B.N.M. Institute of Technology

An Autonomous Institution under VTU, Approved by AICTE

Department of Mathematics

Semester: III			
Course: Fourier Series, Transforms, Statistical and Numerical Techniques **Course Code: 25MAM131 (For ME branch)**			
L:T:P:J	**2:2:0:0**	**CIA**	**: 50**
Credits:	**03**	**SEA**	**: 50**
Hours:	**40**	**SEA Duration**	**: 03 Hours**

Course Learning Objectives: The students will be able to develop the theoretical and practical knowledge of Statistical methods, Laplace transform, Fourier series, Fourier transforms and Z-transforms in a comprehensive manner in various fields of engineering.

Module-1: Curve fitting & Statistical methods	**No. of hours**	**Blooms cognitive Levels**
Examples from Engineering field that require curve fitting and statistical methods. **Curve Fitting:** Curve fitting by the method of least squares-fitting the curves of the form: $y = ax+b$, $y = ax^2 + bx + c$ and $y = ax^b$. **Statistical methods:** Introduction to Moments, Skewness, Kurtosis and problems. Karl Pearson's coefficient of correlation and lines of regression. Experiential Learning component: Problems on curve fitting and statistical methods	L: 04 T: 04	**L1** **L2** **L3**
Module-2: Laplace Transform		
Examples from Engineering field that require Laplace transforms. Transformation for time domain to frequency domain. Definition and Laplace transforms of elementary functions (statements only). Laplace transform of $e^{at} f(t)$, $t^n f(t)$, $\frac{f(t)}{t}$, $\int_0^t f(t)dt$ and $f^n(t)$ (without proof). Laplace transforms of Periodic functions, unit-step function and unit impulse function. *Experiential Learning component: Finding the Laplace transforms of a function.*	L: 04 T: 04	**L1** **L2** **L3**
Module-3: Inverse Laplace Transform		
Examples from Engineering field that require inverse Laplace transforms. Definition and problems. Inverse Laplace transform using convolution theorem (without proof). Solution of linear differential equations. Applications to engineering problems. *Experiential Learning component: Problems on LCR Circuit.*	L: 04 T: 04	**L1** **L2** **L3**
Module-4: Fourier Series & Fourier Transforms		
Examples from Engineering that require Fourier series and Fourier Transforms. **Fourier series**: Periodic functions, Introduction to Fourier Series, Dirichlet's condition. Problems on Fourier series of period 2π. **Fourier Transforms:** Introduction to infinite Fourier transform, Fourier sine and cosine transform and properties, problems on infinite Fourier transform. *Experiential Learning component: Finding the Fourier series and Fourier Transform of a function*	L: 04 T: 04	**L1** **L2** **L3**
Module-5: Numerical Solution of Partial Differential Equations		
Examples from Engineering field that require numerical solution of partial differential equations. Introduction, Difference Quotients, Geometrical Representation of Partial Difference Quotients, Numerical solution of one-dimensional heat equation by Bender-Schmidt Method and Crank-Nicholson, one dimensional wave equation and Laplace's equation by Liebmann's iteration process. *Experiential Learning component: Finding the numerical solution of heat and wave equations.*	L: 04 T: 04	**L1** **L2** **L3**

Course Outcomes: After completing the course, the students will be able to

CO 1: Apply the knowledge of correlation and regression analysis to fit a suitable mathematical model for the statistical data.

CO 2: Apply Laplace transform technique to find the transformation from time domain to frequency domain.

CO 3: Use inverse Laplace transform in solving differential equations arising in network analysis, control system and other fields of engineering

CO 4: Demonstrate Fourier series & transform concepts to study the behavior of periodic functions and their applications in system communications, digital signal processing and field theory.

CO 5: Apply the knowledge of numerical solution of partial differential equations in solving heat, wave, Laplace's and Poisson's equations.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	-	-	2	-	-	-	-	-	-	-
CO 2	3	2	-	-	2	-	-	-	-	-	-	-
CO 3	3	2	-	-	2	-	-	-	-	-	-	-
CO 4	3	2	-	-	2	-	-	-	-	-	-	-
CO 5	3	2	-	-	2	-	-	-	-	-	-	-

Reference Books:

1. E. Kreyszig: "Advanced Engineering Mathematics", John Wiley & Sons, 10"Ed.(Reprint), 2016.
2. B. S. Grewal: "Higher Engineering Mathematics", Khanna Publishers, 44th Ed., 2017.
3. H. K. Dass, " Advanced Engineering Mathematics" S. Chand publication.
4. C. Ray Wylie, Louis C. Barrett : "Advanced Engineering Mathematics", 6" Edition, 2. McGraw-Hill Book Co., New York, 1995.
5. James Stewart : "Calculus —Early Transcendentals", Cengage Learning India Private Ltd., 2017.
6. B.V. Ramana: "Higher Engineering Mathematics" 11th Edition, Tata McGraw-Hill, 2010.
7. Srimanta Pal & Subodh C Bhunia: "Engineering Mathematics", Oxford University Press, 3 Reprint, 2016.

Web links and Video Lectures:

1. https://youtu.be/BsVtMnp3vks
2. https://youtu.be/Nz4WB8-gNBg
3. https://youtu.be/6MXMDrs6ZmA
4. https://youtu.be/r18Gi8lSkfM
5. https://youtu.be/cy_KI_FiS7I
6. https://youtu.be/sMYtHaSIXbU

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Material Science & Metallurgy**	**Credits**	**03**
Course code	**25MEC132**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course Objective:

This course will enable the students to:

- Familiarize the students with fundamentals of material science such as crystallography principles of alloy formation,
- Plastic deformation, mechanical properties, various types of heat treatment processes, isothermal transformation and continuous cooling transformation diagrams.
- Introduce Ceramic, Composite and Polymeric Materials.

Module-I: Crystal Structure & Diffusion		
Pre-requisite: Periodic table, Atomic numbers, and basic crystal structure **Teaching component**: Introduction to Materials: Classifications of materials: Metallic materials, Polymeric materials and ceramic materials. Crystal Imperfections: crystal structures, APF, naming planes and directions, defects in crystals, Point imperfections, Line imperfections, Surface imperfections, Volume Imperfections Numericals. Diffusion: Introduction, Diffusion Mechanisms, steady state diffusion, non-study state diffusion, factors that influence diffusion. Fick's laws of diffusion, Kirkendall effect.	8 Hrs	Apply
Module-2: Mechanical Behavior of Materials		
Pre-requisite: Basics of materials elastic behavior, stress, strain, elongation **Teaching component**: Mechanical Behavior: Stress-strain diagram for ductile and brittle materials, True stress and true strain, linear and nonlinear elastic behavior and properties, Creep: Description of the phenomenon with		

examples, three stages of creep, stress relaxation, Fatigue- Types of fatigue loading with examples, S-N curve, R-R Moore reverse Bending test Dislocations and Plastic Deformations: Basic concepts, characteristics of dislocations, slip systems, slip in single crystals, plastic deformation of polycrystalline materials, Deformation by twinning, Mechanisms of strengthening in metals, Strain hardening.	8 Hrs	Apply
Module-3: Solidification and Phase Diagrams		
Pre-requisite: types of alloys, atomic weight percentage, solidus and liquidus phases **Teaching component**: Solidification and Solid Solutions: Mechanism of solidification, Homogenous and Heterogeneous nucleation, crystal growth. Phase Diagram: Basic terms, phase rule, lever rule, cooling curves, construction and interpretation of different phase diagrams (eutectic, eutectoid, peritectic and peritectoid). Iron - Carbon Equilibrium Diagram: Iron-cementite diagram. Irons, steels and cast irons, High-entropy alloys (HEA) such as Multi-principal element alloys. Superior strength and thermal stability alloys, Aerospace and defence applications.	8 Hrs	Apply
Module-4: Heat Treatment and Metallography		
Pre-requisite: Mechanical properties of alloys and application of different alloys **Teaching component**: Heat treatment: - TTT, CCT diagram, applications- annealing, normalizing, hardening and tempering; micro structural effects brought about by these processes and their influences on mechanical properties; factor affecting hardenability, surface hardening of steels. Age hardening of aluminum alloys, Cryogenic treatment of steels, Toyota Diffusion Technique, plasma nitriding, EB and LB heat treatments. Microstructures of iron-carbon alloys. Aluminum copper system. Metallographic specimen preparation, etchants, principle of X – ray diffraction, SEM and TEM.	8 Hrs	Apply
Module-5: Advanced Materials		
Pre-requisite: Properties of Thermo setting and Thermo plastics **Teaching component**: Composite materials: Definition, classification, type of matrix materials and reinforcements, advantages and application of composites. Energy Materials: Battery materials for EVs, Hydrogen storage materials, Fuel Cell materials, Solar Photovoltaic materials. Bio-materials: A brief introduction to biocompatible materials (Ti alloys, hydroxyapatite ceramics, PEEK polymers), Machine learning for material discovery	8 Hrs	Apply
	Total	**40 Hrs**

Reference Books

1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006
2. Materials Science and Engineering – W.D. Callister, Jr. Wiley India(P) Ltd., 2007
3. Materials Science and Engineering, G.S. Upadhyaya and Anish Upadhyaya, Viva books, 2010
4. Fundamentals of Materials Science-the microstructure-property relationship using metals as model systems, E.J. Mittemeijer, Springer, 2010
5. Microstructural Characterization of Materials – D. Brandon and W.D. Kaplan, John Wiley and Sons, 2008
6. Science of Microscopy, P.W. Hawkes and J.C.H. Spence, Springer, 2007
7. Scanning Electron Microscopy & X-Ray Microanalysis, J. Goldstein et.al, Springer, 2003
8. Transmission Electron Microscopy – B. D. Williams & C. B. Carter, Springer, 2009
9. Materials Characterization Techniques, S. Zhang, Lin Li and Ashok Kumar, CRC Press, 2009

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Additive and Subtractive Manufacturing	Credits	04
Course code	25MEC133	CIE Marks	50
Number of Lecture Hours/Week	3L+2P	SEE Marks	50
Total Number of Lecture Hours	50	Exam Hours	03

Module-I: Conventional and Non-Conventional Machining Process		
Pre-requisite: Metals, alloys and their properties, working principles of machine tools. **Teaching component**: **Conventional Machining:** Orthogonal cutting, Tool wear and tool life, Machinability, cutting tool materials, cutting fluids. **CNC Machining**: Introduction to ISO based G & M codes for NC part programming, Concepts of tool length and radius compensation, Standard canned cycles used in CNC turning and milling centers. **Non-Conventional Machining Process**: Machining, principle of working and processes parameters - wire EDM, Electrochemical machining (ECM), Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining (EBM). **Experiments**: 1. Preparation of model on lathe machine by carrying out facing and turning, knurling, thread cutting operations and measuring taper angle using sine center and thread pitch using pitch gauges 2. Preparation of gear cutting model using milling machine. 3. Measurement of cutting forces for the models prepared on lathe using Lathe tool dynamometer.	**10 Hrs**	**Apply**
Module-2: Plastic & Ceramic Components Manufacturing		
Pre-requisite: Types and uses of plastics & ceramics along with their impacts on environment. **Teaching component**: **Casting and Molding**: Metal casting processes and equipment, Heat transfer and solidification, shrinkage, riser design, casting defects and residual stresses. Classification of Plastics, Ingredients of Molding compounds, General Properties of Plastics, Plastic part manufacturing processes such as compression molding, transfer molding, Injection molding, Extrusion molding, blow molding, Thermoforming, slush molding, laminating. Ceramic Structure, Properties, and Applications, Shaping Ceramics, Glasses Structure, Properties, and applications.	**10 Hrs**	**Apply**

Experiments: 1. Preparation of sand mold cavity using a pattern. 2. To determine compressive strength of foundry sand using universal sand testing machine. 3. To determine shear strength of foundry sand using universal sand testing machine.		
Module-3: Introduction to Additive Manufacturing		
Pre-requisite: Basic understanding of physics and mathematics **Teaching component**: **Introduction and Basic Principles:** Generic AM process, distinction between AM and CNC, AM related technologies- reverse engineering technology. **Development of Additive Manufacturing Technology:** Introduction, computer-aided design technology, other associated technologies, classification of AM processes, metals systems, hybrid systems. **Additive Manufacturing Process Chain:** Introduction, the eight steps in additive manufacture, variations from one AM machine to another, maintenance of equipment, materials handling issues, design for AM, and application areas. **Experiments:** Modelling and 3D Printing of IC Engine components	**10Hrs**	**Apply**
Module-4: Solid, Liquid and Powder Based Methods		
Pre-requisite: Essentials about sintering phenomena, concepts of extrusion and polymerization **Teaching component**: **Photo Polymerization Processes:** Stereo lithography (SL), Materials, resin curing process, Process Benefits and Drawbacks, Applications of Photo Polymerization Processes. **Powder Bed Fusion Processes:** Introduction, Selective laser Sintering (SLS), Materials, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes. **Extrusion-Based Systems**: Fused Deposition Modelling (FDM), Principles, Materials, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes. **Printing Processes**: Material Jetting Fundamentals, Materials, Commercial material jetting machines, process benefits and drawbacks. Binder Jetting working principle, Materials, BJ Machines, Process benefits and Drawbacks in Binder Jetting. **Experiments:** Modelling and 3D printing of consumer products using Fused Deposition Modelling	**10Hrs**	**Apply**
Module-5: Post Processing Methods and Applications of Additive Manufacturing		
Pre-requisite: Awareness of CAD software required for AM, concepts of process and production planning. **Teaching component**: **Post- Processing**: Post processing to - Support material removal, improve surface quality, surface texture improvements, Aesthetic improvements, preparation for use as a pattern, improve accuracy, improve mechanical properties, property enhancements using non-thermal techniques and thermal techniques.		

AM Applications: Medical applications (Surgical and Diagnostic Aids, Prosthetics and Implants, Tissue Engineering and Organ Printing), Aerospace applications, Automotive applications. **Prospectives of AM in industry 4.0:** digital thread and AM, traditional Vs DDM, IoT and AM, Big data and AM, Edge computing, Fog computing, cloud computing, robotics in AM, digital twin in industry 4.0, AI in additive manufacturing. **Experiments:** To study the effect of manufacturing parameters of 3D Printed components	**10Hrs**	**Analyze**

Reference Books

1. Manufacturing Engineering and Technology By S. Kalpak Jain and Steven R Schmid, Seventh Edition, Pearson, 2018.
2. Production Technology by HMT, McGraw Hill Education, 2017
3. Degarmon's Materials and Processes in Manufacturing, 11th Ed. Black, Ronald A Kohser, Wiley India, 2017.
4. Ceramic and glass materials by James F. Shackelford, Springer Publications, 2008
5. Non-Traditional Machining Process by Harsiman Singh Sodhi and Jagjit Singh, 2020
6. Additive Manufacturing Technologies by I. Gibson l D. W. Rosen l B, Stucker Third Edition, Springer, 2021
7. Additive manufacturing by C P Paul and A N Jinoop, first edition, McGraw Hill, 2021
8. Additive manufacturing: Fundamentals and advancements, first edition, CRC Press, 2019.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Fluid Mechanics and Pneumatics**	**Credits**	**04**
Course code	**25MEC134**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:2P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**50**	**SEA Duration**	**03**

Course objectives:

1. To learn about the basic concepts of fluid properties and to calculate the forces exerted by a fluid at rest on submerged surfaces.
2. To understand the force of buoyancy
3. To discuss the basic concepts of fluid flow measuring equipment such as venture meter, orifice meter, notches and losses in flow through pipes
4. To discuss laminar and understand the importance of dimensional analysis
5. To analyse the flow in centrifugal pumps and turbines

Pre-requisite: Calculus and differential equations, Dynamics of Rigid bodies, Numerical analysis.

Module-I: Properties of Fluids and Fluid Statics

Teaching component: **Properties of Fluids**-Introduction to fluid mechanics & its applications, properties of fluids, viscosity, surface tension, capillarity, vapour pressure and cavitation, Introduction to smart fluids and nanofluids. **Fluid Statics:** Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmosphere and vacuum pressure. Manometers, simple and differential manometers, total pressure and location of centre of pressure on horizontal/vertical/inclined plane surfaces (No derivations). **Practical Component:** 1. Measurements of pressure and pressure head by U-tube differential manometer. 2. Determination of force exerted by a jet on flat and curved vanes	Theory: 06 Lab:02	Apply

Module-2: Buoyancy, Fluid Kinematics & Dynamics

Teaching component: **Buoyancy:** Buoyancy, centre of buoyancy, meta-centre and meta-centric height, conditions of equilibrium of floating and submerged bodies. **Fluid Kinematics:** Types of fluid flow-introduction, continuity equation in three dimensions (Cartesian co-ordinate system only), velocity and acceleration, velocity potential function and stream function, Introduction to Computational Fluid Dynamics (CFD) concepts and flow visualization techniques. **Fluid Dynamics**: Introduction, equations of motion, Euler's equation of motion, Bernoulli's equation from Euler's equation, fluid flow measurements: Venturi-meter, orifice meter, Pitot tube, V-notch and Rectangular notch. Introduction to flow sensors and digital flow measurement systems **Practical Component:** • Determination of Cd for Venturimeter and Orifice meter • Determination of Cd for Rectangular and Triangular notch • Find the coefficient of discharge for the given rectangular &V notch	Theory: 06 Lab:04	Apply
Module-3: Flow through pipes and Hydraulic prime movers		
Teaching component: Laminar and turbulent flow, Reynolds number, Frictional losses in pipes, Darcy–Weisbach equation, Hydraulic gradient line (HGL) and total energy line (TEL), Hydraulic turbines: Pelton, Francis, Kaplan, Selection of turbines, Introduction to centrifugal pumps **Practical Component:** 1. To determine the coefficient of friction of a given pipe 2. Determination of efficiency of Pelton wheel / Francis turbine 3. Performance test on Centrifugal pump	Theory: 08 Lab:04	Apply
Module-4: Fluid Power Systems (Hydraulics and Pneumatics)		
Teaching component: Fluid power fundamentals, Hydraulic system components, Hydraulic pumps and cylinders, Hydraulic control valves and symbols, Pneumatic system components, Pneumatic control elements, Comparison of hydraulic vs pneumatic systems, Basic hydraulic and pneumatic circuits, Applications in industry **Practical Component:** 1. Study of hydraulic speed control circuit 2. Design and assembly of pneumatic circuit 3. Performance test on reciprocating air compressor	Theory: 08 Lab:02	Apply

Module-5: Pneumatics		
<u>Teaching component</u>: **Pneumatic System-** Basic pneumatic system, identification of standard pneumatic symbols, pneumatic control elements and components, Basic pneumatic circuits – principle of working of power operated holding devices – chuck and clamping device, applications, study on design of different pneumatics circuits and its simulation - Introduction to electro pneumatics, Applications in robotics, CNC machines and smart manufacturing systems. **Practical Component:** 1. Design and assembly of pneumatic circuit 2. Performance test on a two stage Reciprocating Air Compressor. *3.* Mini-project on industrial automation using pneumatics/electro- pneumatic	Theory: 08 Lab:02	Apply
Total		**50 Hrs**

Text Books and Reference Books
1. Fluid Mechanics F M White McGraw Hill Publications Eighth edition. 2019 2. Fluid Mechanics (SI Units) Yunus A. Cengel John M. Cimbala Tata McGraw Hill 3rd Ed., 2020. 3. A Text Book of Fluid Mechanics and Hydraulic Machines Dr R.K Bansal Laxmi Publishers 4. Hydraulics and pneumatics Andrew Par Jaico Publishing House 2019 5. Fluid Power with applications Anthony Esposito Pearson edition 2000 6. Pneumatic systems - Principles and Maintenance Majumdar S.R Tata McGraw-Hill 2005

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Machine Drawing and GD & T	Credits	03
Course code	25MEC135	CIA Marks	50
Number of Lecture Hours/Week	2L:T:2P:J	SEA Marks	50
Total Number of Lecture Hours	50	SEA Duration	03

Course Learning Objectives: The students will be able to

1. To acquire the Knowledge of CAD software and its features
2. To familiarize the students with Indian Standards on Drawing Practices
3. To impart knowledge of threads forms, Fasteners, Keys, Joints, couplings, Clutch and Brakes
4. To make students to analyse and interpret drawing of machine components to model the assembly drawing manually and using CAD package
5. To acquire the knowledge of limits, fits and tolerances and indicating them on the machine drawing as per BIS standards
6. To understand the part drawings and develop Assembly drawings of Mechanical Systems

Pre-requisite: Knowledge of mathematics and measurement process, Knowledge of sectional views and individual components identification and its working principles, Basic knowledge of different types of joints and its functions.

Module-1: Introduction to Metrology and System of Limits, Fits, Tolerance and Gauging

Introduction to Metrology: Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Accuracy, precision and errors in measurement. **System of Limits, Fits, Tolerance and Gauging:** Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances AI in Metrology & Inspection Closing the loop between the drawing and the physical part. AI-Powered Vision Systems: How AI scans a physical part and compares it to the CAD drawing (Deviation Maps). Automated CMM Programming: Using the GD&T data from the CAD model to automatically generate a path for an inspection robot.	Th+lab 4+2 hrs	Apply

Reverse Engineering: Converting AI-processed point clouds (from 3D scanners) back into parametric machine drawings.		
Module-2: Section of solids, Orthographic Projections of Machine components and Fasteners		
Drawing standards: Code of practice for Engineering Drawing, BIS specifications –Sectional views, Riveted joints, keys, fasteners –bolts, nuts, screws, keys etc. Section of Solids, (Pyramids, Prisms, Cylinder and Cones) Orthographic Projections (with and Without Section). Drawings of various views of Popular forms of Screw threads, bolts, nuts, stud bolts, tap bolts, set screws.	Th+lab 2+6 hrs	Apply
Module-3: 2-D drawings of Mechanical Assembly with sectional Views		
Shaft joints: Cotter joint and Knuckle joint. Keys & Shaft coupling: Muff, Flanged, Flexible, Universal and Oldham's coupling, Rivets: Classification: Butt, Lap (with single and double cover Plate	Th+lab 2+8 hrs	Apply
Module-4: Assembly Drawing of Mechanical Systems		
Conventional representation of surface finish, Roughness number symbol, Symbols of Machine elements. Limits, Fits – Tolerances of individual dimensions–Specification of Fits. Preparation of production drawings and reading of part and assembly drawings. Assembly Drawings - Screws jack, Plummer block, Connecting Rod, Machine Vice.	Th+lab 4+12 hrs	Apply
Module-5: Surface modelling		
The Generative Bracket Project: Generative: Students use generative design to create a lightweight mounting bracket. Reverse Engineering with AI & Simulation: Provide students with a 3D scan of a worn/broken part. Use AI tools to convert the scan to a parametric CAD model. Hybrid Manufacturing Drawings (Generative + Machining): Creating drawings for parts that are 3D printed (generative) and then CNC machined.	Th+lab 2+8 hrs	Apply

Reference Books

1. Machine Drawing –R.K Dhavan
2. Machine drawing -N.D. Bhatt., published by R.C. Patel Charotar Book Stall Tulshi Sadan, Station Road, Annad, India
3. Solidworks Tutorial by SDC publication
4. K.R. Gopalakrishna, "Machine Drawing", Subash Publishers Bangalore.
5. Machine Drawing –K.L. Narayana, P. Kannaiah & K. Venkata Reddy. New Age/ Publishers
6. Geometric Dimensioning & Tolerancing by P.S. Gill. S.K. Kataria & Sons

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Data Structure Using C	Credits	03
Course Code	25MEL136	CIA	50
Number of lecture Hours per week	2L:T:1P:1J	SEA marks	50
Total number of lecture Hours	40	SEA Duration	3

Course Objective: This course will enable students to

- Explain fundamentals of data structures and their applications essential for programming/problem solving.
- Illustrate linear representation of data structures: Stack, Queues, Lists, Trees and Graphs.
- Demonstrate sorting and searching algorithms.
- Findsuitabledatastructureduringapplicationdevelopment/ProblemSolving.

Module-1: Introduction to Data Structures		
Introduction: Data Structures, Classifications (Primitive & Non-Primitive), Data structure Operations, Review of Arrays, Structures, Self-Referential Structures, and Unions. Pointers and Dynamic Memory Allocation Functions. Representation of Linear Arrays in Memory, dynamically allocated arrays. Array Operations: Traversing, inserting, deleting, searching, and sorting. Multidimensional Arrays, Polynomials and Sparse Matrices. **Strings:** Basic Terminology, Storing, Operations and Pattern Matching algorithms. Programming Examples.	8 Hrs	Understand
Module-2: Stacks		
Stacks: Definition, Stack Operations, Array Representation of Stacks, Stacks using Dynamic Arrays, Stack Applications: Polish notation, Infix to postfix conversion, evaluation of postfix expression. Recursion - Factorial, GCD, Fibonacci Sequence, Tower of Hanoi, Ackerman's function.	8 Hrs	Apply
Module-3: Queues		
Queues: Definition, Array Representation, Queue Operations, Circular Queues, Circular queues using Dynamic arrays, Dequeues, Priority Queues.	8 Hrs	Apply
Module-4:Linked Lists		

Linked Lists: Definition, Representation of linked lists in Memory, Memory allocation; Garbage Collection. Linked list operations: Traversing, Searching, Insertion, and Deletion. Doubly Linked lists, Circular linked lists, and header linked lists. Linked Stacks and Queues. Applications of Linked lists – Polynomials, Sparse matrix representation. Programming Examples	8 Hrs	Apply
Module-5: Trees		
Trees: Terminology, Binary Trees, Properties of Binary trees, Array and linked Representation of Binary Trees, Binary Tree Traversals - Inorder, postorder, preorder; Additional Binary tree operations. Threaded binary trees, Binary Search Trees – Definition, Insertion, Deletion, Traversal, Searching, Application of Trees-Evaluation of Expression, Programming Examples	8 Hrs	Apply

Text Books:

1. Ellis Horowitz and Sartaj Sahni, Fundamentals of Data Structures in C, 2nd Ed, Universities Press, 2014.
2. Seymour Lipschutz, Data Structures Schaum's Outlines, Revised 1stEd, McGraw Hill, 2014.
3. Data Structures and Algorithm Analysis in C" by Mark Allen Weiss
4. Introduction to Algorithms" by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein

Reference Books:

1. Gilberg & Forouzan, Data Structures: A Pseudo-code approach with C, 2nd Ed, Cengage Learning, 2014.
2. Reema Thareja, Data Structures using C, 3rdEd, Oxford press, 2012.
3. Jean-Paul Tremblay & Paul G. Sorenson, An Introduction to Data Structures with Applications,2ndEd, McGrawHill, 2013
4. AM Tenenbaum, Data Structures using C, PHI,1989
5. Robert Kruse, Data Structures and Program Design in C, 2ndEd, PHI,1996.
6. Data Structures Using C" by ReemaThareja

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mathematics

Semester: IV		
Course: Complex Analysis, Probability and Optimization Techniques Course Code: 25MAM141 For ME branch)		
L:T:P:J	**2:2:0:0**	**CIA :50**
Credits:	**03**	**SEA : 50**
Hours:	**40**	**SEA Duration: 03 Hours**

Course Learning Objectives: The students will be able to

1 Provide an insight into applications of complex variables and conformal mapping arising in potential theory, quantum mechanics, heat conduction and field theory.

