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UNIVERSITY OF MUMBAI

Revised Syllabus for the M. E. Program

Program: M. E. (Mechanical Engineering)

MACHINE DESIGN

(As per Credit Based Semester and Grading System with effect from the academic year 2012–2013)

Program Structure for
ME Mechanical Engineering (Machine Design)
Mumbai University
(With Effect from 2012-2013)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MDC101	Mechanical Vibration	04	--	--	04	--	--	04
MDC102	Analysis and Synthesis of Mechanisms[$]	04	--	--	04	--	--	04
MDC103	Advanced Stress Analysis[*]	04	--	--	04	--	--	04
MDE101X	Elective I	04	--	--	04	--	--	04
MDE102X	Elective II	04	--	--	04	--	--	04
MDL101	Laboratory I -Finite Element Analysis	--	02	--	--	01	--	01
MDL102	Laboratory II -Vibration Measurement and Analysis[#]	--	02	--	--	01	--	01
Total		**20**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract./ oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
MDC101	Mechanical Vibration	20	20	20	80	03	--	--	100
MDC102	Analysis and Synthesis of Mechanisms[$]	20	20	20	80	03	--	--	100
MDC103	Advanced Stress Analysis[*]	20	20	20	80	03	--	--	100
MDE101X	Elective I	20	20	20	80	03	--	--	100
MDE102X	Elective II	20	20	20	80	03	--	--	100
MDL101	Laboratory I -Finite Element Analysis	--	--	--	--	--	25	25	50
MDL102	Laboratory II -Vibration Measurement and Analysis[#]	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**50**	**50**	**600**

Subject Code	Elective I	Subject Code	Elective II
MDE1011	Advanced Finite Element Analysis[*]	MDE1021	Machine Tool Design
MDE1012	Reliability Engineering[$]	MDE1022	Computational Fluid Dynamics [%]
MDE1013	Rapid Prototyping and Tooling[*]	MDE1023	Tribology[#]
MDE1014	Theory of Plates	MDE1024	Fracture Mechanics

 # Common for Machine Design and Automobile Engineering
*** Common for Machine Design, Automobile Engineering and CAD/CAM and Robotics**
$ Common for Machine Design and CAD/CAM and Robotics
% Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Energy Engineering

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MDC201	System Modeling & Analysis#	04	--	--	04	--	--	04
MDC202	Optimization$	04	--	--	04	--	--	04
MDC203	Statistical Techniques & Design of Experiments	04	--	--	04	--	--	04
MDE203X	Elective III	04	--	--	04	--	--	04
MDE204X	Elective IV	04	--	--	04	--	--	04
MDL203	Laboratory III - CAD/CAM/CIM#	--	02	--	--	01	--	01
MDL204	Laboratory IV - Measurement and Virtual Instrumentation§	--	02	--	--	01	--	01
Total		**20**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract./ oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
MDC201	System Modeling & Analysis#	20	20	20	80	03	--	--	100
MDC202	Optimization$	20	20	20	80	03	--	--	100
MDC203	Statistical Techniques &Design of Experiments	20	20	20	80	03	--	--	100
MDE203X	Elective III	20	20	20	80	03	--	--	100
MDE204X	Elective IV	20	20	20	80	03	--	--	100
MDL203	Laboratory III - CAD/CAM/CIM#	--	--	--	--	--	25	25	50
MDL204	Laboratory IV - Measurement and Virtual Instrumentation§	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**50**	**50**	**600**

Subject Code	Elective III	Subject Code	Elective IV
MDE2031	Process Equipment Design	MDE2041	Diagnostic Maintenance Techniques
MDE2032	Product Lifecycle Management@	MDE2042	Advanced Machine Design
MDE2033	Robotics*	MDE2043	Composite Material$
MDE2034	Micro Electro Mechanical Systems@	MDE2044	Smart Materials and Applications*

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$ Common for Machine Design and CAD/CAM and Robotics
@ Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Manufacturing Systems Engineering
§ Common for Machine Design, Automobile Engineering and Thermal Engineering

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
MDS301	Seminar	--	06	--	--	03	--	03
MDD301	Dissertation I	--	24	--	--	12	--	12
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Subject Code	Subject Name	Examination Scheme						
		Theory				**Term Work**	**Pract./ Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**			
		Test1	**Test 2**	**Avg.**				
MDS301	Seminar	--	--	--	--	50	50	**100**
MDD301	Dissertation I	--	--	--	--	100	--	**100**
Total		**--**	**--**	**--**	**--**	**150**	**50**	**200**

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
MDD401	Dissertation II	--	30	--	--	15	--	15
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Subject Code	Subject Name	Examination Scheme						
		Theory				**Term Work**	**Pract./ Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**			
		Test1	**Test 2**	**Avg.**				
MDD401	Dissertation II	--	--	--	--	100	100	**200**
Total		**--**	**--**	**--**	**--**	**100**	**100**	**200**

Note:

- In case of Seminar (MDS301), 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I (MDD301) and DissertationII (MDD401), 02 Hour / week / student should be considered for the calculation of load of a teacher

Subject Code	Subject Name	Credits
MDC101	**Mechanical Vibration**	**04**

Module	Detailed content	Hrs.
1	**Introduction to Single Degree of Freedom Vibration Systems:** Free, Forced, Undamped,Damped Systems	06
2	**Multi-Degree of Freedom System:** Free Vibration Equation of motion,Influence Coefficients (Stiffness and Flexibility), Generalized Co-ordinates,andCo-ordinate Coupling.Lagrangian's and Hamilton Equations, Matrix Method, Eigen value and Eigen Vector Method	10
3	**Modal Analysis** Introduction, Free vibration response using modal analysis, Forced vibration response using modal analysis, Experimental modal analysis:Necessary equipment's, signal processing, Measurement of mode shapes.	12
4	**Vibration Measurement:** Vibration measuring instruments and sensors, Method for Calibrating Accelerometer, Basic Process of Digital Frequency Analyzer, Digital Analyzer Operating Principles, Factor in the Application of Single Channel Analyzer, Introduction to Conditioning Monitoring and Fault Diagnosis.	12
5	**Vibration Control:** Methods of vibration control:Conventional Methods: By Mass/ Inertia,Stiffness,Damping (Vibration Isolation Principles).Dynamic vibration absorbers.Introduction to Semi-Active and Active vibration Control	10
6	**Non-Linear Vibrations:** Basics of non-linear vibration, Systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase-plane techniques, Duffing's equation, Jump phenomenon, Limit cycle, Pertubation method.	10

References:

1. S.S. Rao, Addison, "Mechanical Vibrations", Wesley Publishing Co., 1990.
2. Leonard Meirovitch, "Fundamentals of vibrations", McGraw Hill International Edition.
3. J .P. Den Hartog, "Mechanical Vibrations", McGraw Hill Book Co. New York, 1958.
4. Shriniwasan P., "Mechanical Vibration Analysis", Tata McGraw Hill, 1982.
5. Thomson W.T., "Theory of Vibrations with applications", George Allen and Unwh Ltd. London,
6. W.T. Thomson, "Theory of vibrations with applications", CBS Publishers, Delhi, 2003.
7. S. Timoshenko, "Vibration problems in Engineering", Wiley, 1974.
8. Asok Kumar Mallik, "Principles of Vibration Control", Affiliated East-West Press.
9. A.H. Church, "Mechanical Vibrations", John Wiley and Sons, Inc, New York, 1994.
10. C. M. Harris, C.E. Crede "Shock and Vibration Hand Book", McGraw Hill Book Co., 1988.

