Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University)

Andheri (W) Mumbai - 400058

COURSE CONTENTS

(M.Tech. in Machine Design)

Year: 2017-18

Sardar Patel College of Engineering, Andheri (West), Mumbai 400058
Year: 2017-18

List of Courses

MTMD101 Stress Analysis
Course Pre-requisites: BTM302, BTM701

Course Objectives:

1. To develop the student's understanding of the foundations of stress and strain
2. To develop the student understands of the displacement field, Hooke's constitutive law.
3. To develop student's skills in analyzing stress problems through the application of the basic laws and equations.

Course Outcomes:

Upon successful completion of the course, students should be able to

1. Apply knowledge of failure theories appropriately to solve problems of practical interest with a variety of loading situations.
2. Analyze and calculate stress/strain distributions for 2D problems of elasticity using stress function approach and evaluate using IT tools like ANSYS, etc.
3. Describe stress strain measurement through experimental technique, and stress-strain relation of composite materials.
4. Describe various equipment required to preform the experimental stress-strain analysis.

Course content:

Sr.No.	Description	Hrs.
1	Analysis of Stress: Introduction to tensor analysis, stress tensors, Cauchy's stress principle, Principal stresses in three dimensions, Equilibrium equations, Octahedral stresses, and Mohr's stress circle.	**5**
2	Analysis of strain: Strain tensors, Strain transformation, Principal strains, Octahedral strains, Mohr Circle for strain, Equations of compatibility.	**5**
3	Stress -Strain Relations: Generalized Hooke's Law, Transformation of compatibility condition from strain components to stress components, Strain energy in an elastic body, St. Venant's principle, Uniqueness theorem.	**5**
4	Two dimensional Problems in Cartesian Coordinate system: Plane stress and plane strain problems, Stress function, Stress function for plane stress and plain strain cases, Solution of two-dimensional problems with different, loading conditions by the use of polynomials.	**5**
5	Two Dimensional Problems in Polar Coordinate System: Strain-displacement relations, Compatibility equation, Stress-strain relations, Stress function and biharmonic equation, Antisymmetric problems, Effect of circular holes on stress distribution in plates.	**8**

	Torsion of Prismatic Bars: General solution of the torsion problem, Torsion of circular and elliptic cross sections.	
6	Experimental stress Analysis: Introduction to Photo elasticity, Moir, Holography,Speckle Methods etc.	**4**
7	Strain Guage Technique: Strain measurement by resistance gauges, types of strain gauges, Equipment for indicating and recording strains transducer and its application.	**4**

Recommended Books:

1. T. G. Sitharam and L. Govindraju, "Applied Elasticity", Interline Publishers, Bangalore
2. Timoshenko, Stephen P.; James Norman Goodier (1970). Theory of Elasticity (Third Ed.). Tata McGraw-Hill India Edition.
3. Y. C. Fung, "Foundations of Solid Mechanics." Prentice- Hall Publishers.
4. Arthur P. Boresi, Richard J. Schmidt- Advanced Mechanics of Materials-Wiley (2003).
5. Advances in Engineering Vol -4- Fatigue Design Handbook (SAE)
6. Collins, Jack A. *Failure of materials in mechanical design: analysis, prediction, prevention*. John Wiley & Sons, 1993.
7. Singh, Sadhu. *Experimental Stress Analysis: A Text Book for Engineering Students*. Khanna publishers, 1982.
8. Dally, James W., and William F. Riley. "Experimental stress analysis." (1965).

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD102 Machine Dynamics and Advance Vibration
Course Pre-requisites: BTM502

Course Objectives:

1. Understand Un-damped, damped, forced SDOF and MDOF systems and its relation to a vibrating system.
2. Understand how to derive eqs. of motion for two degree of freedom systems or higher.
3. Understand how to find frequencies using Rayleigh and Dunkerley Methods.

Course Outcomes:

Upon successful completion of the course, students should be able to

1. Analyze motion of rigid bodies in space and calculate dynamic forces/moments.
2. Solve for response of un-damped, damped, forced SDOF and MDOF mechanical vibrating systems.
3. Design vibration control system.
4. Estimate response of non-linear vibration system using iterative or graphical methods.

Course content:

Sr. No.	Description	Hrs.
1	Dynamics of Particle: Kinematics of particles: Rectilinear Motion, Plane Curvilinear Motion, Rectangular Coordinates Normal and Tangential Coordinates, Polar Coordinates. Kinetics of particles: Newton's Second law Equation of motion, Work and kinetic Energy, Potential Energyy, Impulse and Momentum.	**5**
2	Dynamics of rigid body: Plane Kinematics of rigid body: Absolute Motion, Relative Velocity, Instantaneous center of Zero velocity, Relative Acceleration. Plane Kinetics of rigid body: Work and energy principle. Three dimensional dynamics of rigid body, Euler's equations of motions, Impulse momentum formulation, Work energy formulation.	**5**
3	Discrete Vibration Damped and undamped free vibration,Special cases: Oscillatory, non-oscillatory and critically damped motions, Forced harmonic vibration, Magnification factor, Logarithmic decrement, Generalized and principal coordinates, Derivation of equations of motion, Newton's Method, Energy Method, Lagrange's equation,Influence coefficient method, Properties of vibrating systems: flexibility and stiffness matrices, reciprocity theorem, Modal analysis: undamped, Modal analysis: damped.	**8**
4	Continuous vibration Equations of motion and boundary conditions, natural frequencies and mode shapes. Vibration of strings, Longitudinal and torsional vibration of rods, Transverse vibration of beams, Rayleigh's energy method, Rayleigh-Ritz method, Matrix iteration method.	**5**
5	Practical application of vibration Vibration isolation, Vibration absorber, Tuned and damped absorber, Introductory concept of rotor dynamics, Jeffcott rotor model.	**5**
6	Basics of non-linear vibration – causes of non – linearity – formulation. Solution methods iterative, Graphical, Method of isoclines. Stability of equilibrium state and type of singularity. Limits cycles.	**4**

7	Brief introduction to experimental modal analysis Signal generation, measuring and conditioning instruments, signal analysis instruments, Vibration signatures and standards, Virtual Lab experiments.	**4**

Recommended Books:

1. Rao, Singiresu S., and Fook Fah Yap. *Mechanical vibrations*. Vol. 4. New York: Addison-Wesley, 1995.
2. Leonard Meirovitch- Fundamentals of Vibrations- McGraw-Hill Companies (2000)
3. Engineering Mechanics Dynamics (7^{th} Edition)- J.L. Meriam,L.G.Kraige
4. Shames, I. H. "Engineering mechanics: statics and dynamics, 1996."*PrenticeHall of India, New Delhi*: 911-960.Non – linear mechanical vibration – Srinivasan
5. Kelly, S. Graham. "Fundamentals of mechanical vibrations." (1992).
6. Theory & Practice of Rotor Dynamics
7. Mechanical Vibrations NPTEL Lectures (http://nptel.ac.in/courses/112103112/)
8. Reference websites on Virtual Lab experiments
   http://vlab.co.in/
   http://iitg.vlab.co.in/?sub=62&brch=175
   http://mdmv-nitk.vlabs.ac.in/

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD103 Computer Aided Design
Course Pre-requisites: BTM802, BT207

Course Objectives
The general objectives of the course are to enable the students to

1. Understand the basic analytical fundamentals that are used to create and manipulate geometric models in computer programs.
2. To visualize how the components looks like before its manufacturing or fabrication
3. To learn 2D & 3D transformations of the basic entities like line, circle, ellipse etc
4. To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc.
5. To understand the different types of curves like Bezier curve, B-Spline curve & Graphics Standards
6. To understand different Algorithms for optimization of drawing of basic entities

Course Outcomes
At the end of the course

1. Students will be able to **explain** the theory in CAD
2. Students will be able to **solve** analytical problems on Geometrical Transformations, Algorithms, Bezier & B-Spline Curves.
3. Develop Algorithms for Geometric entities & other types.
4. Students will be able to **formulate** the programs on Geometrical Transformation Algorithms, Bezier & B-Spline Curves using IT tools like C/C++/MATLAB etc.

