M.Tech. in Mechanical Engineering with

Machine DesignCourses

Course Contents

Academic Year 2022-23

Table of Contents

PC-MTMD101Advance Stress Analysis

Course Code	Course Name
PC-MTMD101	Advance Stress Analysis

Course pre-requisites	BTM302, BTM701

Course Objectives

The objectives of this course are

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

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

Module No.	*Details*	*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.	**6**
3	Stress -Strain Relations: Generalized Hooke's Law, Transformation of compatibility	**6**

	condition from strain components to stress components, Strain energy in an elastic body, St. Venant's principle, Uniqueness theorem.	
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.	**7**
5	Introduction to fracture mechanics,Ductile& brittle fracture,LEFM(Elementary),Modes of failure,Griffith's Analysis&Energy Release rate,SIF & its determination,Westergaard's approach(Mode I&II-only elementary treatment),Fracture toughness,J integral(Elementary),Crack growth studies,Paris law Torsion of Prismatic Bars: General solution of the torsion problem, Torsion of circular and elliptic cross sections.	10
6	Experimental stress Analysis: Introduction to Photo elasticity, Moir, Holography,Speckle Methods etc.	**5**
7	Strain Guage Technique: Strain measurement by resistance gauges, types of strain gauges, Equipment for indicating and recording strains transducer and its application.	**5**

Reference 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

PC-MTMD102Computer Aided Design

Course Code	Course Name
PC-MTMD102	Computer Aided Design

Course pre-requisites	BTM802, BT207

Course Objectives
The objectives of this course are 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, Surfaces and G-V lines. 6. To understand different Algorithms for optimization of drawing of basic entities
Course Outcomes
Upon successful completion of the course, students should be able 1. Describe the mathematical basis in the technique of representation of geometric entities including points, lines, and parametric curves, surfaces and solid, and the technique of transformation of geometric entities using transformation matrix 2. Describe key neutral specifications and standards for product data 3. Design parts in modern parametric CAD systems for manufacturing on a Rapid Prototyping machine. 4. Footprints of emerging breakthrough technologies created in the areas of CAD and be able to apply C++ skills in the domain of CAD

Course Content

Module No.	*Details*	*Hrs.*
1	**INTRODUCTION & ELEMENTS OF INTERACTIVE COMPUTER GRAPHICS** The design process, the role of modeling & communication, modeling using CAD, Product life cycle, Concurrent engineering in	**05**

	Product design & development, Collaborative Engineering, computers for design Process, CAD System Architecture.	
2	**TECHNIQUES FOR GEOMETRIC MODELING** Data translators like IGES methodology, DXF (Data Exchange Format), STEP, 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, generative family of parts.	**05**
3	**ALGORITHMS** Evaluation criteria of CAD/CAM software, Line, circle, ellipse algorithm and C or C++ programming for the same. Two dimensional computer graphics, vector generation, the windowing transformation, three dimensional Computer graphics, viewing transformation, Homogeneous coordinates, Visual realism, Hidden line removal & hidden surface removal algorithm, light & shade ray tracing, automation, scripting, animation, write function calling, use a library, continuity C^1, C^2, G^1,G^2	**08**
4	**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, rendering.	**07**
5	**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, Knowledge Enabled Engineering, Representation of Knowledge, and Knowledge base Engineering.	**06**
6	**EMERGING AREAS in CAD** Virtual Prototyping, Design for Assembly and Dis- Assembly, VR and PLM introduction, Reverse Engineering and Data Capture techniques like Contact Inspection methods and Scanning methods	**05**

7	**CAD for Machine Elements and Sub-Assemblies** • Introduction to Object Oriented Programming • Develop Concepts of Mechanical Engineering CAD • Develop Algorithm, Flow Charts and Software for at least 5 Mechanical Engineering Design problems like Design of Gears, Design of Knuckle and cotter Joints etc.	**06**

Reference 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.
9. ASIC/ Parasolid library.

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

PC-MTMD103 Design Laboratory-I

Course Code	Course Name
PC-MTMD103	Design Laboratory-I

Course pre-requisites	BTM 352, BTM701

Course Objectives

The objectives of this course are

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 behaviour of different materials in three dimensions and different factors affecting failures of materials.
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

Upon successful completion of the course, students should be able

1. Demonstrate knowledge about various types of loading and stresses induced in three Dimensions.
2. Apply the knowledge of strain gauges for measuring strain in practical applications.
3. Apply knowledge of CAD to generate and interpret engineering technical drawings of parts and assemblies according to engineering design standards.
4. Demonstrate skill of modeling and assembling of any mechanical system.

List of Experiments (any 8)

Sr. No.	*Details*	*Hrs.*
1	Experiments using strain gauges	**2**
2	Measurement of strain, temperature effects	**2**
3	Fixing of gauges on surfaces	**2**
4	Study of photoelastic bench for stress measurement	**2**
5	Study of polariscope and calibration of disc, beam and tension model	**2**

6	Application of strain gauge techniques: Lecture on strain gauge based methods, Cantilever beam and Portal frame	**2**
7	Study of semiconductor based strain gauges	**2**
8	Case study on thermal stress analysis using different simulation platforms	**2**
9	Case study on stress analysis due to structural loading using different simulation platforms	**2**
10	Case study on stress analysis due to dynamic loading using different simulation platforms	**2**
11	Executing basic algorithms for generation of line, circle, ellipse in any programming language	**2**
12	Executing transformations and projection both in 2D and 3D in any programming language	**2**
13	Generating curves using any programming language	**2**
14	Creation of 3D assembly model.	**2**

PC-MTMD104DesignLaboratory-II

Course Code	Course Name
PC-MTMD104	**Design Laboratory-II**

Course pre-requisites	BTM802

Course Objectives
The objectives of this course are 1. To study the mathematical simulation software for analysis of single and multi degree freedom problem. 2. Perform experimentation and processing the data and demonstration of condition based maintenance tool. 3. To learn the various Techniques used in design of experiments and reliability engineering 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 1. Apply and analyze different systems using mathematical simulation software. 2. Demonstrate acquiring and processing of data. 3. Compile data and write technical reports. 4. Use different software's and interprets results of analysis.

List of Experiments

Sr. No.	***Details***	***Hrs.***
1	Simulation study using mathematical simulation software (or any programming language) on a. Single DOF system b. Multi DOF system	**2**
2	Simulation study of the followings on any simulation platform a. Modal analysis b. Transient analysis c. Harmonic analysis d. Active vibration control	**2** **5**

3	Experimentation a. Acquiring time domain vibration data by using sensors (displacement / velocity / acceleration) b. Demonstration of condition based maintenance tool using vibration techniques	**2**
4	Case study each on DOE and reliability engineering.	**2**
5	Case study on any one rapid prototyping machine.	**2**
6	At least two (02) problems each on design of hydrostatic bearings, design of brakes and clutches.	**2**
7	At least one case studies on application of tribology in machine elements based on the above syllabus.	**2**

MC-MTMD105Research Methodology & IPR

Course Code	Course Name
MC-MTMD105	**Research Methodology & IPR**

Course pre-requisites	BTM898

Course Objectives
The objectives of this course are 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 develop an ability to investigate the phenomenon in a critical manner. 4. Develop critical thinking to find business opportunities and to solve questions related to industries. 5. To get knowledge on various kinds of research questions and research designs
Course Outcomes
Upon successful completion of the course, students should be able 1. To carry out literature survey methodically 2. To formulate the problem statement using research considerations. 3. To carry out data collection systematically and to carry out data analysis using various data analysis tools 4. To be able to investigate what can be patented

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction to Research Definition of Research, How to define the research problem Various considerations for defining research problem	**8**
2	Literature Survey Search Engines, Source of Literature, Identifying the appropriate period for Literature, Key words Primary key words, secondary key words, research Gaps	**4**

3	Data collection Techniques • Interviews techniques, Structured semi-structured, unstructured interviews • Sampling Techniques, simple random sampling, Sample Size Calculation, Sample Design Case study method	**6**
4	Data Analysis Hypothesis , Null and alternate hypothesis statements, Z test, F test, T Test, Chi square Test, Annova	**6**
5	Simulation techniques • Monte Carlo Simulation, Simulation exercises for Product Design , Service Design , System Design	**6**
6	Intellectual property right Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	**6**
7	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems.	**6**

Reference 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.
4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
5. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

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

PC-MTMD203System Modeling & Synthesis of Mechanisms

Course Code	Course Name
PC-MTMD203	System Modeling & Synthesis of Mechanisms

Course pre-requisites	BTM402, BTM502

Course Objectives
The objectives of this course are 1. To Understand what is a model, types of models, purpose of models 2. To Learn the graphical and analytical techniques commonly used in the synthesis of mechanisms. 3. To Orient applications of analytical techniques by means of computer programs. 4. To simplify the mechanism for analysis purposes.
Course Outcomes
Upon successful completion of the course, students should be able 1. Apply mathematically model for a given system and Mechanical Elements. 2. Apply the graphical and analytical techniques commonly used in the synthesis of mechanisms. 3. Formulate and solve problems of synthesis of mechanisms using modern IT tools and Synthesize mechanisms with 3 and 4 accuracy points. 4. Explain and discuss the theory and methodologies employed for design of mechanisms.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction to System and 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.	**6**
2	**Mathematical Modeling of Mechanical Elements** – inertia, stiffness and damper	**6**
3	**Basics of Mechanism:** Rigid body, Kinematic pairs, Lower and Higher pair connections,	**6**

	Kinematic Chain, Mechanism, Four Bar Mechanism, Slider Crank Mechanism, Equivalent mechanisms. **Type Synthesis, Number Synthesis, Dimensional Synthesis** Type, Number & Dimensional synthesis, Accuracy points, Spacing of accuracy points, Chebyshev polynomials.	
4	**Four Bar Coupler Point Curve:** Four bar linkage, coupler curve equation, double points and symmetry, Roberts-Chebyshev theorem	**6**
5	**The Euler Savary Equation and Cubic of Stationary Curvature:** The Euler Savary equation and the Inflection circle, The cubic of stationary curvature.	**6**
6	**Linkage Synthesis with Three Accuracy 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**
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 Complex Number Method	**6**

Reference Books

1. 1.Nicola Bellomoand Luigi Preziosi, “Modeling Mathematical Methods & Scientific Computations”, 1995, CRC Press.
2. Mallik, Asok Kumar, AmitabhaGhosh, and Gunter Dittrich. *Kinematic analysis and synthesis of mechanisms*. CRC Press, 1994.
3. Vu, Hung V., and Ramin S. Esfandiari. Dynamic systems: modeling and analysis. McGrawHill Science, Engineering & Mathematics, 1997.
4. Beyer, Rudolf. "The kinematic synthesis of mechanisms." (1963).
5. Tao, Deh Chang. *Applied linkage synthesis*. Addison-Wesley Pub. Co., 1964.
6. Hartenberg, Richard Scheunemann, and Jacques Denavit. *Kinematic synthesis of linkages*. McGraw-Hill, 1964.

