Analysis of variance:** One way and two way classification (single observation per cell) – basic principles of experimentation – role of randomization, replication, local control – basic designs – CRD, RBD, LSD.

### References:

1. B. S. Grewal, “Higher engineering mathematics”, Khanna Publishers, 2000
2. Michael E. Greenberg, “Advanced engineering mathematics”, Pearson Education
3. Erwin Kreyszig, “Advanced engineering mathematics”
4. E. Balagurusamy, “Numerical methods”, Tata McGraw Hill, 1995

5. Sokol Nikof, "Tensor analysis", John Wiley, New York, 2000
6. Richard A. Johnson, "Miller & Freund's probability & statistics for engineers", Prentice Hall of India, 2006
7. Jay L. Devore, "Probability and statistics for engineering and sciences"
8. B. S. Grewal, "Numerical methods in engineering and sciences", Khanna Publications

L	T	P	C
3	1	0	4

### Module 1

**Free Vibration:** Introduction, Fundamentals of system modeling, Spring, inertia and damping elements, Harmonic motion – Representation and analysis, Use of Fourier series, Single degree of freedom undamped system – Equation of motion, natural frequency, complete response, examples, Single degree of freedom systems with viscous damping – response, under damping, critical damping and over damping, Logarithmic decrement, Free vibration with Coulomb damping, Free vibration with Hysteresis damping. Concept of state space (phase space), state space diagrams for above systems.

### Module 2

**Forced Vibration:** Harmonically excited vibration – equation of motion, response of undamped systems under harmonic force, response of damped systems to harmonic force, frequency response plots, harmonic motion of the base, transmissibility. Response under general periodic force, Use of Fourier series, response due to square wave, triangular wave, half sine wave etc.

### Module 3

**Transient Vibration:** The unit impulse (Dirac Delta), Impulse response, step response, ramp response, response to arbitrary excitations, Time domain method – Convolution Integral, complete response to arbitrary excitation, response spectrum, Frequency domain method – Laplace Transforms, transfer function, general response using Laplace transforms.

### Module 4

**Two Degree of Freedom Systems:** Introduction, Equations of motion, matrix form, coupling in mass, coupling in stiffness, free vibration analysis of 2 dof undamped system, Eigen value problem, natural frequencies, mode shapes, initial conditions to excite a specific mode, response to general initial conditions, **Multi Degree of Freedom System;** normal mode of vibration, flexibility matrix and stiffness matrix, eigen values and vectors, orthogonal properties-modal matrix analysis, matrix inversion method, modal damping in forced vibration, numerical methods.

**References:**

1. Leonard Meirovitch, "Fundamentals of Vibrations", McGraw Hill International, 2001.
2. S. S. Rao, "Mechanical Vibrations", Prentice Hall, 2000.
3. W. T. Thomson, M. D. Dahleh, C. Padmanabhan, "Theory of Vibration with Applications",  
Pearson Education, 2008.
4. Den Hartog, "Mechanical Vibrations", Dover Publishers, 1985.

L	T	P	C
3	1	0	4

### Module 1

**Introduction to Three Dimensional Theory of Elasticity:** Plane stress and Plane strain problems, Differential Equations of equilibrium, strain-displacement relations in cartesian and polar co-ordinates, Boundary conditions, Compatibility conditions, Airy's Stress function, Biharmonic equation, Saint Venant's principle, applications to Polynomials in rectangular co-ordinates - cantilever with point load at free end, simply supported beam with UDL - Pure bending of curved bars, solid disc and disc with a central hole

### Module 2

**Shear center:** Shear stress distribution and Shear center for thin walled open sections circular and semi circular. Determine the shear center of a section like channel, I , L , Z etc.

**Torsion:** Torsion of prismatic shafts, Warping, Semi-inverse method and Stress function method - Membrane analogy, Torsion of bars with elliptical, square and rectangular cross section, Torsion of multi celled thin wall open and closed sections.

### Module 3

**Thin rectangular plates:** Slope and curvature - Governing differential equation, Boundary conditions - Navier solution for a rectangular plate carrying a uniformly distributed load. Membrane stresses.

**Contact stresses:** Problem of determining contact stresses, Assumptions, Expressions for principal stresses, cylindrical bodies in line contact and spherical bodies in point contact.

### Module 4

**Theory of Plasticity:** Fundamental aspects of general inelastic behaviour. Stress-strain curves – plastic flow conditions - Von Mises and Tresca criteria – plastic work – simple applications – elasto-plastic analysis for bending and torsion of bars – residual stresses.

**Introduction to Viscoelasticity:** Rheological models, Maxwell model, Kelvin model and the four-element Maxwell-Kelvin model.

### References:

1. Den Hartog, "Advanced Strength of Materials", McGraw Hill, 1952.

2. S.Timoshenko & J.W.Goodier, "Theory of Elasticity", McGraw Hill, 2007.
3. S.P.Timoshenko, "Theory of Plates & Shells", McGraw Hill, 1958.
4. Seely and Smith, "Advanced Mechanics of Materials", John Wiley, 1952.
5. Filonenko & Borodic, "Theory of Elasticity", Foreign Languages Publishing House, 1965.
6. Fluggue.W, "Handbook of Engineering Mechanics", McGraw Hill, 1962.
7. Prager W., "Introduction to Plasticity", Oxford University Press, 1959.
8. Kachanov.L.M., "Foundations of Theory of Plasticity", North-Holland Publishing Co., 1971.

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### Module 1

**Kinematics:** Review of determination of velocity and acceleration of points and links in mechanisms- Analytical and graphical methods – Use of auxiliary points and special methods for velocity and acceleration determination. Pole, polode, Polode curvature, path curvature, Inflection circle-Euler-Savary Equation-Bobiller theorem- Collineation axis-Hartman's construction

### Module 2

**Synthesis of Mechanisms:** Two position and three position synthesis of four bar linkage and slider crank mechanism. - Relative poles of four bar linkages and slider crank mechanisms - Geometric methods of synthesis with three accuracy points- Design of a function generators using Chebychev Spacing- Overlay method for conditioned crank mechanisms- Transmission angle – Angle design for optimum transmission – Coupler curves – Robert's Law - Cognate mechanisms.

### Module 3

**Analysis of Cams:** Basic curves, pressure, angle-Cam size determination-Cam profile determination-Analytical and graphical. Advanced curves-combination of curves-Polydyne cams. Cam dynamics: Cam force analysis-Dynamics of high speed cam system, source of vibration, Follower response-Phase plane method, Johnson's Numerical Analysis – Position error-Jump and cross-over shock, Spring surge and wind up.

