M. Tech. in
Computer Aided Design and Manufacturing

(Effective from 2022-23)

DEPARTMENT OF MECHANICAL ENGINEERING
MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

Vision and Mission of the Institute

VISION

To attain a distinct identity for the Institute through innovation, knowledge creation and dissemination for the benefit of the society.

MISSION

- To nurture an eco-system for continuous enhancement of value-based teaching and learning process in the emerging areas of technology.
- To train quality human and knowledge resources in the service of society.
- To develop sustainable products and technologies.

Vision and Mission of the Department

VISION

To be a centre of excellence in Mechanical, Production and Industrial Engineering education and research for the benefits of society and humanity.

MISSION

- To educate and develop competent human resources for contemporary industry, academia and research.
- To promote interdisciplinary research and innovation skills in the graduates.
- To enhance the efforts to develop sustainable products, processes and technologies by developing competent entrepreneurs for the benefit of the society.

Department of Mechanical Engineering:

Brief about the Department:

The Department of Mechanical Engineering is one of the oldest departments of the institute and was established in the year 1961. We are the largest community of excellent, energetic, and dynamic faculty, staff and students in the institute. The department is having highly qualified and experienced faculty (36 faculty members) in all streams of Mechanical Engineering. The department is broadly divided into three academic streams in which students receive outstanding education with a wide choice of specializations, electives and research areas. These three academic streams are: Design Engineering, Production and Industrial Engineering and Thermal Engineering.

The department offers eight semester (i.e. 4 year) Bachelor of Technology (B. Tech.) programmes in Mechanical Engineering and Production and Industrial Engineering. Every year 223 students are admitted through JEE (mains) and 15% of this intake is through Direct Admission to Students Abroad (DASA) scheme for the above two B. Tech. programmes. Some students are also through ICCR and MEA (Govt. of India) Schemes.

The department also offers four semester (i.e. 2 year) Master of Technology (M. Tech.) programmes in Computer Aided Design and Manufacturing, Design Engineering, Product Design and Development, Production Engineering and Thermal Engineering. Every year 125 students (25 in each specialization) are admitted through GATE in the above five M. Tech. programmes.

The department also offers Doctor of Philosophy (Ph.D.) programme in various areas of Mechanical Engineering as well as Production and Industrial Engineering. The strength of the department lies in its Ph.D. programme with more than 100 PhDs already been awarded till March, 2022. About 80 research scholars are presently pursuing their PhDs. Every year the department admits Ph.D. students equal to half of the number of faculty holding Ph.D. degree. The department is also a QIP centre for PhD and M. Tech programmes.

Today, the world of Mechanical Engineering changes under the influence of advanced computational tools, improved simulation and analysis, and entirely different manufacturing protocols. This has opened up new vistas of research in the department.

List of Programmes offered by the Department:

Program	Title of the Program
B. Tech.	Mechanical Engineering
	Production & Industrial Engineering
M. Tech.	Computer Aided Design and Manufacturing
	Design Engineering
	Product Design and Development
	Production Engineering
	Thermal Engineering
Ph.D.	Mechanical Engineering

M. Tech. – Computer Aided Design and Manufacturing

Program Outcomes

PO1	Able to independently carry out research/ investigation and development work to solve practical problems in Engineering.
PO2	Able to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery over Computer Aided Design & manufacturing at a level higher than the requirements in the appropriate bachelor program.
PO4	Able to use software and hardware to design and manufacturing fields.
PO5	Able to solve complex engineering problems by integrating modern tools, software and equipment.

SCHEME OF INSTRUCTION

M. Tech. Computer Aided Design and Manufacturing – Course Curriculum Structure

S. No.	Code	Course	Credit	L-T-P	Contact Hours
Semester-I					
1	ME21101	Advanced Mathematics and Optimization	4	4-0-4	
2	ME21131	Computer Aided Design	4	4-0-4	
3		Elective I	4	4-0-4	
4		Elective II	4	4-0-4	
5		Elective III	4	4-0-4	
		Total	**20**		
Semester-II					
1	ME22132	Computer Aided Manufacturing	4	4-0-4	
2	ME22231	CAD/CAM Lab	0	0-0-6	
3		Elective IV	4	4-0-4	
4		Elective V	4	4-0-4	
5		Elective VI	4	4-0-4	
		Total	**16**		
Semester-III					
1	ME23681	State of the art Seminar / Special Study / Term Project	4		
2	ME23631	Thesis	16		
		Total	**20**		

Semester-IV					
1	ME24631	Thesis	20		
		Total	**20**		

List of Electives and Minors: M. Tech. (Computer Aided Design and Manufacturing)

S. No.	Code	Name
1.	ME21340	Finite Element Methods in Engineering
2.	ME21391	Concurrent Engineering
3.	ME21392	Computer Integrated Manufacturing Systems
4.	ME21393	Surface Engineering
5.	ME21394	Modal Analysis of Mechanical System
6.	ME21395	Modelling and Simulation of Manufacturing Systems
7.	ME21396	Robotics and Robot Applications
8.	ME21317	Product Design and Development
9.	ME21397	Production and Operations Management
10.	AM213XX	Computational Fluid Dynamics
11.	ME22398	Mechanical System Design
12.	ME22399	Materials, Manufacturing and Design
13.	ME22309	Design of Micro-Electro-Mechanical Systems
14.	ME22363	Optimization Methods in Engineering
15.	ME22401	Design of Experiments
16.	ME22402	Artificial Intelligence in Engineering
17.	ME22403	Mechatronics and Control Systems
18.	ME22318	Reverse Engineering
19.	ME22404	Rapid Prototyping and Manufacturing

Course Code: ME 21101	Advanced Mathematics and Optimization	Credits: 4-0-0:4

Prerequisites: Engineering Mathematics (Undergraduate level)

Course Outcome

S. No.	Outcomes	BT Level	BT Description
CO1	Students will understand the concept of linear algebra, numerical methods, optimization technique and differential equations.	2	Understand
CO2	Students will be able to develop the algorithm and code for solving linear algebraic equations and eigenvalues problems for engineering applications.	6	Create
CO3	Students will be able to apply numerical methods to solve problems for engineering applications.	3	Apply
CO4	Students will be able to develop differential equations for engineering problems and find their solution.	6	Create
CO5	Students will be able to apply optimization techniques and tools to solve engineering design problems.	3	Apply