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
MDC102	**Analysis and Synthesis of Mechanisms$**	**04**

Module	Detailed content	Hours
1	**Basics of Mechanism:** Rigid body, Kinematic pairs, Lower pairs connections, Higher pair connections, Kinematic chain, Mechanism, Four bar mechanism, Slider crank mechanism, Transmission, deviation and pressure angles, Equivalent mechanisms.	10
2	**Type Synthesis, Number Synthesis, Dimensional Synthesis** Type synthesis, Number synthesis, Dimensional synthesis, Accuracy points, Spacing of of accuracy points, Chebyshev polynomials.	10
3	**Four Bar Coupler Point Curve:** Four bar linkage, coupler curve equation, double points and symmetry, Roberts-Chebyshev theorem.	10
4	**The Euler Savary Equation and Cubic of Stationary Curvature:** The Euler Savary equation and the Inflection circle, The cubic of stationary curvature.	10
5	**Linkage Synthesis with ThreeAccuracy Points (Geometric Methods):** Concept of poles, relative poles, pole triangle of four bar and slider crank mechanism. Application in position generation, function generation problems. **Linkage Synthesis with Four Accuracy Points (Geometric Methods):** Concept of opposite pole quadrilateral, Center point curve, Circle point curve, Application in position generation problems.	10
6	**Linkage Synthesis with Three Accuracy Points (Algebraic Method)** Fredeinstain displacement equation of four bar linkage for three accuracy points, Crank-follower linkage synthesis angular velocities and acceleration **Linkage Synthesis with Three Accuracy Points:** Complex Number Method	10

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References:

1. Rudolf Beyer, "The Kinematic Synthesis of Mechanisms", Chapman & Hall
2. Asok Kumar Malik, Amitabh Ghosh,"Kinematic Analysis and Synthesis of Mechanism"
3. Deh Chang Tao,"Applied Linkage Synthesis", Addison-Wesley Pub. Co.
4. Richard ScheunemannHartenberg andJacques Denavit,"Kinematic Synthesis of Linkages", McGraw-Hill
5. Delbert Tesar,"Graphical Procedures for Kinematic Synthesis of Mechanism", University of Florida

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Subject Code	Subject Name	Credits
MDC103	**Advanced Stress Analysis***	**04**

Module	Detailed content	Hrs.
1	**Analysis of stress in three dimensions:** Stress at a point – components of stress; Principal stresses; Determination of principal stresses; Stress invariants; Determination of maximum shear stresses; Octahedral shear stress,Hydrostatic and Deviatoric Stress Tensors Mohr's Circle for 2D and 3D stress problem.	12
2	**Analysis of strain:** Strain at a point – Components of strain; Differential equations of equilibrium; Conditions of compatibility,Hydrostatic and Deviatoric Strain TensorsMohr's Circle for 2D and 3D strain problem.	10
3	**Stress Strain relationship:** Generalized Hooke's law,Elastic behavior for different materials (Isotropic, Orthotropic and Anisotropic).	10
4	**Electrical Strain Gauges:** Principle of operation and requirements, Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross sensitivity, Rosette analysis, Wheastone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators. Load cell and its types Introduction to Recent Trends in Strain Measurement	08
5	**Fatigue and Fracture:** Introduction to fatigue and fracture mechanics of ductile and brittle fractures mechanism of fatigue failure. Factors affecting fatigue. Methods of improving fatigue strength. Cumulative damage theories. Linear elastic fracture mechanics. Finite life, infinite life, design of machine components, Fracture toughness, Crack growth studies	10
6	**Environmental considerations in design:** Corrosion, corrosion under stress, fretting corrosion and effects of other chemicals. Methods of improving corrosion resistance.	10

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References:

1. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata McGraw-Hill, New Delhi, 1984.
2. M. Ameen, "Computational Elasticity", Narosa Publishing House.
3. Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw-Hill Inc., New York, 1998.
4. Cook and Young, "Advanced Mechanics of Materials", Prentice Hall
5. Richard G. Budynas, "Advanced Strength and Applied Stress Analysis", McGraw Hill
6. Boresi, Schmidt, "Advanced Mechanics of Materials", Sidebottom, Willey
7. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill
8. Timoshenko, "Advanced Strength of Materials, Vol. 1,2", CBS
9. T.L. Anderson, "Fracture Mechanics – Fundamentals and Applications " CRC Press

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Subject Code	Subject Name	Credits
MDE1011	**Advanced Finite Element Analysis***	**04**

Module	**Detailed content**	**Hours**
1	• Introduction to FEA, General FEM procedure, • Approximate solutions of differential equations: FDM method, W-R technique, collocation least square sub-domain and Galerkin method • Numerical integration, Gauss quadrature in 2-D and 3-D • Structure of FEA program, Pre and Post processor, commercially available standard packages, and desirable features of FEA packages. • Principal of minimum total potential, elements of variational calculus, minimization of functional, Rayleigh-Ritz method, Formulation of elemental matrix equation, and assembly concepts.	14
2	**One Dimensional FEM:** • Coordinate system: Global, local, natural coordinate system. Shape functions: Polynomial shape functions, Derivation of shape functions, Natural co-ordinate and coordinate transformation, Linear quadratic and cubic elements, Shape functions using Lagrange polynomials. Convergence and compatibility requirement of shape functions. • One dimensional field problems: structural analysis (step-bar, taper-bar). Structural analysis with temperature effect, Thermal analysis, heat transfer from composite bar, fins. Fluid network and flow through porous medium, analysis of electrical network problems by FEA	12
3	• Trusses, Thermal effects in truss members, Beams. • Two dimensional finite elements formulations, Threenoded triangular element, Four-noded rectangular element, Four-noded quadrilateral element, derivation of shape functions: natural coordinates, triangular elements, and quadrilateral elements. • Six-noded triangular elements, Eight-noded quadrilateral elements, Nine-noded quadrilateral element. • Strain displacement matrix for CST element	10
4	• Penalty Method, Lagrange methods, Multipoint Constraints • Concept of Master/Slave entities • Examples of Contact problems. • Iso-parametric concepts, basic theorem, Iso-parametric, super-parametric, sub-parametric elements, Concept of Jacobian	08
5	• Finite element formulation of Dynamics, application to free-vibration problems, Lump and consistent mass matrices, Eigen value problems. • Transient dynamic problems in heat transfer and solid mechanics. • Introduction to time-integration methods: Implicit and Explicit methods, Convergence, Impact of Mesh quality on convergence	08

6	• Three dimensional elements: Tetrahedron, Rectangular prism (brick), Arbitrary hexahedron. • Three Dimensional polynomial shape functions, Natural co-ordinates in 3D, Three dimensional Truss(space trusses) • Introduction to material models: Introduction to plasticity (Von-Mises Plasticity), Hyper –elasticity. Generating and using experimental data to model material behaviour. • Errors in FEA, sources of errors, method of elimination, Patch test.	08

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References:

1. O.C.Zienkiewicz, R.L.Taylor&J.Z.Zhu, “The Finite Element Method its Basis and Fundamentals”, Butterworth-Heinemann,Elsevier
2. Reddy J. N., “Finite Element Method”, McGraw-Hill
3. S.S.Rao, “The Finite Element Method in Engineering” , 4th Edition, Academic Press, Elsevier
4. U.S.Dixit, “Finite Element Methods for Engineers”,Cengage Learning
5. P.Seshu, “Textbook of FE Analysis”, Prentice Hall
6. Desai and Abel, “Introduction to Finite Elements Methods”, CBS Publication
7. Tirupati R. Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”
8. Erik Thompson, “Introduction to Finite Element Methods”, Wiley India
9. H. Kardestuneer, “Finite Elements Hand Book”
10. R.D.Cook, “Concepts & Applications of Finite Element Analysis”
11. Bathe K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall of India
12. Huebener K.H., Dewhirst D.D., Smith D.E. and Byrom T.G., “The Finite Element Method for Engineers”, John Wiley, New York
13. Logan, “Finite Element Methods” Cengage Learning
14. George Buchanan, “Finite Elements Analysis”, McGrawHill
15. C.S.Krishnamoorthy, “Finite Elements Analysis”, Tata McGraw-Hill
16. RobertCook, “Concept and Application of Finite Element Methods”, Wiley India.

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Subject Code	Subject Name	Credits
MDE1012	**Reliability Engineering$**	**04**

Module	Detailed content	Hours
1	**Probability theory** Probability : Standard definitions and concepts; Conditional Probability, Baye's Theorem. Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. Measures of Dispersion: Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness, Kurtosis.	12
2	**Reliability Concepts** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. Reliability Hazard Models : Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	14
3	**System Reliability** System Configurations : Series, parallel, mixed configuration, k- out of n structure, Complex systems.	08
4	**Reliability Improvement** Redundancy Techniques : Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08
5	**Maintainability and Availability** System downtime, Design for Maintainability : Maintenance requirements, Design methods : Fault Isolation and self diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	10
6	**Failure Mode, Effects and Criticality Analysis** Failure mode effects analysis, severity/criticality analysis , FMECA examples.Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	08

$ **Common for Machine Design and CAD/CAM and Robotics**

References:

1. L.S. Srinath, “Reliability Engineering”, Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, “Reliability and Maintainability Engineering”, Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, “Engineering Reliability”, John Wiley & Sons, 1980.
4. P.D.T. Conor, “Practical Reliability Engineering”, John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, “Reliability in Engineering Design”, John Wiley & Sons.
6. Murray R. Spiegel, “Probability and Statistics”, Tata McGraw-Hill Publishing Co. Ltd.