### Module 4

**Static and Dynamic Force Analysis:** Forces, Couples. Conditions of equilibrium- Free body diagram. Analysis of 4-bar linkage, slider crank mechanisms, spur gears, cams, Helical gears. Force analysis using Coulomb friction and pin joint friction. Dynamic force analysis of spatial mechanism Linear impulse and momentum, Moment of momentum, Components of moment of momentum. Motion of a rigid body, moments and products of Inertia, Translation of axes. Rotation of axes. Measuring moment of Inertia, Euler's equation of motion.

## References:

1. Holowenko, A.R, "Dynamics of Machinery", Wiley, 2007.
2. Allen S. Hall, Jr., "Kinematics and Linkage Design", Prentice Hall, 2007.
3. Shigley, J.E, John J. Uicker, "Theory of Machines and Mechanisms", Oxford University press, 2004.
4. Hartenberg and Denavit, "Kinematic Synthesis of Linkages", McGraw Hill, 1964.
5. Arthur G. Erdman and George N. Sandor, "Mechanisms Design Analysis and Synthesis - Vol. I and II", Prentice Hall of India.
6. J.E.Shigley, "Kinematics analysis of Mechanisms", McGraw Hill, 2007.
7. Robert L. Norton, "Design of Machinery", Tata McGraw Hill, 2004.
8. Rothbart H.A., "Cams", Wiley, 1956.
9. Merit, "Gears", Pitman, 1954.
10. Pahlen R.M., "Fundamentals of Mechanical Design", McGraw Hill, 1962.

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**Module 1**

**Design and analysis of unfired pressure vessels**-stress analysis for modern pressure vessels, membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels, excessive elastic deformation, plastic instability, brittle, rupture, creep.

**Module 2**

**Design of Tall cylindrical self supporting process columns** – supports for short vertical vessels – stress concentration – at a variable thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings - theory of reinforcement – design of circumferential stiffeners, design of covers, pressure vessel design - related components like relief valves etc. – Use of ASME codes.

**Module 3**

**Buckling of pressure vessels** – 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 – Buckling under combined External pressure and axial loading

**Module 4**

**Design and analysis of piping systems** – pipes and tubing under external and internal pressure - design of tube-sheets and tube seats, and use of post-weld heat treatment to effect residual stress in final rupture.

**References:**

1. John F. Harvey, “Pressure Vessel Design”, CBS publishers, 2007.
2. Henry H. Bedner, “Pressure Vessels”, Design Hand Book, CBS publishers, 2007.
3. William. J., Bees, “Approximate Methods in the Design and Analysis of Pressure Vessels and Piping”, Presented at ASME Pressure Vessels and Piping Conference, 1997.
4. ASME Code for Pressure Vessel Design.

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### Module 1

**Fluid power fundamentals:** Introduction - operation principle of fluid power – definitions, units, standards and symbols – advantages and disadvantages – applications in various fields.

**Hydraulic cylinders:** Classification and characteristics - connection types and performance parameters - differential and float concepts - typical cylinder structure - ancillary hydraulic elements.

### Module 2

**Control valves:** Directional control valve - structure and operation of pilot-operated check valves and the directional control valves - standard symbols for representing the elements - concepts of position and way - actuation mechanisms. Pressure control valves – operation - remote pressure adjustment of the pilot-operated pressure relief valve - pressure reducing valve, sequence valve, counterbalance valve and pressure switch. Flow control valves - throttle characteristics of various orifices - flow regulating valve. Cartridge valves, proportional valves and servo valves.

### Module 3

**Hydraulic circuits:** Rapid motion circuits, speed control circuits, synchronous circuits, sequential circuits, counter balance circuits and unloading circuits. Typical hydraulic system examples - movable platform system of modular machine tools - the hydraulic system of truck cranes. **Pneumatic circuits:** Compressed air production and distribution, pneumatic control components, examples of application including electro-pneumatic and hydro pneumatic controls.

### Module 4

**Design of circuits:** Hydraulic circuit design for typical hydraulic systems such as hydraulic press, movable platform of modular machine tools, truck cranes – design calculations. Pneumatic circuit design and associated design calculations.

### References:

1. Pippengar, John J. and Koff, Richard M, “Fluid Power Controls”, McGraw Hill, 1959.
2. Pippengar, John J. and Hicks, Tyler G, “Industrial Hydraulics”, McGraw Hill, 1979.

3. Kirshner, Joseph M, "Fluid amplifiers", McGraw Hill, 1966.
4. Kirshner, Joseph M. and Silas Katz, "Design Theory of Fluidic Components", Academic press, 1975.
5. Dr. Heinza Zoebel. Techn, "Fundamentals of Hydraulic Circuitry", Iliffe, 1970.
6. Leskiewics H.J. and Zarhmba M, "Pneumatic and Hydraulic components and instrumentations in automatic controls", International Federation of Automatic Control, 1980.

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**Module 1**

**Classical optimization techniques:** Introduction to Optimization, Formulation and Solution methodologies, Single variable optimization, Multivariable optimization with no constraints, with equality constraints and with inequality constraints. Unrestricted search method, Interval halving method, Fibonacci method, Golden Section method, quadratic interpolation method, pattern search method, steepest descent method, quasi-Newton method, Hook & Jeeve's method, Lagrange multiplier method

**Module 2**

**Constrained non-linear optimization:** Kuhn-Tucker conditions, quadratic programming, Wolfe's method, method of feasible directions, Frank-Wolf method, convex simplex method, separable programming, Kelley's cutting plane method, penalty and barrier methods

**Module 3**

**Integer and dynamic programming:** Dynamic programming, principle of optimality – tabular and calculus methods of solutions, introduction to integer programming – Gomory's cutting plane method, branch and bound method

**Module 4**

**Calculus of variations:** Problems with fixed end points and moving boundaries, strong and weak variations, first variation, problems with integral constraints, statement only of the corner conditions for discontinuous case, sufficient condition for strong and weak extrema.

**References:**

1. S.S. Rao, "Engineering Optimization", Newage, 1996.
2. N.S. Kambo, "Mathematical Programming Techniques", Affiliated East-West Press, 1984.
3. Els Golts, "Differential Equations and Calculus of Variations", Mir Publications.

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### Module 1

**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 – theories of wear - stages of wear - adhesive and abrasive wear -factors affecting wear.

**Lubrication:** Role of lubrication – Lubricants - Importance of viscosity and methods for measuring viscosity - fundamentals of viscous flow - flow through capillary tubes between parallel plates - radial flow between parallel circular plates – The continuity equation and Reynold’s equation.