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	3
CO2	3	1	3	3	2
CO3	2	-	3	1	2
CO4	2	-	3	1	2
CO5	2	1	3	3	3

Unit	Details	Lectures	CO mapping
1	Linear Algebra: Vector space and its basis, Matrices as coordinate-dependent linear transformation, null and range spaces, Solution of linear algebraic equations: Gauss elimination and Gauss-Jordon methods, LU Decomposition and Cholesky method, Gauss-Seidel/ Jacobi iterative methods, Condition number, Minimum norm and least square error solutions	8	CO1, CO2
2	Eigenvalues and eigenvectors of matrices and their properties, Similarity transformation, Jordon canonical form and orthogonal diagonalization, Mises power method for finding eigenvalues/eigenvectors of symmetric matrices.	8	CO1, CO2

3	Numerical Methods: Solution of a non-linear algebraic equation and system of equations, Interpolation methods, Regression, Numerical Integration.	6	CO1, CO3
4	Ordinary Differential Equations (ODEs): Techniques of the separation of variable and the integrating factor for 1st order ODEs, Solutions of linear, 2nd order ODEs with constant coefficients and Euler-Cauchy ODEs, System of 1st order ODEs, Numerical methods for solving ODEs, Homogeneous, linear, 2nd order ODEs with variable coefficients: power series and Frobenius methods, Sturm-Louville problem, Laplace transform method for non-homogeneous, linear, 2nd order ODEs: discontinuous right-hand sides	8	CO1, CO4
5	Optimization: Introduction to Optimal Design: feasibility and boundedness, topography of search space, classification of methods. Single/Multi variable optimization problems, Gradient and Direct search based methods. Constrained and unconstrained problems, problems with non-linear constraints.	10	CO1, CO5

Text Books:

1	Advanced Engineering Mathematics	Erwin Kreyszig	Wiley Publication
2	Optimization for engineering design: algorithms and examples	Kalyanmoy Deb	Prentice-Hall of India Private Limited Publications

Reference Books:

1	Applied Mathematical Methods	Bhaskar Dasgupta	Pearson Education Publications
2	Advanced Engineering Mathematics	Peter V. O'Neil	Cengage Learning
3	Engineering Optimization: Theory and Practice	S S Rao	New Age International (P) Limited Publishers
4	OPTIMIZATION: Algorithms and Applications	Rajesh Kumar Arora	CRC Press

Course Code: ME21131	Computer Aided Design	Credits: 4-0-0:4

Prerequisites: NIL

Course Outcome

S.N.	Outcomes
CO1	Students will be able to model the objects geometrically with curves, surfaces and solids by their mathematical representations.
CO2	Students will be able to apply geometrical transformations to an available geometric model.
CO3	Students will be able to create different projections of an available geometric model.
CO4	Students will be able to analyse the applications of solid modelling in product development.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	3	3
CO2	2	1	2	3	3
CO3	2	1	2	3	3
CO4	3	1	3	3	3

Unit	Details	Lectures
1	Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.	2
2	Design of Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparameterization, Parametric cubic curve, Blending functions, Truncation, extension, and subdivision, composite curve: continuity requirements, Spline Curves, Bezier Curve, B-Spline Curve, Rational Polynomials, Rational curves, NURBS.	10
3	Geometric Transformations: Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations. Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.	6
4	Design of Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparameterization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline and NURBS Surfaces.	8
5	Design of Solids: Parametric Solid, Tricubic Solid, Curves and surfaces embedded in a Solid, Generalized notion scheme and higher dimension elements. Instances and parametric shapes, Sweep Solids, Controlled Deformable solids. Complex model construction: Topology of Models: Euler's formula, connectivity number, genus, Euler-Poincare formula, topological atlas, Orientation, non-orientable surface, topology of closed curved surfaces, Gauss-Bonnet theorem, Euler operators, Euler object, topological disc, nets.	8

	Graph based models, Boolean algebra, Boolean model construction, Constructive Solid Geometry, Boundary Models, Data transfer in a collaborative environment.	
6	Geometric Properties: Local and global properties of a curve, Local and global properties of a surface, Global properties of complex solids, Relational properties, intersections. Applications in Product Development and other areas.	6

Text and Reference Books:

1	Geometric Modeling	M E Mortenson	McGraw Hill Education
2	Mathematical Elements of Computer Graphics	Rogers and Adams	McGraw Hill Education
3	CAD/CAM: Theory and Practice	Ibrahim Zeid	McGraw Hill Education
4	Computer-Aided Engineering Design	B Sahay and A Saxena	Springer
5	Rapid Prototyping: Principles and Applications	C K Chua, K F Leong and C S Lim	Cambridge University Press

Course Code: ME22132	Computer Aided Manufacturing	Credits: 4-0-0:4

Prerequisites: Manufacturing Science and Technology

Course Outcomes:

S. No.	Outcomes	BT Level	BT Description
CO1	Students will be able to understand the features of CNC machines; realize the differences in structure and tooling of CNC compared to conventional machine tools.	2	Understand
CO2	Students will be able to understand and write manual part programming as well as automated part programming of CNC lathe and CNC machining centre.	3	Apply
CO3	Students will be able to understand FMS and its elements including material handling systems.	2	Understand
CO4	Students will be able to understand the concurrent engineering concepts, shop floor control and process monitoring through computers	2	Understand
CO5	Students will be able to understand the features and application of automated inspection through CMM	2	Understand

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5
CO1	-	1	2	3	-
CO2	-	1	2	3	2
CO3	-	1	2	3	-
CO4	-	1	2	3	-
CO5	-	1	2	3	2

Unit	Details	Lectures	CO mapping
1	Features of CNC Machine tools, Machining Centers	8	CO1
2	NC Part Programming: Manual, Computer Assisted-APT, and CAD/ CAM integration.	10	CO2
3	Flexible Manufacturing Systems and Automated Guided Vehicles: Concepts, classification, types of flexibility, pallets fixtures, work handling systems, AS/RS	8	CO3
4	Concurrent Engineering: Objectives, tools and applications	6	CO4
5	Shop Floor Control and Computer process monitoring	6	CO4
6	Automated quality Control Systems: Computer-aided quality control, Programming and applications of CMM	6	CO5