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

PC-MTMD204Advanced Finite Element Methods

Course Code	Course Name
PC-MTMD204	Advanced Finite Element Methods

Course pre-requisites	BTM703

Course Objectives
The objectives of this course are 1. To provide the student with knowledge and analysis skills in applying basic laws in mechanics 2. Steps used in solving the problem by finite element method. 3. To expose students to some of the recent trends and research areas in finite elements.
Course Outcomes
Upon successful completion of the course, students should be able 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, steady and transient analysis to be conducted. 3. Assess stresses and strains in complex mechanical systems and interpret structural behavior of components by analyzing post processor result. 4. Practical applications related to solver theory.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction:** Element Matrices: Direct stiffness Method, Properties of global stiffness Matrix, Analysis of simply supported beam, One dimensional linear element: Division of region into elements The Linear Element, weight Residual integral Evaluation of the Integral. Variational approach, Glerkin's Methods. Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear, etc,	**6**

2	**FE procedures for 1D formulations:** FE formulation of 1D bar, 2D plane strain, plane stress, and axisymmetric elements; 3D linear elastic continuum, Iso-parametric mapping; numerical integration.	**6**
3	**FE procedures for 2D formulations:** Two Dimensional Elements: Linear Triangular Elements, Rectangular Elements, The displacement functions, Element Shape Functions: Evaluating shape functions Two Dimensional Field equations: Coordinate Systems, Integral equations for the element Matrices, Heat transfer by conduction: two dimensional fins, Long and convection Two Dimensional bodies. Eigen-value problems, Natural vibration of bars and beams.	**6**
4	**FE Applications in Solid Mechanics:** The axial force members, potential energy formulations. The Truss Element, Beam element, plane frame element,Review of tensor algebra; Yield surface, flow rule and hardening rules.	**6**
5	**FE procedures for 3D formulations:** FE formulation for 3D problems, Total Lagrangian and updated Lagrangian descriptions; Quadrilater elements, Tetrahedran element – Jacobian matrix – Stiffness matrix.	**6**
6	**FEA Solver Theory** Overview of using the flow solver, Pressure based solver, Density based solver, Matrix discretization, Multigrid method, Full Multigrid (FMG) Initialization.	**6**
7	**Advances in FEA:** FEM Computations Solution Methods FEM Modeling and Preprocessing FEM Hardware and Post processing Survey of some FE Software Systems, Dynamic system analysis.	**6**

Reference Books

1. Reddy, JunuthulaNarasimha. *An introduction to the finite element method*. Vol. 2, no. 2.2. New York: McGraw-Hill, 1993.
2. K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
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. Zienkiewicz, Olek C., and Robert L. Taylor. *The finite element method for solid and structural mechanics*. Butterworth-heinemann, 2005.
5. Segerlind, Larry J., and H. Saunders. "Applied finite element analysis." (1987): 329-330.
6. A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition

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

PC-MTMD205Design Laboratory-III

Course Code	Course Name
PC-MTMD205	**Design Laboratory-III**

Course pre-requisites	MTMD101, MTMD104

Course Objectives

The objectives of this course are

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 understands of the relationship between the energetic approach and the stress analysis of cracked bodies using simulation tools.
3. To study the finite element analysis software.
4. To apply Finite Element Analysis for real life mechanical component.

Course Outcomes

Upon successful completion of the course, students should be able

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. Analyze different mechanical components using mathematical simulation software.
4. Apply and analyze different mechanical components using FEA software.

List of Experiments

Sr. No.	***Details***	***Hrs.***
1	To Compute space intensity factor using FEM (Displacement Method).	**2**
2	To Compute space intensity factor using FEM (Stress Method).	**2**
3	Computation of J integral using numerical method.	**2**
4	Computation of CTOD for CT specimen using FEM.	**2**
5	Develop numerical code for crack growth rate under fatigue load.	

6	Finite element analysis (FEA) of minimum 03 mechanical components using mathematical simulation software (or any programming language) which must include structural, thermal and coupled structural-thermal analysis.	**2**
7	Finite Element Analysis of a real life mechanical component subjected to both structural and thermal loading, using	**2**

PC-MTMD206 Design Laboratory-IV

Course Code	Course Name
PC-MTMD206	**Design Laboratory-IV**

Course pre-requisites	BTM703

Course Objectives
The objectives of this course are 1. To introduce the concepts of analysis and synthesis of mechanisms. 2. To develop a broad and basic comprehension of different methods of analysis for the determination of motion characteristics of linkage mechanisms. 3. To learn some Case studies of Design of Power Transmission System [mechanical and hydraulic systems] to reinforce their concepts. 4. Learn efficient computational procedures to solve optimization problems.
Course Outcomes
Upon successful completion of the course, students should be able 1. Develop graphical and analytical synthesis techniques and careful problem formulation and solution skills. 2. Develop an ability to solve mechanism problems that may involve selection, specification, design and sizing of mechanisms to accomplish a given task. 3. Analyze vibration characteristics, wear and life of critical components of power transmission systems. 4. Use MATLAB and implement optimization algorithms.
List of Experiments

Sr. No.	***Details***	***Hrs.***
1	Linkage design and experimental verification.	**2**
2	Assembly of mechanisms from links and joints, study of mobility.	**2**
3	Design and selection of linkage mechanisms for specific applications.	**2**
4	Analysis of an existing mechanism/machine or synthesis of a new mechanism to perform a prescribed task.	**2**
5	Calculate sizing of elements of transmission systems like couplings, belts, chains, gears, brakes, clutches, shafts, bearing,	**2**
6	Case studies on Power Transmission System Design.	**2**
7	Implementation of KKT theorem in MATLAB	**2**

PC-MTMD299 Seminar/Mini Project

Course Code	Course Name
PC-MTMD299	Seminar/Mini Project

Course pre-requisites	MTMD105

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.

Sr. No.	Course content (Seminar):	*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):	
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 literature 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 literatures 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	

Program Elective EC-MDPE01: Machine Dynamics and Advance Vibration

Course Code	Course Name
EC-MDPE01	**Program Elective: Machine Dynamics and Advance Vibration**

Course pre-requisites	BTM502

Course Objectives		
The objectives of this course are 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 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		
Module No.	***Details***	***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 Energy, Impulse and Momentum.	**6**
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.	**6**
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	**8**

	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.	
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.	**6**
5	Practical application of vibration-Vibration isolation, Vibration absorber, Tuned and damped absorber, Introductory concept of rotor dynamics, Jeffcott rotor model.	**6**
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.	**5**
7	Brief introduction to experimental modal analysis-Signal generation, measuring and conditioning instruments, signal analysis instruments, Vibration signatures and standards, Virtual Lab experiments.	**5**

Reference 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 (7th 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

Program Elective EC-MDPE02: Additive Manufacturing

Course Code	Course Name
EC-MDPE02	**Program Elective: Additive Manufacturing**

Course pre-requisites	BTM405

Course Objectives
The objectives of this course are 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 different working materials and systems used in rapid prototyping techniques 4. To study layering techniques in rapid prototyping systems
Course Outcomes
Upon successful completion of the course, students should be able 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

Module No.	*Details*	*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	6
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,	6

	CATIA, IDEAs etc.) • Slicing and Scan Path Generation Algorithms • Data Conversion and Transmission • File Formats, IGES, STL • Preprocessing and Post-processing	
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	6
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	6
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.	6

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	6

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", KluwerAcademic 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, SpringerInc.
5. BopayaBidanda, Paulo J. Bartolo, "Virtual Prototyping and Bio Manufacturing in MedicalApplications", 2008, Springer Inc.
6. I. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies RapidPrototyping 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

Program Elective EC-MDPE03: Design for Manufacturing and Assembly

Course Code	Course Name
EC-MDPE03	**Program Elective: Design for Manufacturing and Assembly**

Course pre-requisites	BTM801, BTM802, BTM898

Course Objectives
The objectives of this course are 1. To study the fundamentals of product development cycle. 2. To study manufacturing issues that must be considered in the mechanical engineering design process. 3. To study principles of assembly to minimize the assembly time 4. To study manufacturing process and assembly operations on the cost of product.
Course Outcomes
Upon successful completion of the course, students should be able 1. Understand the product development cycle 2. Know the manufacturing issues that must be considered in the mechanical engineering design process 3. Know the principles of assembly to minimize the assembly time 4. Know the effect of manufacturing process and assembly operations on the cost of product.