Course content:

Sr. No.	Details	Hrs
Module 01	**INTRODUCTION & ELEMENTS OF INTERACTIVE COMPUTER GRAPHICS** The design process, the role of modeling & communication, modeling using CAD, Product life cycle, Concurrent engineering in Product design & development, Collaborative Engineering, computers for design Process, CAD System Architecture.	**04**
Module 02	**TECHNIQUES FOR GEOMETRIC MODELING** Graphics Standards, Line, circle, ellipse algorithm Jupiter Technology, curves, parametric representation of line, circle, ellipse & parabola constructive solid geometry (CSG), Boundary Representation (B-Rep), Geometric Construction methods and its requirements, Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Constraint driven modeling, Feature recognition, Design by feature	**05**
Module 03	**ALGORITHMS** Two dimensional computer graphics, vector generation, the windowing transformation, three dimensional Computer graphics, viewing transformation, Visual realism, Hidden line removal & hidden surface removal algorithm, light & shade ray tracing	**08**

Module 04	**TRANSFORMATION, MAINPULATION** 2D & 3D Transformations (Translation, Rotation, & Scaling & Magnification), Concatenations, Matrix representation, Problems & object oriented programming on Transformations. The parametric representation of geometry, Problems on Bezier,Cubic, B-Spline	**07**
Module 05	**DATA STORAGE** Object transformation, mirror transformation, graphics modeling data structures, Bill of materials from attribute data, The use of Object Orientation & associatively, Engineering data management system, relational data base for design, object Oriental database, Structured Query language, Design information Systems. Artificial Intelligence in Design.	**06**
Module 06	**EMERGING AREAS in CAD** Virtual Prototyping, Design for Assembly (DFA), introduction to Virtual reality (VR) and PLM, Knowledge Base Engineering (KBE) Reverse Engineering and Data Capture techniques like Contact Inspection methods and Scanning methods, CAD-VR Integration, CAD – PLM Integration, Augmented Reality & its applications	**05**
Module 07	**CAD for Machine Elements and Sub-Assemblies** • Develop Algorithm, Flow Charts and Software for Geometrical 2D & 3D Transformations, Gears, Knuckle Joint, Cotter Joints, Bezier curves, B-spline curves etc.	**07**

Recommended Books:

1. Groover, Mikell P. *Computer aided design and manufacturing*. 1987.
2. Zeid, Ibrahim. *CAD/CAM theory and practice*. McGraw-Hill Higher Education, 1991.
3. Hearn, Donald, M. Pauline Baker, and BjarneStroustrup. *Computer Graphics with OpenGL, 3/E*. Prentice-Hall, 2003.
4. McMahon, C. A., and J. Browne. "CADCAM: principles, practice and manufacturing management, 1998."
5. Radhakrishnan, Pezhingattil, S. Subramanyan, and V. Raju. *Cad/cam/cim*. New Age International, 2008.
6. Rao, PosinasettiNageswara. *CAD/CAM: principles and applications*. Tata McGraw-Hill Education, 2004.
7. Neumann W.M., Sproul R.F., *Principle of Computer Graphics*, McGraw Hill Book Co. Singapore, 1989.
8. Rogers, David F., and J. Alan Adams. *Mathematical elements for computer graphics*. McGraw-Hill Higher Education, 1989.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD111 Elective-I: Tribology
Course Pre-requisites: BTM701, BTM801

Course Objectives:

1. To provide overview of tribology and practical implications in machine elements.
2. To understand the material properties, nature of surfaces, their topography and surface characterization techniques.
3. To understand the genesis of friction, the theories/laws.
4. To learn about wear, wear mechanisms, wear theories applied in machine elements.

Course Outcomes:

Upon successful completion of the course, students should be able to

1. Apply the principles of lubrication, lubrication regimes, and theories of hydrodynamic, elasto hydrodynamic and mixed / boundary lubrication.
2. Explain essentials of tribotesting and experimental techniques in Tribology.
3. Discuss and formulate tribological modelling and simulation.
4. Design of mechanical components against wear.

Course content:

Sr.No.	Description	Duration (hrs)
1	Introduction: Overview of Tribology, Lubricants selection for general application and special application such as low tempratures high temperature, extreme pressure etc.	6
2	Friction and Wear: Types of wear and basic mechanism of wear, Wear properties of friction and antifriction metallic and non metallic materials, experimental techniques in evaluation of materials.	6
3	Fluid film journal bearing: petroff equation, Reynolds equation, short bearing and long bearing, full and partial journal bearings of infinite length, design of journal bearings for steady loads and varying loads.	6
4	Hydrodynamic lubrication and bearing design: Basic concept, hydrodynamic lubrication: design of plain fixed pad and tilting pad, slider bearing for study and varying loads.	6
5	Introduction to design of aerostatic bearings, and its applications Elasto-hydrodynamic lubrication: Principle, application to antifriction bearings, cams and gears.	6
6	Antifriction bearing: Rolling Contact Bearings, Bearing types and selsction of rolling contact bearing for different applications/loading condition. Static and dynamic load capacity, left rating.	6
7	Application of Tribology in mechanical elements: Design of mechanical components against wear. Design of friction surfaces used in clutches and brakes. Design of IC engine component against wear, Design of seals.	6

Term work:

1. At least four (04) problems each on design of hydrostatic bearings, design of hydrodynamic journal bearing, design of rolling element bearings, design of brakes and clutches.
2. At least one case studies on application of tribology in machine elements based on the above syllabus.

Text Books:

1.Hirani, Harish. Fundamentals of Engineering Tribology with applications.Cambridge University Press, 2016.

