COURSES OF STUDY FOR

M. TECH.

MECHANICAL SYSTEM DESIGN (MSD)

IN

MECHANICAL ENGINEERING

(Effective From – Admission Batch 2021)

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

Hazratbal, Srinagar, J&K – 190006 - India

Vision and Mission of the Department

VISION

To nurture Mechanical Engineers with a passion for professional excellence, who are ready to take on global challenges and serve the society with high human values.

MISSION

M1: To provide facilities and infrastructure for academic excellence in the field of Mechanical Engineering.
M2: To inculcate in the students a passion for understanding professionalism, ethics, safety, and sustainability, and enable them to contribute to the society.
M3: To nurture creativity of the students and encourage them to come up with innovative solutions to real life problems.
M4: To prepare the student for lifelong learning with global perspective.

Brief about the Department:

Established in the year 1963, the Department of Mechanical Engineering offers a unique opportunity in terms providing first-class pedagogy and world class facilities for conducting cutting-edge research. Being one of the oldest departments of NIT Srinagar, the department has evolved into one of the finest in terms of teaching curriculum and methodology supported by a well-organized and adequately funded research program. We have a very well-established B. Tech program complemented by three M. Tech programs in Mechanical System Design, Industrial Tribology & Maintenance Management and Thermal Engineering. The masters' students are admitted on the basis of a valid GATE score, and some additional seats are reserved for meritorious sponsored candidates. The Research Scholars (PhD) are admitted to the department every year on the basis of a rigorous examination conducted by the institute.

Our curriculum is designed to cater to the needs and aspirations of the industry, and our top class faculty ensures that the students acquire the necessary technical and decision making skills to be the leaders in the dynamic world of industry.

Our department is, perhaps, the most versatile in terms of the range of specializations of its faculty members. We have faculty members who specialize in Haptics and MEMS on one end to High-temperature Tribology, Manufacturing Strategies and Quality Control on the other. The traditional areas of Mechanical Engineering such as Machine Design, Fluid Mechanics and Thermal Sciences are also well-represented. The department has a very strong group working in the area of Friction, Lubrication and Wear, with state-of-the-art research facilities and equipment. Our academic curriculum has improved considerably with the passage of time. Regular Board of Studies meetings are conducted to remove any inadvertent deficiencies. Periodic feedback is taken from the students to improve the quality of the education imparted. Feedback is also taken from the visiting companies during the placement season to orient the curriculum towards the needs of the Industry. Specialized courses are floated to cater to the needs of the PhD scholars, preparing them for subsequent research.

We strive to produce engineering graduates of high quality who are team players, accountable, resourceful and above all, technically competent. I take this opportunity to invite prospective students to our department and benefit from our experienced and wonderful talent pool. Our faculty and staff, I am sure, will deliver with unmatched dedication and professional enthusiasm.

List of Programs offered by the Department:

- Bachelor of Technology (B. Tech.) in Mechanical Engineering
- Master of Technology (M. Tech.) in Industrial Tribology & Maintenance Management (ITMM)
- Master of Technology (M. Tech.) in Mechanical System Design(MSD)
- Master of Technology (M. Tech.) in Thermal Engineering
- Doctor of Philosophy (Ph.D.)

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Credit Scheme

Program	Semester-wise credit distribution				Total Credits
	1st	2nd	3rd	4th	
M. Tech MSD (Mechanical Engineering)	18	16	14	12	60

As per NIT Srinagar Academic Statutes, a student has to complete a minimum of **60 credits** for the award of M.Tech Degree. The credit structure is as follows:

Core Courses	Elective Courses	Dissertation Work
10 Courses (30 Credits)	4 Courses (12 Credits)	D-I & D-II (18 Credits)

1. Full time duration: 2 years
2. Part time duration: 3 years.
3. Full time student has to take 12 to 18 credits in each semester.
4. Part time student has to take 9 to 12 credits in each semester.

List of Courses Offered

S. No.	Course Title	Course Category
01	Design Against Fracture, Fatigue, and Creep	Core
02	Continuum Mechanics	
03	Design Optimization	
04	Advanced Solid Mechanics	
05	Finite Element Method	
06	Viscous Flow Theory	
07	Applied Elasticity	
08	Systematic Design Approach	
09	Advanced Engine Design	
10	Simulation Techniques & MSDM Laboratory	
20	Robot Mechanics	Elective
21	Conduction and Radiation	
22	Vibrations of Structures	
23	Advanced Mechanism Design	
24	Theory of Composites	
25	Dynamics and Control of Mechanical Systems	
26	Acoustics	
27	Product Design and Development	
28	Advanced Manufacturing Systems	
29	Robotics: Control and Vision	
30	Wave Motion	
31	Operations Management	
32	Cryogenic Systems	

33	Exergy Analysis	
34	Design of Energy Systems	
35	Computational Fluid Dynamics	
36	Advanced Thermodynamics	
37	Heating, Ventilation, and Air Conditioning	
38	MEMS and Microsystems Technology	
39	Design and Analysis of Experiments	

National Institute of Technology Srinagar
Department of Mechanical Engineering

Semester Wise Course Scheme

M.Tech (MSD) 1st Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MSDM101	Design Against Fracture, Fatigue, and Creep	3	0	0	3	3
2	MSDM102	Continuum Mechanics	3	0	0	3	3
3	MSDM103	Design Optimization	3	0	0	3	3
4	MSDM104	Advanced Solid Mechanics	3	0	0	3	3
5	MSDM105	Elective-I	3	0	0	3	3
6	MSDM106	Elective-II	3	0	0	3	3
Total			**18**	**00**	**00**	**18**	**18**