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design, Selection of Materials and Shapes.	**6**
2	Properties of Engineering Materials, Selection of Materials – I, Selection of Materials – II, Case Studies – I, Selection of Shapes, Co-selection of Materials and Shapes, Case Studies – II,	**6**
3	Selection ofManufacturing Processes, Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes, Design for Machining, Design for Powder Metallurgy,Design for Polymer	**8**

	Processing, Co-selection of Materials and Processes, Case-Studies – III	
4	Design for Assembly, Review of Assembly Processes, Design for Welding – I, Design for Welding – II, Design for Brazing and Soldering,	**6**
5	Design for Adhesive Bonding, Design for Joining of Polymers, Design for Heat Treatment, Case-Studies - IV	**6**
6	Design for Reliability, Failure Mode and Effect Analysis and Quality, Design for Quality,	**5**
7	Design for Reliability, Approach to Robust Design, Design for Optimization	**5**

Reference Books

1. M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 03.
2. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 00.
3. M F Ashby, Material Selection in Mechanical Design, Butterworth-Heinemann, 1999.
4. T H Courtney, Mechanical Behaviour of Materials, McGraw Hill, NY, 00.
5. K G Swift and J D Booker, Process selection: from design to manufacture, London: Arnold,1997.
6. S S Rao, Engineering Optimization: theory and practice, John Wiley, NY, 1996.
7. G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.
8. J G Bralla, Handbook for Product Design for Manufacture, McGraw Hill, NY, 1998.
9. Houldcroft, Which Process – an introduction to welding and related processes and guide to their selection, Cambridge, Abington Pub., 1990.
10. ASTM Design handbook.

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

Program Elective EC-MDPE04: Tribology in Design

Course Code	Course Name
EC-MDPE04	**Program Elective: Tribology in Design**

Course pre-requisites	BTM701, BTM 801

Course Objectives
The objectives of this course are 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 1. Apply the principles of lubrication, lubrication regimes, and theories of hydrodynamic, elasto-hydrodynamic and mixed / boundary lubrication. 2. Explain essentials of tribo-testing and experimental techniques in Tribology. 3. Discuss and formulate tribological modelling and simulation. 4. Design of mechanical components from the aspect of friction, wear and lubrication

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction: Overview of Tribology, Lubricants selection for general application and special application such as low temperatures, 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, Fault diagonosis in bearings and its solutions.	**6**
6	Antifriction bearing: Rolling Contact Bearings, Bearing types and selection 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**

Reference Books

1. Hirani, Harish. Fundamentals of Engineering Tribology with applications.Cambridge University Press, 2016.
2. Szeri, Andras Z. *Fluid film lubrication: theory and design*. Cambridge University Press, 2005.
3. ABHATIA, J. "Advance in Industrial Tribology." (1998)
4. Chattopadhyay, Ramnarayan. *Surface wear: analysis, treatment, and prevention*. ASM international, 2001.
5. Mang, Theo, Kirsten Bobzin, and Thorsten Bartels. *Industrial tribology: tribosystems, friction, wear and surface engineering, lubrication*. John Wiley & Sons, 2011.
6. 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

Program ElectiveEC-MDPE05: Reliability Engineering and Design of Experiments

Course Code	Course Name
EC-MDPE05	**Program Elective: Reliability Engineering and Design of Experiments**

Course pre-requisites	BTM605, BTM 704

Course Objectives

The objectives of this course are

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

Upon successful completion of the course, students should be able

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.	***Details***	***Hrs.***
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, Null and alternate hypothesis statements, Z test, F test, T Test, Chi square Test, 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.Design for X, Design for Reliability, FMEA	6

Reference Books
1. Jiju Antony, Design of Experiments for engineers and scientists, 2003. 2. Patrick, D. O. *Practical reliability engineering*. John Wiley, 1985. 3. Doebelin, Ernest O. *Engineering experimentation: planning, execution, reporting*.McGraw Hill College, 1995. 4. Pieruschka, Erich. *Principles of reliability*. Prentice-Hall, 1963. 5. Madhav S. Phadke, Quality Engineering using Robust Design, 1989. 6. 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

Program Elective EC-MDPE06: System Modeling and Analysis

Course Code	Course Name
EC-MDPE06	**Program Elective: System Modeling and Analysis**

Course pre-requisites	BTM502, BTM 503

Course Objectives

The objectives of this course are

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

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

Module No.	***Details***	***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**

Reference 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.

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

Program ElectiveEC-MDPE07: Process Equipment Design

Course Code	Course Name
EC-MDPE07	**Program Elective: Process Equipment Design**

Course pre-requisites	BTM502, BTM 801

Course Objectives
The objectives of this course are 1. Learn reading of essential design documents such as P&ID and vessel data sheets. 2. Prepare student to obtain sizes of important process equipment components subjected to different types of loading. 3. 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 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

Module No.	***Details***	***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 equipment's, 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	**6**

	internal pressure loading. Design of cylindrical shells against external pressure; design of stiffener rings, Stress categorization, Manufacturing aspects PWHT, weld consideration design	
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**

Reference 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.

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

Program ElectiveEC-MDPE08: Micro-Electro Mechanical Systems

Course Code	Course Name
EC-MDPE08	**Program Elective: Micro-Electro Mechanical Systems**

Course pre-requisites	BTM405, BTM 503

Course Objectives

The objectives of this course are

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

Upon successful completion of the course, students should be able

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

Module No.	***Details***	***Hrs.***
1	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	**6**
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	**6**

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.	**4**
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 • Modelling of Micro-channel as heat exchanger, accelerometers, microhinges, compound microstructures. • Linear & Nonlinear Model.	**6**
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 andpiezo electric) • Interferometry Techniques,	**8**

	• SPI (Speckle Pattern Interferometry), ESPI (Electronic Speckle PatternInterferometry), • Laser Techniques, Laser Doppler Vibro-metersFluid, Thermal and ChemicalAnalysis • Thermal Analysis Techniques (Theoretical and Experimental), • Fluid Flow Pattern Analysis, • Electro-chemical Analysis, PIV Techniques –spectroscopy	
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	**6**

Reference Books
1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim "Microsensors MEMSandSmart devices", John Wiley and sons, Ltd. 2. NadimMulaf and Kirt Williams, "An Introduction to Microelectromechanical systemsEngineering", 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 - 1Technology", 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

Program ElectiveEC-MDPE09: Entrepreneurship Development and Management

Course Code	Course Name
EC-MDPE09	**Program Elective: Entrepreneurship Development and Management**

Course pre-requisites	BTM704

Course Objectives
The objectives of this course are 1. To acquaint with entrepreneurship and management of business 2. Understand Indian environment for entrepreneurship 3. Idea of EDP, MSME
Course Outcomes
Upon successful completion of the course, students should be able 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 4. Understand business operations of small and medium scale enterprises

Course Content

Module No.	***Details***	***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	7
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	6
4	Women's Entrepreneurship Development, Social entrepreneurship-	**6**

	role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	
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	**6**

Reference Books

1. PoornimaCharantimath, 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. LaghuUdyogSamachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.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

Program ElectiveEC-MDPE10: Design of Power Transmission Systems

Course Code	Course Name
EC-MDPE10	**Program Elective: Design of Power Transmission Systems**

Course pre-requisites	BTM801

Course Objectives

The objectives of this course are

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

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

Module No.	***Details***	***Hrs.***
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.	**8**
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**

Reference Books

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.
6. Bhandari, V.B, *Design of Machine Elements*, Tata McGraw Hill Education Pvt Ltd.
7. Shigley, J.E and C R Mischke, *Mechanical engineering Design*, McGraw Hill Inc.
8. Spotts, M F and T E Shoup, *Design of Machine Elements*, Prentice Hall Inc.
9. Spotts, M F, *Mechanical Design Analysis*, Prentice Hall Inc.
10. John J .Pippenger and Dudley A. Peace, *Basic Fluid Power*, Prentice Hall Inc.
11. Fundamentals of Pneumatics, *Electro-Pneumatics and Electro-Hydraulics*, FESTO Didactic, 2000
12. Michael J. Pinches and John G. Ashby, *Power Hydraulics*, Prentice Hall 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

Program ElectiveEC-MDPE11: Optimization Techniques in Design

Course Code	Course Name
EC-MDPE11	**Program Elective: Optimization Techniques in Design**

Course pre-requisites	BTM605, BT207

Course Objectives

The objectives of this course are

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

Upon successful completion of the course, students should be able

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

Module No.	*Details*	*Hrs.*
1	Need for optimization and historical development classification and formulation of optimization problem, classical optimization methods, Calculus based methods, Enumerative schemes, Rendom search algorithms,	**7**
2	Evolutionary algorithms, Genetic algorithms, Evolutionary programming, Evaluation Strategies, Classifier Systems.Monte Carlo Simulation.	**7**
3	Optimum design of mechanical elements: Purpose and applications of optimum design. Effects of manufacturing errors, characteristics of mechanical systems	**7**
4	Selection of optimum configuration, critical regions materials and dimensions,	**5**
5	Formulation of primary and subsidiary design equations, Limit equations, Normal redundant and incompatible specifications.	**5**

	General techniques.	
6	Digital computers in optimum design. Exact and Interactive techniques	**5**
7	Optimal design of elements and systems, shafts gears, bearings, springs, high speed machinery, cams etc. Case studies.	**6**

Reference 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.
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.