### Module 2

**Hydrodynamic bearings:** Journal bearings eccentricity - pressure distribution – load carrying capacity – 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.

### Module 3

**Hydrostatic bearings:** Hydrostatic lubrication , linear slider bearing, Analysis of oil pads - hydrostatic step bearings - hydrostatic thrust bearing with shoes - role of restrictors - bearing materials and lubricants. Air film lubrication, Aerostatic slide ways.

### Module 4

**Rolling element bearings:** Types - bearings theory - static and dynamic capacities - bearing life – selection of bearings - lubrication and mounting of bearings. Bearing failures.

### References:

1. Radzimovsky, “Theory of lubrication of bearings”, Mir Publications, 1972.
2. O’Conner and Boyd, “Standard Hand Book of Lubrication Engineering”, McGraw Hill, 1968.
3. Fuller D.D., “Theory and practice of lubrication for Engineers”, John Wiley, 1973.

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Module 1

**Introduction :-** Principal stresses and strains – Three dimensional stress – strain relationships – Plane stress and Plane strain conditions. Strain gauges – Types – Mechanical, Optical and Electrical strain gauges – Electrical resistance strain gauges – Gauge factor – Strain gauge circuitry – Temperature compensation – Bridge balancing and calibration of D.C and A.C bridges.

### Module 2

**Application of strain gauges :-** Transverse sensitivity – Selection and mounting of strain gauges – Strain gauge rosettes – Analysis of strain gauge data and stress calculations – Recording equipments for static and dynamic strains – Strain gauge transducers – Introduction to semiconductor strain gauges - Residual stresses - Beneficial and harmful effects – Principle of residual stress measurement methods.

### Module 3

**Photoelasticity:** Theory of photoelasticity - Stress-optic law - Plain Polariscope & Circular Polariscope – Isoclinic & Isochromatic fringes – Partial fringe value and compensation techniques – Tardy’s Method. Photoelastic model materials and their desired properties - use of photo elastic coatings. Applications of Photoelasticity for two dimensional models - Separation of Principal stresses – Scaling models to prototype. Introduction to 3D Photoelasticity.

### Module 4

**Other Stress analysis techniques -** Moire fringe method and Brittle coating technique for stress analysis. Introduction to Holography in stress analysis.

Non-destructive testing – 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

### References:

1. Dalley and Riley, “Experimental stress Analysis”, McGraw Hill, 1991.
2. Sadhu Singh, “Experimental Stress Analysis”, Khanna Publishers, New Delhi, 1996.

3. Dove and Adams, "Experimental Stress Analysis and Motion measurement", Prentice Hall, 1965.
4. Hetenyi, "Handbook of Experimental stress Analysis", John Wiley, 1960.
5. Perry and Lissener, "Strain gauge Primer", McGraw Hill, 1962.
6. W.J. McGonnagle, "Non-destructive Testing", McGraw Hill, 1961.
7. American Society for Metals, "Metals Hand Book – Vol.7", 1984.

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3	0	0	3

**Module 1**

**Introduction:** Definition- Need – General characteristics, Applications. Static Mechanical Properties – Fatigue and Impact Properties - Environmental effects – Long term properties, Fracture behavior and Damage Tolerance. Fibers- Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal matrices – Characteristics of fibers and matrices. Fiber surface treatments, fillers and additives, Fiber content, density and void content.

**Module 2**

**Mechanics:** Rule of mixture – volume and mass fractions – density – void content, Evaluation of four elastic moduli based on strength of materials approach and Semi – empirical model – Longitudinal Young’s modulus – transverse Young’s modulus – major Poisson’s ratio – In-plane shear modulus, Ultimate strengths of a unidirectional lamina. Characteristics of Fiber reinforced lamina – laminates – lamination theory. Inter laminar stresses.

**Module 3**

**Manufacturing:** Bag moulding – Compression moulding – Pultrusion – Filament Winding – Other manufacturing Processes – Quality Inspection Methods. Processing of MMC – diffusion bonding – stir casting – squeeze casting.

**Module 4**

**Analysis:** Stress Analysis of Composite Laminates, Failure predictions – maximum stress theory, maximum strain theory, Tsai-Hill theory, Laminate Design considerations, Modes of failure of composites – First Ply Failure, Partial Ply Failure, Total Ply Failure.

**References:**

1. Autar K Kaw, “Mechanics of Composite Materials”, CRC Press, 2006
2. Chawla K K, “Composite Materials”, Springer – Verlag, 1987
3. Carlos A., Cristóvão M., Manuel J. M. Freitas, “Mechanics of Composite materials and Structures”. Kluwer Academic, 1999.
4. Serope Kalpakjian, Steven Schmid, “Manufacturing engineering and technology”, Prentice Hall, 2009.

5. Mallick, P.K., "Fiber-Reinforced Composites: Materials, Manufacturing and Design",  
Maneel Dekker Inc, 1993.
6. Agarwal, B.D., and Broutman L.J., "Analysis and Performance of Fiber Composites",  
John Wiley, New York, 1990.

L	T	P	C
3	0	0	3

## MONITORING

**Module 1**

**Vibration Control** - Review of Fundamentals of Single Degree Freedom Systems, Multi Degree Freedom Systems and Continuous systems. Reduction of Vibration at the Source - Control of Vibration – by Structural design – Material Selection – Localized additions – Artificial damping – Resilient isolation, Vibration isolation, Vibration absorbers. Active vibration control - review of smart materials – types and characteristics - smart structures.

**Module 2**

**Selecting methods of condition monitoring** - Machine condition monitoring and diagnosis – Vibration severity criteria – Machine maintenance techniques – Machine condition monitoring techniques – Vibration monitoring techniques – Instrumentation systems – Choice of monitoring parameter.

**Module 3**

**Predictive Maintenance and Signature Analysis**- observational and estimation techniques, online techniques specially dealing with instrumentation system, offline technique like visual inspection, non destructive testing and destructive testing for materials, fluids and general mechanical and electrical components, predictive analysis of potential failures and end of useful life. Diagnostic maintenance, applications to specific industrial machinery and plants.

**Module 4**

**Dynamic balancing and alignment of machinery:** Dynamic Balancing of Rotors, Field Balancing in one Plane, two Planes, and in several Planes, Machinery Alignment, “Rough” Alignment Methods, The Face- Peripheral Dial Indicator Method, Reverse Indicator Method, Shaft-to-coupling spool method.