M.Tech (MSD) 2nd Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MSDM201	Finite Element Method	3	0	0	3	3
2	MSDM202	Viscous Flow Theory	3	0	0	3	3
3	MSDM203	Applied Elasticity	3	0	0	3	3
4	MSDM204	Elective-III	3	0	0	3	3
5	MSDM205	Elective-IV	3	0	0	3	3
6	MSDM206	Seminar	0	0	2	2	1
Total			**15**	**00**	**02**	**17**	**16**

M.Tech (MSD) 3rd Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MSDM301	Systematic Design Approach	3	0	0	3	3
2	MSDM302	Advanced Engine Design	3	0	0	3	3
3	MSDM303	Simulation Techniques & MSDM Laboratory	0	0	6	6	2
4	MSDM304	Dissertation-I	0	0	12	12	6
Total			**6**	**0**	**18**	**24**	**14**

M.Tech (MSD) 4th Semester

S. No	Course Code	Course Title	Hours Per Week			Total Contact Hours	Credits
			L	T	P		
1	MSDM401	Dissertation-II	0	0	24	24	12
Total			**0**	**0**	**24**	**24**	**12**

Semester-Wise Elective Options

Semester – 1st		Semester – 2nd	
Elective-I (MSDM105#)	**Elective-II (MSDM106#)**	**Elective-III (MSDM204#)**	**Elective-IV (MSDM205#)**
Vibrations of Structures	Dynamics and Control of Mechanical Systems	Wave Motion	Computational Fluid Dynamics
Advanced Mechanism Design	Acoustics	Operations Management	Advanced Thermodynamics
Theory of Composites	Product Design and Development	Cryogenic Systems	Heating, Ventilation, and Air Conditioning
Robot Mechanics	Advanced Manufacturing Systems	Exergy Analysis	MEMS and Microsystems Technology
Conduction and Radiation		Design of Energy Systems	Design and Analysis of Experiments
		Robotics: Control and Vision	

Detailed Curriculum for 1st Year – 1st Semester Courses

<table>
<tr><td rowspan="3">Subject: Design Against Fracture, Fatigue, and Creep (Code: MSDM101)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
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<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I: Fracture

Limitations of Strength of Materials, Theories of failure, Motivation for Fracture Mechanics, Why Structures Fail, Historical Perspective, Brittle and Ductile Fracture, Modes of Fracture Failure, The Fracture Mechanics Approach to Design, Effect of Material Properties on Fracture, The Energy Criterion, The Stress-Intensity Approach, Crack Growth, Damage Tolerance, An Atomic View of Fracture , Stress Concentration Effect of Flaws, The Griffith Energy Balance, The Energy Release Rate, Stress Analysis of Cracks, Relationship between K and G, Crack-Tip Plasticity, Fracture Toughness, Crack-Tip-Opening Displacement, J- integral.

UNIT II: Fatigue

Stress-Based Approach, Definitions and Concepts, Sources of Cyclic, Loading, Fatigue Testing, Endurance Limit, The Physical Nature of Fatigue Damage, Trends in S-N Curves, Mean Stresses, Variable Amplitude Loading, Notched Members, Notch Effects, Notch Sensitivity and Empirical Estimates of k f , Estimating Long-Life Fatigue Strengths (Fatigue Limits), Notch Effects at Intermediate and Short Lives, Combined Effects of Notches and Mean Stress, Estimating S-N Curves, Use of Component S-N Data, Designing to Avoid Fatigue Failure, Fatigue Crack Growth, Fatigue Crack Growth Rate Testing, Effects of R ratio on Fatigue Crack Growth, Trends in Fatigue Crack Growth Behavior, Life Estimates for Constant Amplitude Loading, Life Estimates for Variable Amplitude Loading Design Considerations, Plasticity Aspects and Limitations of LEFM for Fatigue Crack Growth, Environmental Crack Growth, Strain-Based Approach to Fatigue, Strain versus Life Curves, Mean Stress Effects, Cumulative Fatigue Damage and Life Estimates for Structural Components.

UNIT III: Creep

Introduction, Creep Testing, Physical Mechanisms of Creep, Time–Temperature Parameters and Life Estimates, Creep Failure under Varying Stress, Stress–Strain–Time Relationships, Creep Deformation under Varying Stress, Creep Deformation under Multiaxial Stress, Component Stress–Strain Analysis, Energy Dissipation (Damping) in Materials

Text Books:

1. Anderson TL. *Fracture Mechanics: Fundamentals and Applications*. Taylor & Francis/CRC Press; 2005.
2. Dowling NE, Kampe SL, Milo Vanlandingham Kral. *Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue*. Pearson Education Limited; 2020.

Reference Books:

1. Hertzberg RW. *Deformation and Fracture Mechanics of Engineering Materials*; 1996.

2. Penny R K, Marriott D L. *Design for Creep*. Chapman & Hall; 1995
3. Prashant Kumar. *Elements of Fracture Mechanics*. New York, N.Y., McGraw-Hill Education LLC; 2009.

Subject: Continuum Mechanics (Code: MSDM102)	**Year and Semester: 1st Year and 1st Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Detailed Syllabus:

UNIT I
Introduction, definition of a continuum, vector and tensor algebra, tensor product, symmetric tensors, orthogonal tensors, polar decomposition, tensor and its components, transformation of tensor components, higher-order tensors, tensor calculus, eigenvalues and eigenvectors.