2 Develop the knowledge of probability, joint probability distribution and Optimization Techniques occurring in digital signal processing, design engineering and microwave engineering.

Module-1: Complex Analysis	**No. of Hours**	**Blooms cognitive Levels**
Examples from Engineering that require complex analysis. Review of function of a complex variable, limits, continuity and differentiability. Analytic functions. Cauchy-Riemann equations in Cartesian and polar forms. Consequences of Cauchy-Riemann equations (only statement), construction of analytic function using Milne-Thomson method. *Experiential Learning component: Problems on construction of analytic functions*	L: 04 T: 04	L1 L2 L3
Module-2: Probability Distributions & Joint probability distribution		
Examples from Engineering that require Probability and Joint probability distribution. **Probability Distributions:** Review of basic probability theory. Discrete and continuous Random variables, probability mass/density functions (definitions only). Binomial, Poisson, exponential and normal distributions (without proof). **Joint probability distribution:** Joint Probability distribution for two discrete random variables, expectation, covariance and correlation. *Experiential Learning component: Problems on Binomial, Poisson, Exponential and Normal distributions*	L: 04 T: 04	L1 L2 L3
Module-3: Markov Chain & Sampling Theory		
Examples from Engineering that require Markov Chain and Sampling Theory. **Markov Chain**: Introduction to Stochastic process, Probability vectors, Stochastic matrices, Regular stochastic matrices, Markov Chains, Higher transition probabilities, Stationary distribution of Regular Markov chains and absorbing states, Markovian processes. **Sampling Theory**: Introduction to sampling theory, Testing of hypothesis, level of significance, confidence limits, test of significance of mean and difference of means for large samples-z-test, test of significance of small samples-Student's t- distribution. *Experiential Learning component: Problems on Markovian processes and, Sampling Theory*	L: 04 T: 04	L1 L2 L3

Module-4: Linear Programming		
Examples from Engineering that require Linear Programming. Definition, Characteristics and phases of OR. Modelling with linear programming problem (LPP). Methods of solving LPP: Graphical method, Simplex method, Big-M method and application problems**.** *Experiential Learning component: linear programming problem (LPP)*	L: 04 T: 04	L1 L2 L3
Module-5: Transportation and Assignment Problems		
Examples from Engineering that require Transportation and Assignment Problems. Definition of transportation model, basic feasible solution by different methods (North West Corner Rule, Least Cost method and Vogel's Approximation method), optimal solution (MODI's method). Introduction to Assignment Problems and optimal solution (Hungarian method). *Experiential Learning component: Transportation and Assignment Problems*	L: 04 T: 04	L1 L2 L3

Reference Books:

1. E. Kreyszig: "Advanced Engineering Mathematics", John Wiley & Sons, 10th Edition (Reprint), 2016.
2. B. S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2017.
3. S. D. Sharma: "Operations Research", KedarNath Ram Nath & Co. Meerut, 2014.
4. T. Veerarajan: "Probability, Statistics and Random processes", McGraw Hill Education (India) Private Limited, Third edition, Nineteenth reprint 2017.
5. Operation Research an Introduction-Hamdy aTaha, Pearson Education, 8th edition, 2007.
6. B. V. Ramana: "Higher Engineering Mathematics" 11th Edition, Tata McGraw-Hill, 2010.

Web links and Video Lectures:

1. https://nptel.ac.in/courses/111106141
2. https://www.digimat.in/nptel/courses/video/111107119/L29.html
3. https://archive.nptel.ac.in/courses/122/107/122107036/
4. https://archive.nptel.ac.in/courses/105/105/105105045/
5. https://archive.nptel.ac.in/courses/111/102/111102014/
6. https://archive.nptel.ac.in/courses/111/103/111103159/

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

SEMESTER: 4		
COURSE: Block Chain and Supply Chain Management		
Course Code: 25MEC142	**L: T:P: J:**	**CIA Marks: 50**
Credits: 3	**3-0-0-0**	**SEA Marks: 50**
Hours:	**40**	**SEA Duration: 03 Hours**
Pre-Requisites: Basics of management and entrepreneurship.		
Course Learning Objectives: The students will be able to		
1	To acquaint with key drivers of supply chain performance and their inter-relationships With strategy.	
2	To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems	
3	To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances and Concept of Block Chain Technology.	
Module-1: Basics of Supply Chain Management.		
Introduction: Supply Chain – Fundamentals –Evolution- Role in Economy - Importance - Decision Phases – Supplier Manufacturer-Customer chain. - Enablers/ Drivers of Supply Chain Performance. Industry 4.0- Industrial Internet of things - Industrial Internet Architecture Framework (IIAF), Data Management. Introduction to Supply Chain Tools.	**Theory:06 Lab:02**	**Understand**
Module-2: Strategy Planning		
Strategic Sourcing Vs Outsourcing - Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy. Usage of Supply Chain Tools for strategy planning.	**Theory:06 Lab:02**	**Apply**
Module-3: Worldwide sourcing.		
World Wide Sourcing – Global sourcing- Levels of Global outsourcing- its Benefits- Challenges- Steps to a Successful global sourcing – its Benefits and its Implementation. Supply Chain Network Distribution Network Design - Role - Factors Influencing Options, Value Addition - Distribution Strategies -.	**Theory:06 Lab:02**	**Apply**

Comparison of Theoretical methods with Digital tools for worldwide sourcing.		
Module-4: Network Design and Supply Chain Integration.		
Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design decisions using Decision trees.. Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E Business in supply chain.	**Theory:06** **Lab:02**	**Apply**
Module-5: Introduction to Block Chain		
Distributed systems, History of block chain, Introduction to block chain, Types of block chain, CAP theorem and block chain, Benefits and limitations of block chain, Decentralization and Cryptography. Tokenization of Real-World Assets (RWAs), AI and Block chain Integration, Institutional DeFi Adoption, Block chain-as-a-Service (BaaS), Interoperability Solutions.	**Theory: 08**	**Understand**

Reference Books

1. Business Logistics and Supply Chain Management, Ballou Ronald H, Pearson Education, 5th Edition, 2019.
2. Designing and Managing the Supply Chain: Concepts, Strategies, and Cases, David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, Tata McGraw-Hill, 2022.

Text Books

1. Supply Chain Management- Text and Cases, Janat Shah, Pearson Education, 2016.
2. Supply Chain Management- Strategy Planning and Operation, Sunil Chopra and Peter Meindl, PHI Learning / Pearson Education, 2013.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Semester: 4		
COURSE: Block Chain and Supply Chain Management		
Course Code: 25MEC142	**L: T:P: J:**	**CIA Marks: 50**
Credits: 3	**3-0-0-0**	**SEA Marks: 50**
Hours:	**40**	**SEA Duration: 03 Hours**
Pre-Requisites: Basics of management and entrepreneurship.		
Course Learning Objectives: The students will be able to		
1	To acquaint with key drivers of supply chain performance and their inter-relationships With strategy.	
2	To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems	
3	To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances and Concept of Block Chain Technology.	
Module-1: Basics of Supply Chain Management.		
Introduction: Supply Chain – Fundamentals –Evolution- Role in Economy - Importance - Decision Phases – Supplier Manufacturer-Customer chain. - Enablers/ Drivers of Supply Chain Performance. Industry 4.0- Industrial Internet of things - Industrial Internet Architecture Framework (IIAF), Data Management. Introduction to Supply Chain Tools.	Th+lab 6+2 hrs	Apply
Module-2: Strategy Planning		
Strategic Sourcing Vs Outsourcing - Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy. Usage of Supply Chain Tools for strategy planning.	Th+lab 6+2 hrs	Apply

Module-3: Worldwide sourcing.		
World Wide Sourcing – Global sourcing- Levels of Global outsourcing- its Benefits- Challenges- Steps to a Successful global sourcing – its Benefits and its Implementation. Supply Chain Network Distribution Network Design - Role - Factors Influencing Options, Value Addition - Distribution Strategies -. Comparison of Theoretical methods with Digital tools for worldwide sourcing.	Th+lab 6+2 hrs	Apply
Module-4: Network Design and Supply Chain Integration.		
Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design decisions using Decision trees.. Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E Business in supply chain.	Th+lab 6+2 hrs	Apply
Module-5: Introduction to Block Chain		
Distributed systems, History of block chain, Introduction to block chain, Types of block chain, CAP theorem and block chain, Benefits and limitations of block chain, Decentralization and Cryptography. Tokenization of Real-World Assets (RWAs), AI and Block chain Integration, Institutional DeFi Adoption, Block chain-as-a-Service (BaaS), ***Interoperability Solutions.***	08 hrs	Apply

Reference Books
3. Business Logistics and Supply Chain Management, Ballou Ronald H, Pearson Education, 5th Edition, 2019. 4. Designing and Managing the Supply Chain: Concepts, Strategies, and Cases, David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, Tata McGraw-Hill, 2022.
Text Books
3. Supply Chain Management - Text and Cases, Janat Shah, Pearson Education, 2016. 4. Supply Chain Management- Strategy Planning and Operation, Sunil Chopra and Peter Meindl, PHI Learning / Pearson Education, 2013.

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	Mechanics of Materials	Credits	04
Course code	25MEC143	CIA Marks	50
Number of Lecture Hours/Week	3L:T:2P:J	SEA Marks	50
Total Number of Lecture Hours	50	SEA Duration	03

Course Objectives:

1. Classify the stresses into various categories and define elastic properties of materials and compute stress and strain intensities caused by applied loads in simple and compound sections and temperature changes.
2. Determine the shear force, bending moment and draw shear force and bending moment diagrams, describe behaviour of beams under lateral loads.
3. Derive the equations for principal stress and maximum in-plane shear stress and calculate their magnitude and direction. Draw Mohr circle for plane stress system and interpret this circle. Understand the concept of various stresses and its distribution in thin and thick cylinders.
4. Explain the structural behaviour of members subjected to torque, calculate twist and stresses induced in shafts subjected to bending and torsion. Understand the concept of strain energy and compute strain energy for applied loads.
5. Understand the concept of stability and derive crippling loads for columns. Analyze the failure of machine elements by various theories.

Pre-requisite: Fundamental of mechanics, basics concept of materials and its uses.

Module-I: Simple Stresses and Strain

Teaching component:		
Simple Stresses and Strain: Introduction, Definition and concept and of stress and strain. Hooke's law, Basics of Stress-Strain diagrams, Linear and non-linear elastic properties, mechanical properties in plastic range, factor of safety, Elongation of tapering bars of circular and rectangular cross sections, Elongation due to self-weight (Numericals). Compound bars, Temperature stresses, Compound section subjected to temperature stresses, Elastic constants and their relationship.	Theory:8 Lab: 2	Apply

Practical Component: • Brinell, Rockwell and Vickers's Hardness tests on untreated and heat-treated specimens • Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine		
Module-2: Shear Force and Bending Moment		
<u>Teaching component</u>: Introduction to types of beams, Definition of bending moment and shear force, relationship between load intensity, bending moment and shear force. Shear force and bending moment diagrams for statically determinate beams subjected to points load, uniformly distributed loads, uniformly varying loads, couple and their combinations. **Stresses in Beams** Bending and shear stress distributions in rectangular, I and T Section Beams. **Practical Component** 1. Bending Test on steel and wood specimens 2. Simulation of beams using finite element analysis tool for different loading condition.	Theory:8 Lab: 2	Apply
Module-3: Analysis of stress & strain (Compound Stresses-2 D Stress system) and Stresses in Cylinders		
<u>Teaching component</u>: **Compound Stresses:** Introduction, state of stress at a point, General two dimensional and three-dimensional stress system, Principal stresses in two-dimensional stress system and principal planes. Mohr's circle of stresses. **Thin and Thick Cylinders**: Introduction, Thin cylinders subjected to internal pressure; Hoop stresses, Longitudinal stress and change in volume. Thick cylinders subjected to both internal and external pressure; Lame's equation, radial and hoop stress distribution. **Practical Component:** • Simulation of cylindrical pressure vessel using finite element Model	Theory:8 Lab: 2	Apply
Module-4: Columns and strain energy methods		

Teaching component: **Columns:** Buckling and stability, critical load, columns with pinned ends, columns with other support conditions, Effective length of columns, Secant formulae for columns. **Strain Energy:** Strain energy due to axial, shear, bending, torsion and impact load. Castigliano's theorem I and II and their applications. **Practical Component** • Simulation of of buckling of columns using Solidworks • Izod and Charpy Tests on Mild steel and C.I Specimen	Theory:8 Lab: 2	Apply
Module-5: Theories of failure and Torsion of shaft		
Teaching component: **Torsion in Circular Shaft:** Introduction, pure torsion, Assumptions, derivation of torsion equation for circular shafts, torsional rigidity and polar modulus, Power transmitted by a shaft, Shaft subjected to combined bending and torsion. **Theories of Failure:** Introduction, maximum principal stress theory (Rankine's theory), Maximum shearing stress theory (Tresca's theory), Strain energy theory (Beltrami and Haigh), and maximum strain theory (St. Venant's theory), Distortion theory. **Practical Component** Torsion Test on steel bar	Theory:8 Lab: 2	Apply
Total		**40 Hrs**

Reference Books

1. Mechanics of materials", in SI Units, Ferdinand Beer & Russell Johston, 8th edition,TATA McGraw Hill- 2020
2. Strength of materials, Ramamrutham, 6th edition,2011.

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	Thermal Engineering	Credits	04
Course Code	25MEC144	CIA Marks	50
Number of Lecture Hours/ Week	3L:T:2P:J	SEA Marks	50
Total Number of Lecture Hours	50	Exam Duration	03

Course Objectives:

This course will enable the students to:

1. Introduce the fundamentals of thermodynamics
2. Model processes and systems using principles of thermodynamics
3. Analyse energy interactions and performance of thermodynamic cycles
4. Conduct performance test of IC engines

Pre-requisite: Calculus, Physics

Module-1: First Law of thermodynamics and Reversible & Irreversible Processes		
Introduction and the First Law of thermodynamics: Heat, Work and the System, State of the Working Fluid, Reversible Work, First Law of thermodynamics, Non-Flow Equation, Steady-Flow Equation. ***applications of SFEE to engineering devices*** (Numerical Problems on Non-Flow process) **Reversible and Irreversible Processes**: Reversible Non-Flow Processes, Reversible Adiabatic Non-Flow Processes, Polytropic Processes, Reversible Flow Processes, Irreversible Processes. (No Numerical Problems)	Th: Lab 8:0 Hrs	Apply
Module-2: Second Law of thermodynamics & Air standard cycles		
Second Law of thermodynamics: Heat Engine-Statements of Second Law, Carnot Cycle, Absolute Temperature Scale, Entropy: Clausius Inequality, ***Entropy Increase Principle***, T-S Diagram, Entropy and Irreversibility. (No Numerical Problems on Entropy) **Air Standard Cycles**: Carnot Cycle for a Perfect Gas, Air Standard Cycle (Otto Cycle, Diesel Cycle and Dual Combustion Cycle): Expression for Air Standard Efficiency and Mean Effective Pressure. (***No Derivations***, *Numerical on Otto cycle and diesel cycle only*.)	Th: Lab 8:0 Hrs	Apply

Module-3: IC Engines, Vapour & Gas Power cycles		
IC Engines: Performance Parameters - Calculations and its Measurement - Motoring Method, Willan's Line Method, Morse Test, Heat Balance Sheet, Engine Performance Curves. (Numerical Problems on More test and Heat balance sheet only), ***Introduction to Alternate Fuels: Biofuels, CNG and Hydrogen*** **Steam Cycles:** Rankine Cycle, Enthalpy-Entropy Chart, (Numerical problems on Rankine cycle only) **Gas Turbine Cycles** – Constant Pressure Cycle, Ideal Brayton Cycle (Numerical problems on Bryton cycle only). ***Combined Cycle Power Plant (Introduction)*** **Practical Component** • Determination of calorific value of gaseous fuels using Boy's gas calorimeter. • Assembly and Disassembly of Four Stroke Multi cylinder engine • Performance testing of single cylinder four stroke petrol and diesel engine. • Performance testing of single cylinder Variable compression ratio IC engine. *(some simple topics will be covered through student's presentation. Approximately 5% new contents are)*	Th: Lab 6:4 Hrs	Analyze
Module-4: Refrigeration, Psychometrics and Air Conditioning Systems		
Teaching Component: **Refrigeration:** Reversed Heat Engine Cycles, Vapour Compression Cycles, Refrigeration Load, Pressure-Enthalpy Diagram, ***eco-friendly refrigerants. (numerical Problems)*** **Psychrometry:** Specific and Relative Humidity of Air, Dew Point Temperature, Adiabatic Saturation and Wet Bulb Temperature, Psychometric Chart, (Numerical problems using analytical and Psychometric Chart). Summer and winter Air-Conditioning, Air-Conditioning Processes***. AI-driven HVAC energy optimization (smart building systems)*** **Practical Component** 1. Performance Testing on a Vapour Compression Refrigeration **2.** Performance Testing on Air Conditioning System	Th: Lab 8:4 Hrs	Analyze
Module-5: Heat Transfer		

Teaching Component: Definitions, Fourier Equation and Thermal conductivity, Steady State Conduction, Conduction with Heat Generation, Heat Transfer from Extended Surfaces, (Numerical Problems on Composite wall and cylinders only), Convection: Processes and Properties, Free and Forced Convection, Basics of Radiation, Classification of Heat Exchangers***. AI and Machine Learning in Heat Transfer:*** **Practical Component** 1. Determination of Thermal Conductivity of the material. 2. Determination of Overall Heat Transfer Coefficient of a Composite wall. 3. Determination of Emissivity of a Surface and Stefan Boltzmann Constant 4. Heat transfer Simulation using ANSYS software 5. Demonstration of Data logger for thermal Data Acquisition and processing *(only demonstration)*	Th: Lab 8:4 Hrs	Analyze
Total	**50 Hrs**	

Reference Books

1. Yunus Cengel and Michael Boles (2019). *Thermodynamics: An Engineering Approach*, 9th ed., McGraw-Hill Education.
2. Michael J. Moran and Howard N. Shapiro (2006). *Fundamentals of Engineering Thermodynamics*, 5th ed., John Wiley & Sons, Inc.
3. V Ganesan (2017) *Internal Combustion Engines*, 4th ed. McGraw Hill Education.
4. Incropera F. P. and DeWitt D. P. (2006). *Fundamentals of Heat and Mass Transfer*, 5th ed., John Wiley and Sons.
5. Eastop T. D. and Mcconkey A. (1993). *Applied Thermodynamics for Engineering Technologists*, 5th ed., Pearson Education, Ltd.
6. G.F.C. Rogers and Yon Mayhew (1992). *Engineering Thermodynamics: Work and Heat Transfer*, 4th ed., Pearson Education, Ltd.
7. S. K. Som (2008). *Introduction to Heat Transfer*, Prentice Hall India Pvt. Ltd.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Hybrid and Electric Vehicles**	**Credits**	**02**
Course code	**25MEC145**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**1L:T:2P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**26**	**SEA Duration**	**03**

Course objectives:

1. To understand the models, describe hybrid vehicles and their performance.
2. To understand the different possible ways of energy storage.
3. To understand the different strategies related to hybrid vehicle operation & energy management.

Module-I: Introduction to Hybrid Electric Vehicle		
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, India's dependence of Foreign fuel, Comparison between Electric Vehicle and Hybrid Electric Vehicle.	5 Hrs	Understand
Module-2: Conventional Vehicles		
Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. ***Simple Numerical***. *(solving numerical help the students to understand better)*	5 Hrs	Apply
Module-3: Hybrid Electric Drive:		
Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis	5 Hrs	Apply
Module-4: Electric Drive-trains		
Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Simple Numerical. *(solving numerical help the students to understand the contents better)*	5 Hrs	Apply

Strength of CO Mapping to PO/PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
25MEC145.1	3	3	3	-	-	3	3	-	3	3	-	3	-
25MEC145.2	3	3	3	-	-	3	3	-	3	3	-	3	-
25MEC145.3	3	3	3	-	-	3	3	-	3	3	-	3	-
25MEC145.4	3	3	3	-	-	3	3	-	3	3	-	3	-
25MEC145.5	3	3	3	-	-	3	3	-	3	3	-	3	-
AVERAGE	**3**	**3**	**3**	**-**	**-**	**3**	**3**	**-**	**3**	**3**	**-**	**3**	**-**

Module-5: Battery Management Systems and Charging station:		
Types of Battery sources, energy storage, battery-based energy storage, Battery management system. Introduction to smart charging: Grid to vehicle and vehicle to grid, smart metering and ancillary services, preliminary discussion on vehicle to vehicle and vehicle to personal communication systems, introduction battery charging station.	6 Hrs	Apply
Total		**26 Hrs**

Lab Experiments

1. Experiment to study the components of Electric Vehicle.
2. Experiment to study the power transmission in Electric Vehicle.
3. Experiment to find the Battery life of electric Vehicle.
4. Experiment to compare the performance characteristics of Electric Vehicle with I.C Engine.
5. Experiment to find the heat transmission efficiency of Electric Vehicle.

Reference Books

1. Iqbal Hussain, "Electric and Hybrid Vehicles Design Fundamentals", 1st Edition, CRC Press, 2003.
2. James Larminie, John Lowry "Electric Vehicle Technology Explained", 1st Edition, John Wiley and Sons, 2003.
3. Chris Mi, M. Abul Masrur, David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", Wiley publication, 2011.
4. Allen Fuhs, "Hybrid Vehicles and the future of personal transportation", CRC Press, 2009.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	IoT for Mechatronics System Design	Credits	02
Course code	25MEL146	CIA Marks	50
Number of Lecture Hours/Week	L:T:2P:2J	SEA Marks	50
Total Number of Lecture Hours	26	SEA Duration	03

Module 1: Measurements using Mechatronics System		
1. Introduction to the design of microprocessor-controlled electromechanical systems. 2. Study Electrical and mechanical design, prototyping, and construction and Dissection of a commercial mechatronic product. 3. To study input output characteristics of Linear Variable Displacement Transformer. 4. To study the characteristics of different types of thermocouples. 5. Study the systems and Operation of CNC as Mechatronics system. 6. Operation on Electro-pneumatic and Electro-hydraulic kits as Mechatronics system. 7. Proposed to study the characteristics of Strain Gauge.	10 Hrs	Apply
Module 2: IOT for Mechanical Components		
1. Familiarization with concept of IoT, Arduino/Raspberry Pi/ ESP Node 32/Industrial board and perform necessary software installation. 2. To interface motor using relay with Arduino/Raspberry Pi/ ESP Node 32/Industrial board and write a program to turn ON/OFF motor. 3. To interface sensor with Arduino/Raspberry Pi/ ESP Node 32/Industrial board and write a program to turn ON/OFF Starter Motor when sensor data is detected. 4. To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Linear Actuator when sensor data is detected.	8 Hrs	Apply
Module 3: Simulation of Mechatronics system		

1. Modelling and Analysis of Basic Hydraulic Systems Using MATLAB 2. Modelling and Analysis of Basic Pneumatic System Using MATLAB 3. Case study - Modeling, Simulation And Analysis Of Lung Mechanics Using MATLAB	8 Hrs	Apply
Sample Projects		
1. Develop IoT based smart lock system for Motor cycle/Car 2. Develop IoT based Smart water flow system 3. Develop IoT based home security system 4. IoT Based Humidity and Temperature Monitoring Using Arduino Uno 5. IoT Based Arduino Solenoid Door Lock using RFID 6. IoT Based Petrol Bunk Automation 7. IoT Based Smart Water Monitoring System 8. IoT Based Smart Street Light Management System 9. IoT Based Air Pollution Type Monitoring System 10. IoT Based Plant Watering System 11. IoT based traffic signal control and IoT based Engine faults		
Total: 26 Hrs		

Text Books and Reference Books

1. A. Smaili and F. Mrad, Applied Mechatronics, 2007.
2. Sedra, A. and Smith, K., Microelectronic circuits, Oxford University Press, 7th Ed, 2014.
3. R. Pallàs-Areny and J. Webster, Sensors and Signal Conditioning, Wiley, 2nd ed. 2001.
4. E. O. Doebelin, Measurement Systems Application and Design, Fifth Ed., McGrawHill, 2003.
5. John G. Webster, The Measurement, Instrumentation, and Sensors Handbook (Editor), CRC Press, 1998
6. Electrical and Electronic Measurements and Instruments Sawhney, A.K., 2003, Dhanpat Rai & Sons Pub.
7. Mechatronics Mahalik, N.P., 2003 Tata McGraw-Hill
8. Mechatronics: A multidisciplinary approach (Vol. 10) Bolton, W., 2008, Pearson Education

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Machine Design	Credits	03
Course code	25MEC151	CIA Marks	50
Number of Lecture Hours/Week	2L:2T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Pre-requisites: Mechanics of Materials

Course Objectives:

This Course will enable Students to:

1. Explain the Principles involved in design of machine elements subjected to different types of loads from the stand point of strength and rigidity considerations. Also to Understand and interpret different failure modes and application of appropriate criteria for design of machine elements, analysis of impact loading and stress concentration effect on machine elements subjected to static and fatigue loading.
2. Develop the capability to design elements such as Riveted Joints, Welded Joints, and Threaded Fasteners.
3. Design and develop various mechanical systems involving machine elements such as clutches, brakes and springs.
4. Develop capability to design Gears for power transmission.
5. Develop ability to design and select Bearings from the manufacturer's catalogue.