**References:**

1. Singiresu S. Rao, “Mechanical Vibrations”, Addison-Wesley Publishing Company, 1995.
2. J.O. Den Hartog, “Mechanical Vibrations”, McGraw Hill, Newyork, 1985.
3. R.A.Collacott, “Vibration monitoring and diagnosis”, Wiley, 1979

4. R.A.Collacott, "Mechanical Fault diagnosis and condition monitoring", Wiley, 1977.
5. First course on "Condition monitoring in the process industries", Manchester, edited by M.J.Neale, Nov 1979.
6. Newman, "Management of Industrial Maintenance", Butterworth, 1978.
7. "Condition Monitoring Manual", National Productivity Council, New Delhi.
8. "Terotechnology", Institute of mechanical Engineers, 1975.
9. Rao, J.S., "Vibratory Condition Monitoring of Machines", CRC Press, 2000.
10. "Hand Book of Condition Monitoring", Elsevier Science, 1996.

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Module 1

**Instrumentation:** Introduction to Instruments and their representation. Static and Dynamic characteristics of Instruments, analysis of steady state and transient response.

### Module 2

**Mechanical measurements:** Transducer Elements, Intermediate Elements, Indicating and recording Elements. Mechanical Measurements, a) Frequency Measurement b) Displacement Measurement c) Force Measurement, and d) Torque Measurement

### Module 3

**Pressure, temperature and flow measurements:** Pressure and Vacuum measurement, Flow measurements, Temperature Measurements using Industrial Thermocouples, resistance thermometers, radiation temperature measurements.

### Module 4

**Measurement of vibration:** Study of vibrometer, vibration analyzer - measurement of noise - Study of noise meter, noise analyzer, Signal and system analysis.

### References:

1. B.C Nakra and K.K Choudhary, "Instrumentation Measurement and analysis", Tata McGraw Hill.
2. Earnest O Doebelin, "Measurement systems Applications & Design", McGraw Hill.
3. Rangan C.S., Sharma G.R, Mani V.S.V, "Instrumentation devices and Systems", Tata McGraw Hill, New Delhi.
4. Donald P Eckman, "Industrial Instrumentation", Wiley Eastern Ltd., New Delhi.
5. Beckwith Thomas G., and Buck, N. Lewis, "Mechanical Measurements", Oxford & IBH, New Delhi.

**MMEMD 107****SEMINAR- I**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

Each student shall prepare a seminar paper on any topic of interest related to the core/elective courses being undergone in the first semester of the M. Tech. programme. He/she shall get the paper approved by the Programme Coordinator/Faculty Members in the concerned area of specialization and shall present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

**Goals:** This course is designed to improve written and oral presentation skills and to develop confidence in making public presentations, to provide feedback on the quality and appropriateness of the work experience, and to promote discussions on design problems or new developments or ethical and safety issues in the workplace.

**MMEMD 108      ADVANCED MEASUREMENTS LABORATORY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>3</b>	<b>2</b>

**List of Experiments**

1. Preparation and calibration of Photoelastic sheets.
2. Preparation of Photoelastic models like Discs, Beams and Columns.
3. Stress determination for different models having regular shapes, loaded conventionally, and comparison of results with theoretical values.
4. Measurement of strains for different shapes, by different arrangements of strain gauges.
5. Determination & verification of natural frequency of Transverse vibration of beams with different end conditions.
6. Determination and verification of Logarithmic Decrement of a damped system.
7. Determination and verification of Displacement, Velocity, Acceleration and phase lag of Forced vibration systems.
8. Vibration signature analysis of different existing machines such as      Lathe, Grinder, Blower etc.

L	T	P	C
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### Module 1

Basic concepts of FEM – a general procedure for finite element analysis, brief history of finite element method, linear spring as a finite element, elastic bar, spar/link/truss element. Strain energy, Castigliano's first theorem, minimum potential energy.

### Module 2

Truss structures: The direct stiffness method – Nodal equilibrium equation, element transformation and direct assembly of global stiffness matrix, boundary conditions, constraint forces, element strain and stress, three dimensional trusses.

Flexure - elements – elementary beam theory, flexure element, flexure element stiffness matrix and element load vector, work equivalence for distributed loads, flexure element with axial loading.

### Module 3

Method of weighted residuals – introduction, method of weighted residuals, the Galerkin finite element method, application of Galerkin's method to structural elements - spar element, beam element.

Interpolation function for general element formation – compatibility and completeness requirements, polynomial forms- one dimensional elements, triangular elements, rectangular elements, three dimensional elements, isoperimetric formulations, axisymmetric elements, numerical integration: Gaussian quadrature.

### Module 4

Applications in solid mechanics – plane stress, plane strain – rectangular element, isoparametric formulation of plane quadrilateral element, axisymmetric stress analysis, general three dimensional stress – finite element formulations, strain and stress computations, practical considerations. Torsion – boundary condition, torque. Introduction to FEM software.

### References:

1. David V Hutton, "Fundamentals of finite element analysis", McGraw Hill
2. Daryl L. Logan, "First course in finite element method", Cengage Learning, Singapore.

3. J. N. Reddy, "An introduction to the finite element method", McGraw Hill
4. C. Zienkiewicz, "The finite element method", McGraw Hill, New York.
5. K. H. Huebner, "The finite element method of engineers", John Wiley & Sons, New York.
6. L. J. Segerlind, "Applied finite element analysis", John Wily & Sons, New York.

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### Module 1

**Design Fundamentals** - Importance of design- The design process-Considerations of Good Design – Morphology of Design –Organization for design, **Design considerations** – material selection, functional design, cost analysis. **Fatigue considerations in design** - fatigue in materials – fracture mechanics approach to fatigue – theories of fracture – nucleation and growth of fracture – creep in materials – laws of creep – estimated time to rupture – relaxation and creep in bending.

### Module 2

**Design for wear and corrosion resistance** – contact stresses – the plastic flow process – shape factor – spring back – residual stresses. **Design consideration of rubber springs**, air springs and Belleville springs. **Design for Manufacture** – Design for Assembly –Designing for castings, Forging, Metal Forming, Machining and Welding

### Module 3

**Advanced shaft design** - deflection of stepped shafts – variable cross-section shafts – conjugate beam and strain energy method. **Design of high speed cams** – kinematic design and dynamic design – polydyne cams.