References and Books:

1	Automation, Production System & Computer Integrated Manufacturing	M.P. Groover	Pearson
2	Computer-Aided Manufacturing	T.C. Chang, R.A. Wysk and H.P. Wang	Pearson Education India
3	CAD/CAM Principles and Applications	P N Rao	McGraw Hill Education (India)
4	CAD/CAM/CIM	P Radhakrishnan, S. Subramanyan, V. Raju	New Age International Publishers
5	Numerical Control and Computer Aided Manufacturing	P. N. Rao, N. K. Tewari, T. K. Kundra	McGraw Hill Education
6	Computer Control of Manufacturing Systems	Yoram Koren	McGraw Hill Education
7	Computer Integrated Design and Manufacturing	David D. Bedworth, Mark R. Henderson, & Philip M. Wolfa	McGraw-Hill Education
8	Computer Integrated Manufacturing Technology and Systems	U. Rambold, C. Blume & R. Dilman	Marcel & Dekker

Course Code: ME-22231	CAD/CAM Lab	Credits: 4-0-0:4

S. No.	Course
1.	Study of HMT CNC TRAIN MASTER Lathe.
2.	Study of HMT CNC TRAIN MASTER Machining Centre.
3.	Study of PMT CNC Lathe.
4.	Study of various types of Automatic Tool changers.
5.	Study of different components of robot.
6.	Preparation of small programmes in C for robot for motions (#6 periods)
7.	Programming on HMT Trainer Lathe.
8.	Programming on HMT milling machine.

Course Code: ME-21340	Finite Element Method in Engineering	Credits: 4-0-0:4

Prerequisites: NIL

Course Outcomes:

CO1	Understand the concept of finite element method for solving engineering science problems special reference to thermal and mechanical design problems.
CO2	Understand the formulation and solution of 1-D thermal and elasticity problems such as fins, bars, plane trusses and beam bending problems
CO3	Understand the discretization and interpolation with mapping concept involving 2-D triangular and quadrilateral elements. Applying FE formulation and finding solution of plane and axisymmetric thermal and elasticity problems
CO4	Apply the knowledge of FEM for analysis of transient vibration and transient heat transfer problems. Understand the development of algorithms and write FE code for solving simple thermal and elasticity problems as well as trained about use of commercial software packages for complex engineering problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	1
CO2	3	2	1	2	2
CO3	3	2	1	2	2
CO4	3	1	2	1	1

Unit	Details	Lectures
1	Introduction of FEM: Analysis of engineering science problems with special reference to mechanical design; Capabilities and approaches of FEM; Step by Step procedure for FE formulations; Finite Element Formulation of 1D and 1dof Thermal and Elasticity Problems: Basic procedure of Discretization of 1D domain and Interpolation with mapping concept, Development and evaluation of elemental integrals, Assembly and Imposition of boundary conditions; Solution procedure for system equations; FE formulation of axial heat transfer in plane & annular fin problems and axial deformation of bar problems	12
2	Finite Element Formulation of 1-D and 2dof Problems: Development of element equation and assembly procedure; FE formulation of plane truss analysis and beam bending analysis problems	6
3	Finite Element Formulation of 2-D Thermal Problems: Basic procedure of Discretization of 2D domain and Interpolation with mapping concept, Development and evaluation of elemental integrals; FE formulation of	6

	plane and axisymmetric thermal problems	
4	Finite Element Formulation of 2-D Elasticity Problems: Basic procedure of Interpolation with mapping concept, Development and evaluation of element equation, Imposition of boundary condition; FE formulation of plane and axisymmetric elasticity problems	8
5	Dynamic Analysis using Finite Elements: FE formulation of transient vibrational analysis and transient thermal analysis problems; Algorithmic approach and Software applications: FEA with MATLAB programming and software packages like ANSYS etc.	4

Text Books:

1	The Finite Element Method in Engineering	S.S. Rao	Butterworth-Heinemann, Elsevier
2	Introduction to Finite Elements in Engineering	Chandrupatla and Belegundu	Pearson

References:

1	An Introduction to Finite Element Method	J.N. Reddy	Oxford University Press

Programming Books:

1	The Finite Element Method and Applications in Engineering using ANSYS	Madenci and Guven	Springer
2	The Finite Element Method Using MATLAB	Kwon and Bang	CRC Press

Course code: ME21112	CIM (COMPUTER INTEGRATED MANUFACTUIRNG)	Credits : 3-1-0:4

Pre-requisites: CAD-CAM

Course Outcomes:

S.N.	Outcomes	BT Level	BT Description
CO1	Understand and apply the basics of CAD-CAM to link with the present industrial requirement.	2	Understand
CO2	Identify the levels of integration and required devices for industrial automation and up graduation requirements.	3	Understand
CO3	Identify the parameters of capacity planning, manufacturing resource planning and their effects on current market trends.	3	Apply
CO4	Evaluate and apply the concepts of industry 4.0 environment and to develop business strategy on the basis of studied parameters.	3	Evaluate
CO5	Apply and analyse the required knowledge in developing business competencies, ethics and to develop strategy for dynamic customer's requirement.	3	Apply

Course articulation matrix

	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	3	1
CO2	2	3	3	3	3
CO3	3	3	3	3	2
CO4	3	3	3	3	1
CO5	3	3	3	3	2

Unit	Details	Lectures	CO mapping
1	**Fundamentals of Automation in Manufacturing Systems**: Manufacturing Systems: Concept Objectives, Types and Trends; Concepts of Mechanization, Automation and Integration, Concept of CAD/CAM and CIMS;	5	CO1
2	**Software Technology for CIM System:** Business Database System: File processing, Data Processing and Database Design, File Organization and Relational Analysis; Decision Support System, Personal/Distributed Computing and Local Area Network;	5	CO1
3	**Group Technology and Cellular Manufacturing:** Concept of Group Technology and its Application, classification and Coding Techniques; Clustering	4	CO2