UNIT II
Kinematics of deformation, material description, spatial description, displacement field, deformation gradient, isochoric, homogeneous, and non-homogeneous deformations, volume and area changes. strain measures: Cauchy–green and green-Lagrange deformation tensors and their physical interpretation, Cauchy and Euler strain tensors, transformation of strain tensors, strain invariants, infinitesimal strain and rotation tensors and their physical interpretation, compatibility equations, rigid-body motions, polar decomposition theorem.

UNIT III
Description of stresses, Cauchy stress tensor and Cauchy's formula, transformation of stress components, stress invariants and transformation equations, principal stresses and principal planes, maximum shear stress, first Piola–Kirchhoff stress tensor, second Piola–Kirchhoff stress tensor, equilibrium equations for small deformations, objectivity of stress tensors.

UNIT IV
Constitutive relations: conservation of mass, continuity equation in spatial and material descriptions, balance of linear and angular momentum, general principles of constitutive theory, elastic materials, Cauchy-elastic materials, green-elastic or hyperelastic materials, linearized hyperelastic materials, Hookean solids, generalized Hooke's law, material symmetry planes, monoclinic, orthotropic and isotropic materials.

Text Books:

1. Morton. E. Gurtin, An Introduction to Continuum Mechanics, Academic Press (1982).
2. J. M. Spencer, Continuum Mechanics, Dover Publications (1980).

Reference Books:

1. P. Chadwick, Continuum Mechanics, Dover Publications (1999).
2. J. N. Reddy, Introduction to Continuum Mechanics, Cambridge University Press (2013).

Subject: Design Optimization (Code: MSDM103)	**Year and Semester: 1st Year and 1st Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Detailed Syllabus:

UNIT I: Classical Optimization Theory

Nonlinear Optimization Techniques, Single-Variable Optimization, Multivariable Optimization, Unconstrained Problems, Necessary and Sufficient Conditions, the Hessian matrix, Semi-definite Cases, Saddle Points.

Multivariable Optimization with Equality Constraints, Solution by Direct Substitution, Method of Constrained Variation, Solution by the Method of Lagrange Multipliers, Equality Constraints and the Bordered Hessian.

Basics of Convex Programming, Multivariable Optimization with Inequality Constraints, Slack Variables, Constraint Qualification, Karush Kuhn Tucker (KKT) Conditions, Regularity, Convexity, Convex Programming Problems, Use of the Optimization Toolbox in MATLAB® to solve unconstrained and constrained optimization problems.

UNIT II: Calculus of Variations

Introduction to the Calculus of Variations, Fundamental lemma of Calculus of Variations, Functionals, Examples of Simple Functionals, The First Variation, First Variation with Several Dependent Variables, The Euler-Lagrange equation.

Applications and Extensions of the Euler-Lagrange equation, Isoperimetric problems, Functional Constraints, Applications involving the optimization of a functional subject to constraints, Functionals involving Higher-Order Derivatives.

Applications in Mechanics, Variational Formulations, Strong and Weak forms of Governing equations, the Principle of Minimum Potential Energy, Dynamics of particles, Hamilton's principle and its applications.

UNIT III: Structural Optimization

Introduction to Structural Optimization, General Mathematical Form of a Structural Optimization Problem, Size Optimization of an axially loaded bar for maximum stiffness, Mean compliance, Beam design for stiffness and strength, Optimal design of a beam for given deflection.

Text Books:

There is no single textbook that can be prescribed for this course. You shall have to rely on class notes and the reference books mentioned below.

Reference Books:

1. S. S. Rao, Engineering Optimization, Theory and Practice, Fourth Edition, John Wiley and Sons.

2. Robert Weinstock, Calculus of Variations with Applications to Physics and Engineering, Dover publications, 1974.
3. Peter W. Christensen, Anders Klarbring, An Introduction to Structural Optimization, 2009 Springer Science and Business Media B.V., ISBN 978-1-4020-8665-6.
4. M.P. Bendsoe, O. Sigmund, Topology Optimization: Theory, Methods, and Applications, Springer-Verlag, Berlin Heidelberg.

<table>
<tr><td rowspan="3">Subject: Advanced Solid Mechanics (Code: MSDM104)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I

Introduction to general concept of elasticity, general introduction to stress, Stress at a point (2D and 3D), transformation of stress, Mohr's circle, Principal stress and principal plane, maximum shear plane, pure shear, Equilibrium and compatibility equations, Plane stress and plane strain conditions, Stress invariants, octahedral stress, deviatoric and hydrostatic states of stress.

UNIT II

Strain at a point, transformation of strain, principal strain; shear strain, Constitutive relation, strain–displacement relation, Generalized Hooke's law for isotropic and anisotropic materials, Strain compatibility equation, Airy's stress function and its applications, Energy methods in elasticity.

UNIT III

Large strain and large deformation concepts, Green strain, Euler strain, and finite deformation theory, Strain–displacement relation revisited for large deformation cases, Applications to engineering problems involving anisotropic materials and complex loading.

Text Book:

1. L. S. Srinath, Advanced Mechanics of Solids, 3rd Edition, McGraw-Hill Education, 2009.

Reference Books:

1. Advanced Mechanics of Materials; 4th Edition, A. P. Boresi and O. M. Sidebottom, John Wiley & Sons, 1985.
2. Robert D. Cook and Warren C. Young, Advanced Mechanics of Materials, 2nd Edition, Macmillan Publishing Company, 1999.

Detailed Curriculum for 1st Year – 2nd Semester Courses

<table>
<tr><td rowspan="3">Subject: Finite Element Method (Code: MSDM201)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 2nd Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I
Physical problems and finite element method (FEM), simulations and visualizations in FEM, Integral formulations for numerical solutions, Variational method, sub-domain method, collocation, Galerkin's method, least squares method, element matrices, Analysis of beams, trusses, one dimensional formulations, two dimensional formulations, Co-ordinate systems, local, global and natural, area coordinates and continuity, strong and weak forms, Hamilton's principle, domain discretization, properties of shape functions, shape functions for trusses.