Reference Books:

1. Szeri, Andras Z. *Fluid film lubrication: theory and design*. Cambridge University Press, 2005.
2. ABHATIA, J. "Advance in Industrial Tribology." (1998)
3. Chattopadhyay, Ramnarayan. *Surface wear: analysis, treatment, and prevention*. ASM international, 2001.
4. Mang, Theo, Kirsten Bobzin, and Thorsten Bartels. *Industrial tribology: tribosystems, friction, wear and surface engineering, lubrication*. John Wiley & Sons, 2011.
5. Neale, Michael J., ed. *Lubrication: A Tribology Handbook*. Butterworth-Heinemann, 1993.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD112 Elective-I : Rapid Prototyping and Tooling
Course Pre-requisites: BTM405

Course Objectives:
1. To study the fundamentals of rapid prototyping and tooling technologies.
2. To study basic concepts of rapid prototyping and their application in product development.
3. To study diffrerent working matrials and systems used in rapid prototyping techniques
4. To study layering techniques in rapid prototyping systems

Course Outcomes:
At the end of the course the students shall be able to
1. Describe working principles of rapid prototyping techniques
2. Select proper rapid prototyping techniques for specific technical applications.
3. Select an appropriate material and tools to develop a given product using rapid prototyping Machine.
4. Design layering technique for rapid prototyping

Course Content:

Sr. No.	Syllabus	Hrs
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	4
2.	**Subsystems of RP Machine** • Subsystems of RP achine 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	6
3.	**Liquid Based Rapid Prototyping Systems** • Materials • Stereolithography • Solid Ground Curing • Solid Object UV (Ultra-Violet) Printer • Two Laser System • Micro-stereolithography.	6
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	5

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	5
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.	4
7.	Case Study: Wind-Tunnel Testing with RP Models Case Study: Investment Casting with RP Case Study: Fabrication of microlens arrays Case Study: Fabrication of Scaffolds for medical applications	4

Term Work

1. Assignments based on each module.
2. Seminar based on recent advances in the subject
3. At least one Case study

Reference Books:

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.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD113 Elective-I: Numerical Methods in Engineering
Course Pre-requisites: BTM401 and BT207

Course Objectives:
1. Identify and classify the numerical problem to be solved.
2. Choose the most appropriate numerical method for its solution based on characteristics of the problem
3. Understand the characteristics of the method to correctly interpret the results.

Course Outcomes:
Upon successful completion of the course, students should be able to

1. Explain different types of numerical methods in modern scientific computing, finite precision computation,
2. Calculate and solve numerically: nonlinear equations in a single variable, interpolation and approximation of functions, integration and differentiation of functions
3. Interpret errors in numerical methods and create programs with numerical packages like MATLAB etc.
4. Apply curve fitting, interpolation, extrapolation for solving mechanical engineering problems.

Course content:

Sr.No.	Description	Duration (Hrs)
1	Programming fundamentals. Fundamentals of numerical methods. calculus, binary numbers, error analysis.	5
2	Curve fitting; Interpolation and extrapolation, least square line methods, interpolation by spline functions, Betier curves, Fourier series and trigonometric polynomials.	5
3	Differentiation and integration, solution of nonlinear algebraic and transcendental equations. Numerical differentiation: approximating derivatives, numerical differentiation formulae, central difference formula, differentiation of lagranges and newton polynomials.	5
4	Elements of matrix algebra: eigen values and problems power method, Jacobis method. Numerical integration : quadrature, trapezoidal rule, recursive rules of Romberg integration, adaptive quadrature, gauss legendre integration	5
5	Solution of nonlinear equations:f(x)=0 Iteration for solving x=g(x), bracketing method for locating root, initial approximation and convergent criteria, Newton Raphson and secant methods	5
6	Solution of linear system of AX=B Gauss elimination pivoting, triangularization, iteration methods: Jacobi method, Gauss seidel iteration.	5
7	Solution of differential equations (ODE) Eulers method, Heums method, Taylor series, Runge-Kutta method, boundary value problems, finite difference and finite element method.	5

Recommended Books:

1. Mitchell, A. R. "JH Wilkinson, The Algebraic Eigenvalue Problem (Clarendon Press, Oxford, 1965), 662pp., 110s." *Proceedings of the Edinburgh Mathematical Society (Series 2)* 15, no. 04 (1967): 328-328.
2. Atkinson, Kendall E. *An introduction to numerical analysis*. John Wiley & Sons, 2008.
3. Golub, Gene H. "CF van Loan Matrix computations." *The Johns Hopkins* (1996).
4. Chapra, Steven C., and Raymond P. Canale. *Numerical methods for engineers*. Vol. 2. New York: McGraw-Hill, 2012.
5. Bhat, Rama B., and SnehashishChakraverty. *Numerical analysis in engineering*. Alpha Science Int'l Ltd., 2004.

Term work:

Assignment based on above topics and seminars.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD114 Elective-II: Reliability Engineering and Design of Experiments
Course Pre-requisites: BTM605 and BTM704

Course Objectives:

1. To understand the basic concepts, principles of engineering experimentation and reliability engineering.
2. To learn the various Techniques used in design of experiments and reliability engineering.
3. To analyze the engineering experiments and apply Design of experiments (DOE) techniques for case studies.

Course Outcomes:

At the end of the course the students shall be able to

1. Understand the experimental planning, evaluation procedure and analysis used in industrial environment.
2. Apply the techniques of design of experiments (DOE) for engineering application
3. Learn the evaluation techniques (for example: MTTF and failure rates) for Reliability Engineering.
4. Use DOE and reliability techniques for engineering applications using industrial case studies.

Course Content:

Module No.	Syllabus	Hours
1.	Design of Experiments (DOE): Introduction to Engineering experiments, Measurement of physical parameters, selection of instruments, static and dynamic characteristics of response, Planning of experiments.	6
2.	Measurements and statistical estimation of errors, Basic statistics and data analysis for sample population and distributions, Hypothesis testing, Analysis of Variance (ANOVA)	6
3.	Single and multi variate regression analysis, Linear and non linear regression, Randomization and Blocking, Complete and in complete block designs.	6
4.	Full factorial design (2 level and 3 level experiments), Fractional factorial design, Response surface Methodology, Taguchi techniques for design of experiments.	6
5.	Probability and Distributions for reliability, Reliability management, quality specifications for products/systems, redundancy and diversity evaluation techniques.	6
6.	Reliability Network Modeling (series,parallel, m out of n systems), Network evaluation techniques (conditional probability , cut set, tie set, tree diagram)	6
7.	Failure types, Time dependent reliability, Application of MTTF, MTBF, MTTR for reliability assessment.	6

Term Work

1. Assignments containing numerical problems based on each module.
2. Seminar based on recent advances in the subject
3. At least one Case study each on DOE and reliability engineering.

Text Books:

1. Jiju Antony, Design of Experiments for engineers and scientists, 2003.
2. Patrick, D. O. *Practical reliability engineering*. John Wiley, 1985.

Reference Books:

1. Doebelin, Ernest O. *Engineering experimentation: planning, execution, reporting*.McGraw Hill College, 1995.
2. Pieruschka, Erich. *Principles of reliability*. Prentice-Hall, 1963.
3. Madhav S. Phadke, Quality Engineering using Robust Design, 1989.
4. Douglas C. Montgomery, Design and Analysis of Experiments, 2013.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD115 Elective-II: Research Methodology
Course Pre-requisites: BTM898

Course Objectives

1. To develop an ability to identify, formulate research problem.
2. To develop an ability to apply knowledge of research methodology to engineering Problems.
3. To carry out research on engineering problems.
4. To develop an ability to investigate the phenomenon in a critical manner.
5. Develop critical thinking to find business opportunities and to solve questions related to industries.
6. To get knowledge on various kinds of research questions and research designs

Course Outcomes
Learner shall be able.
1. To carry out literature survey by using various research considerations
2. To formulate the problem statement using research considerations.
3. Demonstrate knowledge and understanding of data analysis in relation to the research process
4. Interpret the analysis perfomed in relation to the research process.