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Subject Code	Subject Name	Credits
MDE1013	**Rapid Prototyping and Tooling***	**04**

Module	Detailed content	Hours
1	**Rapid Prototyping** • Historical Development • Applications: Design, Planning, Manufacturing and Tooling • Applications: Automotive, Jewelry, Coin and Bio-Medical • Fundamentals of Rapid Prototyping, Design Process • Rapid Prototyping Process Chain	10

2	**Subsystems of RP Machine**
	• Subsystems of RP machine
	  o Optical System
	  o Mechanical Scanning System
	  o Computer Interfacing hardware, DAQs
	  o Signal Flow, 3D Model to RP Prototype
	• Introduction to 3D Modeling Softwares (Auto-CAD, PROE, CATIA, IDEAs etc.)
	• Slicing and Scan Path Generation Algorithms
	• Data Conversion and Transmission
	• File Formats, IGES, STL
	• Preprocessing and Post-processing
		10

3	**Liquid Based Rapid Prototyping Systems** • Materials • Stereolithography • Solid Ground Curing • Solid Object UV (Ultra-Violet) Printer • Two Laser System • Micro-stereolithography	10
4	**Solid Based Rapid Prototyping Systems** • Materials • LOM (Laminated Object Manufacturing) System • FDM (Fuse Deposition Modeling) System • Multi-Jet Modeling (MJM) System • Model Maker and Pattern Master • Shape Deposition Manufacturing Process	10
5	**Powder Based Rapid Prototyping Systems** • Materials • SLS (Selective Laser Sintering) • (3DP) Three-Dimensional Printing • (LENS) Laser Engineered Net Shaping • (MJS) Multiphase Jet Solidification • (EBM) Electron Beam Melting	10

6	**Advances in RP Systems and Case Studies** • Advances in RP: Resolution & Accuracy issues, Integrated Hardening Process, Two Photon Process for Micro/Nano Fabrication, Reverse Engineering Process and Applications. • Case Study: Wind-Tunnel Testing with RP Models • Case Study: Investment Casting with RP	10

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References:

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications", World Publishing Co. Pte. Ltd.
2. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems", Kluwer Academic Publishers.
3. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.
4. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer Inc.
5. BopayaBidanda, Paulo J. Bartolo, "Virtual Prototyping and Bio Manufacturing in Medical Applications", 2008, Springer Inc.
6. I. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.

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Subject Code	Subject Name	Credits
MDE1014	**Theory of Plates**	**04**

Module	Detailed content	Hours
1	**Classical Plate Theory (CPT)** • The Elasticity Approach • Assumptions of Classical Plate theory • Moment Curvature Relations • Equilibrium Equations • Governing Biharmonic Equation • Boundary Conditions • Solution of a Problem • Strain Energy of the Plate	10
2	**Analysis of Rectangular Plates** • Recapitulation of Fourier Series • Navier's Method • Levy's Method	10
3	**Analysis of Circular Plates** • Equations of the Theory of Elasticity • Equations of CPT • Solution of for Axisymmetric Problems	10
4	**Dynamics and Stability** • Dynamics of Rectangular Plates • Stability of Rectangular Plates	10
5	**Approximate Solutions** • Rayleigh-Ritz Method • Static Flexure • Buckling • Free Vibration Analysis • Galerkin's Method	10
6	**Advanced Topics** • CPT of Orthotropic Plates • CPT of Layered Plates • CPT of Moderately Large Deformations • Mindlin's Plate Theory	10

References:

1. T.K. Varadan and K. Bhaskar, “Analysis of Plates - Theory and Problems”, Narosa Publishing House
2. Stephen P. Timoshenko and S. Woinowsky-Krieger, “Theory of Plates and Shells”, Tata McGraw Hill
3. C.M. Wang, J.N. Reddy and K.H. Lee, “Shear Deformable Beams and Plates - Relationships with Classical Solutions”, Elsevier
4. N.G.R. Iyengar, “Structural Stability of Columns and Plates”, Ellis Horwood Limited

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Subject Code	Subject Name	Credits
MDE1021	**Machine Tool Design**	**04**

Module	Detailed content	Hours
1	**Introduction to Machine Tools, General Principals of Machine Tool Design:** Types and capabilities of machine tools,Constructional and operational features, Techno-Economical Prerequisites for undertaking the Design of New Machine Tool, General Requirements of Machine Tool Design, Engineering Design Process Applied to Machine Tools	06
2	**Machine Tool Drives** Working and auxiliary motions in machine tools,Mechanical transmission and its elements,Aim of Speed and Feed Rate Regulation, Stepped regulation of speed: Design of speed box, Design of Feed Box,Construction of speed charts, Development of gearing diagram, Determination of gear teeth,module,shaft sizes,centre distances,Other types of speed and feed drives viz Quadrant change gear,Gear cone with sliding key,Norton Gear Box,Meander Drive,Gear boxes with clutched drive like the Ruppert Drive and Schopke drive,Stepless Drives-Mechanical,Hydraulic,Electrical	20
3	**Design of Machine Tool Structures and guideways** Functions of Machine Tool Structures and Their Requirements, Design criteria for Machine Tool Structures, Materials of Machine Tool Structures Static and Dynamic Stiffness, Profiles of Machine Tool Structures, Basic Design Procedure of Machine Tool Structures, Design of Beds, Columns, Bases and Tables,Functions and types of guideways,Design of slideways,Design calculations for slideways,Guideways operating under liquid friction conditions	10
4	**Design of Power Screws:** Design of Power Screws based on strength,stiffness and buckling,Power requirements	08
5	**Design of Spindles and Spindle Supports:** Functions of Spindle Unit and Requirements, Materials of Spindles, Effect of Machine Tool Compliance on Machining Accuracy, Design Calculations of Spindle	10
6	**Acceptance Tests on Machine Tools:** Significance,Performance and geometrical tests on lathe,milling,drilling and shaping machines	06

References:

1. N.K. Mehta, “Machine Tool Design and Numerical Control” Second Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1984
2. S.K. Basu and D.K. Pal, “Design of Machine Tools”, Fourth Edition, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1990.
3. G.C. Sen and A. Bhattacharya, “Principles of Machine Tools”, Second Edition, New Central Book Agency (P) Ltd., Kolkata, 1988.
4. F. Koenigsberger, “Design Principles of Metal Cutting and Machine Tools”, Edition 1964,Pergamon Press Ltd., London.
5. H.C.Town, “The Design and Construction of Machine Tools”
6. Central Machine Tool Research Institute, Bangalore, Machine Tool Design Handbook
7. PSG College of Engg.& Technology, PSG Design Data Book
8. N.K. Acherkan, “Machine Tool Design (Vol.I to Vol.IV)”,Mir Publishers

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
MDE1022	**Computational Fluid Dynamics**%	**04**

Module	**Detailed content**	**Hours**
1	**Introduction:** Definition and overview of CFD, Advantages and applications, CFD methodology	06
2	**Governing Differential Equations:** Governing equations for mass, momentum and energy; Navier-Stokes equations; Mathematical behaviour of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems.	10
3	**Discretization Techniques:** Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods; Finite difference representation of PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria	12
4	**Finite Volume Methods:** FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems FVM solutions to convection-diffusion problems - one and two dimensional, steady and unsteady; Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms	14
5	**Grid Generation:** Structured and Unstructured Grids; General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; multi block structured grids; adaptive grids	10
6	**Turbulence Modeling:** Effect of turbulence on governing equations; RANS, LES and DNS Models	08

% Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Energy Engineering

References:

1. Muralidhar, K., Sundararajan, T., “Computational fluid flow and heat transfer”, NArosa Publishing House, New Delhi1995
2. Ghosdhasdidar, P.S., “Computer simulation of flow and heat transfer”,TataMcGraw-Hill Publishing company Ltd., 1998.
3. Subas, V.Patankar, “Numerical heat transfer fluid flow”, Hemisphere publishing Corporation.
4. Taylor, C and Hughes J.B., “Finite Element Programming of the Navier Stokes Equation”, Pineridge Press Ltd., U.K , 1981.
5. Anderson, D.A., Tannehill , I.I., and Pletcher, R.H., “Computational fluid Mechanics and Heat Transfer”, Hemisphere Publishing Corporation, New York , USA, 1984.
6. Fletcher, C.A.J., “Computational Techniques for Fluid Dynamics 1”, Fundamental and General Techniques, Springer- Verlag , 1987