UNIT II
Strain matrices and element matrices in local and global coordinates for trusses and beams, Rate of convergence and high-order one dimensional elements, Use of commercial code for specific problems on beams and trusses, FEM for frames, Case study of a typical frame e.g., a bicycle, FEM for 2-D solids, construction of shape functions for 2-D elements, strain matrix and element matrices for 2-D elements, linear rectangular element and shape function construction, Gauss integration, Linear quadrilateral elements and coordinate mapping.

UNIT III
Quadratic and cubic triangular elements, rectangular elements and Lagrange elements, Serendipity type of elements and elements with curved edges, FEM for plates and shells, Shape functions and element matrices for plates and shells, elements in local and global coordinate systems for plates and shells, some specific case study on plates and shells using a commercial code, FEM for 3-D solids, meshing and solution procedures.

Text Book:

1. J.N.Reddy, Introduction to the Finite Element Method, 4th Ed., McGraw-Hill, 2019.

Reference Books:

1. Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, and Ted G. Byrom, The Finite Element Method for Engineers, 4th Ed., Wiley, 2001.
2. O.C.Zienkiewicz, R. L. Taylor, and J. Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, 7th Ed., Elsevier, 2013.

Subject: Viscous Flow Theory (Code: MSDM202)	**Year and Semester: 1st Year and 2nd Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Detailed Syllabus:

UNIT I

Historical Outline, Fundamentals equations of motion and continuity applied to fluid flow, General stress system in a deformable body, Stoke's hypothesis, The Navier-Stokes equations, Exact solutions of the Navier-Stokes equations, Parallel flow through a straight channel and Couette flow, The Hagen-Poiseuille theory of flow through a pipe, A general class of non-steady solutions.

UNIT II

Laminar Boundary Layers, Boundary Layer Equations in Plane Flow, General properties and Exact solutions of the boundary-layer equations for Plane flows, Similar solutions of the Boundary-Layer Equations, Wake Behind bodies, Boundary Layer at Moving Wall, Momentum-Integral equations, Energy Integral equation, Moment-of-Momentum Integral Equations, Approximate Methods for the solution of the two- dimensional, steady boundary-layer equations, Laminar flow against pressure gradient.

UNIT III

Boundary Layer Control (Suction/blowing), Continuous suction and Blowing, Similar solutions, Some Experimental results on the Laminar-turbulent Transition, Stability theory, General properties of the Orr-Sommerfield equation, Fundamentals of turbulent flow, Apparent turbulent stresses, Derivation of the stress tensor of apparent turbulent friction from the Navier-Stokes equations, Prandtl's mixing length theory, Von Karman's similarity hypothesis, Universal velocity distribution laws, Von Karman's velocity distribution law.

Text Books:

1. Boundary Layer Theory, Schlichting S., McGraw Hill, 2001.
2. Viscous Fluid Flow by White F.W.,McGraw Hill, 1990.

Reference Books:

1. Advanced Engineering Fluid Mechanics by Muralidhar K.M., Biswas G, *Narosa, 2003.*
2. An Introduction to Fluid Dynamics by Batchelor,G.K., Cambridge University Press, 1990.

<table>
<tr><td rowspan="3">Subject: Applied Elasticity
(Code: MSDM203)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 2nd Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
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<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I
Introduction to the general theory of elasticity: assumptions, applications of linear elasticity, Analysis of stress: stress tensor, two-dimensional state of stress at a point, principal stresses in two dimensions, Cauchy's stress principle, direction cosines, stress components on arbitrary planes, stress transformation. Principal stresses in three dimensions, stress invariants, octahedral stresses, Mohr's stress circle in 2D and 3D; construction methods, Equilibrium equations in Cartesian and polar coordinates for two-dimensional stresses, General state of stress in cylindrical coordinates.

UNIT II
Analysis of strain: types of strain, strain tensor, strain transformation, principal strains, strain invariants, octahedral strains, Mohr's circle for strain; equations of compatibility for strain, Strain rosettes and experimental determination of strain, Stress–strain relations: generalized Hooke's law for isotropic materials, transformation of compatibility from strain to stress components, Strain energy in an elastic body, St. Venant's principle, uniqueness theorem.

UNIT III
Two-dimensional problems in Cartesian coordinates: plane stress and plane strain problems, Airy's stress function, stress functions for plane stress and plane strain, polynomial solutions for different loading conditions, Two-dimensional problems in polar coordinates: strain–displacement relations, compatibility equations, stress–strain relations, stress functions, biharmonic equation, Applications of elasticity theory to engineering problems: pressurized cylinders, rotating disks, bending of beams, thick-walled spheres and cylinders.

Text Books:

1. Timoshenko and Goodier, Theory of Elasticity, McGraw-Hill International, 3rd Ed., 1970.
2. S. Sokolnikoff, Mathematical Theory of Elasticity, McGraw-Hill International, 2nd Ed., 1957.

Reference Books:

1. Y C Fung, Foundation of Solid Mechanics, Prentice Hall Inc., 1965.
2. Xu Zhilun, Applied Elasticity, Willey Eastern Ltd., 1992.