### Module 4

**Introduction to reliability** in design – reliability function, failure data analysis, failure distribution functions, MTTF/MTBF, hazard rate and models, methods of improving reliability, reliability testing. **Industrial product design** – Creative design, ergonomics and aesthetic requirements – quality and maintainability considerations

### References:

1. M.F.Spotts, “Mechanical Design Analysis”, Prentice Hall, 1964.
2. Kare Hellan, “Introduction to Fracture Mechanics”, McGraw Hill, 1985.
3. P. Orlov, “Fundamentals of Machine Design Vol. I, II, III”, Mir publications.
4. C.O. Smith, “Introduction to Reliability in Design”, McGraw Hill, 1976.
5. L.Sreenath, “Concepts in Reliability”, Affiliated East West Press, 2005.

6. Woodson T.T., "Introduction to Engineering Design" McGraw Hill, 1966.
7. W.H. Mayall, Industrial Design for Engineers, Iliffe, 1967.
8. Pahl, G, and Beitz, W., "Engineering Design", Springer – Verlag, NY. 1984.
9. Ray, M.S., "Elements of Engg. Design", Prentice Hall Inc. 1985.
10. Suh, N.P., "The principles of Design", Oxford University Press, NY.1990.
11. Dieter, George E., "Engineering Design - A Materials and Processing Approach", McGraw Hill, International Editions, Singapore, 2000.

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### Module 1

**Chain and belt drives:** Analysis, design and selection of chain drives and belt drives, Tensioning Belt, Timer belts, Sprocket design. Chordal action in Chains, Chain velocity and drive ratio, Length of chain and centre distance. Failure of the chain drives and belt drives.

**Friction drives:** Classification, theory and operation of friction drives, design considerations, including thermal aspects.

### Module 2

**Design of speed gear boxes,** standardization of spindle speeds, speed diagrams, design of housings, lubrication considerations, Step less regulation of speed, Selection of servo and stepper motors, timing belts

### Module 3

**Brakes:** Disc brakes-Graphical and analytical analysis and design of self actuating brakes, fixed, link and sliding anchor drum brakes. Dynamics and thermal aspects of vehicle braking, Design of brakes for applications such as machine tools, modern automobiles, cranes, railway coaches and aircrafts.

### Module 4

**Clutches:** Friction Clutches, Centrifugal Clutches, Analysis, dynamics and thermal aspects of clutches, design of automobile clutch: single plate, multi plate, cone clutch, overrunning clutches.

### References:

1. Newcom and Spurr, "Braking of road vehicles", Chapman and Hall, 1967.
2. Nieman, "Design of Machine elements – Vol. II", Springer Verlag.
3. Reshetov, "Design of Machine elements", Mir Publication, 1978.
4. Dobrovolksy, "Design of Machine elements", Mir Publishers, 1977.
5. Wong, "Theory of Ground Vehicles", Wiley, 2001.

L	T	P	C
3	1	0	4

### Module 1

**Overview of CAD systems:** Conventional and computer aided design processes – advantages and disadvantage – CAD hardware and software – analytical and graphics packages – networking of CAD systems.

**Computer graphics and graphics transformation:** Image processing – transport of graphics data – graphic standards – display and viewing – transformations – customizing graphics softwares.

### Module 2

**Geometric modeling:** Wire frame, surface and solid modeling – applications and advantages – Boolean operations – half-spaces – filleting of edges of solids – boundary representations – constructive solid geometry – sweep representation

### Module 3

**Parametric design and object representation:** Object-oriented representation – types of co-ordinate system – parametric design – definition and advantages – parametric representation of analytic and synthetic curves – parametric representation of surfaces and solids – manipulations. Mechanical assembly – mass property calculation.

### Module 4

**Introduction to finite element analysis:** Basic steps in finite element problems formulation – element type and characteristics – element shapes – co-ordinate systems – 1D link elements and beam elements – shape functions – stiffness matrices – direct stiffness method – 2 D elements – axisymmetric elements – plane stress problem – higher order elements.

### References:

1. Newman & Sproull, “Principles of interactive graphics”, McGraw Hill.
2. C. S. Krishnamoorthy and S. Rajeev, “Computer aided design”, Narosa Publishing House, 1991
3. Ibrahim Zeid, “CAD/CAM theory and practice”, McGraw Hill Inc, 1991

4. Vera B. Anand, "Computer graphics and geometric modelling for engineers", John Wiley & Sons Inc., 1993
5. Sandhu Singh, "Computer aided design and manufacturing", Khanna Publishers, 1998
6. User's Manuals for Ansys, Adams, Pro/Engineer, Cadds 5 and Autocad softwares.
7. R. D. Cook, "Concepts and applications of finite element analysis"
8. Daryl L. Logan, "A first course in the finite element method"
9. David V. Hutton, "Fundamentals of finite element analysis"
10. David F. Rogers and J. Alan Adams, "Mathematical elements for computer graphics", Second Edition, McGraw Hill, 1990

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3	0	0	3

**Module 1**

**Introduction:** Definition, configurations, work envelopes, specifications, and other basic parameters of robots.

**Module 2**

**Kinematic principles:** Position and orientation, co-ordinate systems, relative frames, homogeneous co-ordinates, direct and inverse kinematics, differential motions and the Jacobians.

**Module 3**

**Introduction to dynamics:** Types of motions: slew – joint-interpolated – straight line interpolated motions. Path planning – trajectory planning and control. Drives: electrical, hydraulic, and pneumatic drives – basics and relative merits. Components: harmonic reduction units, servo valves, and grippers. Sensors: basic types including vision, force – torque wrist sensors.

**Module 4**

**Robot application:** Robot motion planning – configuration space concepts. Robot programming concepts: off line programming and simulation – work cell application. Development: requirements – modeling – work cell calibration – layout planning.

Case studies.

**References:**

1. Shiman Y., “Handbook of industrial robotics”, John Wiley & Sons, 1985
2. Deh S. R., “Robotics technology and flexible automation”, Tata McGraw Hill, 1994
3. Craig, J. J., “Robotics: mechanics and control”, Addison Wesley, 1989
4. Groover M. P., “Fundamentals of modern manufacturing materials, processes, and systems”, Prentice Hall, 1996
5. Craig J., “Adaptive control of mechanical manipulators”, Addison Wesley, 1988

6. Snyder W. E., "Industrial robots: computer interfacing and control", Prentice Hall, 1985
7. Song S. M., and Waldron K. J., "Machines that walk", MIT Press, 1988
8. "IEEE journal of robotics and automation"
9. "International journal of robotics research"
10. "IEEE transactions on man, system, and cybernetics"
11. Richard D. Klafter, Thomas A. Chmielwski, Michael Negin, "Robotics engineering, an integrated approach", Prentice Hall of India. 1989
12. Mikell. P. Groover et al., "Industrial robots – technology, programming and application", McGraw Hill, 1980

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### Module 1

**CAD/CAM contents and tools**, Definition of CAD/CAM tools, industrial look at CAD/CAM, **CAD/CAM hardware**: Types of systems: Mainframe-based Systems, minicomputer-based systems, microcomputer-based systems, workstation-based systems, input devices, output devices: architecture of graphics system. Graphic displays: raster display, rasterization, plasma displays, LCD displays, 3 dimensional viewers. Line and circle drawing algorithms: DDA algorithm, Bresenham's line algorithm, midpoint circle algorithm, windowing, clipping: line clipping. **Transformations**: Homogeneous coordinates 2D & 3D transformations, rotation, translation and scaling, combining transformations, hardcopy printers and plotters. Hardware integration and networking: star, ring and bus LAN Configurations. CAD/CAM software graphics standards. **Basic definitions**: Data structure, data base, DBMS, database coordinate system, user interface, software modules: operating system module, graphics module, application module, programming module, communication module.