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Subject Code	Subject Name	Credits
MDE1023	**Tribology#**	**04**

Module	Detailed content	Hours
1	**Introduction** • Tribology • Historical Background • Industrial Importance • Friction and Wear • Lubricants - Types and Properties of Lubricants - Viscosity and Viscometry • Bearings	06
2	**Friction** • Introduction • Laws of Friction • Friction Theories • Other Mechanisms - Hysteresis - Ratchet Mechanism - Stick-Slip - Rolling Friction • Friction on Metals • Friction on Non-Metallic Materials **Wear** • Mechanisms of Wear: Abrasive, Adhesive, Surface Fatigue and Tribo-chemical • Quantitative Laws of Wear • Wear Resistance of Materials	14
3	**Rolling Element Bearings** • Introduction • Selection of Bearings • Stribeck's Equation • Static and Dynamic Load Carrying Capacity • Rated Life • Equivalent Bearing Load • Probability of Survival • Selection of Bearing from Design Data Book	08
4	**Hydrodynamic Bearings** • Introduction • Governing Equations • Hydrodynamic Journal Bearings, Hydrodynamic Thrust Bearings **Hydrostatic Bearings** • Introduction • Circular Step Thrust Bearing • Annular Thrust Pad Bearings, Rectangular Thrust Bearings • Hydrostatic Journal Bearings	14

5	**Gas Lubricated Bearings** • Introduction • Governing Equations • Infinitely Long - Plane Slider Bearings • Infinitely Long - Journal Bearings • Finite Journal Bearings • Other Gas Bearing Types - Tilted-Pad Journal Bearings - Spiral Groove Thrust and Journal Bearings - Foil Bearings - Externally Pressurized Bearings • Squeeze Film Lubrication • Instabilities in Gas-Lubricated Bearings	10
6	**Elastohydrodynamic Lubrication (EHL)** • Introduction • Line Contact: Rigid Cylinder • Line Contact: Elastic Cylinder • Point Contacts • Thermal Correction Factor • Surface Roughness Correction Factor • Lubricant Rheology • Different Regimes in EHL Contacts **Introduction to Nanotribology and Biotribology**	08

 # Common for Machine Design and Automobile Engineering

References:

1. Gwidon W. Stachowiak and Andrew W. Batchelor, “Engineering Tribology”, Elsevier Butterworth Heinemann
2. PrasantaSahoo, “Engineering Tribology”, PHI Learning Pvt. Ltd.
3. B.C. Majumdar, “Introduction to Tribology of Bearings”, Wheeler Publishing
4. John Williams, “Engineering Tribology”, Cambridge University Press
5. S.K. Basu, S.N. Sengupta and B.B. Ahuja, “Fundamentals of Tribology”, PHI Learning Pvt. Ltd.

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Subject Code	Subject Name	Credits
MDE1024	**Fracture Mechanics**	**04**

Module	Detailed content	Hours
1	**Introduction** • A Crack in Structure • Fracture Toughness • Micro and Macro Phenomena of Fracture - Microscopic Aspects: Surface Energy, Theoretical Strength, Microstructure and Defects, Crack Formation - Macroscopic Aspects: Crack Growth, Types of Fracture • Mechanisms of Fracture and Crack Growth - Cleavage Fracture, Ductile Fracture, Fatigue Cracking, Environment Assisted Cracking, Creep Fracture, Service Failure Analysis	10
2	**Linear Elastic Stress Fields in Cracked Bodies** • Introduction • Crack Deformation Modes and Basic Concepts • Westergaard Method • Singular Stress and Displacement Fields • Stress Intensity Factor Solutions • Three-Dimensional Cracks **Linear Elastic-Plastic Stress Fields in Cracked Bodies** • Approximate Determination of the Crack-Tip Plastic Zone • Irwin’s Model, Dugdale’s Model	14
3	**Crack Growth Based on Energy Balance** • Introduction • Energy Balance During Crack Growth • Griffith Theory • Graphical Representation of the Energy Balance Equation • Equivalence between Strain Energy Release Rate and Stress Intensity Factor • Compliance • Crack Stability	08
4	**Fracture Criteria** • Critical Stress Intensity Factor Fracture Criterion • J-Integral and Crack Opening Displacement Fracture Criteria • Strain Energy Density Failure Criterion: Mixed-Mode Crack Growth	08
5	**Dynamic Fracture** • Introduction • Mott’s Model • Stress Field around a Rapidly Propagating Crack • Strain Energy Release Rate • Crack Branching, Crack Arrest • Experimental Determination of Crack Velocity and Dynamic Stress Intensity Factor	08

6	**Introduction to Fatigue Fracture, Environment-Assisted Fracture, Creep Fracture and Crack Detection Methods such as Dye Penetration, Magnetic Particles, Eddy Current, Radiography, Ultrasonics and Acoustic Emission**	12

References:

1. E.E. Gdoutos, “Fracture Mechanics - An Introduction”, Springer
2. D. Gross and T. Seelig, “Fracture Mechanics - With an Introduction to Micromechanics”, Springer
3. D. Broek, “Elementary Engineering Fracture Mechanics”, MartinusNijhoff Publishers
4. R.W. Hertzberg, “Deformation and Fracture Mechanics of Engineering Materials” John Wiley & Sons, Inc.
5. T.L. Anderson, “Fracture Mechanics - Fundamentals and Applications ” CRC Press
6. N. Perez, “Fracture Mechanics”, Kluwer Academic Publishers

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Subject Code	Subject Name	Credits
MDL101	**Finite Element Analysis**	**01**

Module	**Detailed content**	**Lab. Sessions**
1	Finite element analysis (FEA) of minimum 05 mechanical components using mathematical simulation software (or any programming language) which must include structural, thermal and coupled structural-thermal analyses	04
2	Finite element analysis of minimum 05 mechanical components using available FEA software which must include structural, thermal and coupled structural-thermal analyses	05
3	**Laboratory Project:** Finite Element Analysis of a real life mechanical component subjected to both structural and thermal loading, using Mathematical Simulation Software (or any programming language) and Finite Element Analysis Software	06

Assessment:

Laboratory Project : Weightage for Laboratory Project should be 40% in Final Assessment of Laboratory Work

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
MDL102	**Vibration Measurement and Analysis#**	**01**

Module	Detailed content	Lab. Sessions
1	**Simulation study using mathematical simulation software (or any programming language) on** a. Single DOF system b. Multi DOF system	03
2	**Simulation study using finite element software on** a. Modal analysis b. Transient analysis c. Harmonic analysis d. Active vibration control	06
3	**Experimentation** a. Acquiring time domain vibration data by using sensors (displacement / velocity / acceleration) b. Processing the time domain data acquired in experiment 3 (a) using FFT tool to obtain vibration frequencies c. Performing modal analysis of beam / plate type structures d. Demonstration of condition based maintenance tool using vibration techniques	06

 # Common for Machine Design and Automobile Engineering

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
MDC201	**System Modeling and Analysis#**	**04**

Module	Detailed content	Hours
1	**Introduction to System & Mathematical Modeling** System, environment and variables, the state of a system,Physical Laws for Modeling of System, Representation of System in terms of Block Diagram, Reduction of Multiple Subsystems, Signal Flow Graph, Mason's Gain Formula	10
2	**Modeling in the frequency domain** Laplace Transform Review, The Transfer Function, Electrical Network Transfer Functions, Translational Mechanical System, Rotational Mechanical System, Transfer Functions for Systems with Gears, Electromechanical System, Fluid Systems, Thermal Systems, Electric Circuit Analogs, Nonlinearities, Linearization	10
3	**Modeling in the time domain** The General State-Space Representation, Applying the State-Space Representation, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function, Linearization	08
4	**Time response** Poles, Zeros, and System Response, First-Order Systems, The General Second-Order System, Underdamped Second-Order Systems, System Response with Additional Poles, System Response With Zeros, Effects of Nonlinearities Upon, Time Response, Laplace Transform Solution of State Equations, Time Domain Solution of State Equations	08
5	**Stability of System** Linear & Nonlinear System, Stability in Linear and Nonlinear System, Routh-Hurwitz Criterion, Routh-Hurwitz Criterion, Stability in State Space, Phase Plane Method for Nonlinear System **Root locus techniques** Introduction, Defining the Root Locus, Properties of the Root Locus, Sketching the Root Locus, **Frequency response techniques** Introduction, Asymptotic Approximations: Bode Plots, Introduction to the Nyquist Criterion, Sketching the Nyquist Diagram, Stability via the Nyquist Diagram, Gain Margin and Phase Margin via the Nyquist Diagram, Stability, Gain Margin, and Phase Margin via Bode Plots	14
6	**Advanced Modeling and Simulation Techniques** Introduction to Lyapunov Stability and Modeling via Lyapunov, Nonlinear Modeling Techniques such as consideration of Structural Nonlinearity and Material Nonlinearity	10