Detailed Curriculum for 2nd Year – 3rd Semester Courses

<table>
<tr><td rowspan="3">Subject: Systematic Design Approach (Code: MSDM301)</td><td rowspan="3" colspan="2">Year and Semester:
2nd Year and 3rd Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
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<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I

System concepts, Typical Mechanical systems, System design, Old and new Design, Concurrent design approach, Life Cycle Design (LCD), Life Cycle Costs (LCC), Introduction to three phases of design-Conceptual, Embodiment and Detailed Design stage, Conceptual Design stage (CDS) - Feasibility phase of design - Customer requirements/Need analysis, Social status, Market survey, political based, etc. Actual needs, Problem formulation, Analysis of Product Concept hunt, Innovation, creativity, Brain storming, fantasy, Empathy, systematic search, Feasibility analysis, physical reliability, Economic viability, Financial & Social acceptability, Evaluation of concepts using decision making methods, Weighted sum method, Fuzzy decision making, TOPSIS, AHP, Functional Analysis - Reliability, maintainability, Manufacturing, Marketing, Serviceability, Safety, recycling/disposal/ reuse, Structural analysis, Life cycle design parameters at the Conceptual design stage.

UNIT II

Reliability, Failure rate, Reliability of mechanical and Mechatronic systems, Reliability of series and parallel systems, Reliability modelling, Redundancy, Use of linear modelling and nonlinear modelling, Reliability of new and old systems, Reliability, Weight and cost at conceptual design stage, Maintainability Analysis, Diagnozability, Identification and Isolation of Faults, Failure cause analysis, (FCA), Fault tree analysis (FTA), Failure mode and effects analysis (FMEA), and Failure mode, effects and criticality analysis (FMECA) through functions.

UNIT III

Optimization - Single & Multi-variable, Safety & Aesthetics, Material selection as decision making-alternatives, criteria, weight, use of various material selection methods and their application to material selection for gear, bearings, spring, shafts, etc., Recycling/reuse analysis, Embodiment design stage, Synthesis, use of space, spatial analysis, Components and assembly packaging, use of tables for determining relationship for synthesis- with examples; such as hospital rooms, Synthesis of small systems- Heat convector, Washing machine, etc., Detailed design stage - prototyping, Pilot plant level, Documentation, Drawings, Troubleshooting.

(Each Student will be assigned a specific problem related to design, and all knowledge imparted to them will be used in the design problem)

Text Books:

1. Pahl, G. and Beitz,W., Engineering Design, Springer Verlag, London, 1984.
2. Ullman, D. G., The Mechanical Design process, McGraw-Hill, N.Y. 1992.
3. Suh, N. P., The Principles of Design, Oxford University Press, N.Y.1990.

4. Newton, D. and Broomley, R., Practical Reliability Engineering, John Wiley & Sons India, 2002.

Reference Books:

1. International Organization for Standardization (ISO) 14040, Environmental Management-Life Cycle Assessment - Principles and framework, 2nd Ed., ISO Publications, 2006.

<table>
<tr><td rowspan="3">Subject: Advanced Engine Design (Code: MSDM302)</td><td rowspan="3" colspan="2">Year and Semester:
2nd Year and 3rd Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I
Engine Classifications, Geometrical Properties of internal combustion engines, Basic engine definitions and design oriented numericals, Method of verifying the rated power specification of engine manufacturers, Design of automotive spark ignition engine, Design of Racing Car Engine, Design of naturally aspirated diesel engine, Design of turbocharged diesel engine, Design of heavy duty truck diesel engine, Criteria for division of total displacement volume into multi-cylinder engine concept, Concept of firing order.

UNIT II
Balancing of reciprocating and rotary forces in single and multi-cylinder engines, Design considerations for selecting the bore to stroke ratio for engines, Pollution from internal combustion engines, Mechanism of pollution in internal combustion engines, National and European emission standards, Pollution control in internal combustion engines.

UNIT III
Engine performance with alternative fuels, Comparison of Physico-chemical properties of alternative fuels for I C Engines, Study of various factors that govern the fuel - mileage concepts of vehicles based on internal combustion engines, Main components of electronic fuel injection system, Design of electronic fuel injection system, Throttle body injection, port injection and direct fuel injection techniques for internal combustion engines.

Text Books:

1. Heywood J. B., Internal combustion Engine fundamentals, McGraw Hill Book Co.
2. Kevin L Hoag; Vehicular Engine Design, SAE International, USA.

Reference Books:

1. Richard L Bechtold, Alternative Fuels Guide Book, SAE International, USA.
2. D E Winterbone And R J Pearson, Design Techniques For Engine Manifolds - Wave Action Methods For I C Engines, SAE International, USA.

Subject: Simulation Techniques & MSDM Laboratory (Code: MSDM303)	**Year and Semester:** 2nd Year and 3rd Semester	**Total Course Credit: 2**		
		L	T	P
		0	0	6
Evaluation Policy	Continuous Assessment	End-Term		
	60 Marks	40 Marks		

Detailed Syllabus:

UNIT I

Introduction to numerical methods, finite element analysis (FEA) and computational fluid dynamics (CFD), Introduction to commercial software packages such as ANSYS, COMSOL, CATIA , SolidWorks, MATLAB.

UNIT II

Introduction to meshing, selection of optimum mesh for a given problem, grid independence and patch tests, convergence studies, boundary conditions.

UNIT III

Analysis of stresses, strains, deflection, thermal behaviour, and vibration in mechanical components, practical examples on beams, columns, nonlinear deformations, and other structural problems, Individual semester projects to be completed by each student.

UNIT IV

Programming using MATLAB to solve differential equations and perform numerical integration used in FEA, Simulation of different structural problems using MATLAB programming.