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

ProgramElective EC-MDPE12: Advanced Engineering Materials

Course Code	Course Name
EC-MDPE12	**Program Elective: Advanced Engineering Materials**

Course pre-requisites	BTM304

Course Objectives
The objectives of this course are 1. To introducemechanics, physical and chemical properties of materialsIncluding metals, ceramics, polymers and composites. 2. To study phase diagrams and their use in predicting phasetransformation and microstructure 3. To study various types of failures using concept of fracture mechanics, creepand effect of impact **1.** To introduce nano materials, functional materials and their characterization.
Course Outcomes
Upon successful completion of the course, students should be able 4. Demonstrate an understanding of mechanics, physical and chemical properties of materials Including metals, ceramics, polymers and composites 5. Understand existence of imperfections and their effects on mechanical properties of materials and cause of failure 6. Demonstrate understanding of phase diagrams and their use in predicting phase transformation and microstructure 7. Understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact 8. Know Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composites 9. Understand the economic considerations in usage and recycling of materials in human use

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction, Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids: Historical perspective of Materials Science. Classification of materials. Advanced Materials, Future materials, Modern materials, Nano-materials, and materials for additive manufacturing.Atomicstructure. Atomic bonding in solids, Crystal structures, Crystalline and non-crystalline materials. Miller indices. Anisotropic elasticity.	**5**

2	Imperfections in Solids and Mechanical Properties of Metals, Diffusion, Dislocations and Strengthening Mechanisms: Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations; Elastic deformation. Plastic deformation. Yielding under multi-axial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors, Diffusion mechanisms. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion. Characterization of materials .	**5**
3	Phase Diagrams Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system.	**5**
4	Failure: Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behaviour. Stress and temperature effects	**5**
5	Applications and Processing of Metals and Alloys, Polymers, Ceramics, and composites: Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Fabrication and processing of ceramics, Mechanicalbehaviour of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing, Particle reinforced composites. Fibre reinforced composites. Structural composites, Failure nature of composites.	**5**
6	Electrical, Thermal, Optical and Magnetic Properties and economic Considerations:	**5**

	Electrical conduction. Semi conductivity. Super conductivity. Electrical conduction in ionic ceramics and in polymers. Dielectric behaviour. Ferro-electricity. Piezoelectricity Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses Diamagnetism and Para magnetism. Ferromagnetism.Anti-ferromagnetism and ferrimagnetism. Influence of temperature on magnetic behaviour. Domains and Hysteresis, Basic concepts. Optical properties of metals. Optical properties of non-metals. Application of optical phenomena.	
7	Economic, Environmental and Social Issues of Material Usage - Economic considerations. Environmental and societal considerations. Recycling issues. Life cycle analysis and its use in design. Functional materials and applications of various engineering materials.	**6**

Reference Books
1. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons, 07. 2. Modern Physical Metallurgy and Material Engineering, Science, Process, application, Smallman R.E., Bishop R J, Butterworth Heinemann, Sixth Ed., 1999. 3. "Essentials of Materials For Science And Engineering" by Donald R Askeland, Cengage; 2 edition (2013) 4. "Physical Metallurgy, Principles and Practices" by V Raghavan.Prentice Hall India Learning Private Limited; 2 edition (2006) 5. Mechanical Metallurgy by George E.Dieter, McGraw Hill Publications

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

Program Elective EC-MDPE13: Mechanics of Composite Materials

Course Code	Course Name
EC-MDPE13	**Mechanics of Composite Materials**

Course pre-requisites	BTM898

Course Objectives
1. To understand basic concepts and difference between composite materials with conventional materials. 2. To understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level. 3. To understand finding failure envelopes and stress-strain plots of laminates. 4. To develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.
Course Outcomes
Upon successful completion of the course the student should be able to: 1. Student will be able to understand the basic concepts and difference between composite materials with conventional materials. 2. Students will be able to understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level. 3. Students will be able to apply knowledge for finding failure envelopes and stress-strain plots of laminates. 4. Students will be able to develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction** Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus	5
2	**Basic Concepts and Characteristics** Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials.	5
3	**Elastic Behavior of Unidirectional Lamina** Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters	5
4	**Strength of Unidirectional Lamina** Micromechanics of failure; failure mechanisms, Macro-mechanical	5

	strength parameters, Macromechanical failure theories, Applicability of various failure theories	
5	**Elastic Behaviour of Laminate** Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates.	5
6	**Stress and Failure Analysis of Laminates** Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates	5
7	**Micromechanics** of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials	6

Reference Books
1. Isaac M. Daniels, Ori Ishai, "Engineering Mechaincs of Composite Materials", OxfordUniversity Press, 1994. 2. Bhagwan D. Agarwal, Lawrence J. Broutman, "Analysis and Performance of fibercomposites", John Wiley and Sons, Inc. 1990. 3. Mathews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science",CRC Press, Boca Raton, 03. 4. MadhujitMukhopadhyay, "Mechanics of Composite Materials and Structures",University Press, 04. 5. Mazumdar S. K., "Composite Manufacturing – Materials, Product and ProcessingEngineering", CRC Press, Boca Raton, 02. 6. Robert M. Jones, "Mechanics of Composite Materials", Taylor and Francis, Inc., 1999.

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

Program Elective EC-MDPE14: Robotics

Course Code	Course Name
EC-MDPE14	Robotics

Course pre-requisites	BTM402

Course Outcomes
At the end of the course students will be able to 1. Understand basic terminologies and concepts associated with Robotics and Automation 2. Demonstrate comprehension of various Robotic sub-systems 3. Understand kinematics and dynamics to explain exact working pattern of robots 4. Aware of the associated recent updates in Robotics

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction:** Basic Concepts such as Definition, three laws, DOF, Misunderstood devices etc., Elements of Robotic Systems i.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, etc. Automation - Concept, Need,Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.	6
2	**Robot Grippers:** Types of Grippers, Design aspect for gripper, Force analysis for various basic gripper system. Sensors for Robots: - Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.	6
3	**Drives and control systems:** Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems,Control Systems -Types of Controllers, Introduction to closed loop control Control Technologies in Automation:- Industrial Control Systems, Process Industries Verses, Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Control System Components such as Sensors, Actuators and others.	6
4	**Kinematics:** Transformation matrices and their arithmetic, link and joint description, Denavit – Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics	6

	calibration, inverse kinematics, solvability, algebraic and geometrical methods. Velocities and static forces in manipulators: - Jacobians, singularities, static forces, Jacobian in force domain. Dynamics:- Introduction to Dynamics , Trajectory generations	
5	**Machine Vision System:** Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation. Robot Programming :- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Introduction to various types such as RAIL and VAL II etc, Features of type and development of languages for recent robot systems.	6
6	**Modeling and Simulation for manufacturing Plant Automation:** Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant,Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing,Fuzzy decision and control, robots and application of robots for automation.Artificial Intelligence:- Introduction to Artificial Intelligence, AI techniques, Need and application of AI.	6
7	**Other Topics in Robotics**: - Socio-Economic aspect of robotisation. Economical aspects forrobot design, Safety for robot and associated mass, New Trends & recent updates in robotics.	6

Text Books
1. John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2nd Edition, 04 2. Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming andApplications, McGraw – Hill International, 1986. 3. Shimon Y. Nof , Handbook of Industrial Robotics , John Wiley Co, 01. 4. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education. 5. Industrial Automation: W.P. David, John Wiley and Sons.
Reference Books
1. Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 02. 2. Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.

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

Program Elective EC-MDPE15: Advance Fracture Mechanics

Course Code	Course Name
EC-MDPE15	Advance 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

Module No.	*Details*	*Hrs.*
1	Introduction- background, Kinds of failure, modes of failure, brittle and ductile fracture.	4
2	Energy Consideration- Introduction, Griffith analysis, energy release rate.	6
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.	4
7	Fracture mechanics design process, Principles of fracture safe design &fracture control plans,Fail safe & safe life design,Damage tolerant design &leak before break criterion,Numericals, Practical Case studies,Fibre composites & their fracture mechanics	8

Reference 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. 10. Hull D. An Introduction to composite materials,Cambridge University Press,1981 11. Agarwal,B.D and Broutman,L.J. Analysis and performance of fibre composites,John Wiley,1980

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

Audit Course AU1: English for Research Paper Writing

Course Code	Course Name
AU1 AUDIT I	**English for Research Paper Writing**

Course pre-requisites	BTM406

Course Outcomes
Students will be able to: **1.** Understand that how to improve your writing skills and level of readability **2.** Learn about what to write in each section **3.** Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

Course Content

Module No.	***Details***	***Hrs.***
1	Planning and Preparation, Word Order, Breaking up longsentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	5
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	5
3	Review of the Literature, Methods, Results, Discussion,Conclusions, The Final Check.	5
4	Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	5
5	Skills are needed when writing the Methods, skills needed when writing the Results	5
6	Skills are needed when writing the Discussion,skills are needed when writing the Conclusions	5
7	Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	6

Reference Books

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht

Heidelberg London, 2011.		
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

Audit Course AU2:Constitution of India

Course Code	Course Name
AU2 AUDIT I	**Constitution of India**

Course pre-requisites	BT025

Course Objectives
Students will be able to: 1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective. 2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence ofnationhood in the early years of Indian nationalism. 3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution
Course Outcomes
Students will be able to: 1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics. 2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India. 3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution. 4. Discuss the passage of the Hindu Code Bill of 1956

Course Content

Module No.	***Details***	***Hrs.***
1	➢ History of Making of the Indian Constitution: HistoryDrafting Committee, (Composition & Working)	5
2	➢ Philosophy of the Indian Constitution: PreambleSalient Features	5
3	➢ Contours of Constitutional Rights & Duties: ➢ Fundamental Rights ➢ Right to Equality	5