 # Common for Machine Design and Automobile Engineering

References:

1. Nicola Bellomoand Luigi Preziosi, “Modeling Mathematical Methods & Scientific Computations”, 1995, CRC Press.
2. I.J. Nagarathand M. Gopal, “Systems Modeling & Analysis”, Tata McGraw Hill, New Delhi.
3. Jan WillenPoldermanandJan C. Willems, “Introduction to Mathematical Systems Theory- A behavioral Approach”, 1998, Springer.
4. J.L. Shearer, A.T. Murphy and H.H. Richardson, “Introduction to System Dynamics”, 1971, Addison & Wesley.
5. Norman S. Nise, “Control Systems Engineering”,Sixth Edition, 2011, John Wiley & Sons, Inc.
6. Ogata, “Modern Control Engineering”, Prentice Hall
7. Ogata, “System Dynamics”, Pearson Education
8. Hung V Vu & R.S. Esfandi, “Dynamics Systems - Modeling and Analysis”, ThecGraw-Hill Companies Inc.

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Subject Code	Subject Name	Credits
MDC202	**Optimization$**	**04**

Module	Detailed content	Hours
1	**Basic Concepts:** Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Overview of optimization technique, Interdisciplinary nature, Introduction to related software.	10
2	**Linear Programming Problem:** Formulation, Simplex method, Primal to Dual, Dual Simplex method, Sensitivity Analysis.	10
3	**Integer L.P. Model:** Gomory's cutting plane method, Branch & Bound Technique. **Non L.P. Model:** Lagrangian method & Kuhn tucker method.	10
4	**Unconstrained Optimization Technique:** Necessary and sufficient condition – search method (unrestricted Fibonacci and Golden) – Interpolation method (Quadratic, Cubic & Direct root method). Direct search method – Random search, Pattern search and Rosen Brock's hill climbing method.	10
5	**Newtonian Method**: Newton's method, Marquardt's method, Quasi Newton method. **Discrete Event Simulation**: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	10
6	**Response Surface Method:**Response Surface, The Least-Squares Methods, Two-Level Factorial Design, Addition of Center Points, Central Composite Design(CCD), Sequential Nature of RSM, Other Experimental Design	10

$ **Common for Machine Design and CAD/CAM and Robotics**

References:

1. RanjanGanguli, "Engineering Optimization - A Modern Approach" Universities Press
2. Pablo Pedregal, "Introduction to Optimization", Springer
3. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.

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Subject Code	Subject Name	Credits
MDC203	**Statistical Techniques and Design of Experiments**	**04**

Module	**Detailed content**	**Hours**
1	**Engineering statistics** Uncertainty, Statistical Tools and Techniques for Handling Uncertainty, Statistical decision theory, statistical hypothesis, tests of hypotheses and significance, Tests involving normal distribution; One –Tailed and Two tailed tests, test for goodness of fit	10
2	**Curve Fitting, Regression and Correlation** Relationship between Variables, Curve Fitting - Straight Line, Method of Least Squares, the Least Squares Line. Multiple Regression. Linear Correlation Coefficient, Generalized Correlation Coefficient, Rank Correlation. Probability Interpretation of Regression, Probability Interpretation of Correlation.	10
3	**Design of Experiments** Framework of Experimental Design, Classification of Experimental Design, the Role of Experimental Design. Experiments with Blocking Factor: Randomized Complete Block Design, Latin Square Design, Graeco-Latin Square Design. Factorial Experiments: One factor at a time experiment, Two factor factorial design, General factorial design, blocking in factorial design. Two level factorial Designs : The 2^2 Design, 2^3 Design, General 2^k Design. Taguchi's approach to design of experiments Orthogonal Array: Selection and Utilization, Multiple Level Experiments, Special Designs	10
4	**Conducting Tests:** Testing Logistics, Statistical Aspects of Conducting Tests, Characteristics of Good and Bad Data Sets, Example Experiments, Attribute Versus Variable Data Sets	10
5	**Analyzing and Interpretation Methods for Experiments:** Observation Method, Ranking Method, Column Effects Method, Plotting Method, Analysis of Variance (ANOVA), Percent Contribution, Multiple Level Experiments, Special Designs	10
6	**Confirmation Experiment:** Introduction, Estimation of Mean, Confidence Interval Around the Estimation Mean, Transformation of Percentage Data, Capability Estimates, Confirmation Experiments Decision, Example Experiments	10

References:

1. Douglas C. Montgomery, “Design and Analysis of Experiments”, John Wiley and Sons Inc.
2. Sung H. Park, Jiju Antony, “Robust Design for Quality Engineering and Six Sigma”, World Scientific Publishing Co. Pvt. Ltd.
3. Murray R. Spiegel, “Probability and Statistics”, Schaum’s Outline Series, McGraw-Hill Book Company
4. Phillip J. Ross, “Taguchi Techniques for Quality Engineering”, McGraw Hill
5. Ranjit K. Roy, “Design of Experiments using the Taguchi Approach”, John Wiley and Sons Inc.
6. Madhav S. Phadke, “Quality Engineering using Robust Design”, Prentice Hall.

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Subject Code	Subject Name	Credits
MDE2031	**Process Equipment Design**	**04**

Module	Detailed content	Hours
1	**Process Design Parameters :** Introduction to Basic process requirement of plants and projects, Importance of codes and standards and their applications. P&ID, Process Data Sheet, PFD and other documents used for designing. Introduction to various design codes required in Process Equipment Design such as; ASME, Section VIII; API; ASTM; TEMA, etc. and their significance. Review of Design pressures, temperatures, design stresses, factor of safety, minimum shell thickness and corrosion allowance, weld joints efficiency, design loading, stress concentration and thermal stresses, failure criteria. Selection of material for process equipment's using ASME Codes.	10
2	**Design of Pressure Vessels :** Types of pressure vessels, selection of various parameters for their design <u>Pressure vessel subjected to Internal Pressure:</u> Complete design as per ASME code of Cylindrical and spherical shells. Design of various end closures such as: Flat, Hemispherical, Torrispherical, Elliptical and conical. Design of openings : nozzles and manholes. Design of Flanged joints; Gasket selection and design Design of supports for process vessels. <u>Pressure vessel subjected to External Pressure:</u> Design of shell, heads, nozzles, flanged joints and stiffening rings. <u>Design of Tall Vessels / Tall Columns:</u> Determination of equivalent stress under combined loadings including seismic and wind loads application of it to vertical equipment like distillation column.	12
3	**Vessel Supports** Introduction and classification of supports. Design of skirt support considering stresses due to dead weight, wind load, seismic load and periodic vibration. Design of base plate, skirt bearing plate, anchor bolts. Design of Lug and bracket support.	12
4	**Design of Storage Tanks** Study of various types of storage vessels and applications. Atmospheric vessels, vessels for storing volatile and non-volatile liquids. Various types of roofs used in storage vessels. Manholes, nozzles and mounting design. Design of Rectangular tanks.	10
5	**Heat Exhangers** Heat exchangers : Design of vessels, Design of Shell and Tube Heat Exchanger, Study and design of various types of jackets like plain half coil, channel, limpet coil.	08
6	**Agitator** Study of various types of agitators and their applications. Baffling, Power requirement of agitation. General design of agitator including blades, shaft, blade assembly.	08

References:

1. Dr. M.V. Joshi, “Process Equipment Design”, Mc-Millan
2. Browell and Young, “Process Equipment Design:, John Wiley
3. B.C. Bhattacharya, “Introduction to Chemical Equipment Design – Mechanical Aspects”, CBS Publications
4. Standard Codes such as: ASME SEC-VIII, Div I & II; ASTM; API; TEMA.