Course Content:

Module No.	Description	Hrs.
1	**Introduction** Definition of Research: ResearchDefinition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Definition and Dimension of a Theory, Functions and Characteristics; Types of Theory: General Theory and Particular/Empirical Theory. Cases and their Limitations; Causal Relations. Philosophy and validityof research. Objectives of research.	**8**
2	**Characteristics of research** Various functions that describe characteristics ofresearch such as systematic, valid, verifiable, empirical and critical approach.	**4**
3	**Types of research** Pure and applied research. Descriptive and explanatory research. Qualitative and quantitative approaches.	**4**
4	**Research Procedure** Formulating the Research Problem, Literature Review, Developing the objectives, preparing the research design including sample Design, Sample size.	**4**
5	**Considerations in selecting research problem** Relevance, interest, available data,choice of data, Analysis of data, generalization and interpretation of analysis	**4**
6	**Outcome of research** Preparation of the Report on conclusions reached. Testing validity of research outcomes .Suggestions and recommendations, identifying future scope.	**4**

7	**Computer application in research** Introduction to spreadsheet application, featuresand functions, using formulas and functions, data storing, features for statistical dataanalysis, generating charts/ graph and other features. Tools used may be Microsoft Excel, Open office or similar tool. Introduction to presentation tool, features and functions, creating presentation, customizing presentation, showing presentation. Tools used may beMicrosoft Power Point, Open Office or similar tool. Introduction to Internet basedsearches, use of advanced search techniques.	**8**

Term Work: Tutorial work consists on class room tutorial session based on above course content.

Description of Tutorial Topics	Hrs.
1. Definition and characteristics of research	4
2. Types of research	4
3. Research procedure	4
4. Considerations of research	4
5. Outcome of research	4
6. Computer applications in research	4

Recommended Books:

1. Dawson, Catherine, 2002, *Practical Research Methods,* New Delhi, UBS Publishers' Distributors.
2. Kothari, C.R.,1985, *Research Methodology-Methods and Techniques,* New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, *Research Methodology-A Step-by-Step Guide for Beginners*, (2nd ed), Singapore, Pearson Education.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD116 Elective-II: System Modeling and Analysis
Course Pre-requisites: BTM502, BTM503

Course Objectives:

After this course students will be able to:

1. Understand what is a model, types of models, purpose of models
2. Understand the need for quantification and understand the limits of quantification
3. Be able to transform loose facts into an insightful model, to be used as input for requirements discussions and system design and verification
4. Be able to use scenario analysis as a means to cope with multiple alternative specifications and or designs
5. Apply problem-driven light-weight simulations and understand their value and purpose in early design decisions

Course Outcomes:

Upon successful completion of the course, students should be able to

1. Apply mathematical modelling for mechanical Elements, systems, hydraulic/pneumatic element and systems.
2. Describe transfer function representation
3. Analyse system response and stability.
4. Compute transient response of first and second order system.

Course content:

Mod. No.	Description	Duration (hrs)
1	Mathematical modeling of mechanical elements – inertia, stiffness and damper	6
2	Mathematical modeling of mechanical systems- vehicles, articulated vehicle and other mechanical systems	6
3	Mathematical modeling of hydraulic elements and system- pneumatic elements and system.	6
4	Transfer function representation, block diagram, State variable representation, matrix equation.	6
5	Numerical methods and some other solution methods.	6
6	System response and stability – Static and dynamic stability of vehicles and articulated vehicles.	6
7	Transient response of first and second order system – Steady state response – step response, ramp response, impulse response, sinusoidal response, input – convolution integral, stability of system.	6

Recommended Books:

1. Vu, Hung V., and Ramin S. Esfandiari. *Dynamic systems: modeling and analysis*. McGraw-Hill Science, Engineering & Mathematics, 1997.
2. Ellis, John Ronaine. *Vehicle dynamics*. Random House Business, 1969.
3. Kobayashi, Hisashi, and Brian L. Mark. *System modeling and analysis: Foundations of system performance evaluation*. Pearson Education India, 2009.

Term work:
Assignment based on above topics and seminars.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD104 Stress Analysis Laboratory
Course Pre-requisites: BTM352, BTM701

Course Objectives:

1. To study different types of stresses and strains induced in the mechanical components due to external loads in three dimensions.
2. To study the elastic behavior of different materials in three dimensions.
3. To study different types of strain gauges.
4. To study different factors affecting failures of materials.

Course Outcomes:
Students will be able to...
1. Demonstrate knowledge about various types of loading and stresses induced in three Dimensions.
2. Develop the Stress Strain relationship for different types of materials.
3. Apply the knowledge of strain gauges for measuring strain in practical applications.
4. Apply the knowledge different factors of failure for better design of mechanical components.

List of Experiments:
Term work shall consists of any six experiments from the following
1. Experiments using strain gauges.
2. Measurement of strain, temperature effects
3. Fixing of gauges on surfaces.
4. Study of photoelastic bench for stress measurement.
5. Study of polariscope and calibration of disc, beam and tension model.
6. Application of strain gauge techniques: Lecture on strain gauge based methods, Cantilever beam and Portal frame.
7. Study of semiconductor based strain gauges
8. Case study on thermal stress analysis using different simulation platforms
9. Case study on stress analysis due to structural loading using different simulation platforms
10. Case study on stress analysis due to dynamic loading using different simulation platforms

Practical Examination shall be based on above mentioned experiments and oral.

MTMD105 Machine Dynamics and Advance Vibration Laboratory
Course Pre-requisites: BTM502, BTM552

Course Objectives:
1. To study the mathematical simulation software for analysis of single and multi degree freedom problem.
2. To study the finite element analysis software for different analysis and active control vibration.
3. Perform experimentation and processing the data and demonstration of condition based maintenance tool.
4. To give understanding various aspects of mechanical vibrations and their control

Course Outcomes:
Students will be able to
1. Apply and analyze different systems using mathematical simulation software.
2. Apply FEA software for different analysis techniques.
3. Demonstrate acquiring and processing of data.
4. Have understanding about the effect of vibration and vibration control

List of Experiments
Term work shall consists experiments from the following
1. Simulation study using mathematical simulation software (or any programming language) on
a. Single DOF system
b. Multi DOF system

2. Simulation study of the followings on any simulation platform
a. Modal analysis
b. Transient analysis
c. Harmonic analysis
d. Active vibration control

3. Experimentation
a. Acquiring time domain vibration data by using sensors (displacement / velocity / acceleration)
b. Demonstration of condition based maintenance tool using vibration techniques

Practical examination is to be conducted based on above experiments and oral.

