DEPARTMENT OF MECHANICAL ENGINEERING

Course Structure & Evaluation Scheme

M.TECH. COMPUTER AIDED DESIGN

Full Time Programme

(Effective from Academic Session 2023-2024)

SEMESTER I

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Mark
					MSE	TA	Lab	Total		
1	PCC	NME501	Numerical Methods and Computer Programming	4 (3-0-2)	15	20	15	50	50	100
2	PCC	NME503	Optimization for Engineers	4 (3-1-0)	30	20	-	50	50	100
3	PCC	NME505	Computer Graphics & Geometric Modelling	4 (3-0-2)	15	20	15	50	50	100
4	PEC-I		As per list	4 (3-1-0)	30	20	-	50	50	100
Total Credits				**16**						

SEMESTER II

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Mark
					MSE	TA	Lab	Total		
1.	PCC	NME502	Material Selection in Design	4 (3-1-0)	30	20	-	50	50	100
2.	PCC	NME504	Finite Element Method	4 (3-0-2)	15	20	15	50	50	100
3.	PCC	NME506	Product Design & Development	4 (3-1-0)	30	20	-	50	50	100
4.	PEC-II		As per list	4 (3-1-0)	30	20	-	50	50	100
Total Credits				**16**						

SEMESTER III

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Mark
					MSE	TA	Lab	Total		
1.	PEC-III		As per list	4(3-1-0)	30	20	-	50	50	100
2.	OEC I		As per list	3(3-0-0)	30	20	-	50	50	100
3.	Seminar	NME671	Seminar	1 (0-0-2)	-	50	-	50	50	100
4.	Dissertation-I	NME691	Dissertation-I	8 (0-0-16)	-	50	-	50	50	100
Total Credits				**16**						

SEMESTER IV

Sr. No.	Course Type	Subject Code	Course Title	Credits (L-T-P)	Sessional Marks				ESM	Total Mark
					MSE	TA	Lab	Total		
1.	Dissertation-II	NME692	Dissertation-II	16 (0-0-32)	-	50	-	50	50	100
Total Credits				**16**						

Total Programme Credits: 64

PROGRAMME ELECTIVE COURSES (PECs)

PEC I 4[3-1-0]

1. NME 511 Mechatronics
2. NME 513 Robotics & Automation
3. NME 515 Advanced Welding Technology
4. NME 517 Advance Machine Design

PEC-II 4[3-1-0]

1. NME 514 Soft Computing Techniques
2. NME 516 Mechanical System Design
3. NME 518 Simulation Modeling & Analysis
4. NME 520 Smart Materials & Structures

PEC-III 4[3-1-0]

1. NME 611 Advance Materials
2. NME 613 Computational Fluid Dynamics
3. NME 615 Digital Manufacturing

OEC-I 3[3-0-0]

1. NME 617 Design of Experiments
2. NME 619 Solar Energy

Detailed Course Syllabus
for

Master of Technology

COMPUTER AIDED DESIGN

(Full Time)

(Applicable to students admitted in the Academic Session 2023-24 onwards)

Department of Mechanical Engineering
Harcourt Butler Technical University
Kanpur-208002

Programme Core Courses (PCCs)

SEMESTER - I

NME501 NUMERICAL METHODS & COMPUTER PROGRAMMING C[L-T-P] : 4[3-0-2]

Course Objective: Gain proficiency in applying numerical methods to solve a wide range of mathematical problems, including equations, interpolation, linear systems, differentiation, integration, and differential equations.

Course Outcomes: Students will be able to:

CO1	Apply Newton-Raphson and Graeffe's root square methods to solve equations; develop computer-based algorithms and programs for these methods.
CO2	Use Lagrange's and Newton-divided difference formulas, interpolation formulae, cubic spline, and least squares approximation for data analysis.
CO3	Solve linear equations using Cholesky's (Crout's) method, Gauss-Seidel iteration, and develop computer-based algorithms for eigenvalue problems.
CO4	Perform numerical differentiation using difference operators, Simpson's and Boole's rules; approximate integrals using numerical integration methods.
CO5	Apply various methods like Euler's, Runge-Kutta, and relaxation methods to solve differential equations; analyze stability and solve Laplace's and Poisson's equations.

Course Content:

UNIT-1

Solution of Algebraic and Transcendental Equation: Newton-Raphson method including method of complex roots, Graeffe's root square method (Computer based algorithm and programme for these methods)

UNIT-2

Interpolation and Approximation: Lagrange's and Newton-divided difference formula, Newton interpolation formula for finite differences, Gauss's forward and backward interpolation formulae, Bessel's and Laplace-Everett's formulae, Cubic spline, least squares approximation using Chebyshev polynomial.

UNIT-3

Solution of Linear Simultaneous Equations: Cholesky's (Crout's) method, Gauss-Seidel iteration and relaxation methods, Solution of Eigenvalue problems; Smallest, largest and intermediate Eigen values (Computer based algorithm and programme for these methods)

UNIT-4

Numerical Differentiation and Integration: Numerical differentiation using difference operators, Simpson's 1/3 and 3/8 rules, Boole's rule, Weddle's rule.

UNIT-5

Solution of Differential Equations: Modified Euler's method, Runge-Kutta method of 2^{nd}, 3^{rd} and 4^{th} orders, Predictor-Corrector method, Stability of Ordinary differential equation, Solution of Laplace's and Poisson's equations by Liebmann's method, Relaxation method.

Text Books:

1. M. K. Jain, S.R.K. Iyenger and R.K. Jain, "Numerical Method for Scientific and Engineering Computation", Wiley Eastern Ltd.
2. S. K. Gupta, "Numerical Methods for Engineers", Wiley Eastern Ltd.
3. B. S. Grewal, "Numerical Methods", Khanna Publications.
4. A. D. Booth, "Numerical Methods", Academic Press, NY

Reference Books:

1. K.E. Atkinson, "An Introduction to Numerical Analysis", John Wiley & Sons, NY
2. "Numerical Methods for Engineers" by Steven C. Chapra and Raymond P. Canale. Publisher: McGraw-Hill Education.
3. "Numerical Methods in Engineering with Python" by Jaan Kiusalaas. Publisher: Cambridge University Press.
4. Numerical Recipes: The Art of Scientific Computing" by William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery. Publisher: Cambridge University Press.

NME503 OPTIMIZATION FOR ENGINEEERS
C[L-T-P] : 4[3-1-0]

Course Objective:
The course aims at development of understanding regarding optimization of non-linear functions

Course Outcomes:
After successful completion of this course students will be able to:

CO1	Learn classical optimization techniques
CO2	Learn one dimensional minimization methods.
CO3	Solve unconstrained optimization Problems.
CO4	Solve Constrained optimization Problems.
CO5	Apply Genetic Algorithm to Optimization Problems.

Course Content:

UNIT-I
Introduction to Optimization: Introduction, Historical Development, Engineering application, Classification of Optimization Problems. Classical Optimization Techniques: Single variable Optimization, Multi variable optimization without constraint, with constraint and with inequality constraint.