Module-I: Design of Mechanical Elements for Static, Impact and Fatigue Loading		
Introduction: Phases of design; Use of codes and standards, **Static Loading:** Analysis of machine components under the action of axial, bending, shear and torsional loading individually and in combination; Stress concentration, stress concentration factor. **Impact Loading:** Introduction, Impact stresses due to axial and bending. **Fatigue Loading:** Introduction to fatigue failure, mechanism of fatigue failure, types of fatigue loading, S-N Diagram, Endurance limit. Solving numerical with various types of loading condition.	8 Hrs	Apply
Module-2: Riveted & Welded Joints and Threaded Fasteners		

Riveted joints: Analysis of riveted joints, joint eco efficiency, failures of riveted joints, boiler joints, Discussion on engineering applications. **Welded joints:** Types, strength of butt and fillet welds, eccentrically loaded welded joints, Discussion on engineering applications. **Threaded Fasteners:** Stresses in threaded fasteners, design of threaded fasteners under static, design of eccentrically loaded bolted joints. Solution to various numerical	8 Hrs	Apply
Module-3: Springs, Clutches and Brakes		
Springs: Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; Leaf Springs: Stresses in leaf springs, Discussion on engineering applications. **Design of Clutches:** Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories. **Design of Brakes:** Design of band brakes, block brakes	8 Hrs	Apply
Module-4: Gears		
Spur Gears: Definitions, stresses in gear tooth: Lewis's equation and form factor, design for strength, dynamic and wear loads. **Worm Gears:** Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and eco efficiency of worm gear drives.	8 Hrs	Apply
Module-5: Bearings		
Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated and heat dissipated. **Antifriction bearings:** Types of rolling contact bearings and their applications, Ball bearings - static and dynamic load carrying capacities, equivalent bearing load, load life relationship, Discussion on engineering applications.	8 Hrs	Apply
	Total: 40 Hrs	

Reference Books:

1. Shigley's Mechanical Engineering Design Richard G. Budynas, and J. Keith Nisbett McGraw-Hill Education, 10th Edition, 2015.
2. Design of Machine Elements V. B. Bhandari Tata McGraw Hill, 4th Edition, 2016.

Design Data Hand Books:

1. Design Data Hand Book, Dr. K. Lingaiah, Suma Publication, 2006 Edition.
2. Design Data Hand Book, Dr.K. Mahadevan and Balaveera Reddy, CBS Publication, Fourth Edition, 2013.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Smart Materials and MEMS	Credits	03
Course code	25MEC152	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Course Objective:

This course will enable the students to

1. Understand the nature of smart materials and its structural applications.
2. Appreciate the principle of electrorheological fluids.
3. Recognize the damping and absorber need for controlling vibrations of smart systems.
4. Understand and develop piezo electric effect and its contribution towards smart structures.
5. Develop and design shape memory polymers and alloys understanding the crystallographic and thermal effects.

Module-I: Smart Materials and Structures		
Introduction: Definition and classification of smart material, need for smart materials, Smart structures and adaptive systems, closed loop and Open loop smart structures, Sensors, Actuators and Transducers - Applications in aerospace, automotive, robotics and biomedical fields, Introduction to AI-enabled smart monitoring systems. **Piezoelectric Materials:** Piezoelectric effect and properties, Piezoceramic and piezopolymer materials, Piezoelectric sensing and actuation principles, Piezoelectric composites and smart patches, Energy harvesting using piezoelectric materials, Flexible and wearable piezoelectric sensors. **Characteristics of Natural structures**: Characteristics of natural structures, Fiber reinforced organic matrix natural composites, Natural ceramers, Mollusks and bio-inspired structures, Biomimetic sensing, Challenges and opportunities in biomimetics, Bio-inspired robotics and smart sensing applications.	8 Hrs	Understand/ Apply
Module-2: Shape Memory Alloys Fiber Optics		

Shape Memory Alloys: Shape memory effect and pseudoelasticity, Applications of shape memory alloys, Stress-temperature relationship and phase transformation, Modelling of shape memory behaviour, Vibration and structural control using SMAs, Design considerations for SMA-based systems, Embedded NiTiNOL actuators and smart adaptive devices, SMA applications in soft robotics and aerospace morphing structures. **Fiber Optics:** Introduction, Physical Phenomenon of optical transmission, Characteristics of optical fibers, Fiber optic strain sensors, Optical fibers as load bearing elements, Crack detection, Temperature and Pressure measurement applications, Fiber Bragg Grating (FBG) sensors and structural health monitoring.	8 Hrs	Understand/ Apply
Module-3: ER and MR Fluids and Vibration Absorber		
ER and MR Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Applications of ER and MR fluids - Clutches, Dampers, others. **Vibration Absorber:** Un-damped vibration absorber, Parallel damped vibration absorber, Analysis vibration absorbers, Gyroscopic vibration absorbers, Active vibration absorbers, Smart and adaptive vibration control systems.	8 Hrs	Understand/ Apply
Module-4: Micro Electro Mechanical Systems & Polymer MEMS		
Introduction: History of MEMS, Intrinsic characteristics, MEMS applications, Internet of Things (IoT) enabled MEMS devices**,** Materials for MEMS. **Microfabrication:** Photolithography, Thermal oxidation, Thin film deposition, Etching. Microelectronics fabrication process flow, Silicon based, 3D microfabrication and nanofabrication concepts**,** Process selection and design. **Polymer MEMS:** Introduction, Polymers in MEMS (Polyimide, SU8, LCP, PDMS, PMMA), Applications: Acceleration, Pressure, Flow, Tactile sensors, Wearable and flexible MEMS sensors	8 Hrs	Understand/ Apply
Module-5: Microfluidics and **Case studies on MEMS**		
Microfluidics: Motivation for microfluidics, Biological concepts in microfluidics, Design and fabrication of selective components, Microchannels and valves, Lab-on-chip and biomedical, diagnostic systems. **Case studies on MEMS:** MEMS Magnetic actuators, MEMS magnetic actuators, Blood pressure (BP) sensors, MEMS microphones, Acceleration sensors, MEMS gyroscopes, MEMS applications in drones, smartphones and healthcare devices.	8 Hrs	Understand/ Apply
Total		**40 Hrs**

Text Books				
Sl. No.	**Title**	**Author**	**Publication**	**Edition**
1	Smart Material Systems and MEMS	Vijay K. Varadan	John Wiley & Sons	2006
2	Smart Materials and Structures	M.V. Gandhi and B.S. Thompson	Chapmen & Hall, London	1992
3	Foundation of MEMS	Chang Liu	Pearson Education	2000

Reference Books				
Sl. No.	**Title**	**Author**	**Publication**	**Edition**
1	Smart Structures Theory	Inderjit Chopra Jayant Sirohi	Cambridge University Press	2013
2	Smart Structures –Analysis and Design	A.V. Srinivasan	Cambridge University Press, New York	2001
3	Piezoelectric actuators: control applications of smart materials	Seung- Bok Choi & Young-Min Han	CRC Press	2010
4	Piezoelectric transducers and applications	Antonio Arnau	Springer	2004
5	Shape Memory Alloys: Modelling and Engineering Applications	Dimitris C. Lagoudas	Springer	2008
6	Shape memory alloys for biomedical applications	T. Yoneyama & S. Mayazaki,	CRC Press	2009
7	Electroactive polymers for robotics applications	Kwang J. Kim & S. Tadokoro	Springer	2007

Department of Mechanical Engineering

Course Name	Kinematics and Dynamics of Mechanical System	Credits	04
Course Code	25MEC153	CIA	50
Number of lecture hours per week	3L:T:1P:1J	SEA marks	50
Total number of lecture hours	50	Exam hours	3

Course Objective:

1. To understand the concept of machines, mechanisms and to analyze a mechanism for displacement, velocity and acceleration at any point in a moving link.
2. To understand the theory of gears, gear trains and belt drives.
3. To understand the analysis of displacement, velocity and acceleration of links of mechanism by graphical and instantaneous methods. To understand the method of generation of cam profiles for different types of motion of followers for various types of cams and followers
4. To understand the force-motion relationship in components subjected to external forces and analysis of standard mechanisms
5. To understand the undesirable effects of unbalances resulting from prescribed motions in mechanism. To understand the principles in mechanisms used for speed control and stability control.

Module-1: Introduction to Kinematic and Mechanism		
Introduction: Definitions: link or element, kinematic pairs, degrees of freedom, Grubler's criterion (without derivation), kinematic chain, mechanism, structure, machine, mobility of mechanism, Grashoff's criterion, inversion. **Kinematic Chains and Inversions**: Inversions of four bar chain; single slider crank chain and double slider crank chain. **Mechanisms**: Quick return motion mechanisms - Whitworth mechanism, crank-&-slotted lever mechanism, intermittent motion mechanisms – Geneva mechanism, ratchet-&-pawl mechanism; toggle mechanism; Davis & Ackerman steering gear mechanism. **Lab Experiment:** 1. Slider crank mechanism using Linkage software 2. Wiper mechanism using Linkage software	10 Hrs	Apply
Module-2: Gear Trains and Belt Drives		
Gear Trains: Simple gear trains, compound gear trains for large speed reduction, epicyclic gear trains, algebraic and tabular methods of finding velocity ratio of epicyclic gear trains. **Belt Drives**: Flat belt drive, ratio of belt tensions, centrifugal tension, power transmitted. Belt thickness and width calculations, selection of V-belts.	10 Hrs	Apply
Module-3: Velocity and Acceleration Analysis of Mechanisms and Cams		

Velocity and Acceleration Analysis of Mechanisms (Graphical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing. Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method. **Cams:** Classification of cams, Types of followers, Cam nomenclature, Follower motions and motion analysis, of SHM, Motion with uniform acceleration and deceleration, uniform velocity, cycloidal motion, Cam profile with offset knife edge follower, roller follower, flat faced follower.	10 Hrs	Analyze
Module-4: Static and Dynamic force analysis		
Static Force Analysis: Static equilibrium, analysis of four bar mechanism, slider crank mechanism, shaper mechanism. **Dynamic Force Analysis**: D'Alembert's principle, analysis of four bar and slider crank mechanism, shaper mechanism.	10 Hrs	Analyze
Module-5: Balancing and Gyroscope		
Balancing: Static and dynamic balancing of rotating masses, force balancing of four bar linkage, Primary and Secondary balancing of reciprocating engine. **Gyroscopes**: Angular velocity, angular acceleration, gyroscopic couple, gyroscopic effect on airplanes, ships, stability of four-wheel and two-wheel automobiles. **Lab Experiment:** 1. Balancing of rotating masses 2. Gyroscope **Lab Experiment:** 1. Spring Mass System 2. Single Rotor Undamped/ Single Rotor Damped 3. Double Rotor undamped 4. Whirling of shaft	10 Hrs	Apply

Sample Project
Self-Balancing system using Gyroscope
Robot Gripper
Pole Climbing Robot
Six bar slider crank hammer mechanism
Robotic Arm

TEXT BOOKS:

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., 4th Edition, 2014.

2. Mechanical Vibrations (English) 8th Edition, G. K. Grover, Nem Chand and Brothers,2015.

REFERENCE BOOKS:

1. Theory of Machines & Mechanisms, Uickers, J.J., Pennock G.R. & Shigley J.E, SI Edition, 3rd Edition, OXFORD University Press, 2017.

2. Theory of Machines, Thomas Bevan, 3rd Edition, Pearson Education Ltd, 2018.

3. Kinematics & Dynamics of Machinery, Robert L. Norton, McGraw Hill, 2015.

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Department of Mechanical Engineering

SEMESTER – V

AI & ML for Mechanical Engineers

Credit: 03

Course Code	**25MEC154**	**CIA Marks**	**50**
Teaching Hours/Week (L: T: P: J)	**2L:0T:1P:1J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Learning Objectives:

This course will enable students to

1. Gain a historical perspective of AI and familiar with basic principles
2. Understand the basic theory underlying ML and differentiate supervised, unsupervised and reinforcement learning
3. Understand the basic concepts of learning and decision trees.
4. Understand Bayesian techniques for problems appear in machine learning
5. Perform statistical analysis of machine learning techniques.

Module-1		
Introduction to AI: The Foundation of AI, History of AI and the State of the Art, Intelligent Agents, foundation and sub area of AI, Industrial AI applications, current trend and development of AI. Introduction to Industry 4.0. **Problem solving:** State Space Search and Control Strategies. **Practical Component:** 1. Implement Breadth First Search 2. Implement Depth First Search 3. Implement A* Algorithm	8 Hrs	Apply
Module-2		
Machine learning Landscape: what is ML?, Why use ML?, Types of ML, Main challenges of ML. Decision Tree Representation, Appropriate Problem for Decision Tree Learning. k-Nearest Neighbor Learning, Locally Weighted Regression, Linear and Polynomial Regression, Radial Basis Functions. **Practical Component:** 1. Implement a Naïve Bayes classification model using Python to classify machine conditions as healthy or faulty based on vibration and temperature data. 2. Build a Decision Tree model using Python to predict tool wear conditions using machining parameters such as cutting speed, feed rate, and depth of cut. 3. Implement the K-Means clustering algorithm using Python to group similar vibration patterns in rotating machinery data.	8 Hrs	Understand

Module-3		
AI for Product Design and Computational Analysis AI in Product Design and Concept Generation, CAD Automation using AI AI-Based Design Optimization, Simulation and Computational Analysis using AI, AI for Material Selection and Structural Analysis, Applications in Mechanical Product Development. **Practical Component:** 1. Product Design Parameter Prediction using Linear Regression 2. Stress Analysis Data Visualization 3. AI-Based Material Selection System	8 Hrs	Apply
Module-4		
AI for Manufacturing Automation AI-Assisted CNC Programming, Automatic Toolpath Generation using AI Intelligent Machining Parameter Selection, Optimization of Cutting Speed, Feed, and Depth of Cut, AI-Based Toolpath Simulation and Verification. **Practical Component:** 1. AI-Based Toolpath Recommendation System 2. CNC G-Code Suggestion Program 3. Tool Selection System using AI	8 Hrs	Analyze
Module-5		
AI for Maintenance Engineering, Quality Control and Documentation AI Applications in Maintenance Engineering, Predictive Maintenance Prompts for AI Models, AI-Based Maintenance Scheduling, AI for Quality Monitoring Writing Non-Conformance Reports (NCR) using Prompts, Generating Inspection Checklists Based on Part Design, AI-Generated Maintenance Checklists and Schedules **Practical Component:** 1. Preventive Maintenance Schedule Generator 2. Predictive Maintenance Prompt Generator 3. Machine Fault Detection using Decision Tree 4. AI-Based Cost Estimation System 5. Digital Maintenance Logbook Generator	8 Hrs	Analyze

Text Books / Reference Books:

1. Saroj Kaushik, Artificial Intelligence, Cengage Learning, 1st Edition 2011.
2. Anindita Das Bhattacharjee, "Practical Workbook Artificial Intelligence and Soft Computing for beginners, Shroff Publisher-X team Publisher.
3. Yuxi (Hayden) Liu, "Python Machine Learning by Example", Packet Publishing Limited, 2017.
4. Tom Mitchell, Machine Learning, McGraw Hill, 2017.
5. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2011.

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Department of Mechanical Engineering

Semester: V		
Subject Code: 25MEL155		
COURSE: DRONE TECHNOLOGY		
Number of Lecture Hours/ Week	**2L: T:1P: 1J:**	**CIA Marks: 50**
Credits:	**03**	**SEA Marks: 50**
Total Hours:	**44**	**SEA Duration: 3 Hours**
Pre-Requisites: Statics and Dynamics		
Course Learning Objectives: The students will be able to		
1.	Impart fundamental knowledge of the electronics industry and drone technology including types, nomenclature, configurations and real-world applications.	
2.	Develop understanding of aerodynamic principles, forces of flight, principal axes of rotation and quadcopter flight dynamics.	
3.	Enable students to identify and explain propulsion systems, key hardware components and use drone simulation techniques effectively.	
4.	Familiarise students with drone battery systems, safety protocols, pre/in/post-flight checklists and the regulatory framework for drone operations in India.	
5.	Equip students with knowledge of on-board sensors, maintenance procedures, systematic testing methodologies and safe hands-on drone flying practice.	
MODULE 1 -- Introduction and Classifications of Unmanned Aerial Vehicle (UAV)/Drones		
Historical references of anCIAnt flight concepts (IKS), Evolution of Drone/UAV technology, Introduction to Drones: types (fixed, rotary, hybrid) and applications, Drone classification by weight category (as per Drone Rules 2021), Building blocks of the Drone system and subsystem, Drone components and its function: frame, motors, propellers, ESC, flight controller, battery, basic Sensors (accelerometer, magnetometer (compass), barometer, GPS), camera, Drone transmitter and receiver, Drone software and firmware, Principles of flight: lift, thrust, drag, weight, the axis of drone motion (pitch, roll, and yaw), aerodynamic principles that enable flight, Regulations and safety: Drone flying rules, regulations and their safety precautions (as per Drone rules 2021) governed by DGCA India.	8Hrs	Apply
MODULE 2-- Drone Motors, Power Systems, and other components		

Motor: Brushless motor, motor specification, thrust-to- weight ratio, KV ratings and motor selection based on application, Electronic Speed Controllers (ESC): working principle and specification, Flight controller: Introduction and working principle, Power Management: batteries, calculation of flying time based on battery capacity, the power distribution board Propellers and its type Frames and its type, 2.5 Sensors in the drone (Gyroscope, Accelerometer, Magnetometer Barometer, GPS, Temperature Sensor)	8 Hrs	Apply
MODULE 3 -- Drone assembly, operation and maintenance		
Component Selection: Frame, Motor, Propeller, Power distribution board, Battery, Flight controllers, Transmitter and Receiver, Cameras, and Sensors (Accelerometer, Magnetometer (Compass), Barometer), Assembly and Integration: Basic wiring and soldering, assembling components into a functional Drone, Procedure for Drone operation, 3Applications: Drones in agriculture, construction, logistics, military and cinematography.	8 Hrs	Analyze

Laboratory Component:

Sl. No	Title of the Experiment	Number Of hours	Blooms Level
1.	Preparation of a report/chart on the history of flight and illustrate the evolution timeline of UAV technology till date	**2**	**Apply**
2.	Exploration of Digital sky platform	**2**	**Apply**
3.	Identification of zones (Red,Yellow,Green) by using Airspace map for any district and area near the airport	**2**	**Apply**
4.	Preparation of a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021	**2**	**Apply**
5.	Identification of mechanical components in drones, and describe their specifications and functions	**2**	**Analyze**
6.	Identification of electrical components in drones, describing their specifications and functions	**2**	**Analyze**
7.	Identification of electronic components in drones, describing their specifications and functions	**2**	**Analyze**
8.	Assemble the quadcopter Drone using the given components	**2**	**Create**
9.	Configuration and operation of Drone transmitter and receiver	**2**	**Create**
10.	Test the assembled drone	**2**	**Create**

Reference Books:

Sr. No.	Author	Title	Publisher/ ISBN Number
1.	Ms. Dharma Nar, Rd. Radhika Kutcha	Drone Technology for Beginners: Learn | Build | Fly Drones	Drone School India and Anne Books Pvt Ltd
2.	Aulik Triatic	Drone Technician Theory	Arahant Publications India Ltd
3.	Terry Kelby, Belinda Kelby	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Shroff Publishers & Distributors Pvt. Ltd, ISBN : 978-9355428899
4.	Gravity Pandya	Basics of Unmanned Aerial Vehicles : Time to start working on Drone Technology	Notion Press Media Pvt Ltd, Chennai, ISBN : 978-1637453865
5.	Dr Raja Mogilev Amirisetty	The Drone Law In India	Gogia Law Agency , ISBN : 978-8193978559
6.	David McGriffy	Make: Drones - Teach an Arduino to Fly	Shroff Publishers & Distributors Pvt. Ltd, ISBN : 978-9355425188
7.	Mr. I.V.S.Yeswanth & Dr. A.V.S.Sridhar Kumar	Fundamentals of Drone Technology	Authors Click Publishing, ISBN : 978-9366652450
8.	Anderson, John D.	Fundamentals of Aerodynamics	McGraw-Hill Education
9.	Beard R.W., McLain T.W.	Small Unmanned Aircraft: Theory and Practice	Princeton University Press
10.	Marques P., Da Ronch A. (Eds.)	Advanced UAV Aerodynamics, Flight Stability and Control	Wiley

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Department of Mechanical Engineering

Course Name	Data Analytics	Credits	03
Course code	25MEC161	CIA Marks	50
Number of Lecture Hours/Week	2L:0T:2P:0J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objective:

1. To introduce students to the fundamental concepts and techniques of data analytics.
2. To equip students with the knowledge to apply statistical and computational methods to analyze data.
3. To provide practical exposure to data cleaning, visualization, and interpretation using real-world datasets.
4. To enable students to use data analytics tools relevant to mechanical engineering applications.
5. To develop basic project skills in data-driven problem solving.

Module-1: Introduction to Data Analytics		
Introduction to Data-Driven Decision Making Introduction to Data Analysis - Analytics, Types of Analytics, Analytics Process Model, Analytical Model Requirements. Data Analytics Life Cycle overview. Basics of data collection, sampling, preprocessing and dimensionality reduction. **Practical Component:** • Sampling techniques using manufacturing production data • Missing value treatment in machine sensor datasets • Dimensionality reduction for mechanical process parameters	8 Hrs	Understand
Module-2: Statistical Measures in Data Analytics		
Descriptive statistics - Measures of central tendency and dispersion, Association of two variables - Discrete variables, Ordinal and Continuous variable, Probability calculus - probability distributions, Inductive statistics - Point estimation, Interval estimation, Hypothesis Testing - Basic definitions, t test, Correlation Analysis, Point and Interval Estimation **Practical Component:** • Statistical analysis of surface roughness and machining parameters • Hypothesis testing on tensile strength of engineering materials • t-test implementation for comparing machining conditions	8 Hrs	Apply

• Correlation analysis between cutting speed and tool wear • Probability distribution analysis of manufacturing defects • Point and interval estimation for production quality measurements		
Module-3: Predictive and Descriptive Analytics		
Introduction to Predictive and Descriptive Analytics, Overview of Machine Learning Techniques, Supervised Learning concepts and workflow, Classification techniques and performance measures, Naïve Bayes Classifier and probabilistic prediction, Regression Analysis for predictive modeling, Unsupervised Learning concepts, Clustering techniques and applications, Hierarchical Clustering using Agglomerative Algorithm, Partitional Clustering using K-Means Algorithm, Cluster evaluation methods, and applications of predictive analytics in real-world problems. **Practical Component:** • Regression analysis for predicting surface roughness • Hierarchical clustering for machine condition monitoring • Model evaluation and accuracy comparison for mechanical datasets • Mini predictive analytics project on industrial machine data	8 Hrs	Apply
Module-4: Data Collection and Pre-processing		
Teaching component: Introduction to Data Collection and Preprocessing, Types of Data Sources: Structured, Semi-Structured and Unstructured Data, Data Acquisition Methods from Databases, APIs, CSV Files and Web Sources, Data Cleaning Techniques, Handling Missing Data using Deletion and Imputation Methods, Detection and Removal of Outliers, Identification and Elimination of Duplicate Records, Data Integration from Multiple Sources, Data Transformation Techniques, Feature Scaling Techniques using Min-Max Scaling and Standardization, and importance of preprocessing in Machine Learning and Data Analytics. **Practical Component:** • Data acquisition from CNC machine sensor datasets • Collection of manufacturing data from CSV and IoT devices • Missing value handling in industrial maintenance records • Outlier detection in vibration and temperature datasets • Feature scaling and normalization of machining parameters • Data integration from multiple manufacturing sources • Preprocessing of predictive maintenance datasets using Python	8 Hrs	Apply
Module-5: Exploratory Data Analysis (EDA) (8 Hours)		
Teaching component: Introduction to Exploratory Data Analysis (EDA), Importance of EDA in Data Analytics, Data Visualization Techniques, Histograms for frequency distribution		

analysis, Boxplots for outlier detection and spread analysis, Scatter Plots for identifying relationships between variables, Heat maps for correlation visualization, Univariate Analysis for single variable interpretation, Bivariate Analysis for studying relationships between two variables, Multivariate Analysis. Correlation Analysis using Pearson correlation coeffiCIAnt, Covariance Analysis, and interpretation of patterns and trends in datasets. **Practical Component:** • Histogram analysis of machining parameter distribution • Boxplot analysis for defect and outlier identification • Scatter plot analysis between feed rate and surface roughness • Heat map visualization of machine sensor correlations • Univariate analysis of production quality parameters • Bivariate analysis of cutting speed versus tool wear • Multivariate analysis using manufacturing datasets • Complete EDA case study on predictive maintenance data using Python tools	8 Hrs	Apply
Total		**40 Hrs**

Sl. No.	Title of the Book	Name of the Author/s	Publisher Name	Edition and Year
1	Data Analytics: The Beginner's Guide to Data Analysis, Data Science, and Big Data	Anil Maheshwari	McGraw Hill Education	2nd Edition, 2021
2	Data Mining: Concepts and Techniques	Jiawei Han, Micheline Kamber, Jian Pei	Elsevier / Morgan Kaufmann	4th Edition, 2022
3	Practical Statistics for Data Scientists	Peter Bruce, Andrew Bruce, Peter Gedeck	O'Reilly Media	2nd Edition, 2020
4	Python for Data Analysis	Wes McKinney	O'Reilly Media	3rd Edition, 2022
5	Introduction to Machine Learning with Python: A Guide for Data Scientists	Andreas C. Müller, Sarah Guido	O'Reilly Media	1st Edition, 2017

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Department of Mechanical Engineering

Course Name	Engineering Project Management and Finance	Credits	03
Course code	25MEC162	CIA Marks	50
Number of Lecture Hours/Week	2L:2T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objective:

- To provide basic knowledge of project planning and decision making in project management.
- To help students to understand the project risk assessment process.
- To facilitate students to develop their acumen in managing multiple project constraints
- To provide basic understanding of financial management.
- To acquaint students with various sources of project finance

Module-1: Project Planning		
Project Initiation: Generation of Ideas & Preliminary Screening of Project Ideas, Project Life Cycle: w/ Real time example, Monitoring Enterprise Environment Factors, Corporate Appraisal & Preliminary Screening, Project Stakeholder(s) and Governance, Define High level Project Objectives & Scope Statement, Draft Project Charter & Stakeholder Register, **Project Management & Organization**: Definition and key components of project management process, Project Management Office (PMO) & Roles and Responsibilities, Developing a detailed Project Management Plan, Organization of Project Management (OPM), Functional Organization – Weak, Balanced, Strong Organization, Estimating & Resource Planning, Capital Budgeting: Covering its concepts, objectives, phases, levels of decision-making, Corporate Appraisal, Regulatory framework for Projects, Vendor Sourcing Selection & Contracts Management, Scope Creep, Impact on Project Planning, Introduction to SWOT analysis, Managing People Problems on Your Team, Manage Conflicts in Projects.	8 Hrs	Understand
Module-2: Project Risk Assessment		
Project Risk Assessment: Types & Measures of Risk, Risk Assessment Tools: Risk matrix and Monte Carlo simulation basics, Risk Response Planning (Mitigation, Avoidance, Transfer, Acceptance), Risk Contingency planning and Mitigating project risks, Risk Analysis in Practice, Selection of Projects under risk, Basic Introduction to: Sensitivity Analysis, Scenario analysis,	8 Hrs	Apply

Decision Tree analysis, Risk Monitoring and Control – legal compliance, demands from external stakeholders, government & environmental regulations, Enterprise Environmental Factors		
Module-3: Multiple Project Constraints		
Project Execution: Leading and Motivating Project Teams, Coordinating Resources, Communication Plans & Stakeholder Management, Quality Control and Assurance, Adhering to the project plan **Project Monitoring and Control:** Tracking plan progress against project management plan, Monitor the overall health and project performance baselines, Managing change requests & recommending corrective actions, Using dashboards for tracking project progress, **Project Closure & Handoff:** Deliverables handoff and final reports, Post-project evaluation and lessons learned, Celebrating successes and recognizing teams, Conduct post project reviews with key stakeholders	8 Hrs	Apply
Module-4: Introduction to Project Finance		
Meaning and objectives/ goals of Financial Management; Functions of Financial Management; Interface of Financial Management with other functional areas. Time value of money – Simple interest & Compound interest, Future value of cash flow; Present value of cash flows(Theory).	8 Hrs	Understand
Module-5: Project Finance and Project Review		
Teaching component: Financial Analysis: Estimation of cost of project and means of financing, Project cash flows: Appraisal criteria: Net Present Value – benefit cost ratio – internal rate of returns urgency – payback period – accounting rate of returns – investment appraisal in practice. Project Review and Administrative Aspect of Project (Theory) **Self- Study –** Project Financing in India: norms and policies of financial institutions, Schemes of assistance, steps in project appraisal by financial institutions.	8 Hrs	Apply
Total		**40 Hrs**

Sl . No.	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Project Planning: Analysis, Selection, Implementation and Review	Prasanna Chandra	7/e, TMH	2011
2	Project Management and Control	Narendra Singh	HPH	2003
3	Project Management	Bhavesh M. Patel	Vikas Publication	2/e
4	Project Management for Business and Technology: Principles and Practice	Nicholas, John M	Pearson	2/e
5	Project Management: The Managerial Process	Gray& Larson	Tata McGraw-Hill	4/e, 2011.

