MECHANICAL ENGINEERING DEPARTMENT
M. M. M. UNIVERSITY OF TECHNOLOGY
GORAKHPUR

Overall Credit Structure for M.Tech. Programme

Credit Courses			
Postgraduate Core (PC)		**Postgraduate Electives (PE)**	
Category	**Min. Credits**	**Category**	**Min. Credits**
Maths (M)	4	Program Electives (PE)	16
Program Core (PC)	22		
Minor Project (MP)	4		
Dissertation (D)	18		
Seminar (S)	2		
	50		**16**
Total		**66 (min.)**	
Audit Courses			
Audit Courses (Other Departments)	**6** (min.)		
Grand Total	**6 (min.)**		

Credit Structure M.Tech. (Computer integrated Manufacturing)

Category **Semesters**	**I**	**II**	**III**	**IV**	**Total**
Maths (M)	5	-	-	-	5
Programme Core (PC)	13	9	-	-	22
Program Electives (PE)	-	8	8	-	16
Minor Project (MP)	-	-	4	-	4
Dissertation (D)			4	14	18
Seminar (S)	-	-	-	2	2
Total	**18**	**17**	**16**	**16**	**67**

Curriculum of M.Tech. (CAD CAM ROBOTICS)

Junior Year, Semester-I

S.N	Category	Paper Code	Subject Name	L	T	P	Credit
1.	M	MMS-610	Foundational Mathematics for Artificial Intelligence	3	1	2	5
2.	PC	MME-301	Advanced Computer-Aided Design	3	1	2	5
3.	PC	MME-302	Introduction to Mechatronics System	3	1	0	4
4.	PC	MME-303	Advanced Engineering Material and Characterization	3	1	0	4
5.	AC		Audit subject				
			Total	**12**	**4**	**4**	**18**

Junior Year, Semester-II

S.N.	Category	Paper Code	Subject Name	L	T	P	Credit
1.	PC	MME-304	Industrial Robotics	3	1	2	5
2.	PC	MME-305	Advanced Computer Aided Manufacturing	3	1	2	5
3.	PE1	MME-3**	Program Elective-1	3	1	0	4
4.	PE2	MME-3**	Program Elective-2	3	1	0	4
5.	AC		Audit subject				
			Total	**12**	**4**	**2**	**18**

Senior Year, Semester-III

S.N.	Category	Paper Code	Subject Name	L	T	P	Credit
1.	PE3	MME-3**	Program Elective-3	3	1	0	4
2.	PE4	MME-3**	Program Elective-4	3	1	0	4
3.	MP	MME-320	Minor Project	0	0	8	4
4.	D	MME-330	Dissertation Part-I	0	0	8	4
			Total	**6**	**2**	**16**	**16**

Senior Year, Semester-IV

S.N.	Category	Paper Code	Subject Name	L	T	P	Credit
1.	S	MME-340	Seminar	0	0	4	2
2.	D	MME-350	Dissertation Part-II	0	0	28	14
			Total	**0**	**0**	**32**	**16**

Program Core (CAD CAM ROBOTICS)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credit s
1.	MME-301	Advanced Computer Aided Design	-	3	1	2	5
2.	MME-302	Introduction to Mechatronics System	-	3	1	0	4
3.	MME-303	Advanced Engineering Material and Characterization	-	3	1	0	4
4.	MME-304	Industrial Robotics	-	3	1	2	5
5.	MME-305	Advanced Computer Aided Manufacturing	-	3	1	2	5
6.	MME-320	Minor Project	-	0	0	8	4
7.	MME-330	Dissertation Part-I	-	0	0	8	4
8.	MME-340	Seminar	-	0	0	4	2
9.	MME-350	Dissertation Part-II	Dissertation Part-I	0	0	28	14

Program Electives (CAD CAM ROBOTICS)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
		PE-1& PE-2 (Semester-II)					
1.	MME-351	Modelling and Simulation of Mechatronics Systems	-	3	1	0	4
2.	MME-352	Optimization Techniques and Design of Experiments	-	3	1	0	4
3.	MME-353	Advanced Mechanics of Solid	-	3	1	0	4
4.	MME-354	Internet of Things and Smart Manufacturing	-	3	1	0	4
5.	MME-355	Advanced Manufacturing Processes	-	3	1	0	4
6.	MME-356	Micro Manufacturing	-	3	1	0	4
7.	MME-357	Additive Manufacturing	-	3	1	0	4
8.	MME-358	Green Manufacturing					
9.	MME-359	Sensors and Actuators					
		PE-3 & PE-4 (Semester-III)					

Audit Courses for M.Tech. (CAD CAM ROBOTICS)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
		Semester-I					
1.	MAS-105	Applied Probability and Statistics	-	3	1	0	4
2.	BOE-04	Principles of Remote Sensing		2	1	0	3
3.	BOE-07	Introduction to Data and File Structures	-	2	1	2	4
4.	MBA-109	Research Methodology	-	3	1	0	4
		Semester-II					
1.	BAS-27	Discrete Mathematics	-	3	1	0	4
2.	BCE-21	Environmental Impact Assessment & Management	-	3	1	0	4
3.	BCS-73	Neural Network & Fuzzy Systems	-	3	1	0	4
4.	BEE-15	Introduction to Microprocessors	-	3	1	2	5
5.	MBA-106	Human Resource Management	-	3	1	0	4

Department of Mechanical Engineering

Madan Mohan Malaviya University of Technology, Gorakhpur-273 010, India

M. Tech. (CAD/ CAM ROBOTICS) Syllabus

MMS-610	**Foundational Mathematics for Artificial Intelligence**
Course category	Basic Sciences & Maths (BSM)
Pre-requisite Subject	NIL
Contact hours/week	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	4
Course Assessment Methods	Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory examination
Course Outcomes	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. The basic terminology of linear algebra in Euclidean spaces, including linear independence, spanning, basis, rank, nullity, subspace, linear transformation, eigen values and diagonalization.
2. Able to apply graphs as unifying theme for various combinatorial problems.
3. Able to perform test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases and non-parametric test such as the Chi-Square test for Independence as well as Goodness of Fit .
4. Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and perform ANOVA and F-test.
5. Able to solve optimization problems using classical optimization techniques.

Topic Covered

UNIT- I

Linear Algebra: Vector Spaces, Subspaces, Linear Dependence, Basis and Dimension, Linear Transformations, Kernel & Image, Matrix Representation of Linear Transformation, Change of Basis, Eigen Values and Eigen Vectors of Linear Operators, Diagonalization. Inner Product Spaces and Orthogonality, Norms and Distance Measures, Orthogonal Projections and Least Squares Method.

UNIT- II

Graph Theory: Connectivity, Cut-vertex, Bridge, Blocks, Vertex-connectivity, Edge-connectivity and some external problems, Planarity:- Plane and Planar graphs, Euler Identity, Non planar graphs, Colorability :-Vertex Coloring, Chromatic index of a graph, Chromatic number of standard graphs, Bichromatic graphs.

UNIT- III

Statistical Hypothesis: Concept of Statistical Hypothesis, Hypothesis, Procedure of Testing the Hypothesis, Types of Error, Level of Significance, Degree of Freedom. Chi-Square Test, Properties, and Constants of Chi-Square Distribution. Student's t-Distribution, Properties & Applications of t-Distribution. Analysis of Variance, F-Test, Properties & Applications of F-Test.

UNIT- IV

Classical Optimization Techniques: Introduction, Review of single and multi-variable optimization methods with and without constraints, Non-linear one-dimensional minimization problems, Examples.

Books/References

Books/References

1. K. Hoffman, R Kunze, Linear Algebra, Prentice Hall of India, 1971.

2. V. Rohatgi., An Introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd. New Delhi.

3. K. Swaroop, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand Publishers.

4. J.K. Sharma, Operations Research, Laxmi Publications. S.S.Rao, Engineering Optimization, New Age International.

5. S. S. Rao, Engineering Optimization, New Age International.

MME-301	ADVANCED COMPUTER AIDED DESIGN

Course category	:	Program Core (PC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The knowledge of computer graphics systems and its hardware such as graphics input, display and output devices.
2. The ability to generate circles and ellipses using Bresenham's algorithm and understand the mathematics behind 3D geometric transformations.
3. Understand analytical representations of different types of parallel such as orthographic, oblique and axonometric projections as well as non parallel such as perspective and stereographic projections.
4. The analytical representations of parametric planar curves and synthetic space curves such as Hermite, Bezier, non rational& rational B-spline curves and their properties.
5. The synthetic surfaces and their parametric representations, different solid modeling techniques and skill of generating 3D geometric models in CAD software.

Topics Covered

UNIT-I	
Graphic Systems Introduction, Graphics systems, Graphics hardware input devices, Display devices, Color displays, Solid state monitors, Output devices, Software configuration and functions, Graphics software standards **Output Primitives** Scan conversion of primitives, Bresenham's Circle generating algorithm and Ellipse generating algorithms, problems.	9
UNIT-II	
3D Transformation Linear transformations, translation, rotation, scaling, reflection and shear, Matrix representation, Overall scaling, Composite transformations, Rotation about local axes parallel to global axes, Rotation about an arbitrary axis, Scaling with respect to fixed point, Reflection through an arbitrary plane. **Projections** Plane geometric projection, Parallel projections–Matrix equations for Orthographic projection, Oblique projection-Cavalier and Cabinet projections, Axonometric projections-isometric, diametric and trimetric projections, Equation for one point, two point and three point perspective projections.	9

UNIT-III	
Curves Classical representation of curves, Parametric analytic curves, Space curves, Hermite curves-Blending functions, properties, Bezier curves-Blending functions, properties, Composite Bezier curves and drawbacks, Non-rational B-spline curves-spline blending functions, blending function formulation, knot vector, uniform, open uniform and non uniform non rational spline blending functions, B-splines curve generation for various control points, Shape control of spline curves, properties, Rational B-spline curves-open uniform, periodic uniform and non uniform knot vector.	9
UNIT-IV	
Surface Description and Generation Parametric representation, Surfaces of revolution, Sweep surfaces, Bilinear surface, Ruled and developable surfaces, Coons bicubic surfaces, Bezier and B-spline surfaces. **3D Graphics** Polygon surfaces-polygon meshes, Wire frame and Solid models-Regularized Boolean set operations, Sweep and boundary representations, Constructive Solid Geometry- unbounded and bounded primitives.	9

EXPERIMENTS

Minimum Eight experiments are to be performed

1. Understanding and use of drafting software AutoCAD.
2. Sketching and solid modeling of a machine component in CAD software such as ProE/ Solidworks etc.
3. Writing and validation of a circle drawing algorithm.
4. Writing and validation of ellipse drawing algorithms.
5. Writing and validation of computer programs for individual geometric transformation such as translation/ rotation/ scaling.
6. Writing and validation of computer programs for combined geometric transformations such as translation/ rotation/ scaling.
7. Writing and validation of computer program for design of shaft under the combined bending and torsional loading.
8. Experiments on generation of analytic curves.
9. Experiments on generation of space curves.
10. Experiments on generation of surfaces.
11. Experiments on generation of solid models in CAD software.
12. Experiments on projection of an object.

Books & References

1. Computer Graphics-Hearn & Baker, Prentice Hall of India
2. Computer Aided Engineering Design-Anupam Saxena & B. Sahay, Anamaya Publishers
3. CAD/CAM Theory and Practice- Ibrahim Zeid& R Sivasubramaniam, McGraw Hill
4. Mathematical Elements for Computer Graphics- DF Rogers & JA Adams, McGraw Hill
5. CAD/CAM-HP Groover & EW Zimmers Jr, Prentice Hall India Ltd
6. Computer Aided Design-S.K. Srivastava, IK International Publications
7. Computer Aided Design-R.K. Srivastava, Umesh Publications

MME-302	**Introduction to Mechatronic systems**	
Course category	:	Program Core (PC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Quiz, Tutorials, and Exam
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Course Outcomes

1. To understand the fundamentals of mechatronic systems and their components.
2. To integrate mechanical, electrical, electronic, and control systems.
3. To develop basic modelling and system analysis skills.
4. To apply mechatronics concepts in real engineering applications.

Topics Covered	
UNIT-I	
Fundamentals of Mechatronic Systems: Introduction to Mechatronics, Evolution and scope of mechatronic systems, Elements of a mechatronic system: Mechanical subsystem, Electrical subsystem, Electronic subsystem, Control subsystem, System integration concept. Examples of mechatronic products. Applications: Automatic washing machine, CNC machine, Automotive systems.	9
UNIT-II	
Sensors and Actuators: Measurement systems and signal conditioning, Types of sensors: Position, velocity, acceleration, Temperature and pressure, Force and strain. Actuators: DC and AC motors Stepper and servo motors, Hydraulic and pneumatic actuators. Selection criteria for sensors and actuators. **Practical/ Practice on :** Sensor interfacing basics, Motor control demonstration, Smart production lines	9
UNIT-III	
Modelling and Control Basics: Mathematical modelling of simple systems, Transfer function and state-space concept, Introduction to feedback control, PID controller (basic idea). System response and stability (basic concept). **Practical/ Hands on :** Modelling of spring-mass-damper system. DC motor simulation using MATLAB/Simulink	9
UNIT-IV	
Embedded Systems and Applications: Introduction to microcontrollers, Basic programming concept (Arduino / similar platform), Interfacing sensors and actuators, Introduction to PLC (overview), Mechatronics in: Robotics, Automotive systems, Smart manufacturing. **Mini Project**: Design of a simple mechatronic system (e.g., temperature control system / automated gate / motor speed control)	9

Books & References

1. Mechatronics: Principles, Concepts and Applications — N. Chandra & R. K. Rajput
2. Mechatronics: Integrated Technologies for Intelligent Machines — K. P. Ramachandran, G. K. Vijayaraghavan & M. Balasubramanian
3. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering — W. Bolton
4. Introduction to Mechatronics and Measurement Systems — David G. Alciatore & Michael B. Histand
5. Mechatronics: Principles and Applications — Godfrey Onwubolu

MME-303	**ADVANCED ENGINEERING MATERIAL & CHARACTERIZATION**	
Course Category	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and One Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Ability to explain the structure–property relationships of advanced engineering materials such as composites, biomaterials, smart materials, nanomaterials, and high-performance alloys.
2. Ability to analyze mechanical, thermal, electrical, and surface properties of advanced materials using fundamental materials science principles.
3. Ability to apply modern material characterization techniques (e.g., XRD, SEM, TEM, DSC, spectroscopy, mechanical testing) to evaluate microstructure and performance.
4. Ability to interpret experimental characterization data to select suitable advanced materials for specific engineering and industrial applications.

Topics Covered

UNIT-I	
Materials and Classification: Introduction, Demand of advanced materials, Classification of different materials and alloys. Macro and micro analysis of materials, Segregation and bonding, Strengthening mechanisms.	9
UNIT-II	
Properties of Materials: Flexural Test, Toughness tests, Creep characteristics, Hardness tests, Fracture test, Griffith's crack theory, Strain hardening, Single crystal growth. **Wear:** Modes of adhesive, abrasive, erosive, fretting, sliding.	9
UNIT-III	
Techniques of Materials Characterization: Definition; importance and application of X-ray diffraction technique for phase identification, Scanning Electron Microscope; Principles of image formation in SEM, energy-dispersive X-ray analysis, Thermo-mechanical behavior of composite materials, DSC, AFM.	9
UNIT-IV	
Modern Materials and Alloys: Super alloys-refractory materials, Shape memory alloys, Advanced Composites- Particulate and dispersion composites, Metal matrix and Ceramic matrix composites, Nano materials, Polymers and polymerization, Engineering applications of different materials.	9

Textbooks

1.	Engineering Materials and Applications, P. Flinn and P.K. Trojan, MIR Publications
2.	Engineering Materials: Polymers, Ceramics and Composites, A.K Bhargava, Prentice Hall of India
3.	Manufacturing processes for Engineering Materials, Serope Kalpakjian, Wesley Publishing Co.

MME-304	**INDUSTRIAL ROBOTICS**	
Course Category	:	Program Core (PC)
Pre-requisites	:	----
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 2
Number of Credits	:	5
Course Assessment Methods	:	Continuous assessment through tutorials, Practicals, attendance, home assignments, quizzes, One Minor test and One Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the Classification of Robots, Robot specifications, applications and Robot Sensors.
2. Ability to solve problems related to Manipulator kinematics, modeling of mechanical systems and elements.
3. Ability to solve problems related to Manipulator dynamics.
4. Ability to design and develop various Robot Control and robot programming for welding, material handling.

Topics Covered

UNIT-I	**9**

Introduction Definition, Classification of Robots, Geometric classification and control classification, Robot Components- manipulator, controller and its elements, sensory devices, Functions of a robot system, Robot specifications and applications, **Robot Sensors** Introduction, Classification, Non-optical position sensors, Optical position sensors, Velocity sensors, Acceleration sensors, Contact and non-contact type proximity sensors.	
UNIT-II	9
Manipulator Kinematics Position and orientation of a rigid body, Homogeneous coordinates, Coordinate transformations-translational, rotational, Matrix operators, Coordinate reference frames, Homogeneous transformations and the manipulator, forward solution, inverse solution, Representation of joints, link representation using D-H parameters. **Mechanical Systems: Components, Dynamics and Modeling** Introduction, Linear motion, Rotational motion, Moment of Inertia-calculation and measurement, Mechanical work and power, Motion conversion, Rotary-to-rotary motion, Rotary-to-linear motion, Problems with real world components, Modeling of mechanical systems, elements, and examples.	
UNIT-III	9
Jacobians: Velocities, Static Forces D-H Convention, Examples of D-H parameters and link transforms, Velocity analysis, linear and rotational velocity of rigid bodies, velocity propagation, Jacobians, Singularities, velocity transformation and inverse velocity and acceleration, force transformation and inverse force, examples. **Manipulator Dynamics** Introduction, Lagrange's equation kinetic and potential energy. Link inertia, Tensor, link Jacobian Manipulator inertia tensor. Newton - Euler formulation, Lagrange - Euler formulation, problems.	
UNIT-IV	9
Robot Control: Linear, Nonlinear and Force Control Control Techniques, Dynamics Systems, Transfer Function and State-Space Representation, Performance and stability of Feedback Control, Closed-loop control in position servo, Effect of friction and gravity, DC servomotor, position with no friction or gravity, position with nonzero friction and/or gravity, PID Control, State-Feedback Control, Joint Controllers. Control of a moving block, Multivariable Robot Control, Stability of Multi-DOF Robot, PD Position Control, Inverse Dynamic Control, Force control. **Robot Programming** Robot control sequencing, Language based programming, Program algorithm, examples, VAL language, robot programming for welding, machine tools, material handling etc.	

List of Experiments:

Minimum Eight experiments are to be performed

1. Forward and Inverse Kinematics analysis of a robotic manipulator.
2. Formulation of Denavit-Hartenberg (DH) parameters.
3. Modeling and assembly of 2DOF/3DOF robot manipulators.
4. Determination of maximum and minimum position of links.
5. Robot simulation for pick and place operations.
6. Programming for industrial tasks (welding, painting, assembly).
7. Simulation of robot kinematics using Robo Analyzer.
8. Introduction to ROS (Robot Operating System) nodes, topics, and services.
9. Interfacing microcontrollers (Arduino/ARM) with sensors.
10. Interfacing DC motors, servo motors, and stepper motors.
11. Image processing for feature extraction and object classification.
12. Edge detection and region of interest extraction.

Textbooks

1. Introduction to Robotics, S.K.Saha, McGraw Hill Publication
2. Robotics: Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford University Press
3. Robot Dynamics and Control, Mark W. Spong, M. Vidyasagar, John Wiley & Sons
4. Robotic Engineering-R.D. Klafter, T.A. Chmielewski and M. Negin, Prentice-Hall International
5. Robotics – K.S. Fu, R.C. Gonzalez & CSG Lee, McGraw Hill International
6. Robotics-K.C. Jain and L.N. Aggrawal, Khanna Publishers
7. Robotics for Engineers- Y. Koren, McGraw Hill
8. Introduction to Robotics – J.J. Craig, Pearson Education

Reference books

1. Robotic Technology-Phillipe Collet, Prentice Hall of India
2. An Introduction to Robot Technology- Coiffet and Chirooza, Kogan Page
3. Robots & Manufacturing Automation – Asfahl , Wiley Eastern
4. Industrial Robots- Groover, Mitchell Weiss, Nagel Octrey- McGraw Hill
5. Robotics Technology and Flexible Automation, S.R. Deb and S. Deb, McGraw Hill Education

ME-305	**ADVANCED COMPUTER AIDED MANUFACTURING**	
Course Category	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 2
Number of Credits	:	5
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding the implementation of automation in production system and ability to know the role of computer in the area of manufacturing.
2. Ability to design and develop various parts of CNC Machines for improving their effectiveness and implementation of adaptive control.
3. Ability to develop manual part program and computer assisted part program for the production of components
4. Ability to understand the various modules of FMS and apply the concept of group technology and computer assisted process planning.

Topics Covered

UNIT-I	
Introduction: Introduction to CAM, CAD/CAM interface, Introduction to Automation, Historical developments and future trends, automation in production system, automation strategies, advantages and disadvantages of automation, Need of NC system, fundamental of NC machine tool, Classification of NC machine tool, suitability and limitations, applications of NC system.	**9**
UNIT-II	
Features of CNC Machine Tool: Development in MCU technology, Principle of operation of CNC, standard controllers, Design considerations of CNC machines for improving machining accuracy – structural members, slideways, spindle drive, feed drive, lead screws; Methods for improving productivity, work holding device, automatic tool changer, features of CNC machining centres **Control of CNC Systems:** Open and Closed loop control systems, feedback devices, interpolators, Adaptive control Systems.	**9**
UNIT-III	
CNC Part Programming: Part programming fundamentals**,** Manual Programming for turning, milling, drilling, etc., Tool length compensation, cutter radius compensation, canned cycle, Do loops, Subroutine and Macro; Concept of computer aided part programming, APT language structure, Geometry, motion and post processor commands, APT part program.	**9**
UNIT-IV	
FMS, CIMS & CAPP: Building blocks of flexible manufacturing systems (FMS), tool management systems, workpiece handling systems, FMS control, computer integrated manufacturing systems, computer aided process planning- variant and generative process planning.	**9**

EXPERIMENTS

Minimum Eight experiments are to be performed

1. Study on Retrofitting of Conventional Milling Machine to CNC Milling Machine.
2. To study the characteristics features of CNC lathe trainer (Model SS-PT-100).
3. To study the characteristics features of CNC Turning (XLTURN)
4. To study the characteristics features of CNC Milling (XLMILL)
5. Write a manual part program for turning operations and prepare the component on CNC Turning.
6. Write a manual part program for Grooving and threading operations and prepare the component on CNC Turning.
7. Write a manual part program for Peck drilling operations and prepare the component on CNC Turning.

8. Write a manual part program using linear and circular interpolation for CNC Milling and prepare the component.
9. Write a manual part program for rectangular pocket milling operation for CNC Milling and prepare the component.
10. Study and perform operations of Flexible Manufacturing System.

Textbooks

1. Computer Control of Manufacturing System by Yoram Koren(McGraw Hill).
2. Computer Aided manufacturing- P. N. Rao , N. K. Tewari & T. K. Kundra (Tata McGraw Hill).
3. CAD/CAM/CIM – P. Radhakrishnan, S. Subrmanyam and V. Raju (New Age International)
4. Automation, Production Systems and Computer Integrated Manufacturing by Mikell P. Groover (PHI)

Reference books

1. Principles of Computer Integrated Manufacturing – S. Kant Bajpai (PHI)
2. Computer Aided Design & Manufacture – C. B. Besant & C. W. K. Lui (East West Press)

Program Elective (PE-1 and PE-2)

MME-351	Modelling and Simulation of Mechatronic Systems	
Course category	:	Program Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Quiz, Tutorials, and Exam
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Course Outcomes

1. To develop advanced modelling skills for multi-domain mechatronic systems.
2. To integrate mechanical, electrical, control, and embedded subsystems.
3. To apply simulation tools for design validation and optimization.
4. To prepare students for research and industrial applications in automation, robotics, and smart systems.

Topics Covered

UNIT-I	
Fundamentals of Mechatronic System Modelling: Introduction to Mechatronic Systems**,** Elements of mechanical, electrical, and electromechanical systems**,** Mathematical modelling using differential equations**,** State-space and transfer function models**,** Basic modelling of: Spring-mass-damper system**,** DC motor system**. Practice/ hands on :**Modelling simple systems using MATLAB/Simulink	9
UNIT-II	
System Dynamics and Control: Dynamic response of systems**,** Time-domain analysis**,** Stability concepts**,** PID controller design**,** Modelling of sensors and actuators	9
UNIT-III	
Simulation Techniques and Tools: Concept of simulation, Continuous and discrete systems**,** Numerical solution methods (basic idea)**.** Introduction to: MATLAB/Simulink, Simscape (multi-domain systems)**,** Model validation and performance analysis**.** **Practice/ Hands on** : Simulation of an electromechanical system**,** Mini modelling assignment.	9
UNIT-IV	
Applications of Mechatronic Simulation: Robotics system modelling (basic manipulator model)**,** Automotive applications (ABS / suspension model – overview)**,** Mechatronics in manufacturing systems**,** Introduction to real-time simulation and digital twin (basic idea)**.** **Practical / Mini Project on** :simulation of a real-life mechatronic system (robot arm / servo system / active suspension)	9

Books & References

1. Modeling and Simulation of Mechatronic Systems using Simscape — Shuvra Das
2. *Mechatronics by Bond Graphs — Vjekoslav Damić & John Montgomery*
3. Mechatronics: Fundamentals and Applications — Clarence W. de Silva et al.
4. Introduction to Mechatronics: An Integrated Approach — Biswanath Samanta
5. Mechatronics: Principles and Applications — Godfrey C. Onwubolu

MME-352	Optimization and Design of Experiments	
Course category	:	Program Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Quiz, Tutorials, and Exam
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Course Outcomes

1. Formulate and solve basic optimization problems.
2. Apply classical optimization techniques to engineering problems.
3. Design and analyze experiments using DoE principles.
4. Optimize mechanical systems and processes using experimental data.

Topics Covered

UNIT-I	
Fundamentals of Optimization: Introduction to optimization**,** Engineering optimization problems**,** Objective function and constraints**,** Types of optimization problems: Single vs multi-objective**,** Constrained and unconstrained**,** Graphical optimization method**,** Introduction to mathematical optimization**. Applications on:** Design optimization of mechanical components**,** Cost and weight minimization problems.	9
UNIT-II	
Classical Optimization Techniques: Unconstrained optimization methods: Single-variable optimization**,** Gradient-based methods (basic idea)**,** Constrained optimization methods: Lagrange multipliers**,** Penalty method (concept only)**.** Introduction to linear programming, Engineering examples**. Practical/ Project on:** Solving optimization problems using MATLAB / Excel	9
UNIT-III	
Design of Experiments (DoE) Basics: Need for Design of Experiments**,** Basic terminology: Factors, levels, response, Main effects and interactions**,** One-factor-at-a-time (OFAT) vs factorial design**,** Full factorial and fractional factorial designs**,** Analysis of variance (ANOVA – basic concept)**. Practical/ Practice on :**Simple factorial experiment analysis**,** Use of software for DoE (Excel / Minitab / MATLAB)	9
UNIT-IV	
Advanced DoE and Optimization Applications: Response Surface Methodology (RSM – basic idea)**,** Taguchi method: Orthogonal arrays**,** Signal-to-Noise ratio**,** Introduction to modern optimization techniques: Genetic Algorithm (concept only)**,** Particle Swarm Optimization (concept only)**,** Integration of DoE and optimization**: Mini Project / Case Study:** Process optimization in manufacturing, Material or parameter optimization using DoE	9

Books & References

1. Engineering Optimization: Theory and Practice – Singiresu S. Rao
2. Optimization Concepts and Applications in Engineering – Ashok D. Belegundu & Tirupathi R. Chandrupatla
3. Introduction to Engineering Optimization – Erik D. Goodman & John B. Sokolowski
4. Numerical Optimization – Jorge Nocedal & Stephen J. Wright
5. Design and Analysis of Experiments – Douglas C. Montgomery
6. Design of Experiments: Statistical Principles of Research Design and Analysis – Robert O. Kuehl
7. Taguchi Techniques for Quality Engineering – Philip J. Ross
8. Statistics and Experimental Design for Engineering – M. Hanif Chaudhry

MME-353	**ADVANCED MECHANICS OF SOLID**	
Course category	:	Program Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Quiz, Tutorials, and Exam
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Course Outcomes

1. To provide a thorough understanding of advanced topics concerning the response of materials and structural elements to applied forces of deformation.
2. Students should obtain an understanding of advanced strength of materials principles and practices that should assist them in making informed design decisions and solving complex problems.
3. Students should be able to perform the torsional analysis of non-circular bars and bending of beams.
4. To acquaint with energy methods to solve structural problems.

Topics Covered

UNIT-I	
Stress Definition of Stress, Body Force, Surface Force and Stress Vector, Normal and Shear Stress Components, Rectangular Stress Components, The Stress Tensor - 3-D, The Stress Tensor is a Linear Transformation - the Cauchy Tetrahedron, Variation of the Stress Tensor from Point to Point in a Body in Equilibrium Equations of Equilibrium, Coordinate Changes and the Stress Tensor 6. Principal Stresses 7. Octahedral Stresses **Strain** Definition of Strain, Deformation in the Neighborhood of a Point, Change in Length of a Linear Element— Linear Components, Rectangular Strain Components, Change in the Angle between Two Line Elements, Lagrangian and Eulerian Coordinate Systems and Equations of Compatibility, Strain Deviator and its Invariants	9
UNIT-II	
Stress - Strain Relations Introduction, Generalized Statement of Hooke's Law, Stress–Strain Relations for Isotropic Materials, Modulus of Rigidity, Bulk Modulus, Young's Modulus and Poisson's Ratio, Relations between the Elastic Constants, Displacement Equations of Equilibrium. **Linear Elasticity** Boundary Conditions and 15 equations of elasticity, Two-Dimensional Problems - plane stress and plane strain problems, Airy Stress Function, Techniques for Solving the Equations of Elasticity, Linear Thermoelectricity, Polar Coordinates - Thick-walled Cylinders, The Airy Stress Function in Polar Coordinates	9

UNIT-III	
Applications of Linear Elasticity and Its Approximations **Torsion**-Introduction, Torsion of General Prismatic Bars–Solid Sections, Alternative Approach, Torsion of Circular and Elliptical Bars, Torsion of Equilateral Triangular Bar, Torsion of Rectangular Bars, Membrane Analogy, Torsion of Thin-Walled Tubes, Torsion of Thin-Walled Multiple-Cell Closed Sections, Torsion of Bars with Thin Rectangular Sections, Torsion of Rolled Sections, Multiply Connected Sections **Bending of Beams** Introduction, Straight Beams and Asymmetrical Bending, Regarding Euler–Bernoulli Hypothesis, Shear Centre or Centre of Flexure, Shear Stresses in