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Subject Code	Subject Name	Credits
MDE2032	**Product Lifecycle Management@**	**04**

Module	Detailed content	Hours
1	**Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	10
2	**ProductDesign:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	10
3	**Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation **Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	10
4	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment,Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	10
5	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	10

6	**Technology Forecasting:** Evolution for technology forecasting and its importance, Future mapping, Methods of technology forecasting such as Relevance Trees, Morphological Methods and Mission Flow Diagram, Combining forecast of different technologies	10

@ Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Manufacturing Systems Engineering

References:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, AntoninoRisitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. SaaksvuoriAntti, ImmonenAnselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

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Subject Code	Subject Name	Credits
MDE2033	**Robotics***	**04**

Module	Detailed content	Hours
1	**Introduction:** Automation & robotics, Robotic System & Anatomy Classification, Future Prospects **Robotic Application in Manufacturing:** Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors **Social Issues and Economics of robotics** **Drives:** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators , Power Transmission Systems**.**	12
2	**Robot &its Peripherals:** End Effecters - types, Mechanical & other grippers, Tool as end effecter **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems **Robotic Cell Design & Control.**	08
3	**Robot Kinematics**: Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot.	12
4	**Trajectory Planning & Robot Dynamics:** Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics –Langrangian Dynamics of one and two link robot arm	08
5	**Machine Vision:** Introduction, Low level & High level vision, Sensing &Digitising, Image processing & analysis, Segmentation, Edge detection, Object description& recognition, Interpretation, Noises in Image, Applications	08
6	**Programming For Robots:** Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot **Robot Intellgence& Task Planning:** Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem solving, Robot learning,Robot task planning.	12

*** Common for Machine Design, Automobile Engineering and CAD/CAM and Robotics**

References:

1. YoremKoren, “Robotics for Engineers”
2. J. F. Engelberger, “Robotics in Practice”
3. Ulrich Rembolds, ChristialBlume, “Computer Integrated Manufacturing Technology and Systems”
4. Ramamurthy, “Computer Aided Design in Mechanical Engineering”
5. Mark Spong, “Robot Dynamics and Control”, Wiley India
6. John Craig, “Robotics”
7. Paul R.P., “Robot Manipulators: Mathematics, Programming and Control”
8. Groover and Simmers,“Industrial Robotics”
9. Ernest Deoblin,“Measurement systems”
10. Beckwith and Lewisbuck, “Mechanical Measurements”
11. K. Ogata,“Modern Control Engineering”,PHI
12. Benjamin Kuo, “Automatic Control Systems”, Wiley India
13. Richard D. KIafter et al, “Robotic Engineering -an Integrated Approach”, PHI
14. Spyros G. Tzafestas, “Intelligent Robotic Systems”

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Subject Code	Subject Name	Credits
MDE2034	**Micro Electro Mechanical Systems@**	**04**

Module	**Detailed content**	**Hours**
1	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	08
2	**Sensors and Actuators in Micro-domain** • Concept of Sensors & Actuators, • Sensing & Actuation Principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys • Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors • Sensors & Actuators for Automotive, Biomedical, Industrial applications • Design of sensor and actuator for few applications such as automobile accelerometer, bimetallic temperature sensor, etc.	12
3	**Fabrication Methods** Microfabrication Methods (VLSI Techniques) • Positive and Negative Photoresists, • Bulk Micromachining, • Surface Micromachining, • Etching (Isotropic and Anisotropic), • Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques. 3D High Aspect Ratio Techniques • LIGA, • AMANDA, • Microstereolithography, • IH-Process, • X-Ray Techniques, • Ion-beam Lithography etc.	10
4	**Modelling and Simulation Techniques** • Scaling Laws, Governing Equations • Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis • Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling • Modelling of Micro-channel as heat exchanger, accelerometers, micro-hinges, compound microstructures. • Linear & Nonlinear Model. • Numerical Methods used for MEMS analysis.	10

<table>
<tr><td>5</td><td>Characterization Techniques
Topography Methods (Optical, Electrical and Mechanical Methods)
• Microscopy, STM (Scanning Tunneling Microscopes),
• SEM (Scanning Electron Microscopes),SPM (Scanning Probe Microscopes), AFM (Atomic Force Microscopes)
Mechanical Structure Analysis
• Deformation & Vibration Measurement Techniques (Piezo resistive and piezo electric)
• Interferometry Techniques,
• SPI (Speckle Pattern Interferometry), ESPI (Electronic Speckle Pattern Interferometry),
• Laser Techniques, Laser Doppler Vibro-meters
Fluid, Thermal and Chemical Analysis
• Thermal Analysis Techniques (Theoretical and Experimental),
• Fluid Flow Pattern Analysis,
• Electro-chemical Analysis,
• PIV Techniques
• Spectroscopy</td><td>12</td></tr>
<tr><td>6</td><td>Introduction to Advances of MEMS and Nanotechnology
• CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method,
• Nano-mechanical Systems (NEMS),
• Nano-tribology, &nano-indentation techniques,
• Domestic and Industrial Applications of nanotechnology
• Molecular Modelling Techniques.
• Social and Ethical Implications of nanotechnology in Society</td><td>08</td></tr>
</table>

@ Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Manufacturing Systems Engineering

References:

1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim "Microsensors MEMS and Smart devices", John Wiley and sons, Ltd.
2. NadimMulaf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", Artech House.
3. NicolaeLobontiu and Ephrahim Garcia, "Mechanics of Microelectromechanical systems", Kluwer Academic Publication.
4. Stanley Wolf and Richard Tauber, "Silicon Processing for the VLSI era Volume -1 Technology", Lattice press.
5. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and sons Ltd.
6. Bhushan, "Springer Handbook of Nanotechnology", Springer Inc.

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
MDE2041	**Diagnostic Maintenance Techniques**	**04**

Module	Detailed content	Hours
1	**INTRODUCTION TO MAINTENANCE:** Introduction to Maintenance, Bath tub curve, Types of maintenance: Preventive maintenance, Reaction to failure maintenance, Condition Based maintenance. Total productive maintenance (TPM), Reliability Centered maintenance (RCM), RCM logic Tree, Merits and demerits of above maintenance system. **Condition Monitoring Techniques:** Vibration Monitoring, Oil/debris analysis, Manual inspection, Current monitoring, Conductivity/insulation monitoring, Performance monitoring, Thermal monitoring (Thermography), Corrosion monitoring, How condition monitoring is implemented, why vibration monitoring is predominantly used in industry,	06
2	**FUNDAMENTALS OF VIBRATION MONITORING:** Causes and effects of vibrations,Characteristics of vibrations, What is phase, Measurement of Phase, Phase Fundamentals, Comparing two waveforms using reference, Cross Channel Phase Analysis. **Transducer Characteristics:** Basic signal attributes, Different Probes: Proximity Displacement probes, Velocity probe, Piezoelectric Accelerometers. Application of above probes, all probes advantages and disadvantages. **Dynamic Signal Characteristics:** Electronic Filters, Time and orbital domain, Time and frequency Domain **Standards for Vibration Monitoring and Analysis:** ISO standard for Evaluation of Vibration Severity: ISO 10816 and ISO 7919, Selection Criteria of measurement and evaluation of vibration severity.	12
3	**VIBRATION ANALYSIS FOR MACHINERY MALFUNCTION:** **Analysis:** Analysis of machinery vibration problems, Methodology of vibration analysis: Condition/vibration monitoring data collection, Trending of data, Time wave form analysis, Signature analysis, Absolute Phase analysis and cross channel phase analysis, Orbit analysis. Root Cause Analysis**.** **Machinery malfunction diagnosis with case studies by using vibration analysis tool:** Methodology of diagnosis of unbalance, misalignment and antifriction bearings defect. Frequency calculation and their significance in signature analysis of antifriction bearing, Mechanical Looseness, diagnosis of foundation problem	16

4	**FUNDAMENTAL OF OIL AND WEAR DEBRIS ANALYSIS:** **Types of Wear:** Mechanism of Mechanical wear, Adhesive wear, Erosive wear, Abrasive wear, fretting wear, Fatigue wear of surfaces, cavitation's wear. **Mechanism of chemical corrosion wear:** Wear of bearing materials, wear of bearing surfaces, Factors influencing wears. **Oil Analysis as Condition Monitoring Techniques**: Oil sampling, Guide lines for representative oil sampling points for machinery, Oil sampling tools, Sampling Analysis, Interpretation of results, oil replacement strategy **Lube oil Testing/Analysis and its significance:** Physical Test- Viscosity test, Flash & Fire point Test, Cloud & pour point test, Carbon residue test etc. Chemical Test- Total Acidic Number (TAN) and Total Basic Number (TBN), Sulphur, Chlorine, Phosphate test.	08
5	**DETECTION AND DIAGNOSIS OF WEAR THROUGH OIL AND WEAR DEBRIS ANALYSIS:** Basic components of wear debris analysis, their characteristics and relationship to wear. The proactive & reactive components of wear & associated products. Wear in lubricated systems. Types of debris, Debris collections, Debris Analysis,Ferrography, Types of debris harmful to lube oil and machinery.	08
6	**NON DESTRUCTIVE TESTING (NDT) TECHNIQUES:** Need of inspection, Types of inspection system, Quality of inspection, Reliability of defect detection, and Benefit & Role of NDT in maintenance of rotating machinery, NDT techniques used: Visual inspection, Liquid Penetrant Testing (LPT), Magnetic Particle Testing (MPT), Ultrasonic testing, Eddy Current Testing, Radiography. Features and Applications of above test in maintenance along with their limitations.	10