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Department of Mechanical Engineering

Course Name	CIM and Robotics	Credits	03
Course code	25MEC163	CIA Marks	50
Number of Lecture Hours/ Week	2L: T:2P:1J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objectives:

This course will enable the students to

1. To familiarize students with Computer Integrated Manufacturing (CIM) concepts and computerized elements used in automated manufacturing systems
2. To provide knowledge on Flexible Manufacturing Systems (FMS) and Lean Manufacturing principles, including system components
3. To introduce the control systems, kinematics along with mathematical tools required for analysing robot motion and transformations.
4. To provide knowledge on Robot Operating System (ROS), robot programming using Python/C++, and robot simulation techniques for developing, controlling, and testing robotic systems in virtual environments.
5. To impart knowledge on PLC programming techniques, industrial control systems, SCADA architecture, and industrial communication protocols used in modern automation and process control applications.

Module-1: Introduction to Computer Integrated Manufacturing		
Introduction to CAD and CAM, Manufacturing Planning, Manufacturing control, Concurrent Engineering, CIM concepts – Computerised elements of CIM system, Types of production, Manufacturing models and Metrics, Mathematical models of Production Performance, Simple problems, Manufacturing Controls, Simple Problems, Basic Elements of an Automated systems, Levels of Automation, Lean Production and Just-In Time Production	8 Hrs	Apply
Module-2: Flexible Manufacturing System (FMS) and Lean Manufacturing		
Physical Components of an FMS. Types of Flexibility, Layout Considerations: Linear Single Machine Layout, Circular Machine Layout, Cluster Machine Layout, Loop Layout; Operational Problems of FMS. Benefits of FMS, Industrial Applications of FMS Systems. Lean Manufacturing: Definition, Principles of Lean Manufacturing, Characteristics of Lean Manufacturing, Value of Product, Continuous Improvement, Focus on Waste, Relationship of Waste to Profit, Four Functions of	8 Hrs	Apply

Lean Production, Performance Measures, The Supply Chain, Benefits of Lean Manufacturing.		
Module-3: Industrial Robotics		
Introduction to industrial robotics, Actuators, Sensors & End-Effectors, Drive systems: electric, pneumatic, hydraulic, Servo vs. stepper motors in robotics, Proximity, force/torque, vision, and tactile sensors, Wrist & Gripper Subassemblies, Robot Performance Parameters, Robot Control System. Forward kinematics: position and orientation, Inverse kinematics: analytical and numerical methods, Introduction to robot dynamics and Jacobian matrix, Trajectory planning: point-to-point and continuous path, Numerical.	8 Hrs	Apply
Module-4: Robot programming, Simulation and ROS		
Introduction to Python/C++ programming in ROS, publisher and subscriber concepts, writing simple publisher and subscriber nodes, services and client programming, debugging tools. Introduction to robot simulation, advantages of simulation, simulation tools overview. Creating simple robot models, importing robot models, sensors and actuators in simulation, wheel and joint control. ROS concepts, ROS distributions, ROS architecture, nodes, master, topics, messages, services, packages, workspaces, ROS file system, ROS command-line tools.	8 Hrs	Apply
Module-5: PLC and SCADA for Industrial Communication		
PLC Programming and Control Systems: PLC programming methods, ladder logic programming, functional block diagrams and sequential function charts, timers, counters and arithmetic functions, data handling and program organization, motor control using PLC. SCADA Systems and Industrial Communication: Introduction to Supervisory Control and Data Acquisition (SCADA), SCADA architecture and components, Human Machine Interface (HMI), data acquisition systems, real-time monitoring and control, industrial communication protocols including Modbus, Profibus, Ethernet/IP and OPC, networking in industrial automation	8 Hrs	Apply
Total Hours	**40**	

Text Books:

[1]. CAD CAM CIM by P Radhakrishnan, S Subramanyan, V Raju, New Age International Publishers, Fifth Edition.

[2]. Automation, Production Systems and computer integrated manufacturing, 10th Edition, Pearson publications.

[3]. Mastering CAD/CAM by Ibrahim Zeid, 2018 Edition, McGraw Hill Publications.

[4]. PLCS & SCADA - Theory and Practice, Prof. Rajesh Mehra and Er. Vikrant, Laxmi Publications Private Limited, 978-9381159118.

[5]. Introduction to Robotics- John J. Craig, Addison Wesley Publishing, 3rd edition, 2010.

Reference Books:

[1]. Principles of Computer Integrated Manufacturing, S. Kant Vajapayee, Prentice Hall of India.

[2]. Lean Manufacturing Systems and Cell Design, J.T. Black (Author), Steve L. Hunter, Society of Manufacturing Engineers, 2004.

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Department of Mechanical Engineering

Course Name	**Finite Element Analysis**	**Credits**	**04**
Course code	**25MEC164**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**2L+2T+1P+1J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course Objective:

This course will enable the students to

1. To learn theory and basic principles of finite element analysis procedure.
2. To apply the concepts of finite elements analysis in finding the solutions to structural problems.
3. To apply finite element concepts to analyse the members under torsional loads.
4. To develop the knowledge and skills needed to use the finite element methods in the field of fluid mechanics and heat transfer.
5. To learn and apply finite element concepts to dynamic problems.

Module-I: Introduction to FEM		
Teaching Component: Introduction: General description of the finite element method, Engineering applications of finite element method, Boundary conditions: homogeneous and nonhomogeneous problems, Displacement method of finite element formulation. Convergence criteria, Discretisation process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, Interpolation models: Simplex, complex and multiplex elements, Introduction to Computer-Aided Engineering (CAE) and Multiphysics simulation.	8 Hrs	Understand & Apply
Module-2: Analysis of Bars and Trusses		
Teaching Component: Linear interpolation polynomials in terms of local coordinate's for1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), 2D isoparametric element, Lagrange interpolation functions, Introduction to adaptive meshing and mesh quality assessment, Generative design and topology optimization techniques, Error estimation and adaptive refinement methods.	8 Hrs	Analyze

Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses. **Practical Component:** 1. Analysis of Bars of constant cross section area, tapered cross section area and stepped bar. 2. Stress Analysis of Truss elements.		
Module-3: Analysis of Beams and Shafts		
Teaching Component: Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load. Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts. **Practical Component:** 1. Finite element analysis of Beams -Simply supported, cantilever, beams with UDL, and beams with varying load etc. 2. Finite element analysis of Torsion of shafts.	8 Hrs	Analyze
Module-4: Analysis of Heat Transfer and Fluid flow		
Teaching Component: Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored in solid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections and straight fins. Introduction to coupled thermal-structural analysis, Heat transfer applications in battery thermal management systems. Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic networks. Multiphysics analysis involving thermal, structural and fluid coupling, Introduction to fluid-structure interaction (FSI***).*** **Practical Component:** Thermal Analysis -2D, 3D problem with conduction and convection boundary conditions Fluid flow Analysis -Potential distribution in the 2 –D and 3-D bodies.	8 Hrs	Analyze
Module-5: Dynamic Analysis		

Dynamic Considerations: Formulation for point mass and distributed masses, Consistent element mass matrix of one-dimensional bar element, truss element, axisymmetric triangular element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications of bars, stepped bars, and beams. Biomechanics and Advanced Applications: FEM applications in biomechanics, Stress analysis of orthopedic implants and bone structures, Introduction to topology optimization and digital twin concepts, Additive manufacturing considerations in FEM. **Practical Component:** Dynamic Analysis to find: a) Natural frequency of beam with fixed – fixed end condition. b) Response of beam with fixed – fixed end conditions subjected to forcing function. Biomechanical Stress Analysis of a Human Femur Bone Using ANSYS**.**	8 Hrs	Analyze
Total		**50 Hrs**

Reference Books

1. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2019.
2. Chandrupatla T. R., Finite Elements in engineering, 4th Edition, PHI, 2017.
3. Fagan M. J., Finite Element Analysis, Theory and Practice, Pearson Education Ltd.
4. Logan D.L., A first course in the finite element method, 6th Edition, 2023.

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Department of Mechanical Engineering

Course Name	Generative AI for Engineering Design	Credits	03
Course code	25MEC1651	CIA Marks	50
Number of Lecture Hours/Week	3L:0T:0P:0J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objective:

1. To introduce the fundamentals of Artificial Intelligence and Machine Learning techniques used in mechanical and manufacturing industries.
2. To understand AI-based predictive maintenance methods for fault diagnosis, condition monitoring, and reliability improvement of mechanical systems.
3. To study AI applications in quality control, defect detection, process optimization, and intelligent inspection systems.
4. To develop knowledge of AI-assisted engineering documentation, automated reporting, and industrial data management techniques.
5. To familiarize students with modern AI tools, smart manufacturing concepts, and Industry 4.0 applications in mechanical engineering.

Module-1: Introduction to Generative AI in Mechanical Engineering		
Teaching component: Introduction to Artificial Intelligence, Machine Learning, and Generative AI, Evolution of AI in Mechanical Engineering, Mechanical Design Process and AI Integration, Basics of Neural Networks and Deep Learning, AI in CAD/CAM/CAE Systems, Digital Engineering and Smart Manufacturing, Applications of Generative AI in automotive, aerospace, robotics, and thermal systems	8 Hrs	Understand
Module-2: Generative Design and Optimization Techniques		
Teaching component: Fundamentals of Generative Design, Topology Optimization of Mechanical Components, Shape and Structural Optimization, Parametric Modelling and AI-driven CAD, Genetic Algorithms and Evolutionary Optimization, Multi-objective Optimization in Mechanical Systems,	8 Hrs	Apply

Lightweight Design for Automotive and Aerospace Components, Case Studies on AI-generated Mechanical Parts		
Module-3: Deep Learning for Mechanical Engineering Applications		
Teaching component: Artificial Neural Networks (ANN) in Mechanical Systems, Convolutional Neural Networks (CNN) for Defect Detection, Recurrent Neural Networks (RNN) for Predictive Maintenance, Generative Adversarial Networks (GANs) in Mechanical Design, AI for Surface Roughness and Tool Wear Prediction, AI-based Vibration and Fault Analysis, Data Collection and Feature Engineering from Sensors, Introduction to Digital Twin Technology	8 Hrs	Apply
Module-4: Generative AI in Manufacturing and Industrial Automation		
Teaching component: AI-assisted CNC Machining and Process Optimization, Generative AI for Additive Manufacturing and 3D Printing, Robotics and Intelligent Automation, AI in Production Planning and Quality Control, AI-based Material Selection and Performance Prediction, Human–Machine Collaboration in Modern Factories, Industrial Case Studies in Mechanical Engineering	8 Hrs	Apply
Module-5: Emerging Trends, Ethics, and Future Applications		
Teaching component: Ethical Issues and Reliability of AI-generated Designs, Sustainability and Green Manufacturing using AI, AI Safety in Mechanical Systems Intellectual Property in AI-generated Products, AI in Electric Vehicles and Autonomous Systems, Future Trends in Generative AI for Mechanical Engineering, Research Opportunities in AI-driven Mechanical Design	8 Hrs	Apply
	Total	**40 Hrs**

Reference Books

1. Stuart Russell & Peter Norvig - Artificial Intelligence: A Modern Approach (3rd or 4th Edition) A comprehensive foundation in AI, including reasoning, planning, and learning.

2. Ethem Alpaydin- Introduction to Machine Learning Useful for understanding ML algorithms, applications, and data-centric design.

3. Karl T. Ulrich & Steven D. Eppinger - Product Design and Development (6th Edition or later) Essential for understanding the structured process of product development.

4. Kevin Otto & Kristin Wood - Product Design: Techniques in Reverse Engineering and New Product Development Hands-on approach to traditional and AI-augmented design processes.

5. Autodesk - Generative Design Field Guide (available free from Autodesk) Practical insights and case studies on AI-driven generative design.

6. Rajkumar Buyya et al. - Internet of Things: Principles and Paradigms For digital twin frameworks, IoT sensors, and data integration.

7. Dietmar P. F. Möller & Roland E. Haas - Guide to Automotive Connectivity and Cybersecurity: Trends, Technologies, Innovations and Applications

Software Documentation & Online Resources

- Autodesk Fusion 360 Generative Design Documentation
- MATLAB & Simulink for AI and Digital Twins (MathWorks)
- AWS IoT TwinMaker Developer Guide
- Unity ML-Agents Toolkit
- MIT Open Course ware on AI and Machine Learning

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Department of Mechanical Engineering

Course Name	Mechatronics	Credits	03
Course code	25MEC1652	CIA Marks	50
Number of Lecture Hours/Week	3L	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Module-I: Introduction to Mechatronics		
Pre-requisite: Fundamentals of sensors and transducers **Introduction**: Scope of Mechatronics, Mechatronics design process, measurement systems, Classification of control system, Basic elements of feedback control systems, Examples of Mechatronics Systems such as Engine management system, Automatic washing machine, MEMS and the automobile air bags. **Sensors and Transducers:** Definition and classification of transducers, Definition and classification of sensors, Difference between transducer and sensor, Principle of working and applications of light sensors, Potentiometers, LVDT, Capacitance sensors, force and pressure sensors, Strain gauges, temperature sensors, proximity switches and Hall Effect sensors.	8 Hrs	Apply
Module-2: Signal Conditioning and Microprocessor systems		
Pre-requisite: Fundamentals of digital number systems and solid-state physics **Signal Conditioning**: Need for signal conditioning, operational amplifiers – inverting and noninverting, protection, filtering, temperature compensation, pulse modulation- pulse amplitude modulation and pulse width modulation. **Microprocessor & Microcontrollers**: Microprocessor Architecture: Microprocessor architecture and terminology CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor. Introduction to microcontrollers, Difference between Microprocessor and Microcontrollers. Selection and Applications of Microcontrollers	8 Hrs	Apply

Module-3: Advanced CNC machines and PLC		
Pre-requisite: Knowledge of working principle of conventional machine tools **Design of modern CNC machines:** CNC Machine Elements: Different types of guide ways- Linear Motion guide ways. Bearings: anti friction bearings, hydrostatic bearing and hydrodynamic bearing. Recirculating ball screws. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. **Programmable Logic Controllers and its Applications**: Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, ladder diagrams circuits, timer counters, internal relays, master control, jump control, shift registers, data handling, and manipulations, analogue input and output, selection of PLC for application. Applications of PLC control.	8 Hrs	Apply
Module-4: Software and System Interfacing in mechatronics		
Pre-requisite: Fundamentals of control systems and sensors **Software Integration**: Software for Mechatronics, Needs and implementation, Control and Intelligence through Software integration for embedded controllers, Issues with software design and Troubleshooting. **Real-time System Interfacing**: Introduction to data acquisition- Interface and communication standards, User interfaces in automation, Real time interfacing, Human Machine Interfaces, Fundamentals of graphical programming, DAQ Interfacing and Control systems design.	8 Hrs	Apply
Module-5: Artificial Intelligence and Mechatronics systems		
Pre-requisite: Knowledge of control systems, Boolean algebra and sensors **Artificial Intelligence**: Concept of intelligent machine, self-regulation, perception and cognition, neural networks, reasoning mechanisms-deterministic and non-deterministic, rule-based reasoning. **Mechatronics Designs**: Comparison of traditional and mechatronic designs. Timed switches, windscreen wiper motion, weighing machines, case studies – pick and place robot, car park barriers, digital camera, automotive control systems, bar code reader, hard disk drive.	8 Hrs	Apply
Total	**40 Hrs**	

Reference Books

1. Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering, W. Bolton Pearson Education 7th Edition, 2018.
2. Mechatronics-Principles Concepts and Applications Nitaigour Premchand Mahalik Tata McGraw Hill 1stEdition, 2003.
3. Mechatronics: Integrated Mechanical Electronic Systems K.P. Ramachandran, G.K Vijayaraghavan, M.S. Balasundaram. Wiley India Pvt. Ltd. New Delhi 2008
4. Mechatronics System Design Devdas Shetty, Richard A. kolk Cengage publishers. Second edition

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Department of Mechanical Engineering

Course Name	**HVAC System Design**	**Credits**	**03**
Course code	**25MEC1653**	**CIA Marks**	**50**
Number of Lecture Hours/ Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Objectives:

This course will enable the students to

1. To introduce the fundamental principles of heating, ventilation, and air conditioning systems.
2. To provide knowledge on the design of various HVAC components like ducts, piping, fans, and cooling coils.
3. To familiarize students with load calculations, system selection, and psychometric analysis.
4. To expose students to various applications and modern trends in HVAC systems.
5. To equip students with the ability to design and analyze HVAC systems for residential, commercial, and industrial buildings.

Module 1: Introduction to HVAC and Psychometrics		
Introduction to HVAC systems and classification, Overview of building requirements: Thermal comfort, Indoor Air Quality (IAQ), Ventilation, Psychometrics: Properties of moist air, psychometric chart, processes– sensible heating/cooling, humidification/dehumidification, mixing of air streams, Psychometric applications in air-conditioning processes.	8 Hrs	Apply
Module 2: Cooling and Heating Load Calculations		
Concepts of sensible heat and latent heat, Internal and external heat gains, Design conditions: Outdoor and indoor, Heat gain through building envelope – walls, roofs, windows, infiltration, Cooling load estimation (CLTD/RTS method), Heating load estimation techniques.	8 Hrs	Apply

Module 3: Air Distribution and Duct Design		
Air distribution systems and air terminal devices, Duct design methods: Equal friction, static regain, velocity reduction, Duct construction, insulation, and sealing, Fan classification, selection, and fan laws, Air balancing and testing methods.	8 Hrs	Apply
Module 4: Refrigeration and HVAC Equipment Selection		
Basics of refrigeration and refrigeration cycles, Components of refrigeration system: Compressors, condensers, evaporators, expansion devices, Types of HVAC systems: DX, chilled water, VRF/VRV, split systems, Equipment selection: AHUs, FCUs, cooling towers, pumps, Introduction to chillers and their performance parameters.	8 Hrs	Apply
Module 5: Control Systems and Energy EffiCIAncy in HVAC		
Thermostats, humidistats, and control devices, Zoning and scheduling, Variable Air Volume (VAV) systems and Building Management Systems (BMS), Energy effiCIAncy in HVAC: Star- rated equipment, energy recovery systems, Codes and standards: ASHRAE, ISHRAE, ECBC guidelines.	8 Hrs	Apply
Total Hours		**40 Hrs**

Textbooks:

1. C.P. Arora – Refrigeration and Air Conditioning, Tata McGraw Hill.
2. Manohar Prasad – Refrigeration and Air Conditioning, New Age International.
3. S. C. Arora and S. Domkundwar – A Course in Refrigeration and Air Conditioning, Dhanpat Rai & Co.

Reference Books:

1. ASHRAE Handbook – Fundamentals, American Society of Heating, Refrigeration and Air-Conditioning Engineers.
2. ISHRAE Guidebook – HVAC Design Practices.
3. W.P. Jones – Air Conditioning Engineering, Butterworth-Heinemann.
4. Dossat, Roy J. – Principles of Refrigeration, Pearson Education.

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Department of Mechanical Engineering

Course Name	Product Design and Development	Credits	3
Course code	25MEC1654	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Course Objective: This course will enable the students to:

1. Learn methods to identify and interpret customer needs using tools like the Voice of the Customer (VOC) and market research.
2. Apply creative techniques (such as Brainstorming, Mind Mapping, and TRIZ) to generate ideas, decompose functions, and mathematically evaluate product concepts using Pugh and weighted decision matrices.
3. Apply Design for Manufacturing and Assembly (DFMA) principles, select materials/processes, perform cost estimation, and integrate quality and reliability methods like Six Sigma.
4. Gain profiCIAncy in modern engineering techniques, including Computer-Aided Design (CAD) 3D modeling, Finite Element Analysis (FEA) stress analysis, ergonomics/user-centered design, and sustainable eco-design.
5. Understand project management fundamentals, Agile methodologies, intellectual property rights (patents, trademarks, copyrights), and industry regulatory/ethical compliance standards.

Module-I: Introduction to Product Design and Development		
Teaching component: Basics of Product Design: Definitions, concepts, and importance of product design. Product Development Process: Phases from idea generation to commercialization. Product Life Cycle: Stages of product life cycle and their impact on design and development. Customer Needs and Requirements: Identifying and understanding customer needs, voice of the customer (VOC), and market research. **Self-study component/Case study:** AI & Recent Trends Augmentation: * AI-Driven Market Insights: Utilizing Large Language Models (LLMs) and sentiment analysis tools for automated Voice of the Customer (VOC) gathering from online reviews, social media, and forums. Predictive PLC: Using machine learning predictive analytics to estimate product obsolescence and optimize launch timeline	8 Hrs	Apply
Module-2: Concept Generation and Selection		

Teaching component: Idea Generation Techniques: Brainstorming, mind mapping, TRIZ, and other creative techniques. Concept Development: Translating customer needs into product concepts, functional decomposition. Concept Selection: Pugh matrix, weighted decision matrix, and other evaluation methods. Prototyping and Testing: Building and testing prototypes, rapid prototyping techniques. **Self-study component/Case study:** Generative AI Ideation: Integrating text-to-image/CAD AI tools (e.g., Midjourney, Vizcom) for rapid visual brainstorming and	8 Hrs	Apply
concept exploration. Automated Decision Matrices: Deploying multi-criteria AI decision-making tools to weight and filter concept selection parameters alongside the traditional Pugh Matrix. Smart Prototyping: Utilizing AI-optimized slicers for 3D printing/rapid prototyping to minimize material waste and predict print failures.		
Module-3: Design for Manufacturing and Assembly (DFMA)		
Teaching component: DFMA Principles: Guidelines for designing products for ease of manufacturing and assembly. Materials and Processes: Selection of materials and manufacturing processes. Cost Analysis: Understanding cost drivers, cost estimation techniques. Quality and Reliability: Designing for quality and reliability, statistical process control, and Six Sigma. **Self-study component/Case study**: AI-DFMA Verification: Utilizing cloud-based CAD manufacturing plugins that leverage machine learning algorithms to audit designs in real-time for casting, machining, or injection molding constraints. Predictive Costing & Material Informatics: Using neural networks to predict global material cost fluctuations and utilizing AI material databases to find bio-based or alternative composite substitutes. Smart Quality Assurance: Implementing computer-vision-based automated defect inspection and machine learning models for predictive maintenance reliability testing.	8 Hrs	Apply
Module-4: Advanced Product Design Techniques		

Teaching component: Computer-Aided Design (CAD): Introduction to CAD software, 3D modelling, and simulation. Finite Element Analysis (FEA): Basics of FEA for stress analysis and optimization. Ergonomics and Human Factors: Designing for human use, ergonomics principles, and user-centered design. Sustainable Design: Eco-design principles, life cycle assessment, and sustainable materials. **Self-study component/Case study**: Generative Design: Utilizing AI algorithms within modern CAD packages to run topology optimization based on target structural loads, weight reduction goals, and manufacturing constraints. AI-Accelerated FEA: Applying physics-informed neural networks (PINNs) to conduct real-time stress and thermal simulations without traditional, computationally heavy meshing grids. AI Ergonomics & Digital Twins: Using computer vision human-pose estimation to assess ergonomic comfort and repetitive strain risks during the digital design phase.	8 Hrs	Apply
Module-5: Project Management and Legal Aspects		
Teaching component: Project Management Fundamentals: Planning, scheduling, and controlling product development projects. Agile Product Development: Introduction to Agile methodologies and practices in product development. Intellectual Property (IP): Patents, trademarks, copyrights, and their relevance in product development. Regulatory and Ethical Considerations: Compliance with industry standards and ethical practices in product design **Self-study component/Case study**: AI Project Assistants: Utilizing predictive project management tools to flag supply chain delays, estimate resource bottlenecks, and dynamic-schedule sprint tasks. Automated IP Screening: Using AI patent search engines to instantly scan global databases for prior art, assessing the freedom-to-operate landscape of newly generated product concepts. AI Ethics & Compliance: Evaluating the carbon footprint compliance of designs automatically against shifting global sustainability regulations via automated compliance checkers.	8 Hrs	Apply
Total		**40 Hrs**

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Department of Mechanical Engineering

Course Name	**Sensors & IOT for Manufacturing**	**Credits**	**03**
Course Code	**25MEC1655**	**CIA**	**50**
Number of lecture Hours per week	**3L:T:P:J**	**SEA marks**	**50**
Total number of lecture Hours	**40**	**SEA Duration**	**3**

Course Objective: This course will enable students to

- Understand concepts and methods behind IOT & Smart Manufacturing.
- Understand the basic concepts of the main sensors used in electromechanical systems
- Understand/implement computer models of common engineering information types.