MTMD106 Computer Aided Design Laboratory
Course Pre-requisites: BTM802

Course Objectives:
1. To study the basics of CAD.
2. Fluent application of engineering techniques, tools and resources.
3. To study Geometric modeling and assembling of any mechanical system.
4. To make appropriate selection of CAD functionality to use as tools in the design process.

Course Outcomes:
Students will be able to…..
1. Apply knowledge of CAD for generation of curves.
2. Generate and interpret engineering technical drawings of parts and assemblies according to engineering design standards.
3. Demonstrate skill of modeling and assembling of any mechanical system.
4. Prepare to be an effective user of a CAD/CAM system.

List of Experiments:
Term work shall consists experiments from the following
1. Executing basic algorithms for generation of line, circle, ellipse in any programming language
2. Executing transformations and projection both in 2D and 3D in any programming language
3. Generating curves using any programming language
4. Creation of 3D assembly model.

Practical examination is to be conducted based on above experiments and oral.

MTMD199/MTMD189 Seminar-I/Mini Project-I
Course Pre-requisites: BTM798, BTM898

Course Outcomes:

1. Student will be able to apply the skill of presentation and communication techniques
2. Student will be able to use the knowledge of the fundamentals of subjects to search the related literature
3. Student will be able to analyze the available resources and to select most appropriate one
4. Students will be able to apply a multidisciplinary strategy to address current, real-world issues.

Course Content: Seminar-I

Sr.no.	Description	Hrs.
1	The student gathers and presents information/data about seminar topic allotted to him/her. The report and presentation shall include review of literature, case studies if applicable, and findings about recent trends in the area of seminar topic. On completion of the work the student shall prepare a report and will give a Seminar on the report.	**48**

Course Content (Mini Project I):

Sr.no.	Description	Hrs.
1	The mini project work extends for a single semester and exposes the student to develop and present his/her work related to specific topic. Student shall select the project topic in consultation with mentor/guide/supervisor to his/her area of specialization and work on it. Student will prepare a report outlining objective of the project work, importance of the study, review of literature published in the relevant field and possible areas for further work. The student shall present seminar on this report.	**48**

Guidelines for Seminar/Mini Project

1. Seminar/mini project should be based on thrust areas in Mechanical Engineering (Machine Design aspect is appreciated)
2. Students should do literature survey and identify the topic of seminar/mini project and finalize in Consultation with Guide/Supervisor.
3. Students should use multiple literature and understand the topic and compile the report in standard format as in front of Examiners.

Assessment Guidelines:

1. Quality of Literature survey and Novelty in the topic
2. Relevance to the specialization
3. Understanding of the topic
4. Quality of Written and Oral Presentation

MTMD201 Fracture Mechanics
Course Pre-requisites: MTMD101

Course Objectives:
1. To expand student's knowledge in the area of linear-elastic fracture mechanics and the stress analysis of cracked bodies with a focus on metallic structurs.
2. To develop student's ability to compute crack-tip stress-intensity factors for two and three-dimensional cracked bodies of LEFM.
3. To develop student understands of the relationship between the energetic approach and the stress analysis of cracked bodies.

Course Outcomes:
Upon successful completion of the course, students should be able to
1. Analyze nature of stresses around a cracked body by applying principles of linear elastic fracture mechanics and compute stress intensity factors.
2. Interpret the result of a fracture mechanics analysis for metallic structures and relate the same to ASME/API.
3. Explain experimental methods for KIc/J- testing using various types of test specimens.
4. Evaluate the fracture related failures.

Course content:

Sr. No.	Description	Hrs.
1	Introduction- background, Kinds of failure, modes of failure, brittle and ductile fracture.	**4**
2	Energy Consideration- Introduction, Griffith analysis, energy release rate.	**8**
3	Stress in cracked bodies- Stress intensity factor, determination of SIF, CTOD.	**8**
4	J integral- Definition, scope, path independence.	**8**
5	Test methods- introduction, KIc test technique, J testing, various test specimens.	**4**
6	Fatigue- introduction, terminology, S-N curve, fractures due to fatigue, Paris law for design of components.	**6**
7	Fracture mechanics design process, Numericals, Practical Case studies.	**4**

Recommended Books:
1. Kumar, Prashant, and Kumar Prashant. *Elements of fracture mechanics*. Tata McGraw-Hill Education, 2009.
2. Anderson, Ted L. *Fracture mechanics: fundamentals and applications*. CRC press, 2005.
3. Maiti, S. K. *Fracture Mechanics: Fundamentals and Applications.* Cambridge University Press, 2015.
4. Kanninen, Melvin F., and Carl L. Popelar. "Advanced fracture mechanics." (1985).
5. Barson, J. M., and Stanley T. Rolfe. "Fracture and Fatigue Control in Structures: applications of fracture mechanics." *American Society for Testing and Materials, West Conshohocken, PA* (1999): 194.

6. Gdoutos, Emmanuel. *Fracture mechanics criteria and applications*. Vol. 10. Springer Science & Business Media, 2012.
7. KRY Simha
8. Handbook by Tada,Sih&Paris
9. Use of visual videos for the course.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD202 Advanced Finite Element Methods
Course Pre-requisites: BTM703

Course Objectives:
1. To provide the student with some knowledge and analysis skills in applying basic laws in mechanics
2. Integration by parts to develop element equation for a spring element
3. Steps used in solving the problem by finite element method.

Course Outcome:
Upon successful completion of the course, students should be able to
1. Formulate simple types of finite elements and apply appropriate boundary conditions.
2. Apply finite element method for obtaining solutions to problems in solid mechanics, Static, transient bukling analysis to be conducted.
3. Discuss variational and Galerkin method for Stiffness Matrix formulation.
4. Assess stresses and strains in complex mechanical systems and interpret structural behavior of components by analyzing post processor result.

Course content:

M. No.	Description	Hrs.
1	Solution of Boundary Value problems: Variational Method, Gelerkin's Method, Least square a Methods, Introduction to meshless FEM and BEM be included in the discussion,FEA and Linking mechanical design with FEA	**6**
2	One dimensional linear element: Division of region into elements The Linear Element, weight Residual integral Evaluation of the Integral.	**6**
3	Element Matrices: Direct stiffness Method, Properties of global stiffness Matrix, Analysis of simply supported beam	**6**
4	Two Dimensional Elements: Linear Triangular Elements, Rectangular Elements, Two Dimensional Field equations: Coordinate Systems, Isoparametric elements and numerical integration, Integral equations for the element Matrices, Heat transfer by conduction: One dimensional fins, two dimensional fins, and Long and convection Two Dimensional bodies.	**6**
5	FE Applications in Solid Mechanics: The axial force members, potential energy formulations. The Truss Element, Beam element, plane frame element, Modelling of bolts for assembly, 3D problems	**6**
6	Two dimensional Elasticity : The displacement functions, Element matrices, Element Shape Functions: Evaluating shape functions	**6**
7	FEM Computations Solution Methods FEM Modeling and Preprocessing FEM Hardware and Post processing Survey of some FE Software Systems	**6**

Recommended Books:
1. Reddy, Junuthula Narasimha. *An introduction to the finite element method*. Vol. 2, no. 2.2. New York: McGraw-Hill, 1993.
2. Rajasekaran, Sanguthevar. *Finite element analysis in engineering design*. S. Chand, 2008.