UNIT-II.
One Dimensional Minimization Methods: Elimination methods- Unrestricted search, Exhaustive search, Dichotomous search, Interval Halving method, Fibonacci Method, Golden section method.

UNIT-III
Unconstrained optimization Techniques: Direct search methods- random search method, Grid search method, Univariate method, Pattern directions, Powell's method. Indirect search Methods- Steepest Decent Method, Conjugate gradient Method, Newton's Method. Davidon-Fletcher-Powell method, BFGS Method.

UNIT-IV
Constrained optimization Techniques: Direct methods- Sequential Linear programming, Zoutendijk's Method of Feasible Directions. Indirect methods-Interior penalty function method, Exterior penalty function Method.

UNIT-V
Modern Methods of Optimization: Overview of Modern Methods of Optimization, Genetic Algorithm.

Text books:
1. Engineering Optimization Theory and Practice by Rao S.S.
2. Optimization Methods for Engineers by N.V.S. Raju, PHI.

3. Genetic Algorithms by Kalyanmoy Deb
4. Genetic Algorithms in search, optimization and machine learning by David E Goldberg, Pearson

Reference books:

1. Operations Research: Applications and Algorithms by Winston W L
2. Integer and Combinational Optimization by G.L.Nemhauser and L.A.Wolsey
3. Multi-objective evolutionary optimization for Product Design and Manufacturing by LihuiWang,
4. Methods of Optimization by Walsh G R.

Web link:

1. https://youtu.be/_awAywLKuEQ
2. https://youtu.be/gY9c1ANeZrQ
3. https://youtu.be/84HOL_EiJ4M

NME505 COMPUTER GRAPHICS & GEOMETRIC MODELLING C[L-T-P] : 4[3-0-2]

Course Objective:
To provide knowledge of CAD hardware and computer-aided geometric modelling.

Course Outcomes:
Student will be able to:

CO1	Understand the role of computer hardware for CAD and plotting.
CO2	Understand the mathematical fundamentals for geometric transformation on the screen.
CO3	Generate various parametric curves.
CO4	Generate various parametric surfaces.
CO5	Make 3D geometric models based on scanning data and business opportunities.

Course Content:

UNIT-1

Introduction to CAD - Computer systems & hardware for CAD, principles of raster scan and vector graphics. Plotting: Points, Line drawing, Circle generation algorithms. Scan conversions: Real time conversions Run length encoding and cell encoding. Computer Graphic & its standards - GKS, IGES.

UNIT-2

Geometric Transformations: Homogenous coordinate system, Scaling, Translation, shear, Reflection about axis & line. Viewing 3D on 2D screen: Representation of 3D shapes, rendering of surfaces and solids, hidden lines, edges ann, Constructive Solid geometry-basic elements & basic operations, Sweep representation. Modelling Softwares – Free & Paid.

UNIT-5

Scanning & Modelling:

3D scanners - Contact & Non-contact type technologies and machines, file formats, steps in Modelling, softwares, brands and prices range. Modelling for healthcare using CT Scan /MRI Data. Applications -Medical, Forensic, prosthetic, footwear, Architectural & Jewelry. Basics of 3D Printing and modelling. Startup stories – business opportunities.

Text Books:

1. D Hearn & M P Baker, “Computer Graphics”, Prentice Hall.
2. IIbrahim Zeid & R Sivasubramanian, “CAD/CAM Theory and Practice” Tata McGraw-Hill.

Reference Books:

1. A Saxena and B Sahay, “Computer Aided Engineering Design”, Anamya Publications.
2. D F Rogers and J A Adams, “Mathematical Elements for Computer Graphics”, McGraw Hill International.
3. H P Grover and E W Zimmers, “CAD/CAM”, Prentice Hall

CG & GM Laboratory:

1. Study of various commercial hardware and software of CAD of popular brands with their configuration, technologies and market price.
2. Create a template for geometric modelling and make a simple 3D model of a given drawing using CAD software.
3. To write MATLAB code for geometric transformations such as translation, scaling, rotation, etc.
4. To study parametric curves & surfaces using tools available in modelling softwares and MATLAB codes.
5. To prepare a 3D model of an object and human hand using 3D Scanner.
6. To prepare a 3D model using CT scan & MRI data.
7. To make a 3D geometric model for 3D printing for FDM based 3D Printer - part orientation & support structures, slicing effects, types of infill and its %, markers, connectors etc.

SEMESTER - II

NME502 MATERIAL SELECTION IN DESIGN
C[L-T-P]: 4[3-1-0]

Course Objective:
This course aims to provide the students an integrated approach for finding suitable material (metals, polymers, ceramics, and composites) for desired mechanical design.

Course Outcomes:
Student will be able to:

CO1	Understand significance, need and development concept for material selection in design.
CO2	Get acquainted with properties of engineering and design consideration for different materials.
CO3	Understand crystal structure of material and its role in mechanical properties.
CO4	Understand material process selection and material selection with multiple constraints.
CO5	Analyze and understand role of Aesthetics in an industrial design.

Course Content:

UNIT-1
Introduction to Design of Mechanical Systems: significance, need identification, Concept development, Embodiment, detailing and Manufacturing. Design Process, criteria for selecting particular engineering material, evolution of engineering material for product design– from stone age to nano material, available material resources, eco-friendly design.

UNIT-2
Engineering materials and their properties, Material Property Charts, Design Considerations for materials: Metallic alloys (Fe, Cu, Al, Zn, Mg, Ti, Ni, -based), Polymers: polyolefins, polyesters, nylons, aramids, resins, elastomers Ceramics: cement, glass, nitrides, carbides, carbon-based, Composites: GFRP, CFRP, cermets, Natural materials: wood, rock, leather, bamboo, etc, Bio-inspired materials, Optimal material selection with and without shape, Various mechanical properties: Elastic Modulus, Strength, Toughness, fatigue life, creep, corrosion resistance and viscosity limited design.

UNIT-3
Structure of material: crystal structure and its role for achieving required mechanical properties, , Metals and Metallic alloys, glasses and ceramics, polymer materials and composite material. Introduction to polymer, composite's microstructure for mechanical design.

UNIT-4
Material processes and process selection, material life cycle and eco-friendly selection, Failure analysis and materials selection for durability. Material design for recycling, carbon footprint, energy, and cost. Material selection with multiple constraints.

UNIT-5

Aesthetics and industrial design, Computer aided materials selection in design, Case Studies: Process Selection- Spark Plug Insulators, Casting an Aluminum con-rod, and Joining a Steel Radiator, Materials Selection- Materials for Flywheels, Materials for Springs, Pressure Vessels and Passive Solar Heating, Material and Shape.

Text Books:

1. M. F. Ashby, Materials Selection in Mechanical Design, Elsevier Publication.
2. J. G. Gerdeen, H. W. Lord and R. A. L. Rorrer, Engineering Design with Polymers and Composites, Taylor & Francis.

Reference Books:

1. M. F. Ashby and K. Johnson, Materials and Design, Butterworth Publication.
2. D.R. Askeland and P.P. Phule, The Science and Engineering of Materials, Thomson Brooks/Cole Publication.
3. Selection for design and manufacturing: theory and practice, Datsko, J. CRC Press.