Module-1: Introduction to Smart Manufacturing		
Introduction to Smart Manufacturing: What is "smart manufacturing" really and how does it differ from conventional/legacy manufacturing **Smart Manufacturing Processes**: Three Dimensions: Demand Driven and Integrated Supply Chains, Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations), Real Time, Sustainable Resource Management (intelligent energy demand management, production energy optimization and reduction of GHG)	8 Hrs	Understand
Module-2: Methodologies and techniques of Smart Design/Fabrication		
Smart Design/Fabrication: Smart Design/Fabrication - Digital Tools, Product Representation and Exchange Technologies and Standards. **Agile (Additive) Manufacturing Systems and Standards**. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception Sensor networks and Devices. **Smart Applications:** Online Predictive Modeling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities	8 Hrs	Apply
Module-3: Mechatronic Systems Design & Smart and Empowered Workers		

Introduction to Mechatronic Systems Design Introduction: Mechatronic, history, applications, and trends, Sensors and transducers, Signal conditioning, Mechanical components, Software development, Pneumatic and hydraulic actuators, Microcontrollers, Basic closed-loop control Smart and Empowered Workers: Eliminating Errors and Omissions, Deskilling Operations, Improving Speed/Agility, Improving Information Capture/Traceability, Improving Intelligent Decision Making under uncertainty Assisted/Augmented Production, Assisted/Augmented Assembly, Assisted/Augmented Quality, Assisted/Augmented Maintenance, Assisted/Augmented Warehouse Operations and Assisted Training	8 Hrs	Understand
Module-4: Information Systems in Manufacturing		
Manufacturing organizations- management, and the networked enterprises, Globalization challenges and opportunities, Dimensions of Information systems, Approaches to study information system, Technical and Behavioural approach, Information Technology Infrastructure	8 Hrs	Apply
Module-5: Introduction to The Internet of Things		
The Internet of Things: An overview; Design Principles for Connected Devices; Internet Principles. **Thinking about Prototyping** – Costs versus ease of prototyping, prototyping and Production, open source versus Closed Source. **Prototyping Embedded devices** – Electronics, Embedded Computing Basics, Arduino/ Raspberry Pi/ Beagle Bone Black/ etc., Electric Imp and other notable platforms Prototyping of Physical Design. Prototyping online Components – Getting Started with an API, Writing a New API.	8 Hrs	Understand

Text and Reference Books

1. A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013, ISBN-10: 111843062X.
2. N. Vengurlekar and P. Bagal, Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management, 1st edition, McGraw-Hill Education, 2013, ISBN-10: 0071790152.
3. M. Kuniavsky, Smart Things: Ubiquitous Computing User Experience Design, 1st edition, Morgan Kaufmann, 2010, ISBN-10: 0123748992.
4. . D. Boswarthick, O. Elloumi, and O. Hersent, M2M communications: A systems approach, Wiley, 1st edition, 2012, ISBN: 978-1119994756
5. J. Edward Carryer, et al., Introduction to Mechatronic Design, Prentice Hall, 1st edition, 2010, ISBN: 978- 8131788257.

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Department of Mechanical Engineering

Course Name	**Total Quality Management**	**Credits**	**03**
Course code	**25MEC1656**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course Objective:

This course will enable the students to

- To Understand various approaches to TQM
- To understand the characteristics of quality leader and his roles in implementing TQM.
- To develop effective feedback and suggestion systems for quality improvement.
- To Enhance the knowledge in Tools and Techniques of quality management

Module-I: Introduction to Total Quality Management		
Teaching component: Introduction: Basic, concepts of Total Quality Management, Principles of TQM, benefits of TQM, Quality in Manufacturing and Service Systems, Benchmarking - Re-engineering - Concurrent Engineering	8 Hrs	Understand
Module-2: Leadership in Quality Management		
Teaching component: Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making.	8 Hrs	Apply
Module-3: Customer Satisfaction and Customer Involvement.		
Teaching component: Customer Satisfaction and Customer Involvement: Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward systems	8 Hrs	Apply
Module-4: Continuous Process Improvement Strategies.		

Teaching component: Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies.	8 Hrs	Apply
Module-5: Quality Management Standards		
Teaching component: QUALITY MANAGEMENT STANDARDS (Introductory aspects only) a. The ISO 9001:2000 Quality Management System Standard b. The ISO 14001:2004 Environmental Management System Standard c. ISO 27001:2005 Information Security Management System d. ISO / TS16949:2002 for Automobile Industry	8 Hrs	Apply
Total	**40 Hrs**	

Text Books /Reference Books

1. **Total Quality Management:** Dale H. Bester field, Publisher - Pearson Education India, ISBN: 8129702606, Edition 03/e Paperback (Special Indian Edition).
2. **Total Quality Management for Engineers:** M. Zairi, ISBN: 1855730243, Publisher: Wood head Publishing.
3. **A New American TQM, four revolutions in management,** Shoji Shiba, Alan Graham, David Walden, Productivity press, Oregon, 1990.
4. **100 Methods for Total Quality Management**: Gopal K. Kanji and Mike Asher, ISBN: 0803977476, Publisher: Sage Publications, Inc.; Edition – 1.
5. **Organizational Excellence through TQM, H**. Lal, New age pub, 2008.

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Department of Mechanical Engineering

Course Name	**MATLAB for Modeling Mechanical Systems**	**Credits**	**03**
Course Code	**25MEC1661**	**CIA**	**50**
Number of lecture Hours per week	**3L:T:P:J**	**SEA Marks**	**50**
Total number of lecture Hours	**40**	**SEA Duration**	**3**

Course Objective: This course will enable students

- Understand core concepts of AI
- Learn how data influences design decisions
- Introduce generative design principles
- Integrate AI with simulation and testing
- Prepare students for real-world AI deployment in product design
- Encourage ethical and sustainable AI practices

Module-1: Introduction to MATLAB and Simulink Environment		
Teaching Component: Introduction to MATLAB syntax and operations, Vectors, matrices, control structures, scripts & functions, introduction to Simulink: blocks, signals, and subsystems, simulation basics: solver configuration, start/stop simulation, libraries and block types in Simulink, modeling simple dynamic systems (mass-spring- damper, RC circuit)	8 Hrs	Understand
Module-2: Mechanical System Modeling in Simulink		
Teaching Component: Translational and rotational mechanical blocks Inertia, damping, stiffness elements, Simscape Foundation: domains and connectors, building subsystem models: 1-DOF and 2-DOF systems, introduction to Simscape Multibody	8 Hrs	Understand
Module-3: Simscape Multibody and Kinematics		
Teaching Component: Overview of Simscape Multibody environment, Frames, joints (revolute, prismatic, spherical), constraints, modeling linkages and rigid bodies, forward and inverse kinematics basics, 3D visualization of mechanism motion, CAD import and parameterization	8 Hrs	Understand
Module-4: Simulation, Control, and Analysis		

Teaching Component: System linearization and transfer function extraction, PID controller design and tuning, Frequency response and time-domain analysis, Simulink Control Design toolbox, Co-simulation with MATLAB scripts and Simulink model	8 Hrs	Apply
Module-5: Advanced Applications of Simulink in Mechanical System		
Teaching Component: Thermal and hydraulic system coupling with mechanical models, Modeling friction, backlash, and nonlinearities parameter optimization using Simulink Design Optimization Introduction to hardware-in-the-loop (HIL) concepts, Industry case studies: automotive suspensions, robotic actuators, etc.	8 Hrs	Apply
Total		**40 Hrs**

Reference Books

- **S. Rao Vallabhaneni -** MATLAB and Simulink Crash Course for Engineers Covers the essentials of using MATLAB and Simulink for dynamic system modeling and analysis.
- **Amos Gilat -** MATLAB: An Introduction with Applications (6th Edition or later) Excellent for understanding MATLAB syntax, scripting, and basic engineering computations.
- **Klee, Harold -** Simulation of Dynamic Systems with MATLAB and Simulink Detailed treatment of system modeling, simulation strategies, and hands-on Simulink use.
- **Shampine, L.F., et al. -** Modeling and Simulation in MATLAB and Simulink Focuses on solving differential equations and dynamic system models in MATLAB/Simulink.
- **Michael Paluszek & Stephanie Thomas -** MATLAB Recipes for Earth Sciences (includes Simulink workflows) Although focused on geosciences, provides a strong application-based Simulink modeling methodology.

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Course Name	**Industrial Automation and Control**	**Credits**	**03**
Course code	**25MEC1662**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Module-I: Introduction to Automation and its Key Components		
Pre-requisite: Fundamental knowledge of solid-state switches and types of sensors **Introduction:** Automation overview, types of automation, requirement of automation systems, Architecture of Industrial Automation system. Human-Machine Interfaces (HMIs), Safety, reliability, and maintainability in automation systems. **Automation Components:** Sensors for - temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices - DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.	8 Hrs	Apply
Module-2: Control Technologies in Industrial Automation		
Pre-requisite: Fundamental knowledge of control systems Introduction to automation and control technologies in the production system. Advanced automation functions – safety monitoring, Maintenance and repair Diagnostics, error Detection and recovery, Five levels of automation and control in manufacturing. Process Industries Versus Discrete Manufacturing Industries, Continuous Control Systems, Discrete Control Systems, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS. Control Requirements, Capabilities of Computer Control, Forms of Computer Process Control.	8 Hrs	Apply

Module-3: Programmable Logic Controllers for Automation		
Pre-requisite: Essentials of logic gates, gate networks and types of automation **Programmable logic controllers:** Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: Modbus & Profibus, Analog digital input and output modules, fundamentals of PLC programming, Ladder diagram, PLC Communication and networking, PLC selection, PLC Installation, ensuring network security and reliability, Advantage of using PLC for Industrial automation, Application of PLC to process control industries. Case studies of PLC applications in industrial automation, Integration of PLCs with SCADA systems.	8 Hrs	Apply
Module-4: Material Handling Systems and Automation System Design		
Pre-requisite: Basics of conventional materials handling and storage methods in industries **Material handling and Identification Technologies** - Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Overview of Automatic Identification Methods. **Automated Manufacturing Systems Design**- Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, Automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.	8 Hrs	Apply
Module-5: Automated Inspection Technologies and Robotics		
Pre-requisite: fundamentals of electronic communication and kinematics Automated Inspection: fundamentals of inspection, automated inspection, Inspection Metrology, Coordinate Measuring Machines, Surface Measurement, Image Acquisition and Digitization, Image Processing and Analysis, Interpretation, Machine Vision Applications, Other Optical Inspection Methods, Noncontact Non-Optical Inspection Techniques **Overview of Industrial automation using robots:** Present status and future trends of Robotics. Robot Definition, Robotics Systems and Robot Anatomy, Specification of Robotics. Resolution, Repeatability and Accuracy of a Manipulator. Basic construction and configuration of pick and place robot, Welding robot. Applications of Robots.	8 Hrs	Apply
		Total 40 Hours

Reference Books

1. Industrial control handbook, Parr, Newnem
2. Programmable logic controller, Dunning, Delmar
3. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986
5. Industrial Instrumentation and Control By. S.K. Singh The McGraw Hill Companies
6. Process Control Instrumentation Technology By. C.D. Johnson, PHI
7. M.P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009.
8. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles
9. and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Thermal Management of Electronic Systems**	**Credits**	**03**
Course code	**25MEC1663**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P: J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course objectives:

1. Understand the importance of thermal and fluid science in modern electronic devices.
2. Learn the design, modeling, and working principles of active and passive thermal management devices.
3. Comprehend the properties of materials and fabrication techniques used for various levels of electronics packaging.
4. Analyze complex heat transfer problems (e.g., heat sinks, heat pipes, and micro-channel heat exchangers) across multiple hardware applications.

Pre-requisite: Tthermodynamics, Fluid mechanics, and Heat Transfer Principles

Module-I: Introduction to Electronics Cooling		
Importance of thermal management in electronic devices (device reliability, failure rates), Modes of heat transfer in electronic systems (conduction, convection, and radiation), Overview of packaging and cooling technologies; equipment, cabinet, board, and chip-level fabrication; physical working principles and failure consequences of overheating. Active and passive methods of cooling.	8 Hrs	Apply
Module-2: Conduction Cooling		
Thermal resistance networks and 1D steady-state conduction, Heat transfer from extended surfaces (fins and pin fins),Thermal resistance networks, conduction in chip carriers and printed circuit boards (PCBs), Thermal Interface Materials (TIMs) and reducing thermal contact resistance heat frames, and synthetic jets.	8 Hrs	Apply
Module-3: Convection Cooling		
Principles of natural and forced convention in electronics. Optimization of heat sinks and metal foams and cold plates, fan selection, micro-channel heat exchangers, fluid selection, and jet impingement techniques.	8 Hrs	Apply
Module-4: Phase-Change Methods		
Liquid cooling heat sinks (mini and micro-channel heat exchangers),Jet impingement and synthetic jet cooling, Heat pipes (principles, types, and	8 Hrs	Apply

operational limits), loop heat pipes, vapor chambers, Immersion cooling, phase change materials (PCMs), and cryogenic cooling		
Module-5: Advanced & System-Level Thermal Management		
Peltier and SEAbeck elements design, radiation cooling for space electronics, thermal management in data centers, and battery packs for electric vehicles. Reliability physics and accelerated testing of electronic packages.	8 Hrs	Apply
	Total: 40 Hrs	

Department of Mechanical Engineering

Course Name	Mechanics of Composite Materials	Credits	03
Course Code	25MEC1664	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Course Objective:

1. Introduce concept of composite material and its constituents.
2. Understand selection of matrix and reinforcement materials and fabrication methods based on the application.
3. Acquire the knowledge about the concepts and processing of polymer matrix composite materials.
4. Understand the micro and micromechanical analysis of polymer composite systems.
5. Introduce the concepts and processing of metal, ceramic and carbon matrix composite materials.

Module-I: Introduction to Composite Materials		
Introduction to Composite Materials: Introduction, classification, applications and constituent of composite materials, Sustainable and green composite materials, Smart composites and multifunctional composites. **Reinforcements:** Introduction, Glass fibers, Boron fibers, Carbon fibers, Organic fibers, Ceramic fibers, Whiskers, Nano reinforcements: Carbon nanotubes (CNTs), Graphene and nano-clays, Natural fiber reinforcements: Jute, Hemp, Sisal and Bamboo fibers. **Matrix Materials:** Polymers, Metals and Ceramic matrix materials. **Interfaces:** Wettability, Crystallographic nature of interface, types of bonding at the interface and optimum interfacial bond strength.	8 Hrs	Apply/ Understand
Module-2: Micro Mechanics of Polymer Matrix Composite Lamina		
Polymer Matrix Composites (PMC): Processing of PMC's; Processing of Thermoset matrix composites, Thermoplastic matrix composites, Sheet moulding Compound and carbon reinforced polymer composites. Interfaces in PMC's, Properties and applications of PMC's. Additive manufacturing (3D printing) of polymer composites. **Micro Mechanical Analysis of a Lamina:** Introduction, Rule of mixture, Evaluation of density and void content of composite material using Rule of mixture, Evaluation of elastic moduli and ultimate strengths of a unidirectional lamina (strength of materials approach), and numerical problems using rule of mixture.	8Hrs	Apply

Module-3: Macro Mechanics of Composite Lamina and Biaxial Strength Theories		
Macro Mechanics of a Lamina: Introduction, Hooke's law for different types of materials, Number of elastic constants, Two-dimensional relationship of compliance and stiffness matrix, Hygrothermal effects in composites and Residual stresses in laminated composites. **Biaxial Strength Theories:** Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai-Wu tensor theory, Lamina Hooke's law for two-dimensional angle lamina, engineering constants, Failure prediction in laminated composites, Progressive damage modelling concepts, Introduction to finite element analysis (FEA) of composite laminates.	8Hrs	Apply
Module-4: Metal Matrix Composites and its Fabrication		
Metal Matrix Composites: Reinforcement materials, types, characteristics and selection, base metals selection. Need for production MMC's and its application. Lightweight MMCs for electric vehicles and aerospace structures, In-situ synthesized MMCs, functionally graded metal matrix composites (FGMMCs). Fabrication Process for MMCs: Powder metallurgy technique, liquid metallurgy technique, diffusion bonding, squeeze technique and secondary processing, Additive manufacturing of MMCs.	8 Hrs	Apply/ Understand
Module-5: Ceramic Matrix Composites and Carbon Fiber/Carbon Matrix Composites		
Ceramic Matrix Composites: Processing of CMC's; Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed oxidation, In situ chemical reaction technique, Sol-gel, Self-propagating high temperature Synthesis. Interfaces, properties and applications of CMC's, Ultra-high temperature ceramic composites (UHTCs), Environmental barrier coatings for CMCs. Carbon Fiber/Carbon Matrix Composites: Processing of Carbon/Carbon composites, Oxidation protection of Carbon/Carbon composites, Properties of Carbon/Carbon composites, and application of Carbon/Carbon composites, Applications in hypersonic vehicles and space systems.	8 Hrs	Apply/ Understand
Total		**40 Hrs**

Text Books

1. Composite Science and Engineering, K. K. Chawla, 3rd Edition, Springer Verlag 2012.
2. Mechanics of Composite Materials, Autar K. Kaw, 2nd Edition, Taylor and Francis, 2005.
3. Fiber Reinforced Composites, Materials, Manufacturing, and Design**,** P. K. Mallick, 3rd Edition, CRC Press, 2007**.**

Reference Books

1. Composite materials hand book, Mel M Schwartz, 2nd Edition, McGraw Hill, 1991.
2. Mechanics of Composite Materials and Structures, Madhujit Mukhopadhya, University Press 2005.

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Department of Mechanical Engineering

Course Name	**PLC and SCADA in Manufacturing Systems**	**Credits**	**03**
Course code	**25MEC1665**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:0T:0P:0J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Objective:

The students will be able:

1. To understand the fundamentals of PLC and SCADA systems used in industrial automation.
2. To learn PLC programming techniques and industrial control applications.
3. To study SCADA architecture, communication protocols and monitoring systems.
4. To analyze automation and control strategies in manufacturing industries.
5. To understand emerging trends in smart manufacturing, Industry 4.0 and industrial automation systems.

Module 1: **Introduction to Industrial Automation and PLC**		
Introduction to industrial automation, automation pyramid and manufacturing systems, fundamentals of Programmable Logic Controllers (PLC), architecture and components of PLC, input and output modules, power supply and memory organization, advantages and applications of PLCs in manufacturing industries, sensors and actuators used in automation systems, relay logic and PLC interfacing.	8 Hrs	
Module-2: PLC Programming and Control Systems		
PLC programming methods, ladder logic programming, functional block diagrams and sequential function charts, timers, counters and arithmetic functions, data handling and program organization, motor control using PLC, control of pneumatic and hydraulic systems, troubleshooting and debugging of PLC programs, industrial applications in conveyor systems, CNC machines and robotic automation.	8 Hrs	
Module-3: SCADA Systems and Industrial Communication		
Introduction to Supervisory Control and Data Acquisition (SCADA), SCADA architecture and components, Human Machine Interface (HMI), data acquisition systems, real-time monitoring and control, industrial communication protocols including Modbus, Profibus, Ethernet/IP and OPC, networking in industrial automation, data logging, alarms and event management, cybersecurity issues in SCADA systems.	8 Hrs	
Module-4: Automation in Manufacturing Systems		

PLC-SCADA integration, distributed control systems (DCS), automated material handling systems, flexible manufacturing systems (FMS), process automation and control strategies, robotics integration in manufacturing, condition monitoring and predictive maintenance, industrial case studies in process and discrete manufacturing industries, energy management and smart factory concepts.	8 Hrs	
Module-5: Emerging Trends and Industrial Applications		
Industry 4.0 and smart manufacturing, Industrial Internet of Things (IIoT), cloud-based SCADA systems, artificial intelligence and machine learning in industrial automation, edge computing in manufacturing automation, industrial safety standards and regulations, applications of PLC and SCADA in automotive, aerospace, power plants and process industries, future trends in intelligent manufacturing systems.	8 Hrs	
Total: 40 Hours		

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Department of Mechanical Engineering

Course Name	Strategic Management	Credits	03
Course Code	25MEC1666	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Course Objectives:

1. To provide a framework for students to understand strategic management concepts and conduct external analysis for competitive advantage.
2. To help students develop a thorough understanding of principles and models related to an organization's internal analysis.
3. To help students understand the different strategy options available for organizations in a complex and dynamic environment.
4. To acquaint students with essential factors in strategy implementation.
5. To provide basic understanding of how to establish and exert strategic control.

Contents of the Module	Hours
Module-1 Introduction to Supply Chain Management	
Introduction, Imperatives and evolution of strategic sourcing -Evolution of Sourcing and changing paradigms, Changing Expectations leading to Supply Management and Strategic Sourcing, Supply Chains and Supply Networks, Return on Assets, Strategic sourcing and Organization's Strategy Importance of supply management. Supply process and Need identification - Procure to pay cycle, Recognition of need, Purchasing and supply process, Purchasing and supply process, Need identification and types.	8 Hrs
Module -2 Sourcing strategy & Technology in sourcing	
Indirect contributions of Supply, Aligning supply objectives with organization's strategy, Procurement in Organizations-1, Procurement in Organizations-2 Developing supply strategy, Developing Sourcing/Supply strategy. Technology in Sourcing, Reverse Auctions, and Success stories about technologies in Sourcing.	8 Hrs
Module -3 Strategic Cost Management, Sustainability and Negotiation	
Strategic cost management Cost analysis, Sustainability in Supply management- 1, Sustainability in Supply management-2, Science Based Targets Negotiation supply management, planning for negotiation, Negotiation strategy.	8 Hrs
Module -4 Contracts and Compensation Arrangements	

Supply contracts, Types of supply contracts-1, Types of supply contracts-2 Supplier selection and evaluation 1, Supplier selection and evaluation 2, Supplier evaluation and selection 3, Outsourcing decisions-1, Outsourcing decisions-2	8 Hrs
Module-5 Global Supply Management and Supply risk	
TOPSIS, Goal Programming, Interpretive structural model, Interpretive structural model. Supply risk management, Risk management framework, Supply risk examples, Assessment of risk, Risk metrics.	8 Hrs
Total	**40 Hrs**

Text Books /Reference Books

1. Strategy and the Business Landscape – Pankaj Ghemawat.
2. Strategic Management – Competitiveness and Globalization: Michael A. Hitt, Duane Ireland, Robert E. Hokinson, South Western, Thomson Learning.
3. Crafting and Executing Strategy, Arthur Thompson, A.J. Strickland, Arun Jain, McGrawhill.
4. Crafting and executing Strategy. A Thompson Jr, Margaret A. and John E Gamble. Mc Graw Hill Publication, New Delhi.
5. Strategic Management – Hitt & Manikutti, Cengage learning,2018.
6. Strategic Management – Fred R David, PHI Learing Private Ltd, New Delhi.

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Department of Mechanical Engineering

Semester: VII		
COURSE: Mechanical Vibration and Control Systems		
Course Code: 25MEC171	**L: T:P: J:**	**CIA Marks: 50**
Credits: 03	**2-2-0-0**	**SEA Marks: 50**
Hours:	**40**	**SEA Duration: 03 Hours**

Pre-Requisites: Engineering Mathematics, Mechanics of Materials, Advanced Manufacturing Technology

Course Learning Objectives: The students will be able to

1	**To develop an understanding of the fundamentals of torsional vibration systems** and analyze the natural frequencies and mode shapes of shaft-rotor systems with and without damping.
2	To introduce analytical and numerical techniques for Multi-Degree-of-Freedom (MDOF) systems and enable determination of their natural frequencies and mode shapes.
3	**To familiarize students with vibration measurement and analysis techniques** for identifying dynamic characteristics and behavior of engineering systems.
4	**To develop the ability to model and analyze control systems** using block diagram reduction techniques and signal flow graph methods.
5	**To provide knowledge of frequency-domain analysis of feedback control systems** and evaluate system stability using polar plots, Nyquist plots, and Bode plots.