	➢ Right to Freedom ➢ Right against Exploitation ➢ Right to Freedom of Religion ➢ Cultural and Educational Rights ➢ Right to Constitutional Remedies ➢ Directive Principles of State Policy ➢ Fundamental Duties.	
4	➢ Organs of Governance: Model Curriculum of Engineering & Technology PG Courses [Volume -II][194] ➢ Parliament ➢ Composition ➢ Qualifications and Disqualifications ➢ Powers and Functions ➢ Executive ➢ President ➢ Governor ➢ Council of Ministers ➢ Judiciary, Appointment and Transfer of Judges, Qualifications ➢ Powers and Functions	5
5	➢ Local Administration: ➢ District's Administration head: Role and Importance, ➢ Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. ➢ Pachayati raj: Introduction, PRI: ZilaPachayat.	5
6	➢ Elected officials and their roles, CEO ZilaPachayat: Position and role. ➢ Block level: Organizational Hierarchy (Different departments), ➢ Village level: Role of Elected and Appointed officials, ➢ Importance of grass root democracy	5
7	➢ Election Commission: ➢ Election Commission: Role and Functioning. ➢ Chief Election Commissioner and Election Commissioners. ➢ State Election Commission: Role and Functioning. ➢ Institute and Bodies for the welfare of SC/ST/OBC and women	6

Reference Books

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

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

Audit Course AU3:Disaster Management

Course Code	Course Name
AU3 -AUDIT II	Disaster Management

Course pre-requisites	BTM399, BTM499

Course Outcomes
1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and Humanitarian response. 2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. 3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. 4. Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction** Disaster: Definition, Factors And Significance; Difference BetweenHazard And Disaster; Natural And Manmade Disasters: Difference,Nature, Types And Magnitude.	5
2	**Repercussions Of Disasters And Hazards:** Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods,Droughts And Famines, Landslides And Avalanches, Man-made disaster:Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	5
3	**Disaster Prone Areas In India** Study of Seismic Zones; Areas Prone To Floods And Droughts,	5

	Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	
4	**Disaster Preparedness And Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.	5
5	**Risk Assessment** Disaster Risk: Concept And Elements, Disaster Risk Reduction, GlobalAnd National Disaster Risk Situation. Techniques Of Risk Assessment	5
6	**Global Co-Operation** In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.	5
7	**Disaster Mitigation** Meaning, Concept And Strategies Of Disaster Mitigation, EmergingTrends In Mitigation. Structural Mitigation And Non-StructuralMitigation, Programs Of Disaster Mitigation In India.	6

Reference Books
1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company. 2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi. 3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

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

Audit Course AU4: Stress Management by Yoga

Course Code	Course Name
AU4: AUDIT II	Stress Management by Yoga

Course pre-requisites	BT107

Course Objectives
1. To achieve overall health of body and mind 2. To overcome stress
Course Outcomes
Students will be able to: 1. Develop healthy mind in a healthy body thus improving social health also 2. Improve efficiency

Course Content

Module No.	*Details*	*Hrs.*
1	➢ Definitions of Eight parts of yog. (Ashtanga)	5
2	➢ Yam and Niyam. Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	5
3	Yoga & The Brain ➢ Brain Based Learning ➢ The Brain ➢ Teaching to the Developing Brain ➢ Supporting the Learning Brain with Yoga	5
4	Social Emotional Learning	5
5	POSITIVE CLASSROOM MANAGEMENT ➢ Transitions and Engagement ➢ Dynamic Teaching ➢ Understanding Behavior	5

	➢ Classroom Boundaries	
6	THE YOGA ENVIRONMENT ➢ Clothing ➢ Assistants • ➢ Adjustments	5
7	➢ Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects- ➢ Types of pranayam	6

Reference Books
1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur 2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata.

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

Audit Course AU5: Value Education

Course Code	Course Name
AU5: AUDIT II	Value Education

Course pre-requisites	

Course Objectives
1. Understand value of education and self- development 2. Imbibe good values in students 3. Let the should know about the importance of character
Course Outcomes
Students will be able to: 1. Knowledge of self-development 2.Learn the importance of Human values 3.Developing the overall personality

Course Content

Module No.	Details	Hrs.
1	Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism, Moral and non-moral valuation. Standards and principles, Value judgements	3
2	Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration, Truthfulness, Cleanliness.	3
3	Honesty, Humanity. Power of faith, National Unity, Patriotism. Love for nature ,Discipline.	3
4	Personality and Behavior Development - Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour.	3
5	Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence ,Humility.	3
6	Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature	3
7	Role of Women, Women empowerment, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively	3

Reference Books
1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi.

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

Audit Course AU6: Pedagogy Studies

Course Code	Course Name
AU6: AUDIT II	Pedagogy Studies

Course pre-requisites	

Course Objectives
1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers. 2. Identify critical evidence gaps to guide the development.
Course Outcomes
Students will be able to understand: 1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries? 2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners? 3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Course Content

Module No.	Details	Hrs.
1	Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching.	3
2	Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.	3
3	Evidence on the effectiveness of pedagogical practices: Methodology for the in-depth stage: quality assessment of included studies, how can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?	3
4	Theory of change, Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches,	3
5	Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and	3

	the community,	
6	Research gaps and future directions, Research design, Contexts Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.	3
7	Teachers' attitudes and beliefs and Pedagogic strategies, Curriculum and assessment, Barriers to learning: limited resources and large class sizes	3

Reference Books

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.

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

Audit Course AU7: Personality Development through Life Enlightenment Skills

Course Code	Course Name
AU7: AUDIT II	Personality Development through Life Enlightenment Skills

Course pre-requisites	

Course Objectives
1. To learn to achieve the highest goal happily 2. 2. To become a person with stable mind, pleasing personality and determination 3. 3. To awaken wisdom in students
Course Outcomes
Students will be able to understand: 1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life. 2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity. 3. Study of Neetishatakam will help in developing versatile personality of students.

Course Content

Module No.	Details	Hrs.
1	Neetisatakam-Holistic development of personality: ▪ Verses- 19,20,21,22 (wisdom) ▪ Verses- 29,31,32 (pride & heroism) ▪	3
2	▪ Verses- 26,28,63,65 (virtue) ▪ Verses- 52,53,59 (dont's) ▪ Verses- 71,73,75,78 (do's)	3
3	Approach to day-to-day work and duties: ▪ Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48, ▪ Chapter 3-Verses 13, 21, 27, 35.	3
4	▪ Chapter 6-Verses 5,13,17, 23, 35, ▪ Chapter 18-Verses 45, 46, 48.	3
5	Statements of basic knowledge: ▪ Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 ▪ Chapter 12 -Verses 13, 14, 15, 16,17, 18	3
6	▪ Personality of Role model. Shrimad BhagwadGeeta: Chapter2 Verses 17, Chapter 3-Verses 36,37,42,	3

7	▪ Chapter 4-Verses 18, 38,39 ▪ Chapter18 – Verses 37,38,63	3

Reference Books

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Sr. No.	Examination	Module
1	T-I	1
2	T-II	2
3	End Sem	1 to 3

Open Elective EC-OP301:Industrial Safety

Course Code	Course Name
EC-OP301 Open Elective	**Industrial Safety**

Course pre-requisites	BTM803/BTM898

Course Outcomes
At the end of the course students will be able to 1. Understand basic safety norms, rules and regulations and hazards 2. Understand maintenance of utility systems and its service life expectancy 3. Understand fault and diagnostics and preventive measures 4. Understand repair cycles of machines and trouble shootings

Course Content

Module No.	*Details*	*Hrs.*
1	Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.	5
2	Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.	5
3	Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity Lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods	5
4	Fault tracing: Fault tracing-concept and importance, decision	5

	treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.	
5	Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor	5
6	Troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive Maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets	5
7	Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance	6

Reference Books

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

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

Open Elective EC-OP302:Operation Research

Course Code	Course Name
EC-OP302 Open Elective	**Operations Research**

Course pre-requisites	BTM803

Course Outcomes
At the end of the course, the student should be able to 1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables. 2. Students should able to apply the concept of non-linear programming 3. Students should able to carry out sensitivity analysis 4. Student should able to model the real world problem and simulate it.

Course Content

Module No.	*Details*	*Hrs.*
1	Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis,	5
2	Formulation of a LPP - Graphical solution revised simplex method-duality theory - dual simplex method - sensitivity analysis parametric programming	6
3	Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem – CPM/PERT	5
4	Scheduling and sequencing – single server and multiple server models – deterministic inventory models –	5
5	Inventory Control Models, Probabilistic inventory control models – Geometric Programming.	5
6	Competitive Models,Single and Multi-channel Problems, Sequencing Models	5
7	Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation	5

Reference Books

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

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

Open Elective EC-OP303: Cost Management of Engineering Projects

Course Code	Course Name
EC-OP303 Open Elective	**Cost Management of Engineering Projects**

Course pre-requisites	BTM803

Course Outcomes		
At the end of the course students will be able to 1. Estimate project cost and project commisioning 2. Analyse cost behaviour in project 3. Know different project strategies 4. Apply quantitative techniques for cost management of engineering projects		
Course Content		
Module No.	***Details***	***Hrs.***
1	Introduction and Overview of the Strategic Cost Management Process	4
2	Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunitycost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational Control; Provision of data for Decision-Making.	4
3	Project: meaning, Different types, why to manage, cost overruns centr various stages of project execution: conception to commissioning. Proj execution as conglomeration of technical and nontechnicalactivities. Detailed Engineering activities. Preproj execution main clearances andDocuments Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar chartsand Network diagram. Project commissioning: mechanical and process	6
4	Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.	6
5	Pricing strategies: Pareto Analysis. TargetCosting, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints.	5
6	Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible	5

	Budgets; Performance budgets; Zero-based budgets. Measurement ofDivisional profitability pricing decisions including transfer pricing.	
7	Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	6

Reference Books
1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

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

Open Elective EC-OP304: Waste to Energy

Course Code	Course Name
EC-OP304 Open Elective	**Waste to Energy**

Course pre-requisites	BTM504

Course Outcomes
At the end of the course students will be able to 1. Classify waste from energy recovery point of view 2. Know biomass pyrolysis and gasification 3. Understand biomass combustion 4. Understand working of biogas plant and importance of biomass energy programme in India

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors	5
2	Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.	5
3	Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.	5
4	Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.	5
5	Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion	5
6	Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion	5
7	Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy	6

	conversion - Biomass energy programme in India.	