References:

1. A. Devies, "Hand Book of Condition Monitoring: Techniques and Methodology", Springer
2. B.K.N. Rao, "Handbook of Condition Monitoring", Elsevier
3. Steve Goldman, "Vibration Spectrum Analysis: A Practical Approach", Industrial Press Inc.
4. Richard O. Duda, Peter E. Hart andDavid G. Stork, "Pattern Recognition", Wiley
5. PareshGirdhar andCornelius Scheffer, "Practical Machinery Vibration Analysis and Predictive Maintenance", Elsevier
6. R. Keith Mobley, "An Introduction to Predictive Maintenance ", Butterworth-Heinemann
7. Robert B. McMillan "Rotating Machinery: Practical Solutions to Unbalance and Misalignment", Fairmont Press
8. Joel Levitt, "Complete Guide to Preventive and Predictive Maintenance Industrial", Press Inc.,
9. R. K. Prasar, "Lubrication Simplified", Publisher, English Edition
10. B.C. Nakra , G.S. Yadava and L. Thuestad, "Vibration Measurement and Analysis", National Productivity Council, New Delhi
11. Barry Hull, Vernon John, "Non-Destructive Testing", ELBS Publication

12. Ron Barroon, “Engineering Condition Monitoring Practice, Methodology and Applications”, Pearson Education
13. Robert Bond Randall, “Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications”, John Wiley and Sons, Inc.
14. Kenneth G. McConnell and Paulo S. Varoto , “Vibration Testing: Theory and Practice”, John Wiley and Sons, Inc.
15. R. A. Collacott, “Mechanical Fault Diagnosis and Condition Monitoring”, Chapman & Hall
16. John Piotrowski, “Shaft Alignment Handbook”, CRC Press
17. Victor Wowk, “Machine Vibration: Alignment”, McGraw-Hill

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Subject Code	Subject Name	Credits
MDE2042	**Advanced Machine Design**	**04**

Module	Detailed content	Hours
1	**Concurrent Engineering** • Design Process • Application of Computers for Design • Product Life Cycle, Product Life Cycle Revised with CAD/CAM • Sequential Engineering • Concurrent Engineering – Definitions, Features, Advantages, • Organizational Structures (Galbraith) • Case Studies on Industries which successfully implemented Concurrent Engineering • Collaborative Engineering	08
2	**Reverse Engineering** • Product Development Approaches – Conventional and Non-Conventional • Reverse Engineering – Definition, Importance, Steps Involved in it and its Applications • Coordinate Measuring Machine (CMM) – Structural Description, Different Probing Systems • Computer Tomography • Case Studies	06
3	**Product / Process Reengineering** • Definition • Shewhart-Deeming Cycle (Plan, Do, Check, Action) • Phases of Reengineering - Reengineering Leadership, Selecting the Reengineering Team - Business Assessment - Setting the Project Scope, Studying the Problem - Understanding the Current Process, Understanding the Current Information Architecture - Preparing for the Redesign - Travelling through the Process Space - Key Concepts in Information Technology - Data Analysis and Reengineering Project - Redesign Principles - Case Study	12
4	**Loss Function and Design Techniques** • Definitions of Quality, Quality Loss Function • Causes of Variation, Average Quality Loss • Exploring Nonlinearity • Classification of Parameters • Steps in Designing Performance into a Product • Functional Design: The Traditional Focus • Loss Functions and Manufacturing Tolerances • Concept Design, Parameter Design, Tolerance Design	14

5	**Product / Process Optimization** • Signal to Noise Ratios for Static Problems • Signal to Noise Ratios for Dynamic Problems • Optimization using Signal to Noise Ratios	10
6	**Robust Design** • Steps in Robust Design • Fundamental Principle • Tools used in robust Design • Application and Benefits of Robust Design	10

References:

1. ImadMoustapha, "Concurrent Engineering in Product Design and Development", New Age International (P) Ltd. Publishers
2. Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw-Hill Publishing Company Ltd.
3. Mikell P. Groover and Emory W. Zimmers Jr., "CAD/CAM: Computer-Aided Design and Manufacturing", Prentice Hall of India Pvt. Ltd.
4. P. Radhakrishnan, S. Subramanyan, "CAD/CAM/CIM", New Age International (P) Ltd., Publishers
5. Vikram Sharma, "Fundamentals of CAD/CAM/CIM", S.K. Kataria and Sons
6. Daniel P. Petrozzo and John C. Stepper, "Successful Reengineering", Jaico Publishing House
7. TapanBagchi Taguchi, "Methods Expalined – Practical Steps to Robust Design", Prentice Hall, India
8. Ernest O. Doebelin, "Engineering Experimentation – Planning, Execution, Reporting", McGraw Hill, Inc.
9. S.P. Gupta, "Statistical Methods", S. Chand and Sons
10. Madhav S. Phadke, "Quality Engineering using Robust Design" , Prentice Hall, Englewood Cliffs
11. Phillip J. Ross, "Taguchi Techniques for Quality Engineering", McGraw Hill
12. Dr. Genichi Taguchi, Yoshika Yokoyama and Yuin Wu, "Taguchi Methods: Design of Experiments", Japanese Standards Association, ASI Press
13. Genichi Taguchi, SubirChowdhury, Yuin Wu, "Taguchi's Quality Engineering Handbook", John Wiley and Sons, Inc
14. Ranjit K. Roy, "Design of Experiments using the Taguchi Approach", John Wiley and Sons, Inc.

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Subject Code	Subject Name	Credits
MDE2043	**Composite Materials$**	**04**

Module	Detailed content	Hours
1	**Introduction to Composite Materials** • Basic Concepts and Terminology • Classification - Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites • Current and Potential Advantages and Applications of Composite Materials	10
2	**MacromechanicalBehaviour of a Lamina** • Review of Definitions: - Stress, Strain, Elastic Moduli, Strain Energy • Hooke's Law for Different Types of Materials - Anisotropic Material, Monoclinic Material, Orthotropic Material (Orthogonally Anisotropic)/SpeciallyOrthotropic, Transversely Isotropic Material, Isotropic Material • Hooke's Law for a Two-Dimensional Unidirectional Lamina - Plane Stress Assumption, Reduction of Hooke's Law in Three Dimensions to TwoDimensions, Relationship of Compliance and Stiffness Matrix toEngineering Elastic Constants of a Lamina • Hooke's Law for a Two-Dimensional AngleLamina • Engineering Constants of an Angle Lamina • Invariant Form of Stiffness and Compliance Matrices for anAngle Lamina • Strength Failure Theories of an Angle Lamina - Maximum Stress Failure Theory, Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu Failure Theory	10
3	**Micromechanical Behaviour of a Lamina** • Volume and Mass Fractions, Density, and Void Content - Volume Fractions, Mass Fractions, Density, Void Content • Evaluation of the Four Elastic Moduli by Strength of Materials Approach, Semi-Empirical Models and Elasticity Approach • Elastic Moduli of Lamina with Transversely Isotropic Fibers • Ultimate Strengths of a Unidirectional Lamina - Longitudinal Tensile Strength, Longitudinal Compressive, Transverse Tensile Strength, Transverse Compressive Strength, In-Plane Shear Strength	10
4	**MacromechanicalBehaviour of a Laminate** • Introduction • Laminate Code • Classical Laminated Plate Theory • First Order Laminated Plate Theory • Laminated Stiffnesses for Selected Laminates - Single Layered Configurations, Symmetric Laminates, Antisymmetric Laminates, Balanced and Quasi-Isotropic Laminates	10