Online resources:

1. https://ocw.mit.edu/courses/2-994-madm-with-applications-in-material-selection-and-optimal-design-january-iap-2007/
2. https://nptel.ac.in/courses/112104122

NME504 FINITE ELEMENT METHOD
C[L-T-P]: 4[3-1-0]

Course Objective:

To provide the Theoretical and practical knowledge of the Finite Element based modeling and analysis for the mechanical systems.

Course Outcomes:
Student will be able to:

CO1	To get the knowledge of classical methods used for approximate analysis.
CO2	To understand the FEM formulations for 1D Problems.
CO3	Apply the FEM for 1-Dimensional heat transfer problems
CO4	Application of FEM with 2D and Higher order elements.
CO5	Application of FEM for vibration problems.

Course Content:

UNIT-1
Classical methods: Introduction, Mathematical modelling - Variational Rayleigh-Ritz-Method, Weighted Residual Methods - Galerkin Method, Discretization based method - FDM. Applications in bar and beam.

UNIT-2
1D-FEM formulations: FEM objectives & approach, Nodes, Types of Elements, approximation function, shape function, Coordinates, Potential Energy Approach, Galerkin Approach, Derivation of stiffness matrix for 1D element using Linear function, Assembly of the Global Stiffness Matrix and Load Vector. Pre-Post processing. Penalty and Elimination approaches. Consider stress-strain and heat transfer

UNIT-3
1D FEM Applications: FEM Methodology for Trusses, Torsions. Stiffness matrix for steady state heat transfer for conduction, convection and heat generation. Solve problems of each case.

UNIT-4
2D FEM & Higher Order Elements: Finite Element Modeling, Constant Strain Triangle (CST), Problem Modeling and Boundary Conditions, Axisymmetric Formulation. Role of Jacobian Matrix, Gauss quadrature method. *FEM with Higher Order Elements:* FEM analysis of Beam, parametric elements, Lagrangian method, Pascal Triangle, Problem Modeling and Boundary, Conditions, 2D – Iso-parametric Elements: Four-Node Quadrilateral, Numerical, Integration, Higher - Order Elements.

UNIT-5

FEM for Dynamic Analysis: FEM Formulation for longitudinal vibration and transverse vibration of beam. Element Mass Matrices, Evaluation of Eigen values and Eigenvectors. Application of popular softwares for FEM. Computational Fluid Dynamics (CFD).

Text Books:

1. R Dhanraj & K Prabhakaran, "The Finite Element Method", OXFORD Higher Education
2. Y.M. Desai, T.I. Eldho, A.H. Shah, "FEM with applications in Engg", PEARSON

Reference Books:

1. Singiresu S. Rao, "Finite Element in Engineering", ELSEVIER
2. C.S. Krishnamoorthy, "Finite Element Analysis" TMH
3. T.R. Chandragupta and A.D Belegundu, "Introduction of FE in Engg", PHI

Experiments related to FEM Laboratory

1. To make general awareness of various FEM packages for specific applications.
2. To find forces, stress strain pattern of straight bar under compression or tension load using conventional approximate methods and verify with FEM packages.
3. To perform stress strain analysis for a beam with rectangular, circular and 'I' sections under various types of flexural loads.
4. To find torsion deflection and moment for a shaft under torsional load.
5. To find reactions and forces in members of a truss.
6. Find the temperature distribution in a composite wall assuming heat transfer conduction and convection, under using FEM package.
7. Find the temperature distribution in a composite wall assuming heat transfer conduction and convection with heat generation within the wall, under using FEM package.
8. Find the natural frequency of Beam with various cross section.

NME506 PRODUCT DESIGN & DEVELOPMENT
C[L-T-P]: 4(3-1-0)

Course Objectives:
The course aims at understanding function of product design, manufacturing phases, forecasting and market analysis, and layout depending on final production requirement. It introduces students to all aspects of production. Product Design and Manufacturing is the practice design of engineering systems through the application of basic knowledge and skills

Course Outcomes:
A student after going through the course will be able to:

CO1	It encourages understanding of the role of management in investigation, implementation of production systems for design ideas, product efficiency, cost-effectiveness, and quality.
CO2	The course provides in-depth knowledge about manufacturing of various products.
CO3	To understand quality issues, Taguchi concept, Design for manufacturing etc.
CO4	Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
CO5	Capability to write patent, copyright, IPR documents for new ideas and innovations

Course Content:

UNIT-1
Introduction: Classification/ Specifications of Products. Product life cycle. Product mix. Introduction to product design. Role of internet and advance software's in product design. Modern product development process, Innovative thinking. Morphology of design, design factors, design criteria.

UNIT-2
Sources of new ideas, Development processes, Product planning, Identification for Customer needs and technology potentials, Innovation and intellectual property rights, Product and process Patents, Patents and patenting processes, Patents & IP Acts. Overview, Disclosure preparation

UNIT-3
Generation, selection & embodiment of concept.Product architecture. Industrial design: process, need. Robust Design: Taguchi Designs & DOE. Design Optimization.
Product design, specifications and Tolerance specifications:
Quality function deployment, Functional specifications of products, Form and function, Development of alternatives.

UNIT-4
Methods of designing for Manufacturing & Assembly, Designs for Maintainability, Designs for Environment, Product costing, Legal factors and social issues. Engg ethics and issues of society related to design of products.

UNIT-5

Form product concept to decommissioning, Environment requirements, Life cycle design, Product data management and Product life cycle management systems, Dependency and concurrent engineering in development of products. Internet based approach to product development involving users.

Text Books:

1. Alan Mumford, “Management Development”, Jaico Publishing House
2. Karl T Ulrich, Steven D Eppinger, “Product Design & Development.” Tata McGrawhill New Delhi
3. Bralla J G “Handbook of Product Design for Manufacture, McGrawhill NewYork
4. University of Mumbai, Mechanical Engineering, M E Product Design and Development

Reference Books:

1. Introduction to Quality Management and Engineering - Sower, Savoie& Renick (Pearson Education Asia).
2. Total Quality Management - Besterfield Dale H (Pearson Education Asia, Second Edition).
3. Total Quality Management: A Practical Approach - H Lal (New Age International)
4. NPTEL course content of Prof. I. Singh, IIT Roorkee

List of
Programme Elective Courses (PECs)

PEC-I 4[3-1-0]

1. NME511 Mechatronics
2. NME513 Robotics & Automation
3. NME515 Advanced Welding Technology
4. NME517 Advance Machine Design

NME511 MECHATRONICS
C[L-T-P]:4(3-1-0)

Course Objectives:
The main objective of mechatronics is to provide knowledge of integration of mechanical and electrical systems with computer which will provide the multidisciplinary exposure for product development.

Course Outcomes:

Student will be able to:

CO1	To understand various elements of mechatronics and transfer functions.
CO2	To understand the concept of sensors and actuators and their interface for different applications.
CO3	To understand basic concept of microcontroller and microprocessor interfacing.
CO4	To understand basic principle of digital converters.
CO5	To get acquainted with applications of mechatronic systems and their modeling.