Reference Books

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley &Sons, 1996.

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

Open Elective EC-OP305: Essentials for NX Designer

Course Code	Course Name
EC-OP305	**Essentials for NX Designers**

Course pre-requisites	None

Course Objectives
1. Document design intent. 2. Create and edit parametric solid models. 3. Create Assembly Structures and Drawings.
Course Outcomes
Upon successful completion of the course, Participants should be able to 1. Get an idea about Design Intent and parametric CAD system. 2. Create 3D CAD models using NX. 3. Prepare assemblies using essential tools in NX assembly environment. 4. Create drawing for manufacturing or presentation.

Course Content

Module No.	*Details*	*Hrs.*
1	Getting to know the NX interface and Coordinate Systems	5
2	Documenting design intent and Creating parts with sketches	5
3	Creating and editing Parametric models	5
4	Examining the structure and working with secondary features	5
5	Modifying geometry of imported parts using synchronous technology	4
6	Loading and working with assemblies	5
7	Creating simple drawings	7

Sr.No.	Examination	Module
1	**T-I (Online MCQs)**	1and 2
2	**T-II (Online MCQs)**	3 and 4
3	**End Sem (Tool Test)**	1 to 7

Open Elective EC-OP306: Advanced Simulation

Course Code	Course Name
EC-OP306	**Advanced Simulation**

Course pre-requisites	None

Course Objectives
1. Fundamentals of stress and strain. **2.** Understand Displacement Field and Hooke's Constitutive law. **3.** Analyze stress problems with the application of basic laws and equations
Course Outcomes
Upon successful completion of the course, Participants should be able to 1. Applying Numerical Methods to solve problems with variety of loading situations. 2. Working with Stress-Strain relation of ductile and brittle materials. 3. Analyze and calculate stress/strain distributions for 1D, 2D and 3D problems. 4. Analyze various types of Engineering Problems and interpolate the results

Course Content

Module No.	*Details*	*Hrs.*
1	Understanding the concepts of Modeling, Assembling and Drawing using NX	5
2	Geometry Simplification and Meshing	5
3	Working with the results and interpolation	5
4	Solving Structural Static Analysis, Buckling Analysis and Natural Frequency Analysis	5
5	Solving Thermal, Response and Nonlinear Analysis	5
6	Solving Symmetry, Assembly FEM and Contact & Gluing problems	5
7	Flexible Body Analysis and Optimization	6

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3, 4

3	End Sem	1 to 7

Open Elective EC-OP307: Composite and Structure Assembly

Course Code	Course Name
EC-OP307	**Composite and Structure Assembly**

Course pre-requisites	None

Course Objectives
1. Understanding the Structure of Composites. **2.** Creating Laminates. 3. Analyzing composite structure problems.
Course Outcomes
Upon successful completion of the course, participants should be able to 1. Create Laminate Composite Structures. 2. Understand Laminate Failure Theory. 3. Analyze Composite Structures and interpolate the results. 4. Optimize Laminate Composite Structures

Course Content

Module No.	***Details***	***Hrs.***
1	Understanding the concepts of Modeling, Assembling and Drawing using NX	5
2	Creating Finite Element Models	5
3	Solving various type of Analysis	5
4	Introduction to Composite Structure, Creating Laminates using zone based Process and Ply based Process.	5
5	Modeling 3D laminates, Solving and Post Processing	5
6	Laminate Theory and Failure Analysis	5
7	Laminate Dynamic Analysis and Optimization	6

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3, 4
3	End Sem	1 to 7

Open Elective EC-OP308: Collaborative Engineering using Team Center

Course Code	Course Name
EC-OP308	**Collaborative Engineering using Team center**

Course pre-requisites	None

Course Objectives
1. To Organize, Manage and Secure product data using Teamcenter 2. To Integrate NX with Teamcenter 3. To 3D Model using NX in Teamcenter Integrated Envirnomemt
Course Outcomes
Upon successful completion of the course, students should be able to 1. Organize, Manage and secure the product data. 2. To Assign, Perform and Track the workflow process. 3. Defining the Assembly Structure in integrated mode. 4. Understand Part Modeling Techniques using NX.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Teamcenter	2
2	Creating and Managing Datasets and Items	3
3	Creating and Managing Product Structure	5
4	Initiating and Managing Workflow Tasks	5
5	Viewing and Working with Vizualization	6
6	Creating Part Models and Assemblies	8
7	How to Integrate NX with Teamcenter	7

Sr.No.	Examination	Module
1	T-I (Online MCQs)	1, 2 &3
2	T-II (Online MCQs)	4 & 5
3	End Sem (Tool Test)	1 to 7

Open Elective EC-OP309: Technomatix Process

Course Code	Course Name
EC-OP309	**Technomatix process**

Course pre-requisites	None

Course Objectives
1. Process Designer Basics 2. Simulating a work cell using Robcad 3. Defining Kinematics using Robcad.
Course Outcomes
Upon successful completion of the course, students should be able to 1. Understanding how to work with Process Designer software. 2. Manage Engineering and Manufacturing data in Process Designer. 3. Creating Robot workcell Layout and sequence of operation. 4. Creating automatic kinematics and parameters in Robcad

Course Content

Module No.	*Details*	*Hrs.*
1	Process Designer Interface and Environment	4
2	Productivity Tools and Placement commands	4
3	Creating and Saving Engineering Data	4
4	Robot Workcell Layout, Modeling and Kinematics	6
5	Workcell and Robot Simulation Techniques	6
6	Automatic Kinematics Creation	6
7	Kinematic Functions	6

Sr.No.	Examination	Module

1	T-I (Online MCQs)	1,2 and 3
2	T-II (Online MCQs)	4 and 5
3	End Sem (Tool Test)	1 to 7

Open Elective EC-OP310: Thermal and Flow Analysis

Course Code	**Course Name**
EC-OP310	**Thermal and Flow Analysis**

Course pre-requisites	None

Course Objectives
1. Fundamentals of Heat Transfer. 2. Understanding Energy Equations. 3. Analyze Thermal and Flow problems
Course Outcomes
Upon successful completion of the course, Participants should be able to 1. Apply Finite Element Method to solve Thermal Problems. 2. Apply Finite Volume Method to solve Flow Problems. 3. Analyze and calculate stress/strain distributions for 1D, 2D and 3D problems. 4. Analyze the Coupled Thermal Fluid problems.

Course Content

Module No.	***Details***	***Hrs.***
1	Understanding the concepts of Modeling, Assembling and Drawing using NX	5
2	Meshing and Applying loading and boundary conditions	5
3	Simulation and Validation	5
4	Introduction to Thermal Analysis (Conduction, Convection and	5

	Radiation)	
5	Thermal Simulation	5
6	Introduction to Flow analysis and Creating Fluid Volume	5
7	Flow Simulation and Mapping Results	6

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3, 4
3	End Sem	1 to 7

Open Elective EC-OP311: Internet of Things

Course Code	Course Name
EC-OP311	Internet of Things

Course pre-requisites	General knowledge of networking, sensing, databases, programming, and related technology

Course Objectives		
Upon successful completion of the course, students will be • Explored to the interconnection and integration of the physical world and the cyber space. • They are also able to design & develop IOT Devices.		
Course Outcomes		
After successful completion of the course student should be able to 1. Describe the theory related to Internet of things 2. Apply theoretical knowledge of IOT in practice 3. Select the hardware & software for different applications. 4. Develop an application using IOT hardware & software		
Course Content		
Module No.	***Details***	***Hrs.***
1	Introduction Fundamentals of Internet of Things (IOT), Components in IOT, Architecture of IOT, Security, Privacy, Advantages, Applications: Smart Vehicles, Medical, Smart city, Smart Supply Chain etc.	5
2	Enabling Technologies of IOT Technology Roadmap, RFID, Augmented Reality, Blue Tooth, Zigbee, WiFi, RFLinks, MEMS etc	5
3	Programming the Microcontroller for IOT Cloud computing and IOT –Arduino/Equivalent Microcontroller platform – Setting up the board - Programming for IOT – Reading from Sensors - Communication-Connecting microcontroller with mobile devices – communication through Bluetooth and USB – connection with the internet using WiFi / Ethernet	5
4	Resource Management Understanding the Elements of IOT (Sensors, Connectivity through network, Application Layer), Overview of Sensors, Gateways, Sensors Available in Market, Selecting the Right Sensor for the Right Use case, Considerations for Mounting Sensors for Right Results	5
5	IOT PROTOCOLS Network Overview, Various Types of Networks, Network Protocols, Selecting the Right Network for the Right Use case, Network Challenges for IOT: Connecting sensors,	5

	Integrating with Application Platform	
6	IOT Platforms Introduction, Necessity of IOT Platform, Industrial Grade Platform, Key IOT Platform Features, IOT Platform Architecture, Getting access to IOT platforms, Introduction to Model based development on IOT platforms	6
7	Challenges & Opportunities of IOT New business markets in IOT, IOT Design Challenges, IOT Design Opportunities, Technological challenges faced by IOT devices	5

Text Books
1. Dieter Uckelmann et.al, "Architecting the Internet of Things", Springer, 2011.
Reference Books
1. CharalamposDoukas, "Building Internet of Things with the Arduino", Create space, April 2002.