5	**Failure, Analysis and Design of Laminates** • Introduction • Failure Criterion for a Laminate • Design of a Laminated Composite • Other Mechanical Design Issues - Sandwich Composites, Long-Term Environmental Effects, Interlaminar Stresses, Impact Resistance, Fracture Resistance, Fatigue Resistance	10
6	**Introduction to Fabrication Techniques for Composites** • Polymer Composites - Liquid Resin Impregnation Routes, Pressurized Consolidation of Resin Pre-Pregs, Consolidation of Resin Moulding Compounds, Injection Moulding of Thermoplastics, Hot Press Moulding of Thermoplastics • Metal Composites - Squeeze Infiltration, Stir Casting, Spray Deposition, Powder Blending and Consolidation, Diffusion Bonding of Foils, Physical Vapour Deposition (PVD) • Ceramic Composites - Powder-Based Routes, Reactive Processing, Layered Ceramic Composites, Carbon/Carbon Composites	10

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References:

1. R.M. Jones, "Mechanics of Composite Materials", Taylor and Francis, Inc.
2. J.N. Reddy, "Mechanics of Laminated Composite Plates and Shells – Theory and Analysis", CRC Press
3. A.K. Kaw, "Mechanics of Composite Materials", Taylor and Francis Group, LLC
4. D. Hull and T.W. Clyne, "An Introduction to Composite Materials", Cambridge University Press
5. L.P. Kollar, G.S. Springer, "Mechanics of Composite Structures", Cambridge University Press

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Subject Code	Subject Name	Credits
MDE2044	**Smart Materials and Applications***	**04**

Module	Detailed content	Hours
1	**Introduction to Smart / Intelligent Materials:** Overview of Smart / Intelligent Materials, Primitive Functions of Intelligent Materials, Intelligence Inherent in Materials, Actuator Materials, Sensing Technologies, Microsensors, Intelligent Systems, Hybrid Smart Materials, Passive Sensory Smart Structures, Reactive Actuator based Smart Structures, Active Sensing and Reactive Smart Structures, Smart Skins	08
2	**Introduction to Highbandwidth - Low straingenerating (HBLS) SmartMaterials** **Piezoelectric Materials** constitutive relationship,electromechanicalcoupling coefficients,piezoelectric constants,piezoceramic materials,variation of couplingcoefficients in hard andsoft piezoceramics,polycrystalline vs singlecrystal piezoelectricmaterials, polyvinyldenefluoride, piezoelectriccomposites **MagnetostrictiveMaterials** constitutiverelationship, magnetomechanicalcouplingcoefficients, Joule Effect,Villari Effect, MatteuciEffect, Wiedemanneffect, Giantmagnetostriction inTerfenol-D, Terfenol-Dparticulate composites,Galfenol and Metglasmaterials.	10
3	**Actuators based on HBLSSmart Materials** **Piezoelectric Actuators** Induced Strain actuationmodel, Unimorph andBimorph Actuators,Actuators embedded incomposite laminate,Impedance matching inactuator design,Feedback Control, PulseDrive, Resonance Drive. **MagnetostrictiveActuators** Magnetostrictive MiniActuators, Thermalinstabilities, Discretelydistributed actuation,ManetostrictiveComposites. **MEMS based Actuators** PiezoelectricMicropumps,Magnetostrictivemicromechanisms,Imaging SystemApplications, InchwormDevices, Inkjet Printers,Piezoelectric Relays,Ultrasonic Motors, andMicroscale Walking Machines. **Sensors based on HBLSSmart Materials** Piezoelectric Sensors, MagnetostrictiveSensors, Techniques of Self-Sensing,MEMS Sensors	12
4	**Introduction to Lowbandwidth - High straingenerating (LBHS) materials** Shape Memory Alloys(SMA) Electro-active Polymers (EAP)	08
5	**Actuators based on LBHSSmart Materials** Shape Memory Alloybased actuators forShape Control Electro-active Polymersfor Work-Volume Generation **Sensors based on LBHSSmart Materials** EAP based sensors SMA based encoders Optical Fibre based Sensing	12

6	**Advances in Smart Materials** • Active Fibre Composites (AFC) • Energy Harvesting Actuators and Energy Scavenging Sensors • Self-healing and Autophagous Smart Materials	10

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References:

1. M.V. Gandhi and B.S. Thompson, “Smart Materials and Structures”, Chapman & Hall,London; New York, 1992 (ISBN: 0412370107)
2. Bryan Culshaw, “Smart Structures and Materials”, Artech House
3. Mel Scwartz, “Encyclopedia of Smart Materials Vol. I and II”, John Wiley & Sons
4. SenolUtku, “Theory of Adaptive Structures : Incorporating Intelligence into Engineered Products”, CRC Press
5. H. Janocha, “Actuators - Basics and Applications”,Springer
6. B. Culshaw, “Smart Structures and Materials”, Artech House, Boston, 1996 (ISBN: 0890066817)
7. A.V. Srinivasan, “Smart Structures: Analysis and Design”, Cambridge University Press,Cambridge; New York, 2001 (ISBN: 0521650267)
8. A.J. Moulson and J.M. Herbert, “Electroceramics: Materials, Properties, Applications”,2nd Edition, John Wiley & Sons, Chichester, West Sussex; New York, 2003 (ISBN:0471497479)
9. G. Gautschi, “Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers”, Springer, Berlin; New York, 2002 (ISBN:3540422595)
10. K. Uchino, “Piezoelectric Actuators and Ultrasonic Motors”, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
11. G. Engdahl, “Handbook of Giant Magnetostrictive Materials”, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X)
12. K. Otsuka and C.M. Wayman, “Shape Memory Materials”, Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)
13. Eric Udd, “Fiber Optic Sensors: An Introduction for Engineers and Scientists”, John Wiley & Sons, New York, 1991 (ISBN: 0471830070)
14. André Preumont, “Vibration Control of Active Structures: An Introduction”, 2nd Edition, Kluwer Academic Publishers, Dordrecht; Boston, 2002 (ISBN: 1402004966)
15. HojjatAdeli, “Control, Optimization, and Smart Structures: High-Performance Bridges and Buildings of the Future”, John Wiley, New York, 1999 (ISBN: 047135094X)
16. T.T. Soong, “Passive Energy Dissipation Systems in Structural Engineering”, Wiley, Chichester; New York, 1997 (ISBN: 0471968218)

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Subject Code	Subject Name	Credits
MDL203	**CAD/CAM/CIM#**	**01**

Module	Detailed content	Lab. Sessions
1	**CAD** a. Executing basic algorithms for generation of line, circle, ellipse in any programming language b. Executing transformations and projection both in 2D and 3D in any programming language c. Generating curves using any programming language	06
2	**CAM** a. Developing GM code or APT part program for machining operations such as facing, turning, threading, tapering, drilling, etc. and executing them on the CNC machine	03
3	**Laboratory Project** Geometric modeling and assembling of any mechanical system consisting of minimum 5 to 6 components using any CAD software and developing GM code or APT part program for manufacturing all the individual components on CNC machines	06

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Assessment:

Laboratory Project : Weightage for Laboratory Project should be 40% in Final Assessment of Laboratory Work

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
MDL204	**Measurement and Virtual Instrumentation**§	**01**

Module	**Detailed content**	**Lab. Sessions**
1	Study of sensor characteristics, selection, calibration and measurement of minimum 05 mechanical parameters such as flow, load, pressure, speed and temperature	05
2	**Virtual Instrumentation** a. Simulation of any system with Virtual Instrumentation (VI) environment using any suitable software b. Interfacing of sensors used for measuring above mentioned parameters in I with VI software and measurement of these parameters on any laboratory model or actual working system	08
3	Demonstration of interfacing of VI software with suitable generic hardware	02

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Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
MDS301	**Seminar**	**03**

Guidelines for Seminar

- Seminar should be based on thrust areas in Mechanical Engineering
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures (at least 10 papers from Refereed Journals) and understand the topic and compile the report in standard format and present infront of Panel of Examiners.(pair of Internal and External examiners appointed by the University of Mumbai)
- **Seminar should be assessed based on following points**
  - Quality of Literature survey and Novelty in the topic
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

NOTE :

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai,OR faculty from Premier EducationalInstitutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. ORa person having minimum Post-Graduate qualification with at least five years' experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes literature survey, identification of problems, analysis and interpretation of results and technical paper writing in the beginning of 3rd semester.

Subject Code	Subject Name	Credits
MDD301 / MDD401	**Dissertation (I and II)**	**12 + 15**

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problemdefinition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problemdefinition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai
- Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)