Course Content:

UNIT-1
Introduction to mechatronics: Dynamic Systems Modelling and Simulation: Equations of motion, transforming, Model linearization, Frequency response. Transfer functions, Controller types and their design using frequency domain and Laplace domain method.

UNIT-2
MEMS sensors and actuators: Direct Current Motors, Stepper and Servo Motors, Piezoelectric strain sensors, Accelerometers and Gyroscope, Hydraulic systems, Pneumatic systems, pumps and valves, designing of hydraulic circuits.

UNIT-3

Embedded electronics: Basics of Microcontroller & Microprocessors architecture and instruction set, PID control, machine cycles, interrupts, instruction set, memory and I/O interfacing, programming techniques, Timer/ Counters, Serial Interfacing and communications, Interfacing to keyboards and displays.

UNIT-4

Converters: AD and DA converters, Op Amps, Digital signal processing, Logic Circuit Devices, Gates-AND, OR, NAND etc. and combinations, PID control.

UNIT-5

Study of Some Mechatronics Devices: Hard disk drive, dot matrix printer, optical sensing and control mechanism in NC machine tools etc. Electro-Mechanical Modeling, Hydraulic, Thermal, and Pneumatic systems. System modelling with structured analysis, Modelling of Mechatronic System.

Text Books:

1. Mechatronics: electronic control systems in mechanical and electrical Engineering, Bolton, William, Pearson Education, 2003.
2. Mechatronics Principles, Concepts and Applications by N.P. Mahalik, McGraw Hill Education, 2017.

Reference Books:

1. Introduction to Mechatronics and Measurement Systems by Alciatore David G.and Histand Michael B., McGraw Hill Education.
2. Mechatronics by Hindustan Machine Tools Ltd., McGraw Hill Education
3. Mechatronics Principles, Concepts and Applications by N.P.Mahalik, McGraw Hill Education.
4. Mechatronics System Design, Devdas Shetty, Richard A. Kolk, PWS Publishing Company.

Online resource:

https://archive.nptel.ac.in/courses/112/107/112107298/
https://nptel.ac.in/courses/112103174
https://onlinecourses.nptel.ac.in/noc21_me27/preview
https://onlinecourses.nptel.ac.in/noc21_me129/preview

NME513 ROBOTICS AND AUTOMATION
C[L-T-P]:4(3-1-0)

Course Objectives:

The objective of this course is to make students acquainted with the field of robotics, and also to provide exposure with aspects of automation, mechanical design with kinematics, Trajectory planning, dynamics of robotic manipulators and control.

Course Outcomes: Student will be able to:

CO1	Understand the fundamentals, terminology, applications of robotics systems
CO2	Provide the learning of kinematics of robotic arms, path planning, and basics of control system for robotics.
CO3	Develop the understanding of dynamics of robotic system and basics of converters.
CO4	Understand required micro-electromechanical systems, mechanisms within the robot.
CO5	Understand controller and advanced knowledge for robotic automation.

Course Content:

UNIT-1
Introduction to robotic technology, Robot systems and anatomy, Robot classification, Robot kinematics, Object location, Homogeneous transformation, Direct and inverse kinematics, Manipulator motions, Robot drives, actuators and control, Drive systems, Hydraulic, Pneumatic Electrical DC and AC servo motors and stepped motors.

UNIT-2
Mechanical transmission method-Rotary-to-rotary motion conversion, Robot motion and path planning control and Controllers, Coordinate transformation, Matrix methods for forward and inverse kinematics analyses, Jacobian and singularity, Dynamic modelling.

UNIT-3
Microprocessor based measurement and control: D/A and A/D conversion, data acquisition systems, encoders, interfacing of motors and transducers. MEMS Accelerometer, Gyroscope. Selection of mechatronic components, Transmission elements like Ball screw and Controllers.

UNIT-4
Robot sensing, Range sensing, Proximity sensing, touch sensing, Force and torque sensing etc., Robot vision, Image representation, Image recognition approaches, Robot Programming, Robot applications in manufacturing, Material Processing operations like Welding & painting, Assembly operations, Inspection automation, CNC Robotics and automation.

UNIT-5
Programmable controllers, sequencing elements and logic control, ladder diagram, PLC and its programming, Motion controllers, Introduction to SCADA (supervisory control and data

acquisition): architecture, Tools, Tags, Developer and runtime packages, graphics, different Scripts for SCADA application, RFID technology.

Text books:

1. Robotics Technology and Flexible Automation, S. R. Deb, Sankha Deb. Second Edition McGraw-Hill Education: New York, 2010.
2. Industrial Robotics -Technology, Programming and Applications, N. Odrey , M. Weiss, M. Groover, R. Nagel, A. Dutta, 2nd Edition, McGraw-Hill Education.

Reference Books:

1. Introduction to robotics. Tata McGraw-Hill Education; Saha SK, 2014.
2. Introduction to robotics: mechanics and control. Pearson Educacion; Craig JJ, 2005.
3. Automation, Production System & Computer Integrated Manufacturing, Groover, Prentice Hall India.
4. Robot Engineering: An Integrated Approach, R.D. Klafter, t.a. Chmielewski and M. Negin, PHI
5. Programmable logic controllers, W. Bolton, Elsevier Ltd,

Online resource

1. https://nptel.ac.in/courses/112105249
2. https://onlinecourses.nptel.ac.in/noc22_de11/preview
3. https://onlinecourses.nptel.ac.in/noc20_me03/preview
4. https://onlinecourses.nptel.ac.in/noc21_me32/preview

NME515 ADVANCE WELDING TECHNOLOGY
C[L-T-P]: 4[3-1-0]

Course Objectives:

At the end of the course the students will learn various concepts related to welding, its application, along with practical purview of various welding process, welding standards, advanced welding process.

Course Outcomes:

After completion of the course a student will be able to:
:

CO1	Understand the importance and application of welding, conventional welding, weld design and inspection/testing.
CO2	Understand the importance and application of welding, conventional welding, formation of arc and arc ignition.
CO3	Develop good knowledge about Thermal and Metallurgical consideration of welding, HAZ, automation and safety in welding.
CO4	Student will have through knowledge about plasma arc, laser beam, electron beam, ultrasonic and diffusion welding.
CO5	Develop good knowledge about explosive welding, underwater welding, metal spraying and surfacing.

Course Content:

UNIT-1
Introduction
Importance and application of welding, problems and drawbacks associated with conventional welding processes, Selection of welding process, Brief review of conventional welding process.

UNIT-2I
Weld Design
Welding machines/equipment's and its characteristics, Heat input and heat flow, Weld defects and distortion, Inspection/testing of welds, Life prediction. Advantages of welding joints over other joining processes

UNIT-3
Thermal and Metallurgical considerations
Thermal considerations for welding, temperature distribution, Analytical/Empirical analysis/formulae, heating & cooling, curves. Metallurgical consideration of weld, HAZ and Parent metal, micro & macro structure. Solidification of weld and properties. Automation in welding, Economics of Welding, Safety in welding.