	Techniques and Cellular Manufacturing;		
4	**Planning and Scheduling Functions in CIM System:** Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP), Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRP-II), Just-In-time Production Systems and Concept of Enterprise Resource Planning (ERP);	6	CO3
5	**Computer-Aided Process Planning:** Approaches – Variant and Generative, Feature Classification and Recognition; Process Classifications and Selections, Machines and Tool Selection, Setting Process Parameters, Process Sheet Documentation;	4	CO4
6	**Advanced Manufacturing Systems:** Lean Manufacturing systems, Agile Manufacturing systems, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems and Agent-Based Manufacturing Systems Industrial Robots, Conveyors, AGVs, Automatic Storage and Retrieval Systems.	6	CO5

Reference Books:

1	Computer-Integrated Manufacturing	James A. Rehg and Henry W. Kraebber	Pearson Education (Singapore) private Ltd., Delhi
2	Automation, Production Systems and Computer-Integrated Manufacturing	Mikell P. Groover	Pearson Education (Singapore) private Ltd., Delhi
3	CAD/CAM Principle and applications	P.N. Rao	TATA McGraw-Hill Publishing Company Limited, New Delhi.

Course Code: ME21396	Robotics and Robot Applications	Credits: 3-1-0:4

Prerequisites: Basic knowledge of Kinematics, Automation and Control Systems

Course Outcomes:

CO1	Students will be able to understand the concepts of robotics and automation systems. Basic components robot manipulator and their working principles.
CO2	Students will be able to Identify and Classify the types of industrial robots based on kinematic structure, DOF, control system and actuation.
CO3	Students will be able to Analyse and evaluate the motion analysis such as Robot kinematics, Motion dynamics, trajectory planning & Robot work envelopes etc. Identify and Classify the types of sensors and actuators.
CO4	Students will be able to Apply and analyse the acquired knowledge for designing the robot, Robot Programming methods for motion planning, gripper force analysis for specific applications. To get familiar with the latest improvements in robotics technology.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	2	3	1
CO2	2	2	3	3	3
CO3	3	3	3	3	1
CO4	3	3	3	3	1

Unit	Details	Lectures
1	**Introduction:** Definition, Classification and Specification; Automation and Robotics; Over view of Robotics; present and future applications – classification by coordinate system and control system.	4
2	**Components of the Industrial Robotics:** Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.	4
3	**Actuators:** Introduction – Characteristics of actuating systems – Comparison of actuating systems – Hydraulic devices – Pneumatic devices – Electric motors and stepper motors – Microprocessor control of electric motors.	4
4	**Robot Manipulator:** Introduction; Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic	6

	Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-PitchYaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation.	
5	**Sensors:** Introduction – Sensor characteristics ,Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, – Position sensors – Velocity sensors – Acceleration sensors – Force and pressure sensors – Torque sensors – Microswitches – Light and Infrared sensors – Touch and Tactile sensors – Proximity sensors – Range-finders – Sniff sensors – Vision systems – Voice Recognition devices – Voice synthesizers – Remote center compliance device. Machine Vision System, Description, Sensing, Digitizing, Image Processing and Analysis and Application of Machine Vision System, Robotic Assembly Sensors and Intelligent Sensors.	8
6	**Robot Programming:** Introduction, Various Teaching Methods, Task Programming, Survey of Robot Level Programming Languages, A Robot Program as a Path in Space, Motion Interpolation, WAIT, SIGNAL & DELAY Commands, Branching, Robot Language Structure, various Textual Robot Languages Such as VAL II, RAIL, AML and their Features, Typical Programming Examples such as Palletizing, Loading a Machine Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion straight line motion – Robot programming, languages and software packages.	8
7	**Robot Applications:** Industrial Applications, Material Handling, Processing Applications, Assembly Applications, Inspection; Application, Principles for Robot Application and Application Planning, Justification of Robots, Robot; Safety, Non-Industrial Applications, Robotic application for sustainable Development.	4

References Book:

1	Robotics and Control	R.K Mittal and I.J. Nagrath	TMH
2	Industrial Robotics-The Application	M.P. Groover, M. Weiss and N.G. Odrey	TMH
3	CAM and Automation	M.P. Groover	PHI Learning
4	Robot Modelling and Control	Spong Mark and Vidyasagar	Wiley India
5	Foundations of Robotics- analysis and Control	Yoshikava	PHI Learning
6	Introduction to AI Robotics	Murphy	PHI Learning
7	Robotics Fundamental concepts and analysis	Ghosal Ashitava	Oxford
8	Introduction to Robotics	S. Saha	TMH
9	Industrial Robots Handbook	Yu Kozyhev	MIR Publication

Course Code: ME-22313/22363	Optimization Methods in Engineering/ Optimization Methods for Mechanical Design	Credits: 3-0-0:3

Prerequisites: Operational research & Mathematics

Course Outcomes:

S. No.	Outcomes	BT Level	BT description
CO1	Student will be able to understand the formulation of optimization problems	2	Understand
CO2	Student will be able to solve the single and multi-variable optimization problems	3	Apply
CO3	Student will be able to solve the constrained and specialized optimization problems	3	Apply
CO4	Student will be able to solve the non-traditional optimization problems.	3	Apply

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	1
CO2	3	2	2	1	1
CO3	3	3	3	3	3
CO4	3	3	3	2	3

Unit	Details	Lectures
1.	**Introduction**- Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation, Engineering Optimization Problems, Calculus Method, Linear Programming- Simplex Method, Concept of Dualit. .	6
2.	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods: Exhaustive Search Method, Bounding Phase Method, Region Elimination Methods: Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method, Application to Root finding	5
3.	**Multivariable Optimization Algorithms:** Optimality Criteria, Unidirectional Search, Direct Search Methods: Box Method, Hooke-Jeeves Pattern Search Method/ Powell's Conjugate Direction Method. Gradient Based Methods: Any two of the following: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method, Powell's Conjugate Gradient Method, Variable-metric (DFP) Method .	6
4.	**Constrained Optimization Algorithms:** Kuhn Tucker Conditions, Transformation Methods: Penalty Function Method, Method of	6

	Multipliers (MOM), Sensitivity Analysis.	
5.	**Specialized Algorithms:** Integer Programming: Penalty Function Method, Branch and Bound Method, Geometric Programming, Applications.	6
6.	**Non-Traditional Optimization Algorithms:** Genetic Algorithms: Basic Theory, Operators, Working, Differences between GAs and Traditional Methods, GAs for Constrained Optimization, Simulated Annealing, Elementary Idea of Neural Networks and Fuzzy Logic, Ant Colony Optimization, Particle Swarm Optimization.	4

Text Books:

S. N.	Book Title	Author	Publication
1	Optimization for engineering design: algorithms and examples	Kalyanmoy Deb	Prentice-Hall of India Private Limited, New Delhi
2	Engineering optimization: theory and practice	Singiresu S Rao	Fourth Edition, New Age International(P) Limited Publishers, New Delhi.