3. Chandrupatla, Tirupathi R., Ashok D. Belegundu, T. Ramesh, and Chaitali Ray. *Introduction to finite elements in engineering*. Vol. 2. Upper Saddle River, NJ: Prentice Hall, 2002.
4. Desai, Chandrakant S., and John Fredrick Abel. *Introduction to the finite element method; a numerical method for engineering analysis*. Van Nostrand Reinhold, 1971.
5. Zienkiewicz, Olek C., and Robert L. Taylor. *The finite element method for solid and structural mechanics*. Butterworth-heinemann, 2005.
6. Segerlind, Larry J., and H. Saunders. "Applied finite element analysis." (1987): 329-330.
7. BEM by Amin, Narosa publishing house.
8. R.D Cook,PleshMalkus

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD203 Analysis and Synthesis of Mechanisms
Course Pre-requisites: BTM402, BTM502

Course Objectives:

1. To Learn the graphical and analytical techniques commonly used in the synthesis of mechanisms.
2. To Orient applications of analytical techniques by means of computer programs.
3. To simplify the mechanism for analysis purposes.

Course Outcomes:

At the end of the course the students shall be able to

1. Apply the graphical and analytical techniques commonly used in the synthesis of mechanisms.
2. Formulate and solve problems of analysis and synthesis of mechanisms using modern IT tools.
3. Explain and discuss the theory and methodologies employed for design of mechanisms.
4. Synthesize mechanisms with 3 and 4 accuracy points.

Course content:

M. No.	Description	Hrs.
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	**6**
2	**Type Synthesis, Number Synthesis, Dimensional Synthesis** Type synthesis, Number synthesis, Dimensional synthesis, Accuracy points, Spacing of of accuracy points, Chebyshev polynomials.	**6**
3	**Four Bar Coupler Point Curve:** Four bar linkage, coupler curve equation, double points and symmetry, Roberts-Chebyshev theorem	**6**
4	**The Euler Savary Equation and Cubic of Stationary Curvature:** The Euler Savary equation and the Inflection circle, The cubic of stationary curvature.	**6**
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.	**6**
6	Linkage Synthesis with Four Accuracy Points (Geometric Methods): Concept of opposite pole quadrilateral, Center point curve, Circle point curve, Application in position generation problems.	**6**
7	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	**6**

Text Books:

1. Mallik, Asok Kumar, AmitabhaGhosh, and Gunter Dittrich. *Kinematic analysis and synthesis of mechanisms*. CRC Press, 1994.

Reference Books:

1. Beyer, Rudolf. "The kinematic synthesis of mechanisms." (1963).
2. Tao, Deh Chang. *Applied linkage synthesis*. Addison-Wesley Pub. Co., 1964.
3. Hartenberg, Richard Scheunemann, and Jacques Denavit. *Kinematic synthesis of linkages*. McGraw-Hill, 1964.
4. Tesar, Delbert. *Graphical Procedures for Kinematic Synthesis of Mechanisms*. University of Florida, 1975.

Term work:

Assignment containing numerical problem based on above topics and seminars

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD211 Elective-III- Process Equipment Design
Course Pre-requisites: BTM502, BTM801

Course Objectives:
The objective of this course is to:

- Learn reading of essential design documents such as P&ID and vessel data sheets.
- Prepare student to obtain sizes of important process equipment components subjected to different types of loading.
- Make students to handle stress/thermal analysis of pressure components using advanced methods such as finite element method.

Course Outcomes:
Upon successful completion of the course, students should be able to

1. Explain and interpret essential design documents such as PFD, P&ID, vessel specification
2. Calculate size of various process equipment components using design rules as well as IT tools.
3. Design vessels, heat exchangers and allied auxiliary components.
4. Discuss loadings, failure modes for process equipment design.

Course content:

M. No.	Description	Duration (Hrs)
1	Role of process equipment engineer in Chemical industry, organization and working of EPC company, Interpretation of process diagrams such as P&ID, equipment layout drawing. Classification of vessels such as tank, flat, bottomed and vertical cylinder tank, vertical cylindrical and horizontal vessels with formed ends as well as spherical or modified spherical vessels. Classification of materials for pressure vessels, Introduction to various process equipments, codes and standards, applications of first principle using ASME codes	8
2	Criteria in vessel design. Elastic bending, plastic instability, cyclic loading stress reversals. Brittle rupture and creep rupture, Membrane theory.	6
3	Design of pressure components such as shell, head, cone for internal pressure loading. Design of cylindrical shells against external pressure; design of stiffener rings, Stress catogarization, Manufacturing aspects PWHT, weld consideration design	6
4	Advanced design topics such as nozzle reinforcement calculation, bolted flange design, selection of gaskets. Elementary stress analysis of pressure parts using finite element methods, Fitness for service assessment	6
5	Design of supports for tall vertical vessels; skirt support subjected to wind and seismic loads, design of saddle supports for horizontal vessels.	6
6	Design of storage tanks, Design of jacketed vessels.	6
7	Elementary heat exchanger design.Tubesheet thickness calculations, baffle plate design	4

Recommended Books:

1. Brownell, Lloyd E., and Edwin H. Young. *Process equipment design: vessel design*. John Wiley & Sons, 1959.
2. Harvey, John F., and H. Saunders. "Theory and design of pressure vessels." (1987)
3. Mahajan, Kanti K. "Design of process equipment: selected topics." (1985).
4. Couper, James R., W. Roy Penney, and James R. Fair. *Chemical process equipment revised 2E: selection and design*. Gulf Professional Publishing, 2009.
5. IS codes and ASME section
6. Heat Exchanger by singh and soler.

Term work:
Assignment based on above topics and seminars, Group projects and mini projects on complete vessel, Group design activities, plant visits

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD212 Elective III- Design of Power Transmission Systems
Course Pre-requisites: BTM801

Course Objectives:

1. After learning this Course the student will understand the Detail Design Procedure of the Transmission Systems – Mechanical, Hydraulic, Pneumatic general description and comparison
2. The student will learn Components like couplings, belts, chains, gears, brakes, clutches, shafts, bearing, housing pumps, valves in detail and will be in position to design and select them suitably.
3. The student will also learn some Case studies of Design of Power Transmission System [mechanical and hydraulic systems] to reinforce their concepts.

Course Outcomes:

Upon successful completion of the course, students should be able to

1. Select and design various mechanical and hydraulic power transmission system.
2. Analyze vibration characteristics, wear and life of critical components of power transmission systems.
3. Calculate sizing of elements of transmission systems like couplings, belts, chains, gears, brakes, clutches, shafts, bearing, housing pumps, valves in detail.
4. Discuss case studies on power transmission system design.