Module-1: Introduction to Vibration, Systems with Single Degree of Freedom and Two Degrees of Freedom

Pre-requisite: Engineering Mathematics, Engineering Mechanics **Teaching component**: Types of vibrations, Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems. Torsional and transverse vibrations, Effect of mass of spring and Problems. Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement. Analysis of forced vibration with constant harmonic excitation. Principle modes of vibrations, Normal mode and natural frequencies of systems– Simple Spring mass systems, double pendulum, torsional systems. **Practical Component:** • Experiment on two rotor torsional shaft system • Simulation of coupled vibration system using MATLAB	8 Hrs	Apply

Module-2: Multi Degree Freedom of Systems		
Pre-requisite: Engineering Mathematics, Engineering Mechanics **Teaching component**: Introduction, Maxwell's reciprocal theorem, Influence coefficients, Rayleigh's method, Dunkerley's method, Stodola method, Holzer's method, Orthogonality of principal modes, method of matrix iteration and Problems. **Practical Component:** • Determination of mode shapes and natural frequencies of multi DOF systems • Modal analysis using ANSYS	8 Hrs	Apply
Module-3: Vibration Measurement, Acoustics and Condition Monitoring		
Pre-requisite: Engineering Mathematics, Engineering Mechanics **Teaching component**: Introduction to vibration measurement techniques including displacement, velocity and acceleration measurement. Working principles and applications of vibration measuring instruments such as seismic instruments, frequency measuring instruments and accelerometers. Machine condition monitoring and diagnosis using vibration analysis for detecting faults like imbalance, misalignment and bearing defects. Fundamentals of acoustics including sound wave propagation, sound pressure, sound intensity, sound power and sound level Sources of noise in machines and industries and methods of noise measurement and noise control including sound absorption and insulation. **Practical Component:** • Measurement of vibration using accelerometers and vibrometers • Sound level measurement and acoustic analysis	8 Hrs	Apply
Module-4: Introduction to Control Systems, Modelling of Physical Systems and Block diagram algebra		
Pre-requisite: Engineering Mathematics, Engineering Mechanics **Teaching component**: Components of a control system, Open loop and closed loop systems. Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic Systems. Block diagram algebra, Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graph. **Practical Component:** • Time response analysis of first and second order systems • Simulation of control systems using MATLAB	8 Hrs	Apply
Module-5: Stability of linear control systems		

Pre-requisite: Engineering Mathematics, Engineering Mechanics **Teaching component**: **Stability of linear control systems:** Routh's criterion, Root locus, Determination of phase margin and gain margin using root locus. Stability analysis using Bode plot, Determination of phase margin and gain margin using Bode plot. **Practical Component:** • Root locus analysis of control systems using MATLAB • Frequency response analysis using Bode plots using MATLAB	8 Hrs	Apply
Total	**40 Hrs**	

Reference Books
1. Mehta, J. S., and Kailey, A. S., *Mechanical Vibrations*, S. Chand & Company, 2014. 2. Nise, Norman S., *Control Systems Engineering*, John Wiley & Sons Inc., 2000.
Text Books
1. Grover, G. K., and Nigam, S. P., *Mechanical Vibrations*, Nem Chand and Brothers, 2012. 2. Singiresu S. Rao, *Mechanical Vibrations*, Pearson Education, 2013. 3. Nagrath, I. J., and Gopal, M., *Control Systems Engineering*, New Age International Pvt. Ltd., 2000.

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Semester: VII		
COURSE: Research Methodology and IPR		
Course Code: 25MEC174	**L: T:P: J:**	**CIA Marks: 50**
Credits: 02	**1L-2T-P-J**	**SEA Marks: 50**
Hours:	**26**	**SEA Duration: 0**3 Hours

Course Learning Objectives: The students will be able :

1	Understanding of various research methodologies and their applications in engineering and technology fields.
2	Design, conduct, and analyze research studies effectively, fostering critical thinking and problem-solving abilities.
3	Provide practical knowledge on the process of filing patents and other IPR-related documentation, emphasizing the strategic use of IPR in academic and industrial research projects.

Module 1: Introduction to Research Methodology		
Introduction, meaning of research, Objectives of research, Types of research, Research approaches, Research methods versus Methodology, Research process, AI tools in research: Use of ChatGPT, Google Scholar, Scopus, and reference managers, Research ethics in AI-generated content	5 Hrs	Apply
Module-2: Research Design		
Introduction, meaning of research design, Features of a good design, Important concepts relating to research design, Different research designs, Design Thinking approach in research problem identification	5 Hrs	Apply
Module-3: SAMPLING DESIGN & MEASUREMENT TECHNIQUES		
Sampling Design: Introduction, Steps in sampling design, Characteristics of a good sample design, Different types of sample designs. Measurement Techniques: Introduction, Measurement scales, Sources of error in measurement.	5 Hrs	Apply
Module-4: DATA COLLECTION & REPORT WRITING		
Data Collection: Collection of primary data, Collection of Secondary Data. Report Writing: Different steps in writing report, Layout of the research report, Plagiarism detection tools, Turnitin, Grammarly, Writing research papers in IEEE/APA format	5 Hrs	Apply

Module-5: Intellectual Property Rights (IPR)		
Introduction, the concept, Intellectual property system in India, Patents act-1970, Trademark act-1999, Protection of intellectual property under TRIPS, Copyright and related rights, Geographical indications, Industrial designs, Patents, Startup ecosystem and innovation commercialization, Patent search databases: World Intellectual Property Organization patent database, Indian patent filing portal awareness.	6 Hrs	Apply
Total	**40 Hrs**	

Reference Books

1. **Intellectual Property: A Very Short Introduction**
   Author: Siva Vaidhyanathan, Publisher: Oxford University Press, Year of Publication: 2017
2. **Intellectual Property Law in India**
   Author: G.R. Dureja, Publisher: Universal Law Publishing, Year of Publication: 2019
3. **A Step-by-Step Guide for Beginners,** Author: Ranjit Kumar, Publisher: SAGE Publications Ltd, Year of Publication: 2019
4. **Research Methodology: From Philosophy of SCIAnce to Research Design** Author: Alexander M. Novikov, Publisher: Springer, Year of Publication: 2018
5. **Intellectual Property Law**
6. Author: Lionel Bently, Brad Sherman, Publisher: Oxford University Press, Year of Publication: 2020

Text Books

1. **Research Methodology: Methods and Techniques**
   Author: C.R. Kothari, Publisher: New Age International Publishers, Year of Publication: 2014

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Department of Mechanical Engineering

SEMESTER – VII

Predictive Maintenance and Condition Monitoring using AI

Credit: 03

Course Code	**25MEC1721**	**CIA Marks**	**50**
Teaching Hours/Week (L: T: P: J)	**2L:1T:0P:1J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Learning Objectives:

This course will enable students to

1. Learn feature extraction and selection techniques for processing data set.
2. Understand basic algorithms used in classification and regression problems.
3. Outline steps involved in development of machine learning model.
4. Familiarize with concepts of reinforced and deep learning.
5. Implement And Analyze machine learning model in mechanical engineering problems.

	Number of Hours	Bloom's Level
Module-1: Fundamentals of Condition Monitoring		
Maintenance Strategies Overview: Reactive vs Preventive vs Predictive Maintenance, Cost-benefit analysis, Key challenges in industrial maintenance. **Fundamentals of Condition Monitoring:** Types of monitoring: Vibration, thermal, acoustic, oil analysis, Role of CM in predictive maintenance, Industry standards (ISO 13374, ISO 17359). Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms.	8 Hrs	Apply
Module-2: Sensors and Data Acquisition		
Sensors and Data Acquisition: Types of sensors: Accelerometers, thermocouples, current transducers, DAQ systems and protocols (e.g., OPC UA, MQTT), Basics of Industrial IoT, IoT Benefits for Predictive Maintenance. **Data Preprocessing:** Handling missing/noisy data, Feature extraction from time-series data, Dimensionality reduction (PCA, t-SNE), Classification & regression for fault detection, Anomaly detection using clustering, Feature importance and explainability	8 Hrs	Understand
Module-3: **Deep Learning & Advanced Analytics**		

Auto encoders for anomaly detection, Remaining Useful Life (RUL) estimation, Transfer learning and model adaptation. AI System Deployment: Real-time inference with edge devices (Raspberry Pi, NVIDIA Jetson), Integration with cloud platforms (AWS, Azure, GCP), Visualization dashboards (Grafana, Power BI)	8 Hrs	Apply
Module-4 : Structural Analysis and Design Optimization		
Design Optimization Techniques using Genetic Algorithms and Neural Networks, Case Studies: Predictive Maintenance and Optimal Design Solutions, Structural health monitoring with AI techniques, Case studies: predictive modeling for structural integrity assessment	8 Hrs	Analyze
Module-5: Infrastructure Monitoring and Management		
Introduction to infrastructure monitoring, IoT and sensor data integration with ML, Implementation of AI and ML algorithms using Python. Ethical considerations in AI and ML applications, Regulatory challenges and standards in civil engineering, Future trends and emerging technologies in AI and ML for Mechanical engineering	8 Hrs	Analyze
Total	**40 Hrs**	

Text Books /Reference Books:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015 4. Stuart Russell and Peter Norvig (1995), “Artificial Intelligence: A Modern Approach,” Third edition, Pearson, 2003.

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	Robot Kinematics and Dynamics	Credits	03
Course code	25MEC1722	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objectives:

This course will enable the students to

1. To Provide a mathematical and geometrical description of robotic manipulators
2. To Understand basic robot control architectures
3. To control both the position and orientation of the tool in the three-dimensional space
4. To study the relationship between the joint variables and the position and the orientation of the tool (Direct kinematics)
5. To precisely control the high-speed motion requires the dynamic model of the system

Prerequisite:

Basics of coordinate systems, mathematical axes configurations, Vector Mathematics

Module-1: Introduction to Robotic systems		
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector	8 Hrs	Apply
Module-2: Direct Kinematics		
Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates, link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and six axis Articulated Robots.	8 Hrs	Apply
Module-3: Inverse Kinematics		
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and six axis Articulated robot.	8 Hrs	Apply

Module-4: Workspace Analysis and Trajectory Planning		
Workspace Analysis, work envelope of a four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, continuous path motion, Interpolated motion, straight line motion	8 Hrs	Apply
Module-5: Manipulator Dynamics		
Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot Newton Euler formulation, Lagrange - Euler formulation, problems.	8 Hrs	Apply
Total		**40 Hrs**

Text Books:

[1]. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd.,

[2]. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd.,

[3]. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Publishing company Ltd.,

[4]. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc.,

Reference Books:

1. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993
2. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001
3. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999
4. Bijay K. Ghosh, Ning Xi, T.J. Tann, Control in Robtics and Automation Sensor - Based integration, Academic Press, 1999

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Department of Mechanical Engineering

Course Name	**Product Life Cycle Management**	**Credits**	**03**
Course code	**25MEC1724**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:0T:0P:0J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course Objective:

The students will be able to:

1. Understand the concepts and importance of Product Life Cycle Management (PLM).
2. Learn product development processes from concept to disposal.
3. Understand PLM tools, technologies, and digital manufacturing integration.
4. Apply PLM concepts in manufacturing and engineering industries.
5. Analyze sustainability, innovation, and collaborative engineering practices in PLM.

Module 1: Introduction to Product Life Cycle Management		
Introduction to Product Life Cycle (PLC) and Product Life Cycle Management (PLM), need, objectives and benefits of PLM, phases of product life cycle, product data and product information management, concurrent engineering and collaborative product development, role of PLM in modern industries, PLM strategies and implementation challenges, applications of PLM in automotive, aerospace and manufacturing industries.	8 Hrs	
Module-2: Product Design and Development		
Product planning and market analysis, engineering design methodology, concept generation and selection techniques, product design process, Design for Manufacturing (DFM) and Design for Assembly (DFA), integration of CAD tools in PLM, Bill of Materials (BOM) management, engineering change management, virtual prototyping and simulation techniques.	8 Hrs	
Module-3: Digital Manufacturing and Data Management		

Product Data Management (PDM), digital manufacturing concepts, integration of CAD/CAM/CAE with PLM systems, digital mock-up and digital factory concepts, cloud-based PLM systems, collaborative engineering platforms, Internet of Things (IoT) and Industry 4.0 applications in PLM, interoperability standards and data security in product lifecycle management.	8 Hrs	
Module-4: Product Lifecycle Processes and Sustainability		
Manufacturing lifecycle management, supply chain integration in PLM, quality management and maintenance strategies, product service management, sustainable product development, green manufacturing and eco-design principles, recycling, remanufacturing and end-of-life management, circular economy concepts and environmental considerations in product lifecycle management.	8 Hrs	
Module-5: Emerging Trends and Industrial Applications		
Smart manufacturing and digital twin concepts, Artificial Intelligence and Machine Learning applications in PLM, additive manufacturing integration with PLM, Augmented Reality (AR) and Virtual Reality (VR) applications in product development, industrial case studies of PLM implementation, overview of PLM software such as Siemens Teamcenter, PTC Windchill and Dassault Systèmes ENOVIA, future trends in PLM and smart factory systems.	8 Hrs	
Total		**40 Hrs**

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Department of Mechanical Engineering

Course Name	**Industrial Robotics and Automation**	**Credits**	**03**
Course code	**25MEC1725**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course objectives:

1. To study the various parts of robots and fields of robotics.
2. To study the electronics circuits used in robotic applications.
3. To study sensors used in robotics.
4. To study the programming aspects of robots for specific applications.
5. To study the control of robots for some specific applications.

Module-I: Introduction		
History, Robots, Robot Usage, Robot Subsystems, Classification of Robots, Industrial Applications.	8 Hrs	Understand
Module-2: Actuators and Grippers		
Electric Actuators, Hydraulic Actuators, Pneumatic Actuators, Selection of Motors, Grippers.	8 Hrs	Understand
Module-3: Sensors, Vision and Signal Conditioning.		
Sensor Classification, Internal Sensors, External Sensors, Vision, Signal Conditioning.	8 Hrs	Understand
Module-4: Programming of Robots & Robot Applications in Manufacturing		
Robot Programming: Methods of Robot Programming, Lead through Programming Methods, A Robot Program as a Path in Space, Robot Language Structure. General Considerations in Robot Material Handling, Machine Loading and Unloading, Processing Applications: Spot Welding, Continuous Arc Welding, Spray Coating.	8 Hrs	Understand
Module-5: Automation in Manufacturing Industries		
Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, and Automated flow lines with storage buffers.	8 Hrs	Understand

Material handling and identification technologies -Overview of material handling systems, Types of material handling equipment, Design of the system, **Automated Manufacturing Systems**-Components, Classification and overview of manufacturing systems, Cellular manufacturing.		
	Total	**40 Hrs**

Reference Books

1. Introduction to Robotics', 2e, S K Saha, Tata McGraw Hill Education Private Limited, 2008
2. 'Industrial Robotics Technology, Programming and Applications', Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, Mc Graw Hill Book company, 1986
3. 'Industrial Robotics', Bernard Hodges, Jaico Publishing House, 1993

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Semester: VII		
COURSE: Digital Marketing		
Course Code: 25MEC1726	**L: T:P: J:**	**CIA Marks: 50**
Credits: 03	**3-0-0-0**	**SEA Marks: 50**
Hours:	**40**	**SEA Duration: 0**3 Hours
Pre-Requisites: Advanced Manufacturing Technology and Basics of Computer Programming		
Course Learning Objectives: The students will be able:		
1	1. To understand the important concepts related to e-marketing	
2	2. To learn the use of different electronic media for designing marketing activities.	
3	3. To acquaint the students with the latest techniques of e-marketing.	
Module-1: Introduction to Digital Marketing		
Pre-requisite: Understanding of Marketing Fundamentals, Communication Skills, Awareness of Current Digital Trends and Analytical Skills **Teaching component**: Concept of Digital Marketing, Origin, traditional versus Digital Marketing. Digital Marketing Strategy- The P-O-E-M Framework, Segmenting and customising Messages, Digital Landscape. Digital advertising Market in India. Skills required in Digital Marketing, Digital Marketing Plan.	8 Hrs	Apply
Module-2 : Display Advertising		
Pre-requisite: Basic Understanding of Marketing Principles**:** Introduction to Digital Marketing**,** Analytical Skills**,** Basic SEO Knowledge**:** **Teaching component**: Concept of Display Advertising, types of display ads, buying models, display plan Targeting- contextual targeting placement targeting, remarketing, interest categories, geographic and language tagging, demographics, mobile, other targeting methods. Programmatic digital advertising, You Tube Advertising.	8 Hrs	Apply
Module-3: Search Engine Advertising.		
Pre-requisite: Basic Marketing Knowledge, Digital Literacy**,** Familiarity with Major Social Media Platforms**,** Understanding of Digital Marketing Tools		

Teaching component: Understanding Ad Placement, Understanding Ad Ranks, Creating First Ad Campaign, Performance Reports. Social Media Marketing: Building a successful Strategy **Live Project:** Create a digital marketing plan	8 Hrs	Apply

Module-4: Social Media Marketing.		
Pre-requisite: Basic Understanding of Digital Marketing, Internet and Browsing Skills, Keyword Research Knowledge **Teaching component**: **Face Book Marketing**: Facebook for business & Facebook insights **LinkedIn Marketing:** LinkedIn Strategy, LinkedIn Analytics **Twitter Marketing:** Building Content Strategy, twitter usage, Twitter Analytics **Instagram & Snapshot:** Objectives of Instagram, Hashtags, Snapshot. Digital Public Relations	8 Hrs	Apply
Module-5: Mobile Marketing.		
Pre-requisite: Basic Digital Marketing Knowledge, Website Fundamentals**,** Google Analytics Basics. **Teaching component**: Mobile Usage, Mobile Advertising- Mobile Advertising Models, advantages of Mobile advertising, Mobile Marketing Toolkit, Mobile Marketing features- Location based services, Social marketing on mobile, QR Codes, Augmented Reality, Gamification. **Tracking mobile campaigns**- Mobile Analytics. **Live Project:** Create a mobile advertising project.	8 Hrs	Apply

Reference Books:
1. Digital Marketing by Seema Gupta, McGraw Hill Education, latest edition.
Text Books
1. Fundamentals of Digital Marketing by Puneet Bhatia, Pearson Publication, Latest edition. 2. Digital Marketing by Hanlon, Sage Publications, Latest edition.

Department of Mechanical Engineering

SEMESTER –VII			
Deep Learning for Mechanical Engineers **Credit: 03**			
Course Code	**25MEC1731**	**CIA Marks**	**50**
Teaching Hours/Week (L: T: P: J)	**2L:1T:0P:1J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Learning Objectives:

This course will enable students to

1. Understand the fundamentals of deep learning.
2. Understanding the working of Convolutional Neural Networks and RNN in decision making.
3. Illustrate the strength and weaknesses of many popular deep learning approaches.
4. Introduce major deep learning algorithms, the problem settings, and their applications to solve real world problems

Module-1		
Introduction: What is a Neural Network, Neural Networks Viewed As Directed Graphs, Feedback, Network Architectures, Rosenblatt‟s Perceptron: Introduction, Perceptron, The Perceptron Convergence Theorem, Relation Between the Perceptron and Bayes Classifier for a Gaussian Environment.	8 Hrs	Apply
Module-2		
Multilayer Perceptrons: Introduction, Batch Learning and On-Line Learning, The Back-Propagation Algorithm, XOR Problem, Heuristics for Making the Back- Propagation Algorithm Perform Better, Back Propagation and Differentiation.	8 Hrs	Understand
Module-3		
Regularization for Deep Learning: Parameter Norm Penalties - L2 Parameter Regularization, Dataset Augmentation, Semi-Supervised Learning. Optimization for Training Deep Models: Challenges in Neural Network Optimization – Ill Conditioning, Local Minima, Plateaus, Saddle Points and Other Flat Regions.	8 Hrs	Apply
Module-4		
Convolution neural networks: The Convolution Operation, Motivation, Pooling, Convolution and Pooling as an Infinitely Strong Prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Convolutional Networks and the History of Deep Learning.	8 Hrs	Analyze

Module-5		
Operations Research Dijkstra's Algorithm, Introduction to Reinforcement Learning, Material transportation in manufacturing facility, Programming Reinforcement Learning for material transportation 1, Programming Linear Regression mechanical properties prediction, Results Discussion on material properties prediction at different temperatures, Material Properties prediction assignment briefing	8 Hrs	Analyze
Total	**40 Hrs**	

Reference Books:

1. Simon Haykin, Neural networks and Learning Machines, Third Edition, Pearson, 2016

2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016. https://www.deeplearningbook.org/lecture_slides.html

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Industrial Internet of Things	Credits	03
Course code	25MEC1732	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objectives:

This course will enable the students to

1. To Understand about the fundamentals of Industrial Internet of Things and its building blocks along with their characteristics
2. To Understand the recent application domains of IoT in everyday life.
3. To Understand the protocols and standards designed for industrial IoT and the current research on it
4. To Understand the other associated technologies like cloud and fog computing in the domain of IoT
5. To Improve their knowledge about the various cutting-edge technologies in the field IoT and machine learning applications.

Prerequisite:

Basics of sensors, transducers, actuators, mechanical drive system, control systems. Python programming.

Module-1: Introduction to Internet of Things		
Teaching Component: Introduction, Physical design of IOT, Logical Design of IOT, IOT applications in industries, enabling technologies, IOT Levels & Deployment Templates.	8 Hrs	Apply
Module-2: IOT and M2M: Introduction		

Teaching component: M2M, Difference between IoT and M2M, SDN and NFV for IOT, IOT System Management with NETCONF-YANG, Need for IOT Systems Management, Simple Network Management Protocol (SNMP), Network operator requirements, NETCONF, YANG, IoT Systems Management with NETCONF-YANG.	8 Hrs	Apply
Module-3: IoT Platforms Design Methodology		
Teaching component: Introduction, IoT Design Methodology, Case Study on IoT System for Weather Monitoring, loT Systems - Logical Design using Python: Introduction, Installing Python, Python Data Types and Data structures, Control flow, Functions, Modules, Packages, File Handling, Operations, Classes, Python Packages of Interest for IoT	8 Hrs	Apply
Module-4: IoT Physical Devices & End points		
Teaching component: What is a loT Device, Raspberry Pi, About the Board, Linux on Raspberry Pi, Raspberry Pi interfaces, Programming Raspberry Pi with Python, Case Studies	8 Hrs	Apply
Module-5: Data Analytics for IoT		
Teaching component: Introduction, Apache Hadoop, Using Hadoop MapReduce for Batch Data Analytics, Apache Oozie, Apache Spark, Apache Storm, Using Apache Storm for Real-time Data Analysis.	8 Hrs	Apply
Total		**40 Hrs**

Text Books:

[1]. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1 stEdition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978-9386873743).,

[2]. Srinivasa K G, "Internet of Things", CENGAGE Leaning India, 2017.

Reference Books:

1. Industry 4.0: The Industrial Internet of Things" by Alasdair Gilchrist
2. Industrial Internet of Things: Cyber manufacturing Systems" by Sabina Jeschke et al

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	**Hydrogen Technology**	**Credits**	**03**
Course code	**25MEC1733**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:0T:0P:0J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Objective:

The students will be able:

1. To understand the fundamentals and properties of hydrogen as an energy source.
2. To study various hydrogen production, storage and transportation techniques.
3. To learn hydrogen utilization technologies including fuel cells and combustion systems.
4. To analyze safety, environmental and economic aspects of hydrogen energy systems.
5. To understand emerging trends and industrial applications of hydrogen technology in sustainable energy systems.

Module 1: **Introduction to Hydrogen Technology**		
Introduction to hydrogen energy, properties and characteristics of hydrogen, hydrogen as a clean and sustainable fuel, hydrogen economy and global energy scenario, advantages and challenges of hydrogen technology, thermodynamics of hydrogen systems, applications of hydrogen in mechanical engineering, role of hydrogen in renewable energy integration and decarbonization.	8 Hrs	
Module-2: Hydrogen Production Technologies		
Conventional hydrogen production methods, steam methane reforming, coal gasification and partial oxidation, electrolysis of water, alkaline and PEM electrolysis systems, biological and photoelectrochemical hydrogen production methods, renewable hydrogen production, green, blue and grey hydrogen concepts, effiCIAncy and environmental considerations in hydrogen production technologies.	8 Hrs	
Module-3: Hydrogen Storage and Transportation		

Hydrogen storage methods including compressed gas storage, liquid hydrogen storage and solid-state storage, metal hydrides and chemical storage methods, hydrogen transportation techniques through pipelines and cryogenic systems, storage materials and performance characteristics, challenges in hydrogen storage and distribution, safety considerations in storage and transportation systems.	8 Hrs	
Module-4: Hydrogen Utilization and Fuel Cell Technologies		
Hydrogen combustion systems, hydrogen-powered internal combustion engines, fundamentals of fuel cells, types of fuel cells including PEMFC, SOFC and AFC, fuel cell components and working principles, efficiency and performance analysis of fuel cell systems, hydrogen applications in automobiles, aerospace, power generation and industrial systems, hybrid energy systems using hydrogen.	8 Hrs	
Module-5: Safety, Sustainability and Emerging Trends		
Hydrogen safety standards and risk assessment, leakage detection and fire safety, environmental impacts and lifecycle assessment of hydrogen systems, techno-economic analysis of hydrogen technologies, policies and regulations related to hydrogen energy, smart hydrogen infrastructure, integration with Industry 4.0 and renewable energy systems, industrial case studies, future trends and challenges in hydrogen technology.	8 Hrs	
Total Hours		**40**

Recommended Text Books

1. Hydrogen and Fuel Cells: Emerging Technologies and Applications by Bent Sørensen, Academic Press, 2nd Edition, 2018.
2. Hydrogen Fuel: Production, Transport, and Storage by Ram B. Gupta, CRC Press, 2nd Edition, 2018.

Reference Books

1. Hydrogen Production: Prospects and Processes by Richard M. Felder and James A. Ritter, Elsevier, 2020.
2. Hydrogen Economy: Opportunities and Challenges by Michael Ball and Martin Wietschel, Cambridge University Press, 2009.
3. Fuel Cell Systems Explained by James Larminie and Andrew Dicks, Wiley, 3rd Edition, 2020.
4. Hydrogen Storage Technologies edited by Lennie Klebanoff, CRC Press, 2016.
5. Hydrogen Safety Engineering and Risk Assessment by Jinyang Zheng et al., Springer, 2022.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Design for Manufacturing and Assembly**	**Credits**	**03**
Course Code	**25MEC1734**	**CIA**	**50**
Number of lecture Hours per week	**3L:T:P:J**	**SEA marks**	**50**
Total number of lecture Hours	**40**	**SEA Duration**	**3**

Course Objective:

1. To equip students with an understanding of the principles of design for manufacturing and assembly, focusing on optimizing product design for ease of manufacturing and assembly.
2. To provide knowledge of various manufacturing processes and how design considerations impact manufacturability and assembly efficiency.
3. To enable students to apply DFMA principles in real-world scenarios, improving product quality and reducing production costs.