References:

S. N.	Book Title	Author	Publication
1.	Engineering optimization - methods and applications.	A. M. Natarajan, P. Balasubramani, A. Tamilarasi	Pearson Education, 2013.
2.	Optimization in Operations research	Rardin, Ronald L.	Pearson Education
3.	Operations Research	Sulabha K. Kulkarni	Springer
4.	Operations Research Theory and Applications	J K Sharma,	MacMillan India Ltd.
5.	https://www.youtube.com/watch?v=aJKuM4U-eYg		
6.	http://www.digimat.in/nptel/courses/video/111105039/L31.html		

Course Code: ME21318	Reverse Engineering	Credits: 4-0-0-4

Pre-requisites: PH-1101 Physics-I and MA-1101 Mathematics-I

COURSE OUTCOME

S.N.	Outcomes
CO1	Understand the various techniques for acquiring 3D coordinates of the points lying on the physical object and pre-process it
CO2	Construct the first order approximation surface with data point (triangular mesh modelling) for the computation of various topological and geometrical properties
CO3	Segment the data points for exact fitting of surfaces
CO4	Construct Surface model so as to be used for various engineering applications like analysis, modification, manufacturing etc.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	-	2	3	1
CO2	2	-	2	3	2
CO3	2	-	2	3	-
CO4	2	-	2	3	3

Unit	Details	Lectures
1	**Introduction:** Need of Reverse Engineering, definition, application	2
2	**Data acquisition technique:** Contact method, coordinate measurement machine and robotic arms Non-contact methods, triangulation , Structured Light etc.	8
3	**Pre - processing technique:** Need of pre-processing, import of the point cloud data, registration , data reduction and filtering	5
4	**Triangular mesh modelling:** Need of triangular mesh model and its definition , topological characteristics, Euler formula for triangular mesh model, various methods of construction of triangular mesh model	8
5	**Segmentation**: Definition and need of segmentation , various methods used for segmentation like edge based and face based method of segmentation	8
6	**Curve and Surface modelling**: Parametric form of curves and a surfaces , Hermite curve and surface, Bezier curve and Surface, B-spline curve and Surface, Introduction of NURBS	8
7	**B-Rep model creation:** Need of consistent and contiguous model, Blending curves and surfaces	3

Text/Reference Books:

1	Reverse Engineering and Industrial Prospective	Raja, Vinesh, Fernandes, Kiran J.	Springer Series in advanced Manufacturing
2	Reverse Engineering- Recent Advances and Applications	Alexander C Telea	Intech Janeza trotline
3	Smart Product Engineering	Michael Abramovici, Rainer Stark	Springer Berlin Heidelberg

Course Code: ME21391	Concurrent Engineering	Credits: X-0-0:X

Unit	Details
1	**Introduction-** Basic concepts, sequential Engineering, sequential engineering Vs CE, why CE, mathematical model for understanding interactions between design and manufacturing, examples, benefits of CE, characterization of CE environment, difficulties associated with performing CE, framework for integration of life-cycle phases in a CE environment, CE techniques.
2	**Design for Manufacturing and Assembly-** DFA Guidelines- system guidelines, handling guidelines, insertion guidelines, and joining guidelines, theoretical minimum number of parts, design for piece part production, potential conflicts between DFA and DFM, manufacturing cost analysis, basic DFM part cost method, basic assembly method (adapted Xerox producibility index), Boothroyd DFA analysis.
3	**Design for Manufacturing-** Estimation of the manufacturing costs, reduction of costs of components, reduction of costs of assembly, reduction of the costs of supporting production; consider the impact of DFM Decisions on other factors.
4	**Product Development Economics-** Elements of Economic analysis, Build a Base-Case Financial Model, Perform Sensitivity Analysis, Use Sensitivity analysis to understand project Trade-Offs, Consider the influence of the Qualitative factors on project success.
5	**CE Techniques -** Quality Function Deployment, The Taguchi Method for Robust Design, Failure Modes and Effects Analysis (FMEA).
6	Design for reliability, design for maintainability, design for serviceability and their implementation.

Text/Reference Books:

1	Systems Approach to Computer Integrated Design and Manufacturing	Nanua Singh	Wiley India
2	Concurrent Engineering	Andrew Kusiak	John Wiley & Sons
3	Concurrent Engineering	Chanan S. Syan and Unny Menon	Chapman & Hall
4	Product Design and Development	Karl T. Ulrich, Steven D. Eppinger, and Anita Goyal	McGraw Hill Publication
5	Product Design for Manufacture and Assembly	G. Boothroyd, P. Dewhurst and W. A. Knight	CRC Press
6	Product Design: Techniques in Reverse Engineering and New Product Development	Kevin Otto and Kristin Wood	Pearson Publication

Course Code: ME21393	Surface Engineering	Credits: X-0-0:X

Introduction to surface engineering – importance and scope of surface engineering, conventional surface engineering practices like pickling, grinding, buffing etc., surface engineering by material addition like electroplating, surface modification of ferrous and non-ferrous materials like nitriding, cyaniding, aluminizing etc. Advanced surface engineering practices like laser assisted surface modification, electron beam assisted modification, spraying techniques like flame and plasma spraying, high velocity oxyfuel, cold spray techniques. Sputter deposition processes, PVD and CVD methods of surface coatings, surface modification by ion implantation and ion beam mixing Characterisation of the engineered surface and coatings like thickness, porosity and adhesion of coatings, surface microscopy and spectroscopic analysis of the modified surfaces. Functional coatings and their applications.