Course content:

M. No.	Course Details	Hour
1.	Different types of prime movers, characteristics, limitation application and selection	**2**
2.	Transmission Systems – Mechanical, Hydraulic, Pneumatic general description and comparison Components like couplings, belts, chains, gears, etc used. Their limitations and use in specific applications. Typical example of mechanical and hydraulic systems.	**08**
3.	Components like brakes, clutches, shafts, bearing, housing pumps, valves etc used. Their limitations and use in specific applications. Typical example of mechanical and hydraulic systems.	**12**
4.	Analysis for applications (automobile m/c Tool, Process engineering) and data for design- Selection of components, Standard components use and selection.	**4**
5.	Synthesis above and get complete solution.	**4**
6.	Analysis of the solution further with respect to vibration, wear, life of critical components, reliability, assembly, maintenance and cost.	**4**
7.	Case studies on Power Transmission System Design	**8**

Term Work

- Assignments based on above modules
- Seminar based on recent advances in the subject
- At least one Case study conducted at industry

Reference

1. Vicker's Industrial Hydraulics Manual, Eaton Hydraulics Training, 5th Edition, 1999.
2. Rohner, Peter. *Industrial hydraulic control: a textbook for fluid power technicians*. Prentice Hall, 1987.
3. Pippenger, John J. Hicks, Tyler G. John J. Pippenger, and Tyler G. Hicks.*Industrial hydraulics*. 1979.
4. Fundamentals of Pneumatics – Festo didactic Gmbh & Co., 2000
5. Esposito, Anthony. *Fluid power with applications*. Prentice-Hall International, 2000.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD213 Elective-III- Micro-Electro Mechanical Systems
Course Pre-requisites: BTM405, BTM503

Course Objectives
1. To introduce basic concepts of MEMS and its applications.
2. To introduce sensors and actuators in Micro-domain.
3. To study modelling and simulation techniques for various applications.
4. Apply knowledge of micro fabrication techniques and applications to the design and manufacturing of an MEMS device or a micro system

Course Outcomes: Learner will be able to…
1. Select appropriate sensors and actuators for a given MEMS application.
2. Select a micro-fabrication technique for a specific MEMS fabrication process.
3. Model and simulate a given MEMS system
4. Design MEMS

Course content:

M. No.	Description	Hrs.
1	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	4
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	5
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.	5
4	**3D High Aspect Ratio Fabrication Techniques** • LIGA, • AMANDA, • Microstereolithography, • IH-Process, • X-Ray Techniques, • Ion-beam Lithography etc	6
5	**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	5

	• Modelling of Micro-channel as heat exchanger, accelerometers, microhinges, compound microstructures. • Linear & Nonlinear Model.	
6	**Characterization Techniques** Topography Methods (Optical, Electrical and Mechanical Methods) • Microscopy, STM (Scanning Tunneling Microscopes), • SEM (Scanning Electron Microscopes),SPM (Scanning ProbeMicroscopes), 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 PatternInterferometry), • Laser Techniques, Laser Doppler Vibro-metersFluid, Thermal and Chemical Analysis • Thermal Analysis Techniques (Theoretical and Experimental), • Fluid Flow Pattern Analysis, • Electro-chemical Analysis, PIV Techniques -spectroscopy	**5**
7	**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 • Social and Ethical Implications of nanotechnology in Society	**4**

Recommended Books:

1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim "Microsensors MEMS andSmart 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.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

Term work:

- Assignments based on each modules of syllabus

MTMD214 Elective-IV- Entrepreneurship Development and Management
Course Pre-requisites: BTM704

Course Objectives:
1. To acquaint with entrepreneurship and management of business
2. Understand Indian environment for entrepreneurship
3. Idea of EDP, MSME

Course Outcomes:
Learner will be able to…
1. Understand the concept of business plan and ownerships
2. Interpret key regulations and legal aspects of entrepreneurship in India
3. Understand government policies for entrepreneurs

Course content:

M. No.	Description	Duration (hrs)
1	**Overview Of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	4
2	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur.	5
3	**Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	5
4	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	5
5	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc.	6
6	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	6
7	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	5

Recommended Books/Websites:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson Education
2. Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr T. N. Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr C. N. Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. MaddhurimaLall, ShikahSahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Term work:

- Assignments based on above modules

Seminar based on recent advances in the subject

- At least one Case study on industry

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD215 Elective-IV: Product Lifecyle Management
Course Pre-requisites: BTM704

Course Objectives:
1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Course Outcomes:
Learner will be able to…
1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility Study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Course content:

M. No.	Description	Duration (hrs)
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	7
2	**Product Design:** 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	6
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	5
4	**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	5

5	**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	5
6	**Life Cycle Assessment and:** Properties, and Framework of LCA, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment.	04
7	**Life Cycle Cost Analysis** "Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	03

Recommended Books:

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. Saaksvuori Antti, 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

Term work: Assignments based on above modules

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD216 Elective-IV -Optimization Methods
Course Pre-requisites: BTM605, BT207

Course Objectives:

1. To introducetools and techniques for optimization to engineering applications
2. To understand the formulation of design equations for mechanical systems.
3. To understand algorithms and methods used for optimization for design of mechanical systems.
4. To design and select optimum configuration of mechanical components and systems.

Course Outcomes:

At the end of the course the students shall be able to

1. Explain different approaches to optimize mechanical systems.
2. Create programs based on different optimization algorithms using IT tools, such as Minitab, MATLAB, etc.
3. Calculate optimum solution to linear and non-linear problems.
4. Apply the numerical and optimization understanding for finalizing design of mechanical designs.

Course content:

M. No	Description	Hrs
1	Need for optimization and historical development classification and formulation of optimization problem, classical optimization methods, Calculas based methods, Enumerative schemes, Rendom search algorithms,	07
2	Evolutionary algorithms, Genetic algorithms, Evolutionary programming, Evalution Strategies, Classifier Systems.	07
3	Optimum design of mechanical elements: Purpose and applications of optimum design. Effects of manufacturing errors, characteristics of meachnical systems	07
4	Selection of optimum configuration, critical regions materials and dimensions,	05
5	Formulation of primary and subsidiary design equations, Limit equations, Normal redundant and incompatible specifications. General techniques.	05
6	Digital computers in optimum design. Exact and Interactive techniques	05
7	Optimal design of elements and systems, shafts gears, bearings, springs, high speed machinery, cams etc. Case studies.	06

Text Books:

1. Rao, Singiresu S., and S. S. Rao. *Engineering optimization: theory and practice*. John Wiley & Sons, 2009.
2. Deb, Kalyanmoy. *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.

Reference Books

3. Mital, K.V., 1996. *Optimization methods in operations research and systems analysis*. New Age International.
4. Taha, Hamdy A. *Operations Research: An Introduction (For VTU)*. Pearson Education India, 1982.
5. Bury, Karl. *Statistical distributions in engineering*. Cambridge University Press, 1999.
6. Fogel, David B. *Artificial intelligence through simulated evolution*. Wiley-IEEE Press, 2009.

Term work: Assignments containing numerical problems based on each module.
Seminar based on recent advances in subject.
At least one case study based on any one optimization method.