UNIT-4

Advanced welding Techniques-1

Principle, equipment, working and applications of Plasma Arc welding, Laser beam welding, Electron beam welding, Ultrasonic welding, and Diffusion welding.

UNIT-5

Advanced welding Techniques-2

Principle, equipment's, working and applications of explosive welding/ cladding, underwater welding, metal spraying and surfacing.

Textbooks:

1. Welding Processes and Technology – Dr. R. S. Parmar (Khanna Publication)
2. Manufacturing technology – Foundry, Forming and Welding- P. N. Rao (Tata McGraw Hill).
3. Khanna O. P. – 'A Text Book on Welding Technology' – Dhanpat Rai and Sons, New Delhi – 2013
4. Kou S. – 'Welding Metallurgy' – John Wiley Publications, New York – 2003 – 2nd Edition.

Reference books:

1. Welding and Welding Technology – Richard L. Little (Tata McGraw Hill).
2. Workshop Technology Vol1-B. S. Raghuvanshi (Dhanpat Rai and Sons)
3. Little R. L. – 'Welding and Welding Technology' – Tata McGraw Hill Publishing Company Limited, New Delhi – 1989
4. Grong O. – 'Metallurgical Modelling of Welding' – The Institute of Materials – 1997 – 2nd Edition

NME517 ADVANCE MACHINE DESIGN
C[L-T-P]: 4[3-0-2]

Corse Objectives:
Understand the importance of design considerations, stress and strain, and factor of safety in engineering design. Learn about the constitutive law governing material behavior under different loads. Develop skills to ensure the reliability and durability of designed components.

Course outcomes: After completion of course, a student will be able to:

CO 1	Design considerations, stress and strain, factor of safety, reliability
CO 2	3D stress and strain, principal stresses, plane stress and strain, contact stresses (Hertz's theory), gears and ball bearings.
CO 3	Material selection, non-metallic materials, plastics, ceramics, composites, case studies
CO 4	Design for fatigue, factors and mitigation, statistical analysis, Miner's rule, Paris Law, design for creep.
CO 5	Introduction to fracture, LEFM, EPFM, Griffith's Law, modes of failures

Course Content:

UNIT-1
Design considerations for machine elements, Product design & development. Concept of stress and strain, constitutive law, factor of safety and reliability.

UNIT-2
Concepts of 3D stress and strain, Principal Stresses, Plane stress and strain condition, constitutive law, Stress equilibrium equations, concepts of strain compatibility, Contact stresses-Hertz's theory and its application to gears and ball bearings.

UNIT-3
Material selection in design, performance index, effect of shape, size and loading. Importance of non-metallic materials like plastics, ceramics, composite materials for design applications. Case studies.

UNIT-4
Design for fatigue, fatigue strength, factors causing fatigue and its mitigation, statistical analysis, Miner's rule, Paris Law. Design for creep, static and temperature induced creep, creep testing; its mitigation.

UNIT-5
Introduction to fracture, LEFM, EPFM, Griffith's Law, Modes of failures.

Text Books:
1. Shigley, "Machine Design"
2. Juvinall, "Machine Design"
3. Sadhu Singh, "Advanced Machine Design"
4. MF Spotts, "Machine Design"

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PEC-II 4[3-1-0]

1. NME 514 Soft Computing Techniques
2. NME 516 Mechanical System Design
3. NME 518 Simulation Modeling & Analysis
4. NME 520 Smart Materials & Structures

NME517 ADVANCE MACHINE DESIGN
C[L-T-P]: 4[3-0-2]

Corse Objectives: Understand the importance of design considerations, stress and strain, and factor of safety in engineering design. Learn about the constitutive law governing material

CO1	Comprehend and apply fuzzy logic principles and fuzzy inference systems to solve complex problems in mechanical engineering.
CO2	Understand and implement artificial neural network architectures and training algorithms to address pattern recognition, fault diagnosis, and optimization challenges in mechanical engineering.
CO3	Understanding the principles of genetic algorithm and their applications in mechanical engineering. Implement genetic algorithms to solve optimization problem and parameter tuning.
CO4	Integrate fuzzy logic, neural networks and genetic algorithms to develop hybrid systems. Apply hybrid soft computing techniques to solve complex mechanical engineering problems
CO5	Understand the concepts of swarm intelligence and its algorithms for optimization. Explore emerging trends and future directions in soft computing for mechanical engineering.

behavior under different loads. Develop skills to ensure the reliability and durability of designed components.

Course outcomes: After completion of course, a student will be able to:

COURSE CONTENT

UNIT 1: Introduction to Soft Computing and Fuzzy Logic

Overview of soft computing techniques and their applications in mechanical engineering, Fuzzy logic, neural networks, genetic algorithms and their roles in problem solving. Basics of fuzzy sets and fuzzy logic, Fuzzy logic controllers and their applications in mechanical systems. Fuzzy inference systems and rule- based reasoning.

UNIT 2: Artificial Neural Networks (ANN)

Fundamentals of artificial neural networks and their architectures, Training algorithms for neural networks, Applications of neural networks in mechanical engineering such as pattern recognition, fault diagnosis and optimization.

UNIT 3: Genetic Algorithms (GA)

Introduction to genetic algorithms and their optimization principles, Genetic operators and encoding techniques, Applications of genetic algorithms in mechanical design, parameter optimization and scheduling problems.

UNIT 4: Hybrid Soft Computing Techniques

Integration of fuzzy logic, neural networks, and genetic algorithms, Hybrid systems for complex problem-solving and optimization, Case studies and Real-world applications of hybrid soft computing techniques in mechanical engineering

UNIT 5: Swarm Intelligence and Emerging Trends

Introduction to swarm intelligence and its algorithms (eg. Ant colony optimization, Particle swarm optimization), Swarm-based optimization techniques for mechanical engineering problems, Comparison of swarm intelligence and other soft -computing techniques.
Emerging trends and future directions in soft computing for mechanical engineering.

Text Books:

1. J.S.R.Jang, C.T.Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI, 2004, Pearson Education 2004.
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, McGraw-Hill, International Editions, Electrical Engineering Series, Singapore, 1997.
3. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y., 1989.
4. R.Eberhart, P.Simpson and R.Dobbins, “Computational Intelligence - PC Tools”, AP Professional, Boston, 1996.
5. Stamatios V. Kartalopoulos “Understanding Neural Networks and Fuzzy Logic Basic concepts & Applications”, IEEE Press, PHI, New Delhi, 2004.
6. Vojislav Kecman, “Learning & Soft Computing Support Vector Machines, Neural Networks, and Fuzzy Logic Models”, Pearson Education, New Delhi,2006.

NME516 MECHANICAL SYSTEM DESIGN
C[L-T-P]: 4(3-1-0)
Course Objectives:
Apply statistical considerations in design and analyze defects and failure modes in components for optimized system visualization and selection of materials across various mechanical designs, including cylinders, pressure vessels, internal engine components, machine tool gearboxes, and material handling systems.