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

Open Elective EC-OP312: Introduction to Big Data Analytics

Course Code	Course Name
EC-OP312	**Introduction to Big Data Analytics**

Course pre-requisites	BTM 301, BTM 401

Course Objectives
1. Understand the role of business analytics within an organization. 2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization. 3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making. 4. To become familiar with processes needed to develop, report, and analyze business data. 5. Use decision-making tools/Operations research techniques. 6. Mange business process using analytical and management tools. **7.** Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.
Course Outcomes
1. Students will demonstrate knowledge of data analytics. 2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics. 3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. 4. Students will demonstrate the ability to translate data into clear, actionable insights.

Course Content

Module No.	*Details*	*Hrs.*
1	Business analytics: Overview of Business analytics, Scope of Business analytics,Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.	5
2	Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.Important Resources,	5

	Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	
3	Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.	5
4	Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.	5
5	Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation UsingAnalytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.	5
6	Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	5
7	Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism. Application of Big Data	6

Reference Books
1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press. 2. Business Analytics by James Evans, persons 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

Open Elective EC-OP313: Introduction to AI and Machine Learning

Course Code	Course Name
EC-OP313	**Introduction to AI and Machine Learning**

Course pre-requisites	Mathematics, Knowledge of programming language (Python preferred)

Course Objectives
The students after studying these topics should be able to 1. understand applications of Artificial Intelligence and Machine Learning for engineering applications 2. apply suitable algorithms for simple engineering problems
Course Outcomes
Upon successful completion of the course, students should be able to 1. discuss applications of Artificial Intelligence for engineering problem solving 2. apply fundamental concepts in machine learning and select popular machine learning algorithms for engineering problem solving 3. compose computer code for solving problems using machine learning algorithms 4. explain advanced machine learning concepts such as Neural Network, Reinforcement Learning.

Course Content

Module No.	***Details***	***Hrs.***
1	Artificial Intelligence, Intelligent agents, types of learning, steps involved in problem solving using Machine Learning	5
2	Linear regression, Decision trees, overfitting	5
3	Instance based learning, Feature reduction, Collaborative filtering-based recommendation	5
4	Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM	5
5	Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network	5
6	Clustering: k-means, adaptive hierarchical clustering	2
7	Introduction to Reinforcement Learning, Applications and case studies	6

Text Books
1. Tom Mitchell, Machine Learning, First Edition, McGraw- Hill (1997). 2. Stuart Russel and Peter Norvig, Artificial Intelligence – A modern approach, Pearson (2015) 3. EthemAlpaydin, Introduction to Machine Learning, PHI (2015). 4. Gopal M., Applied Machine Learning, McGraw Hill (2018)

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3, 4
3	End Sem	1 to 7

Open Elective EC-OP314: Introduction to Augmented Reality

Course Code	Course Name
EC-OP314	**Introduction to Augmented Reality**

Course pre-requisites	General knowledge of CAD Modelling

Course Objectives
• Explore the basic concepts of Augmented Reality. • They are also able to design & develop AR application.
Course Outcomes
After successful completion of the course student should be able to 1. Describe the theory related to Augmented Reality 2. Apply theoretical knowledge of AR in practice 3. Select the hardware & software for different applications. 4. Develop interactive augmented reality applications for both PC based mobile devices using a variety of novel input devices

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction** History of AR, Basics of Augmented Reality, Architecture/Framework, Various applications of AR in Automotive & Auto Component industries, Construction Managemen, Educationt etc. AR Browsers, Marker & Marker less AR	5
2	**Enabling Technologies of Augmented Reality**	5

	Mobile, Camera, Cloud Computing, Unity, AR with Google Sketch up	
3	**Remote Maintenance/Training using AR** Architecture, Benefits, Challenges	5
4	**Lighting and Illumination Issues in AR** Conversion of CAD Model to AR Model	5
5	**HOLOLENS INTERFACE**	5
6	**Integration of AR** Integration with IOT. Integrating with CRM, New market Opportunities of AR, Business models, Revenue models & AR in Other Fields	6
7	**Challenges & Opportunities of AR** New business markets in AR, Technological challenges faced by AR	5

Text Books
1.Burdea, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2003/2006. 2. Steve Aukstakalnis Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR 3. Jonathan Linowes, Krystian, Augmented Reality for Developers, 2017. 4. Stephen Cawood and Mark Fiala, Augmented Reality: A practical guide

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

Open Elective EC-OP315: Composite Materials

Course Code	Course Name
EC-OP315	**Composite Materials**

Course pre-requisites	Manufacturing Science, Material Science

Course Objectives

- Explain types of composite materials and their applications
- Describe manufacturing processes for composite materials
- Discuss mechanical properties of composites

Course Outcomes

After successful completion of the course student should be able to

1. explain types of composite materials and identify its applications to mechanical engineering systems
2. discuss constituents of different types of composites
3. describe manufacturing processes for composite materials
4. define simple mechanical properties of composites

Course Content

Module No.	*Details*	*Hrs.*
1	**Overview of composite materials** Historical background, Classification based on structure and matrix, Advantages and limitations, industry applications,	06
2	**Composite materials** Reinforcement fibers, whiskers, polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC),	06
3	**Composite Science** Material and microstructure parameters of layered and phased composites, micro and macro approaches to study and prediction of structure property relations.	06
4	**Introduction to micromechanics** Anisotropy of composites, anisotropic elastic constants, failure criteriaunder multiaxial loading, interlaminar failure mechanism	06
5	**Composite manufacturing processes** Manufacturing of reinforcement fibers and whiskers, preparation of fillers, additives and pigments for PMC, manufacturing of matrix polymers, manufacture of metallic matrices, processing of ceramics, manufacture of foams, honeycombs and adhesives.	06
6	**Composite post processing operation** Machining, cutting, polishing, welding of thermoplastic PMC, bonding,riveting and painting	06

7	**Composite product design** Material considerations in composite product design, material design ofthermal, optical, acoustic, electrical design requirements, design exercise for design of simple structural element such as tension bar and ring,	06

Text Books
1. K.K. Chawla, Composite Materials – Science & Engineering, Springer-Verlag, New York, 1987.
2. Analysis and Performance of Fiber Composites, Bhagwan D. Agarwal, Lawrence J. Broutman, K. Chandrashekhara, Wiley, 2006
3. Handbook of Composites, George Lubin, Van Nostrand, Reinhold Co., 1982

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

Open Elective EC-OP316: Digital Twin

Course Code	Course Name
EC-OP316	Digital Twin

Course pre-requisites	CAD, Sensors, Simulation

Course Objectives

- To understand the fundamentals of industry 4.0 & digital twin
- To understand the enabling technologies for digital twin
- To understand how to build a digital twin
- To study application areas of digital twin
- To understand digital twin as an interdisciplinary technology along with its integrtaion
- To understand New business and Revenue models of digital twin

Course Outcomes

Upon successful completion of the course, students should be able

1. Explain & write basic concepts of digital twin
2. Identify various enabling technologies of digital twin.
3. Apply theoretical knowledge in practice
4. Develop small application using digital twin related software

Course Content

Module No.	*Details*	*Hrs.*
1	INDUSTRY 4.0: Introduction to industry 4.0, Technologies drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics.	4
2	Evolution of Digital Twins, Introduction to Digital twin, Basic concepts of Digital twins ,Growth drivers for digital twin, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, Augmented digital twin, Smart & Connected design, accelerating industry 4.0 using Digital Twin	6
3	Enabling technologies for Digital Twin like Artificial Intelligence (AI), Machine Learning(ML), Deep Learning (DL), Big Data Analytics, Internet of Things (IOT), Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Cloud Computing Services (CCS) etc.	6
4	How to build a digital Twin, Steps in building digital twin, integration of IOT & CAD, integration of IOT, BIM data & machine Learning, Hardware & Software related to digital twin, working of a digital twin, Digital Twin Platforms Concurrent engineering & digital twin, digital twin as a smart service to	6

	industries.	
5	Use cases of Digital Twin in Product development, Logistics Manufacturing, Simulation, Predictive Maintenance, Asset Maintenance, Construction industry, Facility Management Architecture, Electrical engineering, digital twin driven power transformer service, Health Care & etc.	5
6	Integration of Digital Twin with Product Life Cycle Management (PLM), Big Data Analytics, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supplier Relationship Management(SRM), Manufacturing Execution Systems (MES) etc.	4
7	Building New business/Revenue models, Developing maturity model of digital twin, Benefits of Digital Twins, Challenges in applying & implementing digital twins Future research areas of digital twin, Careers in Digital twin, Digital Twin Engineer, Application and case studies	5

Text Books

1. Digital Twin: Possibilities of the new Digital twin technology, AnandIyer, 2017, 35 Pages
2. Digital Twin Development & Deployment on the Cloud, Ist edition, Nassim Khaled BibinPattel AffanSiddiqu, ISBN**:** 9780128216316, ELSEVIER, pages 592
3. Digital Twin Technologies & Smart Cities, Maryam Farsi, AlirezaDaneshkhah, Amin Hosseinian-Far, Hamid Jahankahani, Springer, ISBN 978-3-030-18731-6
4. Digital Twin Driven Smart Manufacturing, By Fei Tao, Meng Zhang, A.Y.C. Nee, ISBN 978-0-12-817630-6, ELSEVIER, pages 257
5. Advances in Computers, The Digital Twin Paradigm for Smarter Systems and Environments: The Industry, Pethuraj&PreethaEvanjaline,ELSEVIER, pages 257, ISBN 978-0-12-818756-2, ISSN 0065-2458

Reference Books

1. Digital Twin Driven Smart Design by Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, ELSEVIER, ISBN 978-0-12-818918-4, Pages 333
2. Handbook Of Digital Enterprise Systems: Digital Twins, Simulation And Ai, by Wolfgang Kühn, world scientific publishing co., ISBN 978-981-120-073-1, Pages 229.
3. Digital Twin Complete Self-Assesment Guide, 1976302927, 9781976302923sment Guide, GeradusBlokdyk, CreateSpace Independent Publishing Platform, 2017, Pages 120.