List of elective courses

S. No.	Course Code	Course Title	L	T	P	Total Contact Hours	Credits
1	MSDM105#	Robot Mechanics	3	0	0	3	3
2	MSDM105#	Conduction and Radiation	3	0	0	3	3
3	MSDM105#	Vibrations of Structures	3	0	0	3	3
4	MSDM105#	Advanced Mechanism Design	3	0	0	3	3
5	MSDM105#	Theory of Composites	3	0	0	3	3
6	MSDM106#	Dynamics and Control of Mechanical Systems	3	0	0	3	3
7	MSDM106#	Acoustics	3	0	0	3	3
8	MSDM106#	Product Design and Development	3	0	0	3	3
9	MSDM106#	Advanced Manufacturing Systems	3	0	0	3	3
10	MSDM204#	Robotics: Control and Vision	3	0	0	3	3
11	MSDM204#	Wave Motion	3	0	0	3	3
12	MSDM204#	Operations Management	3	0	0	3	3
13	MSDM204#	Cryogenic Systems	3	0	0	3	3
14	MSDM204#	Exergy Analysis	3	0	0	3	3
15	MSDM204#	Design of Energy Systems	3	0	0	3	3
16	MSDM205#	Computational Fluid Dynamics	3	0	0	3	3
17	MSDM205#	Advanced Thermodynamics	3	0	0	3	3
18	MSDM205#	Heating, Ventilation, and Air Conditioning	3	0	0	3	3
19	MSDM205#	MEMS and Microsystems Technology	3	0	0	3	3
20	MSDM205#	Design and Analysis of Experiments	3	0	0	3	3

Detailed Curriculum for Elective Courses

<table>
<tr><td rowspan="3">Subject: Robot Mechanics
(Code: MSDM105#)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I: Foundations

Robotics and Automation, Hard and Soft Automation, Robot Classification, Robot Specification, Capacity and Speed, Reach and Stroke, Repeatability, Precision, Accuracy, Spatial Transformations, Representation of Position and Orientation, Descriptions, Positions, Orientations, and Frames, Mappings, Changing Descriptions from Frame to Frame, Operators, Translations, Rotations, and Transformations, Transformation Arithmetic, Transform Equations, Transformation of Free Vectors.

UNIT II: Forward Kinematics

Manipulator Kinematics, Link Description, Link-Connection Description, Denavit-Hartenberg notation, Convention for Affixing Frames to Links, Actuator space, Joint space, and Cartesian space, Kinematics of Industrial Robots, Computational considerations.

UNIT III: Inverse Manipulator Kinematics

Introduction, The Notion of Manipulator Subspace, Closed-form solutions, Algebraic and Geometric Solutions, Algebraic Solution by Reduction To Polynomial, Pieper's Solution, Examples of Inverse Manipulator Kinematics, Repeatability and Accuracy, Jacobians, Velocities and Static Forces, Notation for Time-Varying Position and Orientation, Linear and Rotational Velocity of Rigid Bodies, Angular Velocity, Motion of the Links of a Robot, Velocity Propagation from Link to Link, Singularities, Static Forces in Manipulators, Jacobians in the Force Domain, Cartesian Transformation of Velocities and Static Forces.

UNIT IV: Manipulator Dynamics and Trajectory Planning

Manipulator Dynamics, Acceleration of a Rigid Body, Mass Distribution, Newton's Equation, Euler's Equation, Iterative Newton Euler Dynamic Formulation, Lagrangian Formulation of Manipulator Dynamics, Trajectory Generation, General Considerations in Path Description and Generation, Joint-Space Schemes, Cartesian-Space Schemes, Geometric Problems with Cartesian Paths, Description of Paths, Robot Programming Language, Planning Paths using Dynamic Models, Collision-Free Path Planning.

Text Books:

1. John J. Craig, Introduction to Robotics: Mechanics and Control, Pearson, 3rd Ed., Pearson 2004.

Reference Books:

1. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, 3rd Edition.
2. K. S. Fu, R C Gonzalez, C S G Lee, Robotics: Control, Sensing, Vision, and Intelligence,McGraw-Hill Book Company, International Edition, 1987
3. Bruno Siciliano, Oussama Khatib (Editors), Springer Handbook of Robotics, Springer-Verlag Berlin, Heidelberg, 2008.

<table>
<tr><td rowspan="3">Subject: Conduction and Radiation (Code: MSDM105#)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I

Introduction, Thermal energy equation in a solid medium, Fourier's law revisited, thermal conductivity tensor, Initial and boundary conditions, non-dimensionalization, fin equation, Steady state in one dimension, slab and circular geometries, heat conduction in fin, steady state in two dimension, heat conduction in square domain, heat conduction in cylindrical coordinates.

UNIT II

Unsteady heat conduction in one and two dimensional regions, bonded one dimensional domain, transient response of linear systems, semi-infinite solids, time-dependent boundary conditions, time-dependent source terms, One dimensional phase change, Stefan condition, movement of phase front in super-cooled liquid, heat transfer in solid and liquid phases, Inverse heat Transfer, method of sensitivity coefficients, least squares approach, linear and nonlinear inverse problems.

UNIT III

Planck's law, special form, radiation intensity, energy exchange between black surfaces, Energy exchange between diffuse-gray surfaces, Gas radiation, combined conduction and radiation, radiative exchange in a participating medium, exact solution of the radiative transport equation.

Text Books:

1. Heat Conduction by N. Ozisik, John Wiley, John Wiley, 2012.
2. Heat Conduction by Kakac, S., Yener, Y., Naveira-Cotta, C.P., CRC Press, 2018.

Reference Books:

1. Conduction and Radiation by K. Muralidhar and J. Bannerjee, Narosa Publishers, 2009.
2. Thermal Radiation Heat Transfer by Sigel and Howell, McGraw Hill, 2014.