Course Outcomes:
After completion of this course, the students will be able to

CO1	Understand machine tool gearbox design, including applications, speed range determination, and graphical representation techniques.
CO2	Apply statistical considerations in design, including frequency distribution, normal distribution, tolerance analysis, and mechanical reliability assessment.
CO3	Design belt conveyor systems for material handling, considering capacity, belt tensions, conveyor pulleys, and power requirements.
CO4	Design cylinders and pressure vessels, including thin cylinders, spherical vessels, principal stresses.
CO5	Apply statistical considerations in analyzing defects and failure modes in components.

COURSE CONTENT
UNIT 1:
Design of Machine Tool Gearbox:
Introduction to machine tool gearboxes, design and its applications, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, deviation diagram, difference between numbers of teeth of successive gears in a change gear box.

UNIT 2:
Statistical considerations in design:
Frequency distribution-Histogram and frequency polygon, normal distribution-units of central tendency and dispersion-standard deviation-population combinations-design for natural tolerance-design for assembly-statistical analysis of tolerances, mechanical reliability and factor of safety.

UNIT 3:
Design of Belt conveyor system for material handling:
System concept, basic principles, objectives of material handling system. Belt conveyors, Flat belt and troughed belt conveyors, capacity of conveyor, rubber covered and fabric ply belts, belt tensions, conveyor pulleys, belt idlers, tension take-up systems, power requirement of horizontal belt conveyors for frictional resistance of idler and pulleys.

UNIT 4:

Design of Cylinders and Pressure vessels:

Thin cylinders and spherical vessels, Wire wound cylinders. Thick cylinders: Principal stresses in cylinder subjected to internal/external pressure, Lame’s equation, Clavarion’s, and Bernie’s equations, Auto frettage, Compounding of cylinders, Gasketted Joints, Thickness of cylindrical and spherical shells

UNIT 5:

Optimum Design and DFMA: Optimum Design:

Objectives of optimum design, adequate and optimum design, Johnson‘s Method of optimum design, primary design equations, subsidiary design equations and limit equations, optimum design with normal specifications of simple machine elements-tension bar, transmission shaft and helical spring, Pressure vessel Introduction to redundant specifications (Theoretical treatment).

Design for manufacture, assembly and safety:

General principles of design for manufacture and assembly (DFM and DMFA), principles of design of castings and forgings, design for machining, design for safety.

Text Books:

1. Anup Goel, Mechanical System Design: Applications of Fundamentals, Technical Publications, 2020.
2. S P Patel, Mechanical System Design, JAICO.
3. K.U. Siddiqui, Mechanical System Design, New Age International Publication.
4. Shigley’s Mechanical Engineering Design,8th Edition, McGraw Hill.

Reference Books:

1. V B Bhandari, Design of Machine Elements, 3/e McGrawHill.
2. R C Juvinall, Fundamentals of Machine Component Design, 4/e, Wiley.
3. R L Norton, Machine Design An Introduction, Pearson.
4. E J Hearn, Mechanics of Materials, BH

NME518 SIMULATION MODELING & ANALYSIS
C[L-T-P]: 4(3-1-0)

Course Objectives:

This course deals with essential discussions on system simulations, particularly emphasizing the application in manufacturing, services, and computing. The students will be able to grasp the modeling concepts and build the appropriate simulation models.

Course Outcomes:

Upon successful completion of this course, the students will be able to:

CO1	Understand the basics of simulation modeling and replicating practical situations in organizations.
CO2	Identify and adequately state decision problems and modeling using the simulation framework.
CO3	Verify and validate the simulation model to choose the suitable methodology using simulation techniques.
CO4	Interpret results/solutions for a given problem or situation, and formulate the managerial guidelines with suitable recommendations.
CO5	Improving the system performance by integrating with optimization techniques.

Course Content:

UNIT-I

Introduction: Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study.
Review of basic probability and statistics, random variables and their properties, Estimation of means variances and correlation.

UNIT-II

Physical Modelling: Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation.
Verification and Validation of Model: Model Building, Verification, Calibration and Validation of Models.

UNIT-III

System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages. System Dynamics: Growth and Decay models, Logistic curves, and System Dynamics diagrams.

UNIT-IV

Probability Concepts in Simulation: Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs. Tests for Random number- Frequency test, Runs test, Auto-correlation test. *Simulation of Mechanical Systems***:** Building Simulation models, translational and rotational mechanical systems, and Simulation of hydraulic systems.

UNIT-V

Simulation of Manufacturing Systems: Simulation of waiting line systems, Job shop with material handling and Flexible manufacturing systems, Simulation software for manufacturing, and Case studies. *Simulation Software***:** Selection of Simulation Software, Simulation packages, and trends in Simulation Software.

Optimisation Via Simulation: Meaning, difficulty, Robust Heuristics, Random Search

Text Books:

1. Geoffrey Gordon, "System Simulation," Prentice Hall
2. Robert E. Shannon, "System Simulation: The Art and Science," Prentice Hall
3. B. Wayne Bequette, "Process Dynamics: Modeling, Analysis, and Simulation," Prentice Hall
4. Alexander Mielke, "Analysis, modeling and simulation of multiscale problems," Springer.
5. Law, A.M., "Simulation Modeling and Analysis" (5th edition), McGraw-Hill
6. Robinson, S., "Simulation: The Practice of Model Development and Use" (2nd edition), Red Globe Press

Reference Books:

1. J. Schwarzenbach and K.F. Gill, "System Modelling and Control", Edward Arnold.
2. Charles M close and Dean K. Frederick "Modelling and Analysis of Dynamic Systems," Houghton Mifflin.
3. Allan Carrie, "Simulation of manufacturing," John Wiley & Sons.
4. Barry L. Nelson, "Stochastic Modeling: Analysis and Simulation," Dover Publications
5. Lawrence M. Leemis, Stephen K. Park: "Discrete – Event Simulation: A First Course," Pearson Education, 2006.ISBN: 978-0131429178

Web links:

1. https://nptel.ac.in/courses/112107220
2. https://nptel.ac.in/courses/103107096
3. https://ocw.mit.edu/courses/3-021j-introduction-to-modeling-and-simulation-spring-2012/
4. https://cse.mit.edu/research_categories/computational-modeling-and-simulation/
5. https://ocw.mit.edu/courses/3-021j-introduction-to-modeling-and-simulation-spring-2012/339679e5c88d14753ed39d6b3311993f_MIT3_021JS12_P1_L1.pdf
6. Winter Simulation Conference Archive (online and open, available at https://informs-sim.org/)
7. https://www.youtube.com/watch?v=maH8ormsIeU

NME520 SMART MATERIALS AND STRUCTURES
C[L-T-P]: 4[3-1-0]

Course Objectives:
This course deals with important smart materials and its applications for smart structures.

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

CO1	understand the basics of various types of smart materials.
CO2	understand the sensors made of smart materials.
CO3	design smart actuators using smart materials.
CO4	design of smart composite using smart materials.
CO5	Apply the smart materials and smart composites for advance structures.