Module-1: Introduction to DFMA		
Definition and Importance of DFMA: Overview, history, and significance. DFMA Methodology: Steps in the DFMA process. Design for Manufacturing (DFM): Principles, guidelines, and tools. Design for Assembly (DFA): Principles, guidelines, and tools. Cost Reduction Strategies: Impact of DFMA on reducing production costs. Case Studies: Real-world examples of DFMA implementation.	8 Hrs	Understand
Module-2: Materials Selection in DFMA		
Material Properties: Understanding properties critical to manufacturing and assembly. Material Selection Process: Criteria and methods for selecting materials.	8 Hrs	Understand
Impact of Material Selection on Design: How materials affect design choices. Manufacturing Processes for Selected Materials: Compatibility and considerations. Environmental Considerations: Sustainable materials and eco-design.		

Module-3: Design for Manufacturing		
Manufacturing Process Overview: Overview of key manufacturing processes (casting, forging, machining, etc.). Design Guidelines for Machining: Tolerances, surface finish, and geometric design. Design Guidelines for Casting and Forging: Considerations for parting lines, drafts, and shrinkage. Design for Sheet Metal Fabrication: Bend radius, tool accessibility, and material handling. Design for Injection Molding: Gate location, wall thickness, and ejection mechanisms.	8 Hrs	Understand
Module-4: Design for Assembly		
Assembly Process Overview: Types of assembly processes (manual, automated, robotic). Ease of Assembly: Simplifying designs for ease of assembly. Minimizing Part Count: Reducing the number of parts in a design. Design for Fastening and Joining: Guidelines for screws, rivets, adhesives, and welding. Error-proofing Assembly: Poka-yoke and other methods to prevent assembly errors.	8 Hrs	Apply
Module-5: Advanced DFMA Techniques and Applications		
DFMA Software Tools: Introduction to tools like Boothroyd Dewhurst DFMA software. Concurrent Engineering: Integration of DFMA in product development processes. DFMA in Product Life Cycle: Considering DFMA at different stages of product life. Design for Disassembly and Recycling: Incorporating end-of-life considerations. Lean Manufacturing and DFMA: How lean principles align with DFMA.	8 Hrs	Apply
Total	**40 Hrs**	

Text Books:

1. **"Product Design and Development for Manufacturing and Assembly",** *Authors:* Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRC Press, 3rd Edition.
2. **"Design for Manufacturing: A Structured Approach"** *Authors:* Corrado Poli, Elsevier Science, 1st Edition.
3. **"Design for Manufacturability and Concurrent Engineering",** *Authors:* David M. Anderson, CRC Press, 4th Edition.

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	**Digital Twin for Manufacturing Systems**	**Credits**	**03**
Course code	**25MEC1735**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course objectives:

1. To understand digital twin and its Architecture.
2. To understand Data Acquisition in digital twin.
3. To understand the application of data communication in digital twin.
4. To understand the Data-driven modelling and machine learning for digital twins.
5. To know Digital twin Application.

Module-1: Introduction to Digital Twins and Architecture		
Overview of Digital Twins, Definition and history, Importance in manufacturing, Industry 4.0 and the role of digital twins	8 Hrs	Understand
Module-2: Data acquisition in digital Twin		
The Need for Electronics in Manufacturing, signal processing and importance of digital twin, Image Processing for Digital Twin: Image enhancement, segmentation and introduction to image processing in manufacturing.	8 Hrs	Understand
Module-3: Data communication in digital twin		
Overview, IoT and Network IoT Framework, Introduction to the Edge, Fog, and Cloud Computing, The Necessity of Cloud and Edge Computing in Industry, Real-Life Example in Manufacturing.	8 Hrs	Apply
Module-4: Data-driven modelling and machine learning for digital twins		
Introduction to Artificial Intelligence, Requirement of Artificial Intelligence in a Digital Twin, Mathematical modelling, Physical and process modelling, Predictive maintenance, Real-time analytics.	8 Hrs	Apply
Module-5: Digital Twin Application		
Digital Twins for Design and Manufacturing, Digital Twins for Service, Challenges and Intelligence, Real-Life Examples in Manufacturing.	8 Hrs	Apply
	Total	**40 Hrs**

Reference Books

1. "Building Industrial Digital Twins Design, Develop, and Deploy Digital Twin Solutions for Real-world Industries Using Azure Digital Twins" Shyam Varan Nath, Pieter van Schalkwyk, Dan Isaacs Packet Publishing.
2. "Digital twin driven smart design "Tao F, Liu A, Hu T, Nee AY. Academic Press; 2020.
3. "Digital Twin Technology Fundamentals and Applications", Manisha Vohra Wiley 2022.
4. "Digital Twin – Fundamental, Concepts to Applications in Advanced Manufacturing" Surjya Kanta Pal, Debasish Mishra, Arpan Pal Samik Dutta, Debashish Chakravarty, Srikanta Pal Springer.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Semester: VII		
COURSE: Accounts and Financing for Engineers		
Course Code: 25MEC1736	**L: T:P: J:**	**CIA Marks: 50**
Credits: 03	**3-0-0-0**	**SEA Marks: 50**
Hours:	**40**	**SEA Duration: 03 Hours**

Pre-Requisites:

Course Learning Objectives: The students will be able to :

1	Comprehend and interpret key financial statements such as balance sheets, income statements, and cash flow statements.
2	Perform financial analysis using various financial ratios and metrics to assess the financial health of engineering projects and companies.
3	Introduce cost accounting methods and techniques, including job costing, process costing, and activity-based costing, to aid in budgeting and cost control.

Module 1: Introduction to Accounting		
Pre-requisite: Basic Mathematics, Fundamental Economic Concepts, Basic knowledge of business operations and structures **Teaching component**: **Fundamentals of Accounting:** Introduction to accounting principles, Types of accounting: financial, managerial, and cost accounting, The accounting equation and double-entry bookkeeping **Financial Statements:** Components of financial statements: balance sheet, income statement, cash flow statement, Understanding and analyzing financial statements, Key financial ratios and their interpretation. **Accounting Standards and Ethics:** Overview of Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS), Ethical considerations in accounting.	8 Hrs	Apply
Module-2: Cost Analysis and Management		
Pre-requisite: Fundamentals of Engineering Economics, Introduction to Accounting Principles, Basic Knowledge of Project Management **Teaching component**: **Cost Concepts and Classification:** Fixed, variable, and mixed costs, Direct and indirect costs, Product and period costs **Costing Methods:** Job order costing, Process costing, Activity-based costing (ABC) **Cost Control and Reduction:** Techniques for cost control, Cost- benefit analysis, Break-even analysis.	8 Hrs	Apply
Module-3: Budgeting and Financial Planning		

Pre-requisite: Basic Accounting Principles, Financial Mathematics, Knowledge of the basic principles of financial management **Teaching component**: **Budgeting Basics:** Importance of budgeting in engineering projects, Types of budgets: operating, capital, and cash budgets, Preparing a budge **Financial Planning:** Forecasting financial needs, Developing a financial plan for engineering projects, Variance analysis: comparing budgeted and actual performance **Capital Budgeting:** Evaluation of capital projects, Techniques: Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Profitability Index.	8 Hrs	Apply
Module-4: Financing and Investment		
Pre-requisite: Basic Accounting Principles, Understanding the concept of the time value of money, Familiarity with fundamental economic principles such as supply and demand, Basic understanding of corporate finance concepts **Teaching component**: **Sources of Finance:** Equity vs. debt financing, Internal vs. external financing, Short-term and long-term financing options **Financial Instruments:** Stocks, bonds, and loans, Venture capital and private equity, Government grants and subsidies **Investment Analysis:** Risk and return analysis, Portfolio diversification, Capital Asset Pricing Model (CAPM).	8 Hrs	Apply
Module-5: Financial Management in Engineering Projects.		
Pre-requisite: Basic Accounting Principles, Financial Analysis, Techniques, Knowledge of cost accounting methods, Understanding, of economic analysis techniques **Teaching component**: **Project Financing:** Financing mechanisms for engineering projects, Public-Private Partnerships (PPP), Project financing structures **Financial Risk Management:** Identifying and assessing financial risks, Strategies for managing financial risks, Insurance and hedging **Case Studies and Real-World Applications:** Analysis of financial management in successful engineering projects, Lessons learned from project failures, Future trends in financial management for engineers	8 Hrs	Apply

Reference Books

1. Engineering Economy" by Leland Blank and Anthony Tarquin

Text Books

1. "Financial Management for Engineers" by Arthur J. Keown, John D. Martin, and J. William Petty
2. "Principles of Corporate Finance" by Richard A. Brealey, Stewart C. Myers, and Franklin Allen
3. "Cost Accounting: A Managerial Emphasis" by Charles T. Horngren, Srikant M. Datar, and Madhav V. Rajan

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	AI & ML in Materials Science and Engineering	Credits	03
Course Code	25MEC1811	CIA	50
Number of lecture Hours per week	3L:T:P:J	SEA marks	50
Total number of lecture Hours	40	SEA Duration	3

Course Objective: This course will enable students

1. To introduce students to the fundamental concepts of AI and ML and how they can be applied to materials engineering problems.
2. To equip students with the skills needed to apply AI and ML techniques in analyzing materials data and predicting materials properties.
3. To foster innovation and encourage the development of new AI/ML-driven approaches for materials discovery and optimization.

Module-1: Introduction to AI & ML in Materials Engineering		
Overview of Artificial Intelligence and Machine Learning: Basic concepts and definitions of material science. Applications in Materials Science: Historical background and current trends. Data Collection and Preprocessing: Techniques for gathering and cleaning data specific to materials engineering. Supervised Learning Models: Regression and classification models relevant to materials properties prediction.	8 Hrs	Understand
Module-2: Unsupervised Learning & Clustering in Materials Engineering		
Introduction to Unsupervised Learning: Key concepts and differentiation from supervised learning. Clustering Techniques: Application of clustering in microstructure analysis and phase identification. Dimensionality Reduction: Techniques like PCA (Principal Component Analysis) and their importance in materials data. Case Studies: Practical examples where unsupervised learning has been applied in materials engineering	8 Hrs	Understand
Module-3: Neural Networks & Deep Learning for Materials Science		

Introduction to Neural Networks: Fundamentals of neural networks and their architecture. Deep Learning Models: Application of convolutional neural networks (CNNs) in image recognition of materials microstructure. Reinforcement Learning: Basics and applications in materials discovery and optimization. Hands-on Session: Implementing basic neural network models for materials property prediction	8 Hrs	Understand
Module-4: Predictive Modeling in Materials Engineering		
Predictive Analytics: Understanding predictive modeling and its significance in materials engineering. ML Algorithms for Property Prediction: Application of algorithms like Decision Trees, Random Forest, and SVM in predicting mechanical properties of materials. Model Evaluation: Techniques for evaluating model performance, including accuracy, precision, recall, and F1-score. Advanced Applications: Predictive maintenance, failure analysis, and lifecycle assessment of materials using AI.	8 Hrs	Apply
Module-5: Future Directions & Ethical Considerations		
Emerging Trends: AI-driven materials discovery, generative models, and automated experimentation. Sustainability and AI in Materials Engineering: The role of AI in sustainable materials development. Ethics in AI Applications: Discussing the ethical implications and challenges of AI in materials research. Project Work: Students will present a project applying AI/ML techniques to a materials engineering problem.	8 Hrs	Apply
Total	**40 Hrs**	

Reference Books

1. Database System Concepts" by Abraham Silberschatz, Henry F. Korth, and S. Sudarshan
2. "Fundamentals of Database Systems" by Ramez Elmasri and Shamkant B. Navathe
3. "SQL: The Complete Reference" by James R. Groff and Paul N. Weinberg

"NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence" by Pramod J. Sadalage and Martin Fowler

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Department of Mechanical Engineering

Course Name	Robotics and Intelligent System	Credits	03
Course code	25MEC1812	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Course Objective:

This course will enable the students to

1. Develop the students' knowledge in various robot structures and their workspace.
2. Enhance students' skills in performing spatial transformations associated with rigid body motions.
3. Develop students' skills in performing kinematics analysis of robot systems.
4 Provide the student with knowledge of the singularity issues associated with the operation of robotic systems, trajectory planning and robot control.

Module-I: System Modeling		
Pre-requisite: Robotics basics Biological and Cognitive Paradigms for Robot Design, Declarative-Procedural-Reflexive Hierarchy for Decision-Making and Control, Articulated Robots, Joint-Link (Denavit- Hartenberg) Transformations, Mobile Ground Robots, Uninhabited Air Vehicles, Intelligent Agents	8 Hrs	Apply
Module-2: Control System Principles-		
Open- and Closed-Loop Control, Time-domain and Frequency-domain Analysis, Optimality and Constraints, Stability and Performance, Adaptation, Control Actuation, Closed-form and Probabilistic Path Planning	8 Hrs	Apply
Module-3: Computing, Measurement, State, and Parameter Estimation		
Sensors and Sensing, Formal and Fuzzy Logic, Turing Machines and Concepts of Machine Learning, Analog and Digital Systems, Probability and Error Models, Sensor-Based Estimation, Extended Kalman and Particle Filters, Simultaneous Location and Mapping (SLAM)	8 Hrs	Apply
Module-4: Decision-Making and Machine Learning		
Decision Trees, Bayesian Belief Networks, Classification of Data Sets, Task Planning for Individual and Multiple Agents, **Numerical Methods for Evaluation and Search-** Monte Carlo Simulation, Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization	8 Hrs	Apply

Module-5: Expert Systems		
Production Systems, Forward Chaining, Backward Chaining, **Neural Networks for Classification and Control-** Training and Implementation of Network Architectures, Feed-Forward Networks, Associative Networks, Cerebellar Model Articulation Controller, Deep-Learning Algorithms	8 Hrs	Apply
	Total: 40 Hrs	

Text Books /Reference Books

1. H. Asada and J.-J. Slotine, Robot Analysis and Control, J. Wiley & Sons, 1986.
2. C. Asfahl, Robots and Manufacturing Automation, J. Wiley & Sons, 1992.
3. D. Auslander, J. Ridgely, and J. Ringgenberg, Control Software for Mechanical Systems, Prentice-Hall, 2002.
4. G. Bekey, Autonomous Robots, MIT Press, 2005.
5. M. Brady, J. Hollerbach, T. Johnson, T. Lozano-Perez, and M. Mason, Robot Motion: Planning and Control, MIT Press, 1984.
6. H. Choset, Principles of Robot Motion, MIT Press, 2005.
7. Computational Principles of Mobile Robotics by Gregory Dudek and Michael Jenkin, Second Edition
8. Craig, *Introduction to Robotics Mechanics and Control*, Pearson, 2018.
9. G. Long, *Fundamentals of Robot Mechanics*, Quintus-Hyperion, 2015.
10. L. Joseph, *Learning Robotics Using Python*, PACKT, 2015.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Computational Fluid Dynamics (CFD)**	**Credits**	**03**
Course code	**25MEC1813**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**03**

Course Objectives:

This course will enable the students to

1. To introduce the fundamentals of fluid flow modeling and the governing equations.
2. To familiarize students with numerical discretization methods and solution procedures.
3. To enable students to apply finite difference and finite volume methods to various flow problems.
4. To develop practical skills in setting up CFD problems and interpreting numerical results.
5. To promote critical thinking in analyzing and validating CFD results for engineering applications.

Module 1: Introduction to CFD and Governing Equations		
Introduction to CFD and its applications in engineering, Advantages and limitations of CFD, Derivation of governing equations of fluid flow: continuity, momentum, and energy equations (conservation form), Classification of PDEs: elliptic, parabolic, and hyperbolic equations, Physical boundary conditions and initial conditions.	8 Hrs	Apply
Module 2: Finite Difference Method (FDM)		
Introduction to discretization techniques, Finite difference approximation of derivatives: forward, backward, and central differences, Taylor series and truncation error, Solution of algebraic equations: Gauss-Seidel and TDMA, Discretization of 1D steady and unsteady heat conduction equations, Stability, consistency, and convergence.	8 Hrs	Apply

Module 3: Finite Volume Method (FVM)		
Finite volume method for 1D steady diffusion problems, Discretization of convection and diffusion equations, Upwind, central, and hybrid differencing schemes, SIMPLE algorithm and pressure-velocity coupling, Discretization of 2D steady state conduction problems	8 Hrs	Apply
Module 4: Grid Generation and Solution Procedures		
Structured vs. unstructured grids, Grid generation techniques: algebraic and PDE-based methods, Importance of grid quality and mesh refinement, Boundary conditions in FVM, Solution algorithms for Navier-Stokes equations, Overview of multigrid and segregated methods.	8 Hrs	Apply
Module 5: Applications and Introduction to CFD Software		
Applications of CFD in thermal, aerospace, and automotive industries, Case studies: flow over a flat plate, flow in a pipe, heat exchanger design, Turbulence modeling: brief introduction to RANS and k-ε models, Introduction to commercial CFD tools (e.g., ANSYS Fluent, OpenFOAM), Guidelines for setting up a CFD problem: preprocessing, solution, and post-processing, Validation and verification of CFD results.	8 Hrs	Apply
Total		**40 Hrs**

Textbooks:

1. H.K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education.
2. Jiyuan Tu, Guan Heng Yeoh, and Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Elsevier.

Reference Books:

1. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor & Francis.
2. Tapan K. Sengupta, Fundamentals of Computational Fluid Dynamics, Universities Press.
3. Anderson, J.D., Computational Fluid Dynamics: The Basics with Applications, McGraw Hill.
4. Ferziger, J.H., and Perić, M., Computational Methods for Fluid Dynamics, Springer.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Operation Research with AI	Credits	03
Course code	25MEC1816	CIA Marks	50
Number of Lecture Hours/Week	3L:0T:0P:0J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	03

Course Objective:

The students will be able:

1. To understand the fundamental concepts and applications of Operations Research in mechanical engineering systems.
2. To develop mathematical models and apply optimization techniques for industrial decision-making problems.
3. To learn intelligent and metaheuristic approaches for solving complex engineering optimization problems.
4. To apply data analytics, predictive modelling, simulation and decision support techniques in manufacturing and operations management.
5. To understand emerging intelligent technologies and their applications in smart manufacturing and industrial systems.

Module 1: **Fundamentals of Operations Research and Intelligent Systems**		
Introduction to Operations Research (OR), scope and applications in mechanical engineering, phases of OR methodology, mathematical modelling and optimization concepts, decision-making techniques, intelligent systems and computational intelligence, role of intelligent optimization in Industry 4.0, smart manufacturing and industrial engineering applications.	8 Hrs	
Module-2: Optimization Techniques and Metaheuristic Algorithms		
Formulation of linear programming problems, graphical and simplex methods, transportation and assignment problems, integer and nonlinear programming concepts, sensitivity analysis, metaheuristic optimization techniques including genetic algorithms, particle swarm optimization, ant colony optimization and simulated annealing, applications in production planning, scheduling and resource allocation.	8 Hrs	
Module-3: Data Analytics and Predictive Modelling in OR		

Introduction to data analytics in engineering systems, regression and forecasting techniques, predictive maintenance concepts, reliability prediction, inventory and demand forecasting models, clustering and classification methods for industrial applications, data-driven optimization approaches, applications in supply chain management, manufacturing systems and process optimization.	8 Hrs	
Module-4: Simulation and Intelligent Decision Support Systems		
Simulation concepts and Monte Carlo simulation, queuing theory and waiting line models, game theory and decision analysis, multi-criteria decision-making methods, fuzzy logic and fuzzy optimization, expert systems and decision support systems, intelligent maintenance and logistics management, industrial applications in manufacturing and operations management.	8 Hrs	
Module-5: Emerging Trends and Industrial Applications		
Digital twins and smart factory concepts, AI-driven production scheduling and process planning, robotics and autonomous manufacturing systems, Industrial Internet of Things (IIoT) integration in operations management, cloud-based industrial analytics, optimization in additive manufacturing systems, industrial case studies in mechanical engineering, ethical considerations and future trends in intelligent operations management.	8 Hrs	
Total		**40 Hrs**

Text Books

1. Operations Research by J. K. Sharma, 7th Edition, McGraw-Hill Education, 2021.
2. Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig, 4th Edition, Pearson, 2021.
3. Data Analytics for Engineering and Construction Project Risk Management by Khaled El-Rayes and Hyun Woo Lee, Wiley, 2020.

Reference Books

1. Introduction to Operations Research by Frederick S. Hillier and Gerald J. Lieberman, 11th Edition, McGraw-Hill Education, 2021.
2. Fuzzy Sets and Fuzzy Logic: Theory and Applications by George J. Klir and Bo Yuan, Prentice Hall, 2015.
3. Digital Twin Driven Smart Manufacturing by Fei Tao and Ang Liu, Academic Press, 2019.
4. Simulation Modeling and Analysis by Averill M. Law, 6th Edition, McGraw-Hill Education, 2022.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Micro-Electro Mechanical Systems (MEMS)	Credits	03
Course code	25MEC1561	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3 Hours

Course Objective:

This course will enable the students to

1. Understand the nature of smart materials and its structural applications.
2. Appreciate the principle of electrorheological fluids.
3. Recognize the damping and absorber need for controlling vibrations of smart systems.
4. Understand and develop piezo electric effect and its contribution towards smart structures.
5. Develop and design shape memory polymers and alloys understanding the crystallographic and thermal effects.

Module-I: Smart Materials and Structures		
Introduction: Definition and classification of smart material, need for smart materials, Smart structures and adaptive systems, closed loop and Open loop smart structures, Sensors, Actuators and Transducers - Applications in aerospace, automotive, robotics and biomedical fields, Introduction to AI-enabled smart monitoring systems. **Piezoelectric Materials:** Piezoelectric effect and properties, Piezoceramic and piezopolymer materials, Piezoelectric sensing and actuation principles, Piezoelectric composites and smart patches, Energy harvesting using piezoelectric materials, Flexible and wearable piezoelectric sensors. **Characteristics of Natural structures:** Characteristics of natural structures, Fiber reinforced organic matrix natural composites, Natural ceramers, Mollusks and bio-inspired structures, Biomimetic sensing, Challenges and opportunities in biomimetics, Bio-inspired robotics and smart sensing applications.	8 Hrs	Understand Apply
Module-2: Shape Memory Alloys Fiber Optics		
Shape Memory Alloys: Shape memory effect and pseudoelasticity, Applications of shape memory alloys, Stress-temperature relationship and phase transformation, Modelling of shape memory behaviour, Vibration and structural control using SMAs, Design considerations for SMA-based		

systems, Embedded NiTiNOL actuators and smart adaptive devices, SMA applications in soft robotics and aerospace morphing structures. **Fiber Optics:** Introduction, Physical Phenomenon of optical transmission, Characteristics of optical fibers, Fiber optic strain sensors, Optical fibers as load bearing elements, Crack detection, Temperature and Pressure measurement applications, Fiber Bragg Grating (FBG) sensors and structural health monitoring.	8 Hrs	Understand Apply
Module-3: ER and MR Fluids and Vibration Absorber		
ER and MR Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Applications of ER and MR fluids - Clutches, Dampers, others. **Vibration Absorber:** Un-damped vibration absorber, Parallel damped vibration absorber, Analysis vibration absorbers, Gyroscopic vibration absorbers, Active vibration absorbers, Smart and adaptive vibration control systems.	8 Hrs	Understand Apply
Module-4: Micro Electro Mechanical Systems & Polymer MEMS		
Introduction: History of MEMS, Intrinsic characteristics, MEMS applications, Internet of Things (IoT) enabled MEMS devices, Materials for MEMS. **Microfabrication:** Photolithography, Thermal oxidation, Thin film deposition, Etching. Microelectronics fabrication process flow, Silicon based, 3D microfabrication and nanofabrication concepts, Process selection and design. **Polymer MEMS:** Introduction, Polymers in MEMS (Polyimide, SU8, LCP, PDMS, PMMA), Applications: Acceleration, Pressure, Flow, Tactile sensors, Wearable and flexible MEMS sensors	8 Hrs	Understand Apply
Module-5: Microfluidics and Case studies on MEMS		
Microfluidics: Motivation for microfluidics, Biological concepts in microfluidics, Design and fabrication of selective components, Microchannels and valves, Lab-on-chip and biomedical, diagnostic systems. **Case studies on MEMS:** MEMS Magnetic actuators, MEMS magnetic actuators, Blood pressure (BP) sensors, MEMS microphones, Acceleration sensors, MEMS gyroscopes, MEMS applications in drones, smartphones and healthcare devices.	8 Hrs	Understand Apply
Total		**40 Hrs**

Text Books				
Sl.	**Title**	**Author**	**Publication**	**Edition**
1	Smart Material Systems and MEMS	Vijay K. Varadan	John Wiley & Sons	2006
2	Smart Materials and Structures	M.V. Gandhi and B.S. Thompson	Chapmen & Hall, London	1992
3	Foundation of MEMS	Chang Liu	Pearson Education	2000

Reference Books				
Sl. No.	**Title**	**Author**	**Publication**	**Edition**
1	Smart Structures Theory	Inderjit Chopra Jayant Sirohi	Cambridge University Press	2013
2	Smart Structures –Analysis and Design	A.V. Srinivasan	Cambridge University Press, New York	2001
3	Piezoelectric actuators: control applications of smart	Seung- Bok Choi & Young-Min Han	CRC Press	2010
4	Piezoelectric transducers and applications	Antonio Arnau	Springer	2004
5	Shape Memory Alloys: Modelling and Engineering Applications	Dimitris C. Lagoudas	Springer	2008
6	Shape memory alloys for biomedical applications	T. Yoneyama & S. Mayazaki,	CRC Press	2009
7	Electroactive polymers for robotics applications	Kwang J. Kim & S. Tadokoro	Springer	2007

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Sustainable Energy Technology	Credits	03
Course Code	25MEC1562	CIA	50
Number of lecture Hours per week	3L:T:P:J	SEA marks	50
Total number of lecture Hours	40	SEA Duration	3

Course Objective: This course will enable students to

1. Explain the concept of sustainability and determine the threats for sustainability in any area
2. Discuss environmental Agreements and Protocols
3. Discuss different global environmental issues
4. Describe life cycle assessment for products made of different materials
5. Discuss environmental impact assessment in real time problems

Module-1: Introduction to Sustainable Engineering		
Introduction - Sustainable development, concepts of sustainable development: three pillar model, egg of sustainability model, Atkisson's pyramid model, prism model, principles of sustainable development, Contemporary Integrative Frameworks, **Environmental Ethics and Legislations** – Environmental ethics and education, multilateral environmental agreements and protocols, enforcement of environmental laws in India, Constitutional basis: Articles 48A and 51A(g); right to healthy environment under Article 21	8 Hrs	Understand
Module-2: Environmental Issues		
Local Environmental Issues- Solid waste, impact of solid waste on natural resources, zero waste concept and three R concept. Climate-resilient design: flood-proofing, heat-resilient infrastructure, coastal engineering **Global Environmental Issues-** Resource degradation: deterioration of water resources, land degradation,air pollution, climate change and global warming.	8 Hrs	Understand
Module-3: Tools for Sustainability		