Text/Reference Books:

1	Introduction to Surface Engineering	P. A. Dearnley	Cambridge University Press
2	Introduction to Surface Engineering and Functionally Engineered Materials	Peter M. Martin	Wiley
3	Surface Engineering of Metals: Principles, Equipment, Technologies	Tadeusz Burakowskiand TadeuszWierzchon	CRC Press
4	Basics of Surface Technology	Kamraj and Radhakrishanan	New Age International Publisher

Course Code: ME21394	Modal Analysis of Mechanical System	Credits: X-0-0:X

Theoretical Basis: Single-Degree-of-Freedom (SDOF) System, Presentation and Properties of FRF Data for SDOF System, Undamped Multi-Degree-of-Freedom (MDOF) Systems, MDOF Systems with Proportional Damping, MDOF Systems with Structural (Hysteretic) Damping – General Case, MDOF Systems with Viscous Damping – General Case, Modal Analysis of Rotating Structures., Complex Modes, Characteristics and Presentation of MDOF FRF Data, Nonsinusoidal Vibration and FRF Properties, Complete and Incomplete Models, Sensitivity of Models, Analysis of Weakly Non-linear Structures.

Response Function Measurement Techniques: Test Planning, Basic Measurement System, Structure Preparation, Excitation of the Structure, Transducers and Amplifiers, Analysers, Digital Signal Processing, Use of Different Excitation Signals, Calibration, Mass Cancellation, Rotational FRF Measurement, Measurements on Non-Linear Structures, Multi-point Excitation Methods, Measuring FRFs and ODSs using the Scanning LDV.

Modal Parameter Extraction Methods: Preliminary Checks of FRF Data, SDOF Modal Analysis Methods, SDOF Modal Analysis in the Frequency Domain (SISO), Global Modal Analysis Methods in the Frequency Domain, MDOF Modal Analysis in the Time Domain, Modal Analysis of Non-Linear Structures.

Derivation of Mathematical Models: Modal Models, Refinement of Modal Models, Display of Modal Model, Response Models, Spatial Models, Mobility Skeletons and System Models.

Applications: Comparison of and Correlation of Experiment and Prediction, Adjustment or Updating of Models, Coupled and Modified Structure Analysis, Response Prediction and Force Determination, Test Planning.

References:

1	Modal Testing - Theory, Practice & Application	D.J. Ewin	John Wiley & Sons
2	Modal Analysis	He, J., Fu, Z. F.	Butterworth-Heinemann
3	Vibration: Fundamentals and Practice	De Silva, C.W.	CRC Press, New York
4	Vibration testing: Theory and Practice	McConnell K. G.	John Wiley & Sons, NY

Course Code: ME21395	Modelling and Simulation of Manufacturing Systems	Credits: X-0-0:X

1. Introduction to modeling: Concept of system, Continuous and discrete systems, Types of models, Steps in simulation study, Statistical models in simulation, Discrete, Continuous, Poisson and empirical distributions.
2. Simulation programming techniques, Output data analysis for a single system, Comparing alternative system configurations.
3. Statistical procedure for comparing real world observations with simulation output data, Generation of arriving processes, Verification and validation of simulation models.
4. Monte Carlo simulation and its application in queuing models and inventory models.
5. Simulation of manufacturing and material handling system.
6. Case studies on simulation packages.

References:

1	Simulation Modeling and Analysis, Fourth Edition	Averill M Law	John Wiley & Sons
2	System Simulation. Second Edition,	Geoffrey Gordon	Prentice-Hall of India Private Ltd., New Delhi, India
3	Discrete-Event System Simulation, Fourth Edition	Jerry Banks, John S. Carson II, Barry L. Nelson and David M. Nicol.	Pearson Education (Singapore) Private Limited, Indian Branch, Delhi.
4	Simulation Modeling Handbook - A Practical Approach	Chung, A. C.	CRC Press LLC, Florida, USA.
5	Simulation: The Practice of Model Development and Use	Robinson S.	John Wiley & Sons, Ltd., England
6	Simulation of Manufacturing Systems	Carrie A.	John Wiley & Sons, Ltd., England

Course Code: ME21317	Product Design and Development	Credits: X-0-0:X

S. No.	Details
1.	Introduction and Characteristics of Product Development.
2.	Who designs & develops products- Industrial & Practical Examples.
3.	Creative thinking- Invention- innovation & inventiveness in a society.
4.	Development Process & Organization.
5.	A Generic Development Process & Concept Development.
6.	Identifying Customer Needs.
7.	Concept Generation, Concept Selection
8.	Product Architecture, Industrial Design.
9.	Human Factors & System Information Input- Text graphics, symbols and codes,
10.	Work Place Design- case studies.
11.	Human Factors Application – case studies.
12.	Human Errors – accidents and safety. Techno legal issues
13.	Intellectual Property Rights

Text/Reference Books:

1	Product Design & Development	Karl T. Ulrich, Steven D Eppinger	McGraw Hill Publishers
2	The Mechanical Design Process	David G. Ullman	
3	Human Factors in Engineering Design	Mark S Sanders & Ernst J. Mc Cornick	McGraw Hill Publishers
4	Product Design and Process Engineering	Benjamin W Nishel& Alan B Draker	McGraw Hill Publishers

Course Code: ME21397	Production and Operations Management	Credits: X-0-0:X

1. **Introduction:** Flexible production era, Evaluation of service organization, learning curves
2. **Forecasting:** Elements and steps in forecasting, Types of forecasting: Qualitative and quantitative types, Errors in forecasting.
3. **Aggregate Planning:** Purpose, inputs of aggregate plan, planning, processes and strategies, Methods and techniques, Mathematical charting and heuristics.
4. **Managing inventory with dependent demands:** MRP, Lot sizing in MRP Implementing MRP systems, MRP II, ERP.
5. **Operation scheduling:** scheduling systems, scheduling methods, in flow and job-shops, assembly lines.
6. **Capacity Planning:** Definition and measurement of capacity, adjusting capacity, capacity strategies.
7. **Facility Location and Layout:** facility location factors and methods, different facility layouts and their optimization: flow shop, Job-shop, Cellular layout, assembly line and project processes.
8. JIT, lean and synchronous manufacturing and theory of constraints
9. **Supply-chain Management:** Creating and effective supply chain, supply chain strategy, performance measurement outsourcing.