Sr. No.	Examination	Module
1.	**T-I**	1,2 and part of 3
2.	**T-II**	Remaining part of 3,4 and part of module 5
3.	**End Sem**	1 to 7

MTMD204 Laboratory-IV- Fracture Mechanics
Course Pre-requisites: MTMD101, MTMD104

Course Objectives:

1. To expand student's knowledge in the area of linear-elastic fracture mechanics and the stress analysis of cracked bodies with a focus on metallic structures using simulations.
2. To develop student's ability to compute crack-tip stress-intensity factors for two and three-dimensional cracked bodies of LEFM using simulation tools.
3. To develop student understands of the relationship between the energetic approach and the stress analysis of cracked bodies using simulation tools.

Course Outcomes:

Upon successful completion of the course, students should be able to

1. Analyze nature of stresses around a cracked body by applying principles of linear elastic fracture mechanics and compute stress intensity factors using simulation tools.
2. Interpret the result of a fracture mechanics analysis for metallic structures using simulation tools.
3. Study KIc/J- testing using various types of test specimens using simulation tools.
4. Evaluate the fracture related failures using simulation tools.

List of Experiments:

1. To Compute space intensity factor using FEM (Displacement Method).
2. To Compute space intensity factor using FEM (Stress Method).
3. Computation of J integral using numerical method.
4. Computation of CTOD for CT specimen using FEM.
5. Develop numerical code for crack growth rate under fatigue load.

Practical examination is to be conducted based on above experiments and oral.

MTMD205 Laboratory V- Advance Finite Element Methods
Course Pre-requisites: BTM703

Course Objectives:
1. To study the mathematical simulation software.
2. To study the finite element analysis software.
3. To apply Finite Element Analysis for real life mechanical component.

Course Outcomes:
Students will be able to…..
1. Analyze different mechanical components using mathematical simulation software.
2. Apply and analyze different mechanical components using FEA software.
3. Analyse complex real life mechanical component.
4. Synthesise different mechanical components using FEA software

Detailed Laboratory content
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 analysis.

2. 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.

Practical examination is to be conducted based on above experiments and oral.

MTMD299/MTMD289 Seminar-II/Mini Project-II
Course Pre-requisites: MTMD199 or MTMD189

Course Outcomes:

1. Student will be able to apply the skill of presentation and communication techniques
2. Student will be able to use the knowledge of the fundamentals of subjects to search the related literature
3. Student will be able to analyze the available resources and to select most appropriate one

Course content (Seminar-II):

Sr.no.	Description	Hrs.
1	The student gathers and presents information/data about seminar topic allotted to him/her. The report and presentation shall include review of literature, case studies if applicable and findings about recent trends in the area of seminar topic. On completion of the work the student shall prepare a report and will give a Seminar on the report.	**48**

Course Content (Mini Project II):

Sr.no.	Description	Hrs.
1	The mini project work extends for a single semester and exposes the student to develop and present his/her work related to specific topic. The work at this stage may involve review of literature, laboratory experimental work, case study, field data collection and analysis etc. On completion of the exhaustive literautre work the student shall prepare a report and will give a seminar on the report.	**48**

Guidelines for Seminar-II/Mini Project

1. Seminar/ mini project should be based on thrust areas in Mechanical Engineering (Machine Design aspect is appreciated)
2. Students should do literature survey and identify the topic of seminar/ mini project and finalize in Consultation with mentor/Guide/Supervisor.
3. Students should use multiple literature and understand the topic and compile the report in standard format as in front of Examiners.

Assessment Guidelines:

1. Quality of Literature survey and Novelty in the topic
2. Relevance to the specialization
3. Understanding of the topic
4. Quality of Written and Oral Presentation

MTMD396 Seminar on Literature Review
Course Pre-requisites: MTMD189/ MTMD 199/ MTMD 289/ MTMD 299

Course Outcomes:

1. Student will be able to apply principles of ethics and standards, skill of presentation and communication techniques
2. Student will be able to integrate the knowledge of the fundamentals of subjects to search the related literature and devise solution
3. Student will be able to use knowledge for formulation / fabrication of the desired project
4. Student will be able to analyze the available resources and to select most appropriate one

Course content:

Sr. No.	Description	Hrs.
1	The project work extends through the third and fourth semester. The project work is defined based on the interest of the students to specialize in a particular area. Students are expected to carry out independent research work on the chosen topic and submit a report for evaluation. The work at this stage may involve review of literature, laboratory experimental work, case study, field data collection and analysis etc. On completion of the exhaustive literautre work the student shall prepare a report and will give a seminar on the report.	**48**

MTMD397 Dissertation Stage-I Seminar
Course Pre-requisites: MTMD189/ MTMD 199/ MTMD 289/ MTMD 299

Course Outcomes:

1. Student will be able to apply principles of ethics and standards, skill of presentation and communication techniques
2. Student will be able to integrate the knowledge of the fundamentals of subjects to search the related literature and devise solution
3. Student will be able to use knowledge for formulation / fabrication of the desired project
4. Student will be able to analyze the available resources and to select most appropriate one

Course content:

Sr.no.	Description
1	Student shall finalize a theme, related to mechanical engineering (design engineering area) for the dissertation work. Student shall prepare a report on the theme outlining importance of the theme of the study, objective, scope of work, methodology, and a review of literature published in the relevant area. The student shall present seminars on this report.

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

1. Quality of Literature survey and Novelty in the problem
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization
4. Clarity of objective and scope

MTMD498 Dissertation Stage-II Seminar (Pre-Synopsis)
Course Pre-requisites: MTMD396/ MTMD397

Course Outcomes:

1. Student will be able to apply principles of ethics and standards, skill of presentation and communication techniques
2. Student will be able to integrate the knowledge of the fundamentals of subjects to search the related literature and devise solution
3. Student will be able to use knowledge for execution of the desired project and validation of the results obtained
4. Student will be able to analyze the experimental data/ findings

Course content:

Sr.no.	Description	Hrs.
1	Student shall study the problem of dissertation in the light of outcome of Stage I and Stage II seminars. On completion of data collection, analysis, and inferencing, the student shall prepare an interim report and shall present a seminar on the work done, before the submission of Synopsis.	**48**

Guidelines for Assessment of Dissertation II

Dissertation II should be assessed based on following points

1. Quality of Literature survey and Novelty in the problem
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization or current Research / Industrial trends
4. Clarity of objective and scope
5. Quality of work attempted
6. Validation of results
7. Quality of Written and Oral Presentation

MTMD499 Dissertation & Viva-Voce
Course Pre-requisites: MTMD498

Course Outcomes:

1. Student will be able to apply principles of ethics and standards, skill of presentation and communication techniques
2. Student will be able to integrate the knowledge of the fundamentals of subjects to search the related literature and devise solution
3. Student will be able to use knowledge for formulation / fabrication of the desired project
4. Student will be able to analyze the experimental data/ findings and disuss the merits and limitations of the project work

Course content:

Sr.no.	Description
1	Student shall study the problem of dissertation in the light of outcome of Stage I and Stage II. On finalization of the dissertation student shall submit the dissertation report. The student shall have to appear for a Viva-voce examination for the dissertation.