<table>
<tr><td rowspan="3">Subject: Advanced Mechanism Design (Code: MSDM105#)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I

Review of concepts related to Kinematic analysis of mechanisms, I/p and O/p links, path tracer points, planar links, Six bar chains, watt, Stephenson's mechanisms, Scotch yoke, Slider - crank chains, Expansion of revolute pairs, Equivalent linkages, Grashof's criteria, parallelogram and deltoid linkages, Transmission and Deviation angles, Instant center, Determination of transmission and deviation angles.

UNIT II

Determination of Instant centers, Displacement analysis, complex number analysis, Velocity analysis, Mechanical advantage, Acceleration analysis, Inertia forces in linkages, Type, number and dimensional synthesis, Definition of coupler curve using watt's linkage, Correlation of angular position, Accuracy points, Optimum spacing of accuracy points, structural error.

UNIT III

Chebyshev spacing, distributing displacement error, Chebyshev Polynomials, Equation of Coupler curve, Multiple points, double points, cusps, crunodes, Cognate linkages, Robert-Chebyshev theorem, Drawing of cognates, 5-bar cognate, 3-bar curve, R-C theorem, Properties of coupler curve, Euler-Savary equation, Acceleration polygon, Instant center of acceleration. Bobillier theorem, Inflection Curve, inflection circle, Hartmann construction, Bobillier construction, Analytical synthesis techniques, Graphical synthesis and analytical synthesis, Graphical synthesis with two, three and four prescribed positions and points, Freudenstein's equation for three-point function generation.

Text Book:

1. Advanced Mechanism Design, Erdman and Sandor, PHI

Reference Book:

1. Kinematic Synthesis of Linkages, Hartenberg and Denavit, McGraw Hill

<table>
<tr><td rowspan="3">Subject: Acoustics
(Code: MSDM106#)</td><td rowspan="3" colspan="2">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I

Fundamentals of Vibrations: Introduction, The simple oscillator, Complex exponential method of solution, Transient response of an oscillator, Power relations, Equivalent electrical circuits for oscillators, The Fourier Transform, Transverse Motion: Vibrations of extended systems, Transverse waves on a string, The one dimensional wave equation, General solution of the wave equation, The wave nature of the general solution, Initial values and boundary conditions, Reflection at a boundary, Forced vibration of an infinite string, Forced vibration of a string of finite length, Normal modes of the fixed string, Acoustic measurements.

UNIT II

The Two-Dimensional Wave Equation: Vibrations of a plane surface, The wave equation for a stretched membrane, Free vibrations of a rectangular membrane, Free vibrations of a circular membrane, Normal modes of membranes, The diaphragm of a condenser microphone, Vibration of thin plates, The Acoustic Wave Equation and Simple Solutions: The equation of state, the equation of continuity, The Euler's equation, The linear wave equation, Speed of sound in fluids, Harmonic plane waves, Energy density, Acoustic intensity, Specific acoustic impedance, Spherical waves, The inhomogeneous wave equation, The point source.

UNIT III

Radiation and reception of acoustic waves: Radiation from a pulsating sphere, Acoustic reciprocity and the simple source, The continuous line source, Radiation from a plane circular piston, Radiation impedance, Fundamental properties of transducers (directional factor, beam pattern, beam width, source level, directivity).Reflection and Transmission of Acoustic Waves: Transmission from one fluid to another: normal incidence, and oblique incidence, Normal specific acoustic impedance, Reflection from the surface of a solid: normal incidence, oblique incidence.

Text Book:

1. L. E. Kinsler, Austin R. Frey, A. B. Coppens, J. V., Sanders, Fundamentals of Acoustics, 4th Edition, John Wiley & Sons.

Reference Book:

1. Philip M. Morse, K. U. Ingard, Theoretical Acoustics, Princeton University Press.

<table>
<tr><td rowspan="3">Subject: Advanced Manufacturing Systems (Code: MSDM106#)</td><td colspan="2" rowspan="3">Year and Semester:
1st Year and 1st Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
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<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I
Advanced manufacturing system concepts, Manufacturing automation, types of automations, Application of CAD to manufacturing systems, Design for manufacturing and assembly, Materials handling equipment.

UNIT II
Introduction to CNC programming, Computer Integrated Manufacturing Systems, Robots, their classifications and applications, Introduction to Industry 4.0 and 5.0. Rapid Prototyping and Additive Manufacturing.

UNIT III
Advances in Machining: High speed machining, Introduction to Micro/ Nano machining, Abrasive Micro machining, Diamond Micro- grinding/turning, Ultrasonic Micromachining, Electric-discharge Micro-machining, Laser beam machining, Ion Beam Machining, Electron Beam Machining.

UNIT IV
Introduction to Micro fabrication: High resolution lithography, Measuring techniques for nano features, Microhardness tester, Factories of the future, Advances in forming: Electro-hydraulic forming, Electro-magnetic forming, Hydro forming, Surface coating: Chemical vapour deposition, and physical vapour deposition.

Text Books:

1. Degarmo, E.P., Black, J.T. and Kohser, R.A, Materials and Processes in Manufacturing, Prentice Hall of India, 2006.
2. Amitabh Ghosh and Ashok Kumar Mallick, Manufacturing Science, Pearson, 3rd edition.