Tools for Sustainability - Environmental Management System (EMS) **C**oncept of ISO14000, Life Cycle assessment (LCA): Basic components, Advantages, Disadvantages, Case study. Environmental impact assessment (EIA), Environmental auditing, Bio mimicking, Case studies.	8 Hrs	Understand
Module-4: Sustainable Habitat		
Sustainable Habitat - Concept of green building, green building materials, green building certification and rating: green rating for integrated habitat assessment (GRIHA), leadership in energy and environmental design (LEED) rating. **Sustainable Industrialization and Urbanization –** Sustainable urbanization, industrialization, material selection, pollution prevention, industrial ecology, industrial symbiosis, poverty reduction. ***Industrial ecology: study of material and energy flows in industrial systems.***	8 Hrs	Apply
Module-5: Green Technology and Green Business		
Green technology and Green Business: Sustainable business, green technology, green energy, green manufacturing, green construction, green transportation, green chemistry and green computing, ***AI and sustainability: AI as a tool for climate modelling vs. AI energy consumption***	8 Hrs	Apply
Total	**40 Hrs**	

Reference Books

1. D. T. Allen and D. R. Shonnard. Sustainability Engineering: Concepts, Design and Case Studies,1st Edition, Prentice Hall, 2011.
2. A.S. Bradley, A. O. Adebayo, P. Maria. Engineering applications in sustainable design and development, 1st Edition, Cengage learning, 2016.
3. R. L Rag and Lekshmi Dinachandran Remesh. *Introduction to Sustainable Engineering, 2nd* Edition, PHI Learning Pvt. Ltd., 2016.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Product Design and Development	Credits	03
Course Code	25MEC1563	CIA	50
Number of lecture Hours per week	3L:T:P:J	SEA marks	50
Total number of lecture Hours	40	SEA Duration	3

Module-1: Introduction to Product Design and Development		
Teaching Component: • **Basics of Product Design**: Definitions, concepts, and importance of product design. • **Product Development Process**: Phases from idea generation to commercialization. • **Product Life Cycle**: Stages of product life cycle and their impact on design and development. • **Customer Needs and Requirements**: Identifying and understanding customer needs, voice of the customer (VOC), and market research	8 Hrs	Understand

Module-2: Concept Generation and Selection		
Teaching Component: • **Idea Generation Techniques**: Brainstorming, mind mapping, TRIZ, and other creative techniques. • **Concept Development**: Translating customer needs into product concepts, functional decomposition. • **Concept Selection**: Pugh matrix, weighted decision matrix, and other evaluation methods. • **Prototyping and Testing**: Building and testing prototypes, rapid prototyping techniques.	8 Hrs	Understand

Module-3: Design for Manufacturing and Assembly (DFMA)		
Teaching Component: • **DFMA Principles**: Guidelines for designing products for ease of manufacturing and assembly. • **Materials and Processes**: Selection of materials and manufacturing processes. • **Cost Analysis**: Understanding cost drivers, cost estimation techniques. • **Quality and Reliability**: Designing for quality and reliability, statistical process control, and Six Sigma.	8 Hrs	Understand
Module-4: Advanced Product Design Techniques		
Teaching Component: • **Computer-Aided Design (CAD)**: Introduction to CAD software, 3D modelling, and simulation. • **Finite Element Analysis (FEA)**: Basics of FEA for stress analysis and optimization. • **Ergonomics and Human Factors**: Designing for human use, ergonomics principles, and user-centered design. • **Sustainable Design**: Eco-design principles, life cycle assessment, and sustainable materials.	8 Hrs	Apply
Module-5: Project Management and Legal Aspects		
Teaching Component: • **Project Management Fundamentals**: Planning, scheduling, and controlling product development projects. • **Agile Product Development**: Introduction to Agile methodologies and practices in product development. • **Intellectual Property (IP)**: Patents, trademarks, copyrights, and their relevance in product development. **Regulatory and Ethical Considerations**: Compliance with industry standards and ethical practices in product design	8 Hrs	Apply

Text and Reference Books

1. K. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, 1st edition, Prentice Hall, 2001. ISBN-13: 978- 0130212719.
2. V. Raja and K. Fernandes, Reverse Engineering: An Industrial Perspective, Springer- Verlag, 2008. ISBN: 978-1-84628-855-5.
3. K. A. Ingle, Reverse Engineering, McGraw-Hill, 1994. ISBN-13: 978-0070316935.
4. L. Wills and P. Newcomb, Reverse Engineering, 1st edition, Springer-Verlag, 1996.
5. C. K. Chua, K. F. Leong and C. S. Lim, Rapid Prototyping: Principles and Applications, 4th edition, WorldSCIAntific, 2010. ISBN: 978-981-277-897-0.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	Introduction to Drone Technology	Credits	03
Course code	25MEC1564	CIA Marks	50
Number of Lecture Hours/Week	3L:T:P:J	SEA Marks	50
Total Number of Lecture Hours	40	SEA Duration	3

Course Objective:

- Understand the fundamentals of drone technology, classifications, and applications.
- Gain knowledge on drone components, subsystems, and their working including sensors, flight controllers, communication systems, and payloads.
- Understand regulatory frameworks, airworthiness standards, and certification processes governing drone operations.
- Analyze drone structural design and propulsion systems including aerodynamics, materials, and energy systems.
- Develop understanding of drone control systems, stability, tuning, communication, simulation, and real-world applications.

Module-1: Basics of Drone		
Introduction & History: Evolution of drones from military use to modern commercial and recreational applications, UAV types and classifications, nano drones & swarm drones. Principles of drone flight including aerodynamics, lift, thrust, drag, stability, Degrees of Freedom, stick movements, flight modes, and basic manoeuvres, structural strength, material, and thermal management. Introduction to AI-enabled autonomous drones, obstacle avoidance systems, and modern UAV applications in agriculture, surveillance, mapping, logistics, and disaster management.	8 Hrs	Understand
Module-2: Components and Systems of Drone		
Basic Components: Airframe, Propellers, ESCs, Motors Control Systems: Microcontrollers, Microprocessors, Sensors, Pre-flight Checks: Visual Inspection, Battery Check, Firmware Updates, Communication: Flight Planning Transmitter and Receiver Systems, Arduino Integration: Sensors Interface, Programming Structures in Arduino IDE, Telemetry,	8 Hrs	Understand

Aspects of Airframe Design: Scale Effects, Packaging Density, Aerodynamics, Structures and Mechanisms, Modular Construction, Ancillary Equipment, Design for Stealth.		
Module-3: Drone Airworthiness, Regulations and Certification		
DGCA Rules & Regulations: Indian civil aviation guidelines for RPAS (Remotely Piloted Aircraft System), Pilot Licensing Requirements: Types of drone licenses and eligibility criteria, NPNT Compliance: No Permission No Take-off system, Certifications and Approvals: UIN (Unique Identification Number), UAOP (Unmanned Aircraft Operator Permit), Airworthiness Standards and Operational Safety for UAVs, Drone Maintenance and Pre-flight Inspection Procedures, Privacy, Security and Ethical Issues in Drone Operations	8 Hrs	Understand
Module-4: Basics of Structures and Propulsion		
Drone Structural Design: Frame types, payload mounting, vibration dampening, centre of gravity, balance and stability. Payload Systems: Camera payloads, LiDAR, delivery mechanisms, gimbal systems, and payload integration. Propulsion Systems: Electric propulsion using batteries and BLDC motors, hybrid propulsion systems, miniature IC engines, and solar-powered drones for extended endurance. Power and Energy Systems: Battery technologies, power distribution systems, ESC operation, energy efficiency, and endurance optimization. Emerging Concepts: Lightweight drone structures, modular drone design, and high-efficiency propulsion technologies.	8 Hrs	Understand
Module-5: **Testing, Tuning, Control Stability and Communications**		
Tuning & Calibration: PID Tuning for Stability, Sensor Calibration Manufacturing Constraints: Prototyping Techniques Cost and Time Considerations, Simulator, raining: Software: Real Flight, Lift-off, DRL Simulator, Purpose: Risk-Free Training, Practice Complex Manoeuvres, Control and Stability: Static and dynamic stability, attitude control, vibration effects, wind disturbances, and methods for improving drone stability and manoeuvrability. Communications: Communication Media, Radio Communication, Mid-air Collision (MAC), Avoidance, Communications Data Rate and Bandwidth Usage, Antenna types.	8 Hrs	Understand
Total	**40 Hrs**	

Reference Books:

Sl. No	Author	Title	Publisher
1.	Ms. Dharna Nar, Dr. Radhika Kotecha	Drone Technology for Beginners: Learn | Build | Fly Drones	Drone School India and Ane Books Pvt Ltd, ISBN: 978-8197222184
2.	Aalok Tripathi	Drone Technician Thoery	Arihant Publications India Limited, ISBN: 978-9364378895
3.	Terry Kilby, Belinda Kilby	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Shroff Publishers & Distributors Pvt. Ltd, ISBN: 978-9355428899
4.	Garvit Pandya	Basics of Unmanned Aerial Vehicles : Time to start working on Drone Technology	Notion Press Media Pvt Ltd, Chennai, ISBN: 978-1637453865
5.	Dr Raja Mogili Amirisetty	The Drone Law In India	Gogia Law Agency, ISBN: 978-8193978559
6.	Anderson, John D.	Fundamentals of Aerodynamics	McGraw-Hill Education
7.	Beard R.W., McLain T.W.	Small Unmanned Aircraft: Theory and Practice	Princeton University Press
8.	Marques P., Da Ronch A. (Eds.)	Advanced UAV Aerodynamics, Flight Stability and Control	Wiley

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	**Reverse Engineering**	**Credits**	**03**
Course Code	**25MEC1671**	**CIA**	**50**
Number of lecture Hours per week	**3L:T:P:J**	**SEA marks**	**50**
Total number of lecture Hours	**40**	**SEA Duration**	**3**

Course Objective: This course will enable students to

- Understand the Reverse Engineering (RE) Methodology
- Disassemble products and specify the interactions between its subsystems and their functionality
- Understand Computer-Aided RE and Rapid Prototyping Technology

Module-1: Introduction Reverse Engineering		
Introduction: Reverse engineering fundamentals- Generic Process-Three phases of Reverse Engineering-Phase I: Scanning, Phase II: Point processing, Phase III: Geometric model development. Impact of Reverse Engineering on various Engineering fields	8 Hrs	Understand
Module-2: Methodologies and techniques of Reverse Engineering		
Methodologies and techniques of Reverse Engineering: Computer aided reverse engineering, Computer vision and reverse engineering, Structured light range imaging, Scanner pipeline	8 Hrs	Understand
Module-3: Reverse engineering hardware and software		
Reverse engineering hardware and software: Introduction, Reverse engineering hardware, Fundamental RE Operations, Reverse engineering software, Selection of a reverse engineering system, Inspections Applications & Manufacturing Approaches, Case studies with implementation	8 Hrs	Understand
Module-4: Rapid Prototyping		
Introduction to rapid prototyping: Need & Development of RP systems, RP process chain, Impact of Rapid prototyping and Tooling on Product Development, Benefits, Digital prototyping, Virtual prototyping, Applications, Relationship between reverse engineering and rapid prototyping, Case studies with implementation.	8 Hrs	Apply

Module-5: Acceptance, Legality and Industrial Applications of RE		
Legality of Reverse Engineering – Patent – Copyrights –Trade Secret Third-Party Materials Reverse Engineering in the Automotive Industry; Aerospace Industry; Medical Device Industry, Moving towards Mass Customization Mini project exercise based on understanding of modules contents	8 Hrs	Apply
Total	**40 Hrs**	

Text and Reference Books

1. K. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, 1st edition, Prentice Hall, 2001. ISBN-13: 978-0130212719.
2. V. Raja and K. Fernandes, Reverse Engineering: An Industrial Perspective, Springer-Verlag, 2008. ISBN: 978-1-84628-855-5.
3. K. A. Ingle, Reverse Engineering, McGraw-Hill, 1994. ISBN-13: 978-0070316935.
4. L. Wills and P. Newcomb, Reverse Engineering, 1st edition, Springer-Verlag, 1996. ISBN-13: 978-1475788280.
5. C. K. Chua, K. F. Leong and C. S. Lim, Rapid Prototyping: Principles and Applications, 4th edition, World Scientific, 2010. ISBN: 978-981-277-897-0.

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	**3 D Printing**	**Credits**	**3**
Course code	**25MEC1672**	**CIE Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEE Marks**	**50**
Total Number of Lecture Hours	**40**	**Exam Hours**	**3 Hrs.**

1	To impart knowledge of fundamentals of various Additive Manufacturing Technologies.
2	To make students aware of advanced additive manufacturing technologies
3	To expose students about design parameters for additive manufacturing.
4	To expose the students to various materials used in additive manufacturing.
5	To expose the students to understand the role of additive manufacturing applications in various domains and its association with modern technologies.

Module 1: Fundamentals of AM and Processes

	No. of Hrs	**Blooms cognitive Levels**
Generic AM Process, benefits of AM over CNC machining, AM related technologies (reverse engineering, CAD, CAM, CAE), general integration of AM machine, classification of AM Processes. Heat sources for AM processes, maintenance of equipment, material handling issues. AM Software for slicing and STL file manipulation, introduction to Software's for additive manufacturing process- CURA, MIMICS and MAGICS. Processe**s:** basic working principle, process benefits, drawbacks and applications of - Vat photo polymerization(Stereolithography), Powder bed fusion method (Selective laser sintering method), material extrusion (Fused deposition modeling), sheet lamination method	8	Apply

Module 2: Advanced Processes

Material Jetting-Material processing fundamentals, material jetting machines, process parameters, benefits and drawbacks. **Binder jetting** – fundamentals of binder jetting, process variations, binder jet machines, process benefits and drawbacks **Direct energy deposition**- General DED process, Material delivery, laser engineered net shaping, electron beam based metal deposition processes, wire arc additive manufacturing, Friction Stir Additive Manufacturing (FSAM), benefits and drawbacks **Direct write technology**: introduction to DW, laser transfer DW, thermal spray DW, electroforming, applications of DW, technical		Apply

challenges of DW. **Hybrid additive manufacturing**: Introduction to Hybrid additive manufacturing processes, Secondary hybrid AM processes – machining, rolling, burnishing, ablation, pulsed laser deposition, re-melting	8	
Module 3: Design for Additive Manufacturing		
DFAM concepts: Introduction, Design for Manufacturing and Assembly, Core DFAM Concepts and Objectives- Opportunistic vs. Restrictive DFAM, AM Unique Capabilities, Shape Complexity, Hierarchical Complexity, Functional Complexity, Material Complexity **Design Opportunities:** Part Consolidation Overview, Design for Function, Part Consolidation Consequences, Customized Geometry, Hierarchical Structures, Multifunctional Designs, Elimination of Conventional DFM Constraints, Industrial Design Applications, Role of Design Standards **Design for Four-Dimensional (4D) Printing:** Definition of 4D Printing, Shape-Shifting Mechanisms and Stimuli, Shape-Shifting Types and Dimensions **Computer-Aided Design Tools for AM:** Challenges for CAD, Solid Modeling CAD Technologies, Commercial CAD Capabilities, **Design Space Exploration:** Design of Experiments, Design exploration software, introduction to optimization methods	8	Apply
Module 4: Materials for additive Manufacturing		
Liquid based material: Liquids for VPP, Liquid Polymer Material for MJT and BJT, Liquid Metal Material for MJT, Liquid Ceramic Composite Materials for VPP and MJT. **Powder-Based Materials:** Polymer Powder Material for PBF, Metal Powder Material for PBF, DED, and BJT, Ceramic Powder Material for BJT, Ceramic Powder Material for PBF, Composites Produced by PBF, Composites Produced by DED, Composites Produced by BJT **Solid-Based Materials:** Solid Polymer Feedstock for MEX, Solid Metal Feedstock for DED and MEX SHL, Solid Ceramic Feedstock for SHL and MEX. **Material Issues in AM:** Build Orientation, Keyholes, Chemical Degradation and Oxidation, Reactive Processes, Assistive Gas and Residual Particles, Cracks, Delamination, Distortion, Inclusions, Poor Surface Finish, Porosity, Shelf Life or Lifetime of the Feedstock, Support Structures.	8	Apply
Module 5: Applications and Role of Additive Manufacturing in Industry4.0		
AM Applications: Medical applications (Surgical and Diagnostic Aids, Prosthetics and Implants, Tissue Engineering and Organ Printing), Aerospace applications, Automotive applications **Industrial drivers for AM adoption**: Value pf physical models, functional testing and rapid tooling, societal implications of AM **AM and Industry 4.0**: Digital twin in Industry 4.0, Sustainability with additive manufacturing in Industry 4.0, Manufacturing scenario with additive manufacturing in Industry4.0, Quality, qualification, and certification of additive manufacturing products with Industry 4.0, Transformation to IIoT based additive manufacturing, Manufacturing	8	**Apply**

scenario with additive manufacturing and Industry4.0, Future factory with Industry4.0 and additive manufacturing Sequence of operations in a smart factory equipped with additive manufacturing and Industry 4.0 technologies.		

Reference Books

1. Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker Mahyar Khorasani, third edition, Springer Nature Switzerland AG 2021

2. Additive Manufacturing: A Tool for Industrial Revolution 4.0, Woodhead Publishing 2021, edited by M. Manjaiah, K Raghavendra, N. Balashanmugam, J. Paulo Davim

3. Additive Manufacturing Technology, Hari Prasad,A.V.Suresh by Cengage publication, 2019

4. Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing by Andreas Gebhard, Hanser Publishers, 2011.

5. Rapid Prototyping: Principles and Applications in Manufacturing by RafiqNooran, John Wiley & Sons publishers, 2006

B.N.M. Institute of Technology

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Department of Mechanical Engineering

Course Name	**Industry 4.0**	**Credits**	**3**
Course code	**25MEC1673**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course Objective: This course will enable the students:

1. To describe the forces acting between the tire and the road during the operation of a vehicle.
2. To describe design and basic function of the vehicle systems: steering and suspension.
3. To describe the principle and performance of vehicle in various modes such as longitudinal, vertical and lateral directions.
4. To identify the various forces and loads and performance under acceleration, ride and braking.
5. To compile the models of the vehicle systems to a vehicle level model, and use it to verify vehicle function requirements for manoeuvre's that mainly are either of longitudinal, lateral and vertical.

Module-1: Introduction to Industry 4.O and Cloud Manufacturing		
Pre-requisite: Knowledge of Advanced Manufacturing Techniques and basics of AI and ML **Teaching component**: Introduction to Industry 4.0, The Various Industrial Revolutions, Digitalization and the Networked Economy Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, The Journey so far: Developments in USA, Europe, China and other countries Comparison of Industry 4.0 Factory and Today's Factory, Difference between conventional automation and Industry 4.0, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation **Cloud Manufacturing and the connected factory**: Virtualization, Cloud Platforms, Big data in production, Cloud-based ERP and MES solutions, Connected factory applications, IT security for cloud applications **Self-study component/Case study**: Use of AI and IoT in Automated Production flow line	8 Hrs	Apply

Module-2: Human Robot Collaboration and AI in Production System

Pre-requisite: Industrial Robots **Teaching component**: Human-Robot Collaboration in Industry, Example video Airplane Assembly and others- Collaborative Robots- Collaborative Robots, examples (Yumi, IIWA, UR, Panda)-Types of Human-Robot Collaboration - Safety of Human-Robot Collaboration (Standards and Norms in the EU) - Applications with Collaborative Robots (examples of existing or future applications in the field of manufacturing) **Artificial Intelligence in Production: Machine Learning Application:** Basics of Machine Learning, The Machine Learning Process, Into Machine Learning working cycle, Preparing Data, Running Experiments, Finding the Model, Training the Model, Deploying and using a Model, Machine Learning in practice **Self-study component/Case study**: Human-Robot Collaboration applications and safety issues, think about areas of application	8 Hrs	Apply
Module-3: The Smart work piece & Digital twins in production		
Pre-requisite: Smart machine Tools **Teaching component**: The intelligent work piece as basic functionality in implementing Industry 4.0. What is an intelligent work piece? How to make a workpiece intelligent? Work piece tagging, QR codes and RFID, Communication between work piece and environment, Applications for smart work pieces (examples of existing or future applications in the field of manufacturing) **Digital twins in production:** Basic concepts of Digital Twins, Benefits, impact and challenges, Features and Implementation of Digital Twins, Types of Digital Twins, Digital Twin use cases, Applications for digital twins in production (examples of existing or future applications in the field of manufacturing) **Self-study component/Case study**: Digital Twins in Production, Service and Repair, think about these and other applications	8 Hrs	Apply
Module-4: Introduction to Assistance systems for production		
Pre-requisite: Advanced Production System **Teaching component**: **Assistance systems for production**	8 Hrs	Apply

The connected worker within the Industry 4.0 scenario, Diversity- driven workplaces (barrier free workplaces, accessibility in production), Human- and task-centered assistance systems (e.g. motion capture system for training employees, etc.) Technical tools ("Ambient Assisted Working" (AAW)) Mobile information technologies, Shop floor information systems, Production line support systems (pick by light, assembly display systems, assembly control by vision) Manipulator systems and intelligent chairs, Human work support by using exoskeletons, Applications assistance systems in production (examples of existing or future applications in the field of manufacturing) **Self-study component/Case study**: Human power support by use of exoskeletons in production		
Module-5: Augmented Reality in Manufacturing		
Integrating Design and Manufacturing: Training Shop Floor Workers: Supporting complex Assembly Operations: Service and Maintenance: Supporting complex Sales solutions: Executive Oversight and Data Visualization, Applications with Augmented Reality. Business issues in Industry 4.0, Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world **Self-study component/Case study**: Safety and Security in networked Production Environments	8 Hrs	Apply
	Total	**40 Hrs.**

Reference Books

1. A. McEwen and H. Cassimally, Designing the Internet of Things, Wiley,
2. N. Vengurlekar and P. Bagal, Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management, McGraw-Hill Education.

Text Books

1. M. Kuniavsky, Smart Things: Ubiquitous Computing User Experience Design, Morgan Kaufmann.
2. Dr. Alp Ustundag and Emre Cevikcan. Industry 4.0: Managing the Digital Transformation, Springer series in advanced manufacturing.
3. Bartodziej, Christoph Jan," The Concept Industry 4.0" Best master.

B.N.M. Institute of Technology

An Autonomous Institution under VTU

Department of Mechanical Engineering

Course Name	**Human Factors and Ergonomics**	**Credits**	**03**
Course code	**25MEC1674**	**CIA Marks**	**50**
Number of Lecture Hours/Week	**3L:T:P:J**	**SEA Marks**	**50**
Total Number of Lecture Hours	**40**	**SEA Duration**	**3 Hours**

Course Objective:

This course will enable the students to

1. Understand and describe current theories, methods, and design principles related to human factors and ergonomics
2. Identify, formulate, and solve problems in the areas of human factors and ergonomics
3. Apply appropriate theories and methods to analyze and design human-technology systems which are safe and effective for people to use and operate
4. Communicate effectively about human factors and ergonomics engineering problem solutions, and system designs

Module-I: Human Factors and energy expenditure

Teaching component: **Fundamentals of Human Factors Engineering**: Human Biological, Ergonomic and psychological capabilities and limitations, Concepts of human factors engineering and Ergonomics, Man-Machine system and Design philosophy. **Physical work and energy expenditure**: Manual lifting, Work posture, Repetitive motion, Provision of energy for muscular work, Heat stress, Role of oxygen physical exertion, Measurement of energy expenditure, Respiration, Pulse rate and blood pressure during physical work, Physical work capacity and its evaluation.	8 Hrs	Understand

Module-2: Anthropometry and Ergonomics

Teaching component: **Anthropometry**: Physical dimensions of the human body as a working machine, Motion size relationships, Static and dynamic anthropometry, Anthropometric design principles, Using anthropometric measures for industrial design. **Ergonomics and product design**: Ergonomics in automated systems, Expert systems for ergonomic design, Anthropometric data and its application in ergonomic design, Limitations of anthropometric data, Use of computerized database.	8 Hrs	Understand
Module-3: Machine Controls and Design in Work Place		
Teaching component: **Machine controls:** Improvement of human work place through controls, Displays and Controls, Shapes and sizes of various controls and displays, Multiple display and control situations, Design of major controls in automobiles and machine tools, Principles of hand tool design. **Work place and seating design**: Design of office furniture, Redesign of instruments, Work process: Duration of rest periods, Design of visual displays, Design for shift work.	8 Hrs	Understand
Module-4: Visual and Temperature Ergonomics in Workplace		
Teaching component: **Colour and light:** Colour and the eye, Colour consistency, Colour terms, Reactions to Colour and Colour continuation, Colour on engineering equipments. **Temperature-Humidity-Illumination and Contrast**: Use of Photometers, Recommended illumination levels, the ageing eye, Use of indirect (Reflected) lighting, Cost efficiency of illumination. Special purpose lighting for illumination and quality control.	8 Hrs	Understand
Module-5: Sound Ergonomics in Workplace		
Teaching component: **Measurement of sound**: Noise exposure and hearing loss, Hearing protectors, Analysis and reduction of noise, Sources of vibration and performance effect of vibration. **Ergonomic Performance Indicator**: Concepts of ergonomic performance and its indicators, principal and base parameters of EPI, safety awareness, 3D approaches in design of EPI model, applications of EPI, Product design assessment.	8 Hrs	Understand
Total		**40 Hrs**

Text Books /Reference Books

1. M. S. Sanders and E. J. McCormick, Human Factors in Engineering Design, VII Edition, McGraw Hill International, 1993.
2. P. V. Karpovich and W. E. Sinning, Physiology of Muscular Activity", VII Edition, Saunders (W.B.) Co Ltd., 1971.
3. Applied Ergonomics Handbook, I.P.C. SCIAnce and Technology Press Limited, 1974.
4. M. Helander, A Guide to the Ergonomics of Manufacturing, II Edition, CRC Press, 1997.