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3 & 4
3	End Sem	1 to 7

Open Elective EC-OP317: Industry 4.0

Course Code	Course Name
EC-OP317	INDUSTRY 4.0

Course pre-requisites	CAD, BIM, Sensors, Data base

Course Objectives

- To understand the various industrial revolutions
- To understand the enabling technologies for industry 4.0
- To understand the power of data analytics
- To understand importance of Connectivity
- To understand interdisciplinary concept & technology convergence
- To understand New business and Revenue models in light of industry4.0

Course Outcomes

Upon successful completion of the course, students should be able

5. Explain & write basic concepts of industry 4.0
6. Identify various enabling technologies of industry4.0.
7. Apply theoretical knowledge in practice
8. Develop small application using various technologies of industry4.0.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction to Industry 4.0:** Evolution of industry 4.0, Technologies drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics & enabling technologies of industry 4.0. Relevance of industry4.0 to Mechanical & Civil engineering.	4
2	**Introduction to Augmented Reality:** Basics of AR, Mixed Reality, Enabling technologies of AR, Marker based & Marker less AR. Software & Hardware of AR, Creating AR experience, Applications of AR in Mechanical & Civil engineering, Challenges	6
3	**Introduction to Virtual Reality:** Basics of VR, Software & Hardware of VR, Challenges, Applications in Mechanical & Civil engineering, Robotic automation & Collaborative robots (COBOTS)	6
4	**Introduction to Artificial Intelligence:** Knowledge Based, Rules based **Introduction to Machine Learning:** Overview of Supervised, Unsupervised & Reinforced learning Algorithms **Introduction to Deep Learning:** Overview of Artificial Neural Network (ANN), Convolutional Neural Network (CNN),	6

	AUTOENCODERS Algorithms	
5	**Introduction to Internet of Things (IOT):** Sensors, IOT Protocols, IOT Platforms, Selection of sensors & IOT Platform, enabling technologies, micro controller, micro processer, Arduino board, Raspberry Pi, Sending Analog Data on Cloud Server, Smart Product Development, Smart Cities, Smart Manufacturing, Smart Logistics etc.	5
6	**Introduction to Big Data Analytics:**Evolution of big data, big data tools, 6V of big data, Basics of big data, HADOOP Ecosystem, HDFS data storage, data processing, RDBMS & NOSQL data base management, Challenges of big data, Sentiment Analytics, Predictive Analytics, Graph Analytics etc.	4
7	**Introduction to Cloud Computing:** Cloud Computing basics, Cloud deployment models like Software as a Service (SAAS), Platform as a Service (PAAS), Infrastructure as a Service (IAAS), Mobile Computing Virtualization, Technology providers vs. Cloud providers vs. Cloud vendors, Cyber Security Business Issues in industry4.0, Opportunities, Challenges, Skillsets, Startegies	5

Text Books

1. Industry 4.0: Managing The Digital Transformation Book by Alp Ustundag and EmreCevikcan, Publisher:Springer International Publishing, ISBN:9783319578705, 3319578707
2. Shaping the Fourth Industrial Revolution A Guide to Building a Better World, by Klaus Schwab, Nicholas Davis, Publisher:Penguin Books Limited, ISBN:9780241366394, 0241366399
3. Dieter Uckelmann et.al, "Architecting the Internet of Things", Springer, 2011
4. Data Analytics : The Complete Beginner's Guide - Step By Step Instructions (The Black Book) Kindle Edition, by Byron Francis
5. The Enterprise Cloud: Best Practices for Transforming Legacy IT, by James Bond
6. Augmented Reality: Principles & Practice Paperback, by Schmalstieg/Hollerer
7. Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, by Tony Parisi, Publisher:O'Reilly Media, ISBN:9781491922781, 1491922788

Reference Books

1. CharalamposDoukas , "Building Internet of Things with the Arduino", Create space, April 2002
2. Big Data and Analytics 1st Edition, Kindle Edition, by SubhashiniChellappan Seema Acharya
3. Cloud Computing: Concepts, Technology & Architecture, by RichardoPuttini, Thomas Erl, and Zaigham Mahmood
4. Handbook of Augmented Reality, by BorkoFurht, Publisher:Springer New York, ISBN:9781461400646, 1461400643

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3 & 4
3	End Sem	1 to 7

Open Elective EC-OP318: Generative Design

Course Code	Course Name
OE-BTM6	GENERATIVE DESIGN

Course pre-requisites	CAD, BIM, MACHINE LEARNING, FEA

Course Objectives

- To understand the fundamentals of generative design
- To understand the enabling technologies for generative design
- To understand how to develop generative design
- To study application areas of generative design
- To understand generative design as an interdisciplinary technology
- To understand, how ML & DL can be used in generative design
- To understand, how evolutionary & genetic algorithms help generate multiple design solutions

Course Outcomes

Upon successful completion of the course, students should be able

9. Explain & write basic concepts of generative design
10. Identify various enabling technologies of generative design.
11. Apply theoretical knowledge in practice
12. Develop multiple design solutions using related software

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction to Industry 4.0:** Technologies drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics & enabling technologies of industry 4.0, Relevance of GE in INDUSTRY4.0	4
2	**Overview of Generative Design (GE):** Introduction to GenerativeDesign,, Components of GE, Significance of GE in Mechanical & Civil Engineering structures & components, Enabling Technologies, Generative Design Framework, CAD & BIM models in GE, CAD & FEA integration, Additive Manufacturing	6
3	**Artificial Intelligence:** Overview of AI, Rule based design **Machine Learning based Design Generation:** Overview of Supervised, Unsupervised & Reinforced learning Algorithms for Generative Design **Deep Neural Design Generation:**Artificial Neural Network (ANN),Convolutional Neural Network (CNN), Auto Encoders & Decoders for Generative Design (GE) & Generative Adversarial Networks (GAN)	6
4	**Topology Optimization:**Problem Formulation, Design Parameterization, Structural Optimization, Sensitivity Analysis,	6

	Algorithms for solving problems & implementation, Convergence of solution, Optimal solution	
5	**Evolutionary & Genetic Algorithms:**Biological evolution, Fitness evaluation, Selection, Crossover/recombination, mutation, next generation, evolutionary strategies, overview of Genetic & evolutionary programming	5
6	**CASE STUDIES on Generative Design for Mechanical & Civil Engineering.** Defining Generative Objects,Defining Obstacle regions, Defining Preserve regions, selecting load, Selecting Manufacturing method, solving generative study, viewing generative outcomes. FEA Analysis of multiple design solutions for various results like stress, deformation etc.	6
7	**Benefits & Applications:** benefits & applications of Generative Design in Mechanical & Civil Engineering, Future Scope. New Business & Revenue models.	3

Text Books

1. "Topology Optimization: Theory, Methods, and Applications" by Bendsoe and Sigmund
2. “Generative Design” Visualize, Program, and Create with JavaScript in P5.js by Benedikt Gross, HartmutBohnacker, Julia Laub, Claudius Lazzeroni · 2018, ISBN: 9781616897840, 1616897848, Publisher: Princeton Architectural Press
3. “Generative Design: Form-finding Techniques in Architecture” , By AsteriosAgkathidis · 2016, Publisher:Laurence King Publishing, ISBN: 9781780676913
4. “Deep Learning with Python” by François Chollet,
5. “Introduction to evolutionary computing” by Agoston E Eibe, Publisher:Springer Berlin Heidelberg, ISBN:9783662448748, 3662448742
6. “Genetic algorithms in search, optimization, and machine learning” Book by David E. Goldberg
7. Python Machine Learning, Machine Learning and Deep Learning with Python, Scikit-learn, and TensorFlow 2, 3rd EditionBy Sebastian Raschka, VahidMirjalili · 2019, ISBN:9781789958294, 1789958296, Publisher:Packt Publishing

Reference Books

1. "A Hands-On Introduction to Topology Optimization" by Amir M. Mirzendehdel and Krishnan Suresh "Homogenization and Structural Topology Optimization: Theory, Practice and Software" by BehroozHassani and Ernest Hinton
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, by AurelienGeron, ISBN-10 : 1492032646, Publisher : O'Reilly Media; 2nd edition (October 15, 2019)

Sr.No.	Examination	Module
1	T-I	1, 2
2	T-II	3 & 4

3	End Sem	1 to 7

DS-MTMD398: Seminar on Literature Review

Course Code	Course Name
DS-MTMD398	Seminar on Literature Review

Course pre-requisites	MTMD 299

Course Outcomes
1. Student will be able to search literature related to the project topic 2. Student will be able to analyse finding of literature review 3. Student will be able to identify research gap 4. Student will be able to integrate the knowledge to define the problem statement appropriately 5. Student will be able to apply principles of ethics and standards, skill of presentation and communication techniques

Course Content

Module No.	*Details*	*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 literature work the student shall prepare a report and will give a Seminar on the report.	48

DS-MTMD399: Dissertation Seminar Stage-I

Course Code	Course Name
DS-MTMD399	**Dissertation Seminar Stage-I**

Course pre-requisites	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

Module No.	*Details*
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

DS-MTMD498:Dissertation- Seminar Stage-II

Course Code	Course Name
DS-MTMD498	**Dissertation- Seminar Stage-II**

Course pre-requisites	MTMD398/ MTMD399

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		
Module No.	***Details***	***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

DS-MTMD499: Dissertation & Viva-Voce

Course Code	Course Name
DS-MTMD499	**Dissertation & Viva-Voce**

Course pre-requisites	MTMD398/ MTMD399/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 discuss the merits and limitations of the project work	
Course Content	
Module No.	***Details***
1	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.