### Module 2

**Geometric modeling**: Types and mathematical representation of curves, wire frame models, wire frame entities, curve representation, parametric representation of analytic curves: line, circles, parametric representation of synthetic curves: Bezier curves. **Types and representation of surfaces**: Surface models, surface entities, surface representation, parametric representation of analytic surfaces: ruled surfaces, surface of revolution, tabulated cylinder, parametric representation of synthetic surfaces: Bezier Surface. **Types and representation of solids**: Solid models, solid entities, solid representation, B-rep, CSG, sweep representation.

### Module 3

**Computer numerical control of machine tools**: Principles types of CNC machine tools and their construction features – tooling for CNC – ISO designation for tooling – CNC operating systems - CNC Part Programming - detailed manual part programming on lathe & milling machines using G & M codes, programming (a typical control system), computer aided CNC part programming – generation of tool path, generation of G & M codes, optimization of tool path (to reduce machining time), - CNC part programming with CAD system - machining

centers, 5 axis machining - design changes for manufacturing problems. (Features available on typical CAM software).

#### **Module 4**

**Computer aided process planning:** Group technology and process planning: concepts of group technology. traditional & computer aided process planning, retrieval & generative process planning, machinability data systems, computer-generated time standards, generation of route sheets, selection of optimal machining parameters, methods. **Computer process monitoring:** Process control methods, direct digital control, supervisory computer control, steady state optimal control, on line search strategies, adaptive control.

#### **References:**

1. Alavudeen & N. Venkateshwaran, "Computer integrated manufacturing", PHI, 2005
2. Bresenham, J. E., "Ambiguities in incremental line rastering", IEEE Computer Graphics and Applications, Vol. 7, No. 5, May 2000
3. Chris McMahon & Jimmie Browne, "CAD CAM principles, practice and manufacturing management", Pearson Education, 2000
4. David Parrish, "Flexible manufacturing", Butterworth - Heinemann Ltd, 2004
5. Donald Hearn & M. Pauline Baker, "Computer graphics", Pearson Education, 2004
6. Eckland, Eric, "Improved techniques for optimising iterative decision - variable algorithms, drawing anti-aliased lines quickly and creating easy to use color charts", CSC 462 Project Report, Department of Computer Science, North Carolina State University, Spring 1999
7. Foley, J. D. and A. Van Dam, "Fundamentals of interactive computer graphics", Addison - Wesley 1982
8. Fu, K. S., Gonzalez, R. C. and Lee, C. S. G., "Robotics - control, sensing, vision and intelligence", McGraw Hill
9. Ibrahim Zeid and R Sivasubramanian, "CAD/CAM theory and practice", McGraw Hill, 2002
10. J. D. Foley, A. Van Dam, S. K. Feiner, J. F. Hughes and R. L. Phillips, "Introduction to computer graphics", Addison Wesley, 1997
11. Koren, Yoram, "Robotics for engineers", McGraw Hill

12. Mike Mattson, "CNC programming principles and applications", Delmar Cengage Learning, 1999
13. Noff, Shimon Y., "Handbook of robotics", John Wiley & Sons
14. Shirley, Peter, "Fundamentals of computer graphics", 1st Edition, A. K. Peters Ltd., 2002
15. Schilling, Robert J., "Fundamentals of robotics, analysis & control", Prentice Hall of India, 2004
16. Rooks B. (Editor), "Robot vision & sensory controls", Vol.3, North Holland

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### Module 1

**Multi Degree of Freedom Systems:** Equations of motion by Newton's laws, matrix formulation, Equations by Stiffness coefficients and flexibility coefficients, Lagrangian dynamics. Undamped free vibration of multi DOF systems, Eigen value problem, natural frequencies, mode shapes, repeated Eigen values, general solution for undamped systems, expansion theorem, semi definite systems, systems with proportional damping. Numerical methods – Matrix iteration method, Holzer's method.

### Module 2

**Continuous systems:** Introduction, Exact solutions – Eigen value problem, Boundary conditions, Transverse vibration of strings, mode shapes of strings, Longitudinal vibration of bars, Torsional vibration of shafts, Lateral vibration of beams, orthogonality of normal functions. Numerical methods – Rayleigh's method, Rayleigh's quotient, Rayleigh Ritz method. Holzer's method.

### Module 3

**Random variables and random processes:** Probability space, Events, Axioms of probability, Random Variable, Cumulative Distribution function, Probability density function, Expectation, Variance, Gaussian, Binomial, Poisson and Exponential random variables, Multiple random variables, Joint distribution function, Joint density function, Joint moments. Functions of random variables.

Conceptual introduction to random process, Ensemble of random variables, Stationary random process, Different types of stationarity, Ergodic process, Auto correlation function and properties, Power spectral density, Cross correlation function and cross spectral density, Wide band process, narrow band process, white noise.

### Module 4

**Random Vibrations:** Examples of systems subjected to random forces, response of single dof system to stationary random process – mean of the response process, auto correlation of the response process, spectral density of the response process. Response to white noise. Random

vibration of multi degree of freedom systems, Direct method – transfer function and impulse response functions for the system, expression for response, mean value of response, auto correlation, spectral density of response. Response by Normal mode method.

### **References:**

#### Modules 1 and 2:

1. Leonard Meirovitch, “Fundamentals of Vibrations”, McGraw Hill International, 2001.
2. S. S. Rao, “Mechanical Vibrations”, Prentice Hall, 2000.
3. W. T. Thomson, M. D. Dahleh, C. Padmanabhan, “Theory of Vibration with Applications”, Pearson Education, 2008.