COURSE CONTENT

UNIT-1: Introduction to Smart Materials
Principles of Piezoelectricity, Perovskite Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magneto strictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids

UNIT-2: High-band width, low strain smart sensors
Piezoelectric Strain Sensors, In-plane and Out- of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magneto strictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors

UNIT-3: Smart Actuators
Modelling Piezoelectric Actuators, Amplified Piezo Actuation - Internal and External Amplifications, Magneto strictive Actuation, Joule Effect, Wiedemann Effect, Magneto volume Effect, Magneto strictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

UNIT-4: Smart Composites
Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams

UNIT-5: Advances in Smart Structures & Materials

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self- Healing Polymers, Intelligent System Design, Emergent System Design

Text Books:

1. Brian Culshaw, Smart Structures and Materials, Artech House, 2000
2. Gauenzi, P., Smart Structures, Wiley, 2009 (c) Cady,
3. W. G., "Piezoelectricity", Dover Publication.

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PEC-III 4[3-1-0]

1. NME611 Advance Materials
2. NME613 Computational Fluid Dynamics
3. NME615 Digital Manufacturing

NME611 ADVANCED MATERIALS
C[L-T-P]: 4(3-1-0)

Course Objective:
To provide a thorough understanding of advanced materials, allowing students to apply their knowledge in a variety of industrial applications.

Course Outcomes:

CO1	Explain the concepts and principles of advanced materials and manufacturing processes.
CO2	Understand the applications of all kinds of Industrial materials.
CO3	Apply the material selection concepts to select a material for a given application.
CO4	Define Nanotechnology, Describe nano material characterization.
CO5	Understand the behaviour and applications of smart materials, ceramics, glasses and non-metallic materials.

COURSE CONTENT

UNIT 1: Classification and Selection of Materials
Classification of materials, properties required in Engineering materials, Selection of Materials; Selection for mechanical properties, strength, toughness, fatigue and creep. Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

UNIT 2: Composite Materials:
Fiber reinforced, laminated and dispersed materials with metallic matrix of aluminium, copper and Titanium alloys and with non-metallic matrix of unsaturated polyesters and epoxy resins. Development, Important properties and applications of these materials.

UNIT 3: Ceramics and Glasses
Bio-ceramics: Nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine. Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.

UNIT 4: Modern Metallic Materials

Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides. Non-metallic Materials: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers.

UNIT 5: Smart Materials

Shape Memory Alloys, Varistors and Intelligent materials for bio-medical applications. Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.

Text Books:

1. Introduction to Engineering Materials & Manufacturing Processes NIIT Prentice Hall of India
2. Engineering Design: A Materials and Processing Approach G.E. Dieter McGraw Hill 1991
3. Engineering Materials Properties and Selection Kenneth G. Budinski Prentice Hall of India

Reference Books

1. Engineering Material Technology James A. Jacobs & Thomas F. Kilduff Prentice Hall
2. Materials Science and Engineering WD. Callister Jr. Wiley India Pvt. Ltd 2010
3. Materials Selection in Mechanical Design M.F. Ashby Pergamon Press 1992
4. Selection of Engineering Materials Gladius Lewis Prentice-Hall, New Jersey

NME613 COMPUTATIONAL FLUID DYNAMICS
C[L-T-P]:4(3-1-0)

Course Objectives:
The course aims to provide the understanding of computational fluid dynamics with practical applications.

Course Outcomes:
Upon completion of this course, the students will be able

CO1	To briefly introduce Computational Fluid Dynamics, specifically, analysis of fluid mechanics and heat transfer.
CO2	To enhance the understanding of solid mechanics-related problems and to equip students with necessary engineering skills.
CO3	To enable the students to solve engineering problems using commercial software packages such as ANSYS Fluent and MATLAB.
CO4	To understand the students with data analysis and presentation, numerical simulations.
CO5	To enable the students to apply the CFD knowledge in the fluid flow problems.

COURSE CONTENT

UNIT-1
Introduction: Need of CFD as a tool, role in R&D, Illustration of the CFD approach, Governing equations (Mass, momentum, and energy), Partial differential equations- Parabolic, Hyperbolic, and Elliptic equations.

UNIT-2
Different forms of Governing equations: Conservative, Non-conservative form and primitive variable forms of Governing equations. Decoupling of Governing equations, Characteristic variables. Relation between the two non-conservative forms.

Turbulence Modeling: Introduction Reynolds averaged Navier-Stokes equations, RANS modeling.

UNIT-3
Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.
Solution Algorithms: Discretization schemes for pressure, momentum and energy equations – Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, solution of Navier-Stokes equations.

UNIT-4
Overview of Numerical methods: Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation.

UNIT-5
CFD Solution Procedure and Case Studies: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results report and visualization.
Case Studies: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.

Text Books:
1. T.J. Chung, Computational Fluid Dynamics, , Cambridge University Press
2. P.S. Ghoshdastidar, Computational fluid dynamics and heat transfer, Cengage learning, 2017.
3. Charles Hirsch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics – Vol 1 &Vol 2, Butterworth- Heinemann, 2007

Reference Books:
1. Pletcher, R. H., Tannehill, j. C., Anderson, d., Computational fluid mechanics and heat transfer, 3rd ed., CRC press, 2011, ISBN 9781591690375.
2. H. K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson, 2007, ISBN: 0131274988
3. Moin, P., Fundamentals of engineering numerical analysis, 2nd ed., Cambridge university press, 2010, ISBN 9780521805261 (e- book available).
4. Ferziger, J. H., Numerical methods for engineering application, 2nd ed., Wiley, 1998.
5. Ferziger, J. H., Peric, m., Computational methods for fluid dynamics, 3rd ed., Springer, 2002.

Web Links:
1. https://nptel.ac.in/courses/112105045
2. https://www.youtube.com/watch?v=t7jS7V_6TGQ&ab_channel=nptelhrd
3. https://onlinecourses.nptel.ac.in/noc23_ch10/preview
4. https://canes.mit.edu/computational-fluid-dynamics-cfd
5. https://www.cfd-online.com

NME615 DIGITAL MANUFACTURING
C[L-T-P]: 4[3-1-0]

Course Objective:

The course aims to provide students with a comprehensive understanding of digital manufacturing principles, technologies, and applications, and to develop their proficiency in utilizing CAD/CAM software, additive manufacturing techniques, digital simulation, robotics, and Industry 4.0 concepts.

Course Outcomes:

After completion of course, a student will be able to:

Course Content:

UNIT 1: Introduction to Digital Manufacturing
Overview of digital manufacturing concepts, advancements, and Industry 4.0, Role of digital technologies in modern manufacturing processes, Sustainability and green manufacturing in the digital era. Overview of unmanned aerial vehicle and their applications in various manufacturing industries. Role of UAV's in digital manufacturing processes, such as inspection, surveillance, inventory management and logistics optimization.

UNIT 2: Design and CAD/CAM
Principles of Computer-Aided Design (CAD) and 3D modeling techniques using CAD software, Design for Manufacturing and Assembly (DFMA) considerations, CAM software and its role in transforming CAD designs into machine instructions, Toolpath generation and optimization.