Text/Reference Books:

1	Production and Operations Management	Everett E. Adam, Jr. Ronald J. Ebert
2	Production and Operations Management	Joseph S. Martinich
3	Modern Production/Operations Management	E. S. Buffa and R. K. Sarin
4	Operations Management for Competitive Advantage	Chase Jacobs, Aquilano
5	Operations Management	Krajewski and Ritzman

Course Code: AMXXXXX	Computational Fluid Dynamics	Credits: X-0-0:X

Course Code: ME22398	Mechanical System Design	Credits: X-0-0:X

Engineering Process and systems Approach: Fundamentals of Technical System: System, plant, Equipment, machines,Assemblies and components, Systems approach: structure and steps during life phases of the system, Application of Systems concepts in Engineering. General approach to design, Identification of Engineering functions, Conversion of energy, material and signals, Functional relationship, Working interrelationship: physicaleffects,Design phases, Engineering Activity Matrix, Defining the proposed effort, Role of Engineer, Engineering Problem Solving Concurrent Engineering, A case study.
Problem Formulation: Defining and formulating a design problem Nature of Engineering Problems, Needs Statement: customer requirements and company requirements, engineering characteristics, Constraints, Quality function deployment/ house of quality, Engineering design specification. System Theories General methodology of problem solving, Functional description of system, System analysis view points, black box approach, state theory approach, Function structure, function variants, relocating functions, subdividing functions, combining and eliminating functions, Concept evaluation: absolute and relative, Decision Process Approach, Case study.
System Modelling and linear graph modelling: Need for modelling, Modelling types and purposes, Linear graph modelling concepts, relating LGT to lumped element models of physical systems. Graph Modelling and Analysis Process, manipulation of graph theory rules, Path problem, Network flow problem. Case Study; Mathematical Modelling Concepts: Bondgraph approach. Case Study
Optimization Concepts: Optimisation process, Motivation and freedom of Choice, goals and objectives- Criteria, calculus method of optimization: Lagrange multiplier, Methods of optimisation-analytical: nonlinear optimization.
System Evaluation: Feasibility Assessment, planning horizon, time value of money, financial analysis. A case study
Decision Analysis: Elements of a decision problem, Decision model, probability, Expected monetary value, Utility value, Baye's theorem. Case Study.
System Simulation Simulation Concepts, simulation models, Iconic, Analog, Analytical, Simulation Process Problem definition, input model construction, Waiting line simulation, Solution process, limitations of simulation approach: A case study.
Axiomatic Approach of Suh: Problem definition and FRs, Hierarchy of FRs and DPs Suh's Axioms and corollary, Decomposition of Design process, Design for manufacture,

Text/Reference Books:

1	Systematic Mechanical Designing: A Cost and Management Perspective	M.S. Hundal	ASME Press
2	Engineering Design: A Materials and Processing Approach	GE Dieter	McGraw Hill
3	Design Engineering and design for manufacture	J. R. Dixon	Field Stone Pub.
4	The Mechanical Design Process	David G. Ullman	McGraw Hill
5	Engineering Design	R. J. Eggert	Pearson/Prentice Hall

6	Elements of Engineering Design	Martin S Ray	Prentice Hall
7	Principles of Design	Nam P Suh	McGraw Hill
8	Total Design	Stuart Pugh	Pearson Education
9	Optimisation Techniques	S. S. Rao	
10	System analysis and Project Management	Cleland, Willium and King	McGraw Hill
11	Modelling and Simulation of Mechanical Systems using Bondgraph	Amalendu Mukherjee, Ranjit Karmakar	

Course Code: ME22399	Materials, Manufacturing and Design	Credits: X-0-0:X

1. Why study design process- Understanding Mechanical design – Designer's and Design team.
2. Materials in Design –Evolution of Engineering materials –Metals- Plastics - composites Applications – Automotive Industry- Consumer Goods- Construction & Civil Structure Industrial Applications.
3. Introducing modelling and synthesis for structural integrity- Modeling and Simulation -the Role of Models in Engineering -case studies--Similitude and Scale Models - Simulation - Geometric Modeling on the Computer -Finite-Element Analysis - Computer Visualization Rapid Prototyping –case studies.
4. Materials Selection -Performance Characteristics of Materials -The Materials Selection Process -Sources of Information on Materials Properties-Economics of Materials - Design Example--Materials Substitution, Recycling and Materials Selection.
5. Embodiment design- Product architecture- Industrial design- Human factors design – design for environment.
6. Design Against Failure- fatigue -corrosion -wear etc.
7. Manufacturing processes & process selection Classifying processes -Shaping- joining finish- etc.
8. Plastics –different types- manufacturing Processes -case studies.
9. Materials & the environment Life cycle – packaging material –case studies.
1. Economic Decision Making -Cost Comparison - Materials and energy consuming systems – Eco selection -case studies. Methods of Developing Cost Estimates, Life Cycle Costing – case studies.
2. The Origin of Laws -Contracts - Liability -Product Liability -Protecting Intellectual Property -The Legal and Ethical Domains concern for the environment and for individual Case studies.