#### Module 3:

1. Peyton Z. Peebles, “Probability, Random Variables and Random Signal Principles”, Tata McGraw Hill, 2002.
2. A. Papoulis, S. U. Pillai, “Probability, Random Variables and Stochastic Processes”, Tata McGraw Hill, 2003.

#### Module 4:

1. P. H. Wirsching, T. L. Paez, K. Ortiz, “Random Vibrations: Theory and Practice”, Dover Publications, 1995.
2. L. D. Lutes, S. Sarkani, “Random Vibrations” Analysis of Structural and Mechanical Systems”, Butterworth Hienmann, 2003.

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### Module 1

**Fracture mechanics:** The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation - limit analysis. Damage tolerant fracture mechanics – Fatigue testing methods - statistical nature of fatigue data - theories of fatigue - crack initiation and growth in fatigue - notches and stress concentration – Stress intensity solutions for 2-D and 3-D crack geometries – Fractography - Structure modes and types.

### Module 2

**Analysis of crack tip field:** Elements of elasticity - linear elastic crack tip fields. Stress intensity factor - energy release rate - Criterion for crack growth - Crack resistance curve - Principles of crack arrest - Small-scale yielding (SSY) - crack growth relation in SSY - Stable crack growth in SSY. Irwin plastic zone correction- Actual shape of plastic zone - Plane stress - Plane strain.

### Module 3

**Fatigue crack growth:** Fatigue crack growth test - stress intensity factor, factors affecting stress intensity factor - variable amplitude service loading - Dynamic energy balance – crack arrest - retardation model.

### Module 4

**Nonlinear fracture mechanics:** J integral – Elastic – plastic stationary crack tip fields, ductile structure criterion, J-controlled crack growth and stability – Tearing modulus – the x factor. Engineering approach to plastic fracture - J-integral – testing single specimen testing - standard test methods.

**Fracture design:** Selection of materials - fatigue crack growth rate curve - stress intensity factor range - use of crack growth law.

### References:

1. Kanninen, M.F and Popelar, C.H, “Advanced fracture mechanics”, Oxford University Press, 1985.
2. Knott, J.F., “Fracture in engineering materials”, Butterworth, 1973.

3. Hertzberg, R.W., "Determination of fracture mechanics of engineering materials", Wiley, 1983
4. John M. Barson and Stanley T. Rolfe, "Fracture and Fatigue Control in Structures", Prentice Hall, Inc, USA, 1987.

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<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Module 1**

**Research:** Meaning – purpose - types of research - identification, selection and formulation of research problem - research questions - research design - formulation of hypothesis - review of literature.

**Data for research:** Primary and secondary data - collection methods – processing data

**Basic statistical measures:** Measures of central tendency and variation - skewness and kurtosis.

**Module 2**

**Measures of relationship:** Correlation – correlation coefficient for ungrouped data and grouped data – rank correlation – auto correlation, linear regression - simple regression and multiple regression.

**Probability:** Definition – discrete and continuous probability distributions: binomial, poison, uniform, exponential and normal distributions.

**Sampling technique:** Sampling theory – sampling methods – sampling distributions – confidence interval estimation - sample size – advantages and limitations of sampling.

**Module 3**

**Hypothesis testing and estimation:** Fundamentals of hypothesis testing - testing of significance mean, proportion, variance and correlation – goodness of fit test.

**Non - parametric tests:** Sign test, Kolmogorov-Smirnov test – Mann-Whitney test - Kruskal-Wallis test.

**Module 4**

**Design of experiments:** Analysis of variance (ANOVA) - completely randomized design - randomized complete block design - latin square designs, Factorial design -  $2^n$  factorial design –  $2^2$  and  $2^3$  factorial design - Yates' algorithm for  $2^n$  factorial experiment.

**References:**

1. Panneerselvam, R., “Research methodology”, Prentice Hall of India Private Limited, New Delhi, 2006

2. Kothary, C. R., "Research methodology: methods and techniques", New Age International, New Delhi, 2008
3. Goddard, W. and Melville, S., "Research methodology – an introduction", Juta & Co. Ltd., Lansdowne, 2007

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**Module 1**

**An overview of CFD:** Fluid properties, characteristics, governing equations - potential, inviscid and viscous flow. Classification of partial differential equations. Co-ordinate transformations: General and special (Cartesian, Cylindrical and Spherical Co-ordinates). Derivation of equations for generalized curvilinear coordinates, finite difference approximations for space and time coordinates.

**Module 2**

**Viscous flow:** A Finite difference scheme for solution of viscous flow – stream function-vorticity-vorticity transport equation-solution of stream function equations-wall vorticity estimation-solution of vorticity transport equation-procedure for drawing contours (Stream function and iso-vorticity) plot and velocity vector plot. Applications on flow past bodies such as isolated airfoils and airfoils in cascades.

**Module 3**

**Grid generation and solution:** Stability analysis - solution of Laplace equation for regular and irregular geometrics using finite difference method. Numerical Grid Generation- Elliptical and Hyperbolic grids. Solution of time dependent problems- Explicit and implicit schemes. Implementation of prescribed and gradient boundary conditions.

**Module 4**

**Finite volume method:** Finite volume method for convection - diffusion equations- Governing equations for incompressible variables in primitive variables - upward –hybrid and power law schemes - Discretization for one, two and three dimensions - false diffusion – Calculation flow field - Algorithms for pressure velocity coupling- semi implicit method for pressure linked equations - solution of two and three dimensional problems in Cartesian and cylindrical coordinate systems.

**References:**

1. J.D. Anderson, “Computational Fluid Dynamics”, McGraw Hill, 1995.

2. Fletcher C.A., "Computational Techniques for Fluid Dynamics - Vol 1 & 2", Springer Verlag, 1988.
3. S V Patankar, "Numerical Heat Transfer", Hemisphere, 1980.
4. K Muralidhar and T Sundrarajan, "Computational Fluid Flow and Heat Transfer", Narosa Publishers, 1996.
5. K.Muralidhar and G. Biswas, "Advanced Engineering Fluid Mechanics", Narosa Publishers, 1996.

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**Module 1**

**Introduction:** Basic Acoustic Principles - Acoustic terminology and definitions - Plane waves-harmonic solution-velocity of sound in inviscid fluids-relationship between wave length particle velocity, acceleration – Energy density – acoustic intensity – reference standards and measurement- Transmission through one, two and three media. Transmission through pipes-branched and unbranched-resonators-Transmission loss reflection at plane surface-standing waves and standing wave apparatus, spherical waves – radiation – simple source –hemispherical source-radiating piston-pressure intensity distribution-Beam width and directivity index

**Module 2**

**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.

**Module 3**

**Noise reduction:** Human reaction to sound-definitions of speech interference level, perceived noise level, phon and sone etc, hearing loss-principles of noise control-control at source, during transmission and at receiver-protection of receiver-Acoustic insulation-acoustic materials-acoustic filter and mufflers – plenum chamber-noise criteria and standards- noise and number index guide lines for designing quieter equipments – reducing machine noise generated by bearings, gears, motors, fans, propellers, generator sets, cooling towers, pump-sets, pipes etc.