UNIT 3: Additive and Subtractive Manufacturing
Principles and applications of 3D printing and additive manufacturing techniques, Material selection, process parameters and post processing considerations. Traditional machining processes (eg. Milling, turning, drilling) and CNC programming, Material selection and considerations for digital manufacturing

UNIT 4: Simulation, Robotics, and Quality Control
Simulation software for predicting and optimizing manufacturing processes, Finite element analysis(FEA) and Computational fluid dynamics(CFD), Introduction to industrial robotics: Basics of robotics in manufacturing and assembly lines, Statistical process control (SPC) techniques for monitoring and improving product quality, Inspection methods and metrology in a digital manufacturing environment.

UNIT 5: Advanced Topics and Applications
Integration of IoT devices and sensors in digital manufacturing systems, Real time monitoring, data analytics and predictive maintenance. Virtual Reality (VR) and Augmented Reality (AR) applications in digital manufacturing, Digital prototyping and virtual assembly, Concept of digital twins and their role in smart manufacturing, Integration of UAV's with digital manufacturing technologies, such as IoT, data analytics and automation, Implementation of Industry 4.0 principles in manufacturing processes. Supply chain and logistics optimization in the digital era, Case studies and analysis of real-world digital manufacturing implementations.

Text Books:

1. Chandrakant Patel, Digital Manufacturing Chun-Hsien Chen
2. Digital Manufacturing and Assembly Systems in Industry 4.0 (Science, Technology, and Management) Hardcover by Kaushik Kumar (Editor), Divya Zindani (Editor), J. Paulo Davim (Editor)

3. Zude zhou , shane and Dejun chen, Fundamental of digital Manufacturing Science (Springer).
4. Arif sirinterlikci, Yalcin ertekin A comprehensive approach to digital manufacturing.

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OEC-I 3[3-0-0]

1. NME 617 Design of Experiments
2. NME 619 Solar Energy

OEC-I: NME617 **DESIGN OF EXPERIMENTS**
C[L-T-P]: 3[3-0-0]

Course Outcomes: Students will be able to

CO1	Understand principles of experimental design and apply statistical measures for data analysis.
CO2	Design factorial experiments, analyze factor effects and interactions, and implement fractional factorial and central composite designs.
CO3	Apply analysis methods and perform ANOVA using YATE's algorithm for interpreting experimental data.
CO4	Design experiments using Taguchi's orthogonal arrays, modify arrays, and use linear graphs and interaction assignment techniques.
CO5	Evaluate noise sensitivity, calculate signal-to-noise ratios, and apply Taguchi's methods for parameter and tolerance design strategies.

Course Content:

UNIT-1
Introduction
Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments. Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level.

UNIT-2
Experimental Design
Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Twolevel experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs

UNIT-3
Analysis and Interpretation Methods
Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data

UNIT-4

Experiment Design Using Taguchi's Orthogonal Arrays

Types of Orthogonal Arrays, selection of standard orthogonal arrays, linear graphs and Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs.

UNIT-5

Signal to Noise Ratio

Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal the –better-type, Larger-the-better type. Parameter and tolerance design concepts, Taguchi's inner and outer arrays, parameter design strategy, tolerance design strategy

Text Books:

1. D.C. Montgomery, Design and Analysis of Experiments, Wiley India, 5th Edition, 2006, ISBN – 812651048-X.
2. Madhav S. Phadke, Quality Engineering Using Robust Design, Prentice Hall PTR, Englewood Cliffs, New Jersey 07632,1989, ISBN: 0137451679.
3. SILVA MB, Design Of Experiments Applications Edition 2014, Design Of Experiments Applications Edition 2014
4. WU C.F.J, Experiments Planning Analysis And Parameter Design, WILEY INDIA.

Reference Books:

1. Robert H. Lochner, Joseph E. Matar, Designing for Quality - an Introduction Best of Taghuchi and Western Methods or Statistical Experimental Design, Chapman and Hall, 1990, ISBN – 0412400200
2. Philip J. Ross, Taguchi Techniques for Quality Engineering: Loss Function, Orthogonal Experiments, Parameter and Tolerance Design, McGraw-Hill, 2nd Edition, 1996, ISBN: 0070539588.
3. Bradley Jones, Optimal Design Of Experiments : A Case Study Approach, John Wiley & Sons Inc.
4. Paul Allen, Design Of Experiments For 21st Century Engineers, Lulu.com.

OEC-I: NME619 **SOLAR ENERGY**
C[L-T-P]: 3[3-0-0]

Prerequisite: Engineering Thermodynamics

Course Objectives:

This course on solar energy aims at developing understanding about availability of solar energy, its utilization and systems run on solar energy for power generation, cooling, heating and other applications.

Course Outcomes:

After completion of course, the students will have ability to,

CO1	Understand solar energy availability, associated geographical issues and its measurement.
CO2	Design, analyze and develop solar thermal systems for various applications.
CO3	Design, analyze and develop solar photovoltaic systems for different applications.
CO4	Understand and analyze solar energy economics.
CO5	Demonstrate holistic understanding of the various solar energy applications and think of certain modifications in them for better performance and utility.

Course Content:

UNIT-1

Introduction, Energy alternative, Devices for thermal collection and storage, Thermal applications; Solar radiation: Instruments for measuring solar radiation, Solar radiation geometry, Empirical equations for prediction of the availability of solar radiation, Solar radiation on tilted surfaces.

UNIT-2

Liquid flat-Plate Collectors: General performance analysis, Transmissivity absorptivity product and overall loss coefficient and heat transfer correlations, Collector efficiency factor, Analysis of collectors similar to the conventional collector. Testing procedures, Alternatives to the conventional collector.

UNIT-3

Solar Air Heaters: Performance analysis of a conventional air heater, Other types of air heaters. Concentrating Collectors: Flat plate collectors with plane reflectors, Cylindrical parabolic collector, Compound parabolic dish collector, Central receiver collector.

UNIT-4

Thermal energy storage: Sensible heat storage, Latent heat Storage, Thermo-chemical storage. Solar distillation: Introduction, working principal of solar distillation, Thermal efficiency of distiller unit, External heat transfer, Top loss coefficient, Bottom and side loss coefficient, Internal heat transfer, Radioactive loss coefficient, convective loss coefficient, Evaporative loss coefficient, Overall heat evaluation of distillation output, Passive solar stills, Conventional solar still, Basin construction, Thermal analysis of conventional solar still.

UNIT-5

Photovoltaic Systems: Introduction doping Fermi level, P-N junction characteristics, Photovoltaic effect, Photovoltaic material, Module, Cell temperature, Economic analysis: Introduction, cost analysis.

Text books:

1. Solar Energy, by S.P Sukhatme, Tata McGraw Hill.
2. Solar Enery Fundamentals and Applications by H P Garg,
3. Solar Energy and Non- Conventional Energy Resources by Domkundwar, Dhanpat rai & Co.
4. Solar Energy Fundamentals, Design, Modelling and Applications by G N Tiwari.

Reference books:

1. Solar Energy: Thermal Processes by Duffie John A, and Beckman W.A, John Wiley & Sons.

Web Links:

1. https://youtu.be/BWqjPHGM5D0
2. https://youtu.be/PFFoCx2WINY
3. https://youtu.be/27z-kOQzW2M