Text/Reference Books:

1	Engineering Design: A Materials and Processing Approach	GE Dieter	McGraw Hill
2	Materials Selection in Mechanical Design	M.F Ashby	Butterworth-Heinmann
3	Handbook of Product Design for Manufacturing	James G Bralla	
4	Manufacturing Engineering and Technology	S. Kalpakjian	Prentice Hall
5	Practical Engineering Failure Analysis	HaniMTawancy, Anwar ul- Hamid, Abbas	Marcel Dekker, New York
6	Introduction to Engineering design- Modelling, Synthesis & Problem solving strategies	Andrew Samuel & John Weir	
7	Mechanical Design Process	David G Ullman	McGraw Hill
8	Composites Manufacturing- Materials Products and process manufacturing		

9	Fatigue Design Handbook	Society of Automotive Engineers, Inc

Course Code: ME22309	Design of Micro-Electro-Mechanical Systems	Credits: X-0-0:X

1. **Overview of Micro Electro Mechanical systems (MEMS) and Microsystems:** MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Mirco-optical Components, Application of Microsystems in Automotive Industry, Application of Microsystems in other Industries: Health care, Aerospace, Industrial Products, Consumer Products, Telecommunications; Scaling Laws in Miniaturization
2. **Working Principles of Microsystems:** Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics
3. Engineering Science for Microsystems Design and Fabrication: Atomic structure of matter, Ions and Ionization, Molecular theory of matter and Intermolecular forces, Doping of semiconductor, Diffusion process, Plasma Physics, Electrochemistry
4. Engineering Mechanics for Microsystems Design: Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, fracture mechanics
5. **Thermo-fluid Engineering and Microsystems Design:** Fluid flow in micro conduits, Heat conduction in multilayered thin films and in solids at sub-micrometer scale
6. Materials for MEMS and Microsystems: Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials
7. **Microsystems Fabrication and manufacturing Processes:** Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process
8. **Microsystems Design:** Design Constraints: Selection of Materials, manufacturing processes, signal transduction, electromechanical system, packaging. Process Design: Photolithography, Thin film fabrications, Geometry shaping. Mechanical Design: Geometry of MEMS components, Thermo mechanical loading, stress analysis, dynamic analysis, interfacial fracture analysis. Mechanical Design using FEM: FEM formulation, Simulation of micro fabrication processes, Design of Silicon Die of a Micro pressure sensor, Design of micro fluidic network systems, Design of Micro gas turbine rotor, bearings.

Text/Reference Books:-

1	MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering	Hsu, T.R.	John Wiley & Sons, Inc. New Jersey
2	Fundamentals of Microfabrication	Madau, M. J.	Taylor & Fransis CRC Press
3	Handbook of MEMS: Introduction and Fundamentals	Gad-el-Hak	Taylor & Fransis CRC Press

Course Code: ME22401	Design of Experiments	Credits: X-0-0:X

Basic Concepts: Fundamentals of experimental design, Selection of an appropriate design, Criteria for evaluation, Factors and levels, Review of statistical inference, Importance of optimized design, Functional design, Parametric design.

Single Factor Experiments: Completely randomized design, Analysis of variance (ANOVA), Effect of total sum of Squares, Randomized block design, Randomized incomplete block design, Latin square design.

Factorial Experiments: Two way analysis of variance, Fixed, Random and Mixed models, Expected mean square rules, Nested and nested factorial designs, Effect of confounding, Fractional factorial design, Response Surface Methodology – Central composite designs, The method of steepest ascent, response surface designs.

Robust Design: Steps in designing performance in to a product, Taguchi‘s definition of quality, Loss functions and manufacturing tolerances, Additivity, Orthogonal arrays vs. classical statistical experiments, Graphic evaluations of main effects, Selecting factors for Taguchi Experiments, Concept of S/N Ratios – its significance in robust design, Case studies of S/N ratios in optimization, Identifying control and noise factors, Ishikawa Diagram, Constrained Robust Design Approach, Applications.

References:

1	Design and Analysis of Experiments	Douglus Montgomery	John Wiley & Sons
2	Fundamental concepts in design of experiments	Charles R. Hicks, Holt, Rinehort and Winston	
3	Methods Explained: Practical steps to Robust Design	Tapan P. Bagchi	Prentice-Hall
4	Experimental Designs	WG and Cox, GM	Asia Publishing House
5	Quality Engineering using robust design	M.S. Phadke	Prentice-Hall
6	Taguchi Techniques for quality engineering	P.J. Ross	McGraw-Hill

Course Code: ME22402	Artificial Intelligence in Engineering	Credits: X-0-0:X

1. Introduction to knowledge-based intelligent systems, Rule-based expert systems, Expert system structure.
2. **Fuzzy expert systems:** fuzzy sets, fuzzy relations, fuzzy implications, construction of data base and rule base, inference mechanisms, defuzzification methods.
3. **Artificial neural networks:** neurons and neural networks, single layer perceptrons, multi-layer neural networks, learning processes, radial basis function networks, recurrent neural networks. Hybrid intelligent systems.

References:

1	Artificial Intelligence: A Guide to Intelligent Systems	M. Negnevitsky	Addison-Wesley
2	Neural Networks: A comprehensive Foundation	S. Haykin	Pearson Education
3	Introduction to artificial neural systems		Jaico Publishing House
4	Neural Networks for Modelling and Control of Dynamic Systems, A Practitioner's Handbook	M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen	Springer
5	An Introduction to Fuzzy Logic for Practical Applications	K.Tanaka and T. Niimura	Springer
6	Fuzzy logic with engineering applications	T. J. Ross	Wiley India Pvt. Ltd
7	Fuzzy logic: intelligence, control and information	J. Yen and R. Langari	Pearson Education

Course Code: ME22403	Mechatronics and Control Systems	Credits: X-0-0:X

Introduction to Mechatronic systems and components.
System Modeling, Transfer functions, Block diagrams, Signal flow graphs.
Time Response of first and second order systems, Stability analysis, Steady state analysis.
Root locus analysis, Controller design using root locus: Lead compensation, Lag compensation. Frequency response analysis, Frequency domain compensation techniques: Lead and lag compensators.
Sensors and their interface, Electric Actuators, Pneumatic and Hydraulic Actuators, Basics of Microcontroller, I/O interfacing, A/D and D/A conversion.

References:

1	Mechatronics	Bolton, W.	Pearson Education Ltd.
2	Mechatronics	Necsulescu, D.	Pearson Education Ltd.
3	Mechatronics: Integrated technologies for intelligent machines	Smaili, A. and Mrad, F.	Oxford University Press
4	Introduction to Mechatronics and Measurement Systems	Histand, M. B. and Alciatore, D. G.	McGraw-Hill Education (ISE Editions)
5	Modern Control Engineering	Ogata, K.	Pearson Education
6	Control Systems Engineering	Nagrath, I. J. and Gopal, M.	New Age International
7	Automatic Control Systems	Kuo, B. C. and Golnaraghi, F.	Wiley India Pvt. Ltd