**Module 4**

**Environmental noise control:** Noise ratings, human tolerance levels, equivalent sound level and loudness contours - Engine noise and muffler designs - Noise control through barriers and enclosures and absorbent linings - Vehicular noise and control.

Sound transmission through structures – noise control by damping and other methods. Principles of noise control in an auditorium-requirements of a good auditorium.

**References:**

1. Kinsler and Frey, "Fundamentals of Acoustics", Wiley, 1950.
2. Berenek, L.L., "Noise and Vibration control", McGraw Hill, 1971.
3. Harris, C.K., "Handbook of Noise control", McGraw Hill, 1979.
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.

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<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Module 1**

**Kinematics of Machine tools:** Classifications of motions for shaping surfaces, Kinematic structure of Machine tools having mechanical and non mechanical kinematic constraints. Machine tool dynamics, Selection of power drives. Design of drives. Transmission ratio, Design and classification of Speed and feed gear boxes, Step less drives, Bearing selection, Mechanism for rectilinear motion, Reversing devices.

**Module 2**

Design of Machine tool structures like beds, columns, Tables, Cross rails, Carriages, Design of slide ways and Circular ways-Static and Dynamic stiffness, Profiles, application of new materials – treatment of slide ways. Thermal aspect in machine tool design, Machine tool noise and concepts of noise control

**Module 3**

**Automatic machine tools and Transfer machines with control systems:** Selection of control systems, Control systems with pre-selection of speeds or feeds, Manual and Automatic controls, Remote controls, Safety devices in machine tools. Significance of Machine tool automation, working members, Application of CAD/CAM/CIM in Machine tool design, N.C machines, C.N.C Machines, Transfer machines & their controls. Recent trends in machine tool design.

**Module 4**

**Hydraulic & Pneumatic Systems for machine tools:** General principles of Hydraulic and Pneumatic drives. Different types control valves for Hydraulic and Pneumatic circuits, Hydraulic & Pneumatic circuit design for machine tools.

**References:**

1. M. Weck, “Handbook Of Machine Tools, Vol. 1-4”, John Wiley, USA. 1980.
2. Cyril Donaldson, G.H.LeCain & V.C. Goold, “Tool Design”, Tata McGraw Hill, 1973.
3. J. Tlusty & F.Koenigsbeger, “Machine Tool Structure, Vol. I”, Pergamon press, UK, 1970.

4. Pippengar, John J. and Koff Richard M, "Fluid Power Controls", McGraw Hill, 1959.
5. Pippengar, John J. and Hicks, Tyler G, "Industrial Hydraulics", McGraw Hill, 1979.
6. Leskiewics H.J. and Zarhmba M., "Pneumatic and Hydraulic components and Instrumentations in Automatic Controls", International Federation of Automatic controls, 1980.
7. Acherkan N., "Machine Tool Design", Vol. I – IV, Mir Publications.
8. Mehta, N.K., "Machine Tool Design", Tata McGraw Hill, 1989.

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<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

Each student shall prepare a seminar paper on any topic of interest related to the core/elective courses being undergone in the second semester of the M. Tech. programme. He/she shall get the paper approved by the Programme Coordinator/Faculty Members in the concerned area of specialization and shall present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

**Goals:** This course is designed to improve written and oral presentation skills and to develop confidence in making public presentations, to provide feedback on the quality and appropriateness of the work experience, and to promote discussions on design problems or new developments or ethical and safety issues in the workplace.

**MMEMD 208 COMPUTER AIDED ENGINEERING  
DESIGN LABORATORY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>

**Computer aided drafting:** Use of AutoCAD or Drawing Editor for 2-D drafting, plan/elevation/side view, etc.

**3D Solid modeling:** Part creation, surface generation and solid modeling of machine parts, assembly of parts (simple exercises only).

**Finite Element Analysis:** Creation of models, use of different elements, mesh generation, assigning material properties, treatment of different loads and boundary conditions. Solution - static and dynamic analysis. Post-processing – displacement, stress and strain plots – stress concentration. Various exercise problems using software (simple exercises only).

**Software:** Students must be trained in 3D Modeling and Finite Element Software such as ProE, SolidWorks, ANSYS, NASTRAN or COSMOS, as part of the Lab exercise.

**MMEMD 301****INDUSTRIAL TRAINING**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>20</b>	<b>10</b>

The student shall undergo an industrial training for a minimum period of 12 weeks in an industry / company approved by the institution and under the guidance of a staff member in the concerned field. The candidate is also required to identify, define, formulate and offer an acceptable solution for a problem observed in the organization. At the end of the training he/she has to submit a report on the work being carried out.

**MMEPI 302****THESIS – PHASE I**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>10</b>	<b>5</b>

The thesis (Phase I) shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the candidate has executed.

In Phase I of the thesis it is expected that the student should decide a topic of thesis, which is useful in the field or practical life. It is expected that students should refer national and international journals, proceedings of national and international seminars. Emphasis should be given to the introduction to the topic, literature review, and scope of the proposed work along with some preliminary work/experimentation carried out on the thesis topic.

Student should submit Phase I thesis report in two copies covering the content discussed above and highlighting the features of work to be carried out in part I of the thesis. Student should follow standard practice of thesis writing.

The candidate will deliver a talk on the topic and the assessment will be made on the basis of the term work and talks there on by a panel of internal examiners one of which will be the internal guide. These examiners should give suggestions in writing to the student to be incorporated in thesis work Phase II.

**MMEMD 401****MASTER'S THESIS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>30</b>	<b>15</b>

In the fourth semester the student has continue thesis work and present the report. At the end of successfully finishing the work he/she has to submit a detailed report and has to present for a viva-voce. The work carried out should lead to a publication in a National / International Journal or Conference. They should have submitted the paper before M. Tech. evaluation and specific weightage should be given to accepted papers in reputed journals or conferences.

**MMEMD 402****MASTER'S COMPREHENSIVE VIVA**

A comprehensive Viva-voce examination will be conducted to assess the student's overall knowledge in the specified field of engineering. At the time of viva-voce, certified reports of seminar, team exercise, industrial training and thesis works are to be presented for evaluation.