Reference Book:

1. Serop K. Steven, Manufacturing Processes for Engineering Materials, Prentice Hall of India, 2004.

Subject: Robotics: Control and Vision (Code: MSDM204#)	**Year and Semester: 1st Year and 2nd Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Detailed Syllabus:

UNIT I: Control Systems Analysis and Design in State Space

State-Space representations of Transfer-Function, Time–Invariant State Equation, Controllability, Observability, Pole Placement, Design of Servo Systems, State Observers, Design of Regulator Systems with Observers, Quadratic Optimal Regulator Systems.

UNIT II: Control of Robot Manipulators

Linear Control of Manipulators: State-Space Methods, Control-Law partitioning, Trajectory-following control, Disturbance rejection, Continuous versus Discrete–Time Control, Modeling and Control of a single joint, Architecture of an Industrial-Robot Controller.

Nonlinear Control of Manipulators: Nonlinear and Time-varying systems, Multi-Input, Multi-Output control systems, Control problem for manipulators, Practical considerations, Current Industrial-Robot Control Systems, Lyapunov Stability Analysis, Cartesian–based Control Systems.

Force Control Of Manipulators: Application of industrial robots to assembly tasks, Framework for control in partially constrained tasks, Hybrid position and force control problem, Force control of spring-mass system, Hybrid position/force control scheme.

UNIT III: Robot Vision

Image Representation, Image Geometry, Image Formation, Image Processing, Edge Detection, Boundary Detection Run-Length Encoding, Region Segmentation, Thresholding, Region Labelling, Shape Analysis, Line Descriptors, Area Descriptors, Principal Angles,

Perspective Transformations: Inverse Perspective Transformations, Pixel Coordinates.

Camera Calibration.

Text Book:

1. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, Third Edition.

Reference Books:

1. K. Ogata, Modern Control Systems, Prentice-Hall of India, 5th edition, 2010.
2. Peter Corke, Robotic Vision: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, Volume 142.
3. Bruno Siciliano, Oussama Khatib (Editors), Springer Handbook of Robotics, Springer–Verlag Berlin, Heidelberg, 2008.

<table>
<tr><td rowspan="3">Subject: MEMS and Microsystems Technology (Code: MSDM205#)</td><td rowspan="3" colspan="2">Year and Semester:
1st Year and 2nd Semester</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
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<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
</table>

Detailed Syllabus:

UNIT I
Definition of MEMS, Scaling and Miniaturization Concepts, Silicon as a MEMS Material, Mechanical Properties of Silicon, Fabrication Technologies, Introduction to Micro-Fabrication, Silicon Based MEMS Processes, Surface Micromachining, Sacrificial Etching Process, Bulk Micromachining and Silicon Anisotropic Etching, Bulk Versus Surface Micromachining, Mechanical Components in MEMS.

UNIT II
Review of Essential Electrical and Mechanical Concepts, Conductivity of Semiconductors, Review of Solid Mechanics for Design of Mechanical Components, Crystal Planes and Orientation, Mechanical Properties of Silicon and the related Thin Films.

UNIT III
Review of Electrostatics and Electrodynamics, Electrostatic Sensing and Actuation, Analysis of Comb Drives, Dynamics of Comb Drives, Electrostatic sensing and Actuation, Piezoelectric Sensing and Actuation, Piezoresitive Sensing, Thermal Sensing and Actuation, Scaling Laws, Instrumentation for MEMS testing and Characterization.

Text Book:

1. Chang Liu, Foundations of MEMS, 2nd Edition, Pearson, 2012.

Reference Books:

1. Senturia, S. D., Microsystem Design, KluwerAcademic Publisher, 2000.
2. Nadim M, An Introduction to Microelectromechanical Systems Engineering, Artech House,1999.

Subject: Design and Analysis of Experiments (Code: MSDM205#)	**Year and Semester: 1st Year and 2nd Semester**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Detailed Syllabus:

UNIT I
Determining central tendency using various methods: Mean, Median and Mode, Sampling and Sampling Distribution, Standard Deviation, Variance, Basic statistical concepts, Hypothesis testing, Confidence intervals, Strategy of experimentation, basic principles, guidelines for designing experiments, Simple comparative experiments: randomized designs, Experiments with a single factor: The Analysis of variance, Analysis of the fixed effects model, practical interpretation of results.

UNIT II
Randomized Blocks, Latin Squares & Related designs: Randomized complete block designs, Latin Square design, Factorial design: Basic definitions and principles, the two-factor factorial designs, statistical analysis of the fixed effects model, estimating the model parameters, the assumption of no-interaction in a two-factor model.

UNIT III
The general factorial design, 2^k factorial designs: The 2^2 design, the 2^3 design, the General 2^k factorial design, Two level fractional factorial design: Introduction; the one half fraction of the 2^k design; the one quarter fraction of the 2^k design; the 3^2 design, the 3^3 design; the Taguchi design: orthogonal array, signal-to-noise ratio, analysis of variance, Examples of L_8 and L_9 Taguchi design.

UNIT IV
Fitting regression models: Introduction; multiple linear regression models; estimation of the parameters in linear regression models; Hypothesis testing in multiple regressions, test for significance of the regression, Response surface methodology, computer-based data analysis.

Text Book:

1. Montgomery Douglas C. (2005, 2008), Design & Analysis of Experiments, 5th Ed. John Wiley and Sons, New York.

Reference Books:

1. Richard L. Levin and David S. Ruben, Statistics for Management, Hall of India Pvt. Ltd., New Delhi.
2. Angela M. Dean and Daniel Voss (2000), Design and Analysis of Experiments, Springer, NY.
3. Jiju Antony (2003), Design of Experiments for Engineers and Scientists. 1st Ed. Butterworth-Heinemann.
4. Hines and Montgomery. (1990), Probability and Statistics for Engineers, John Wiley and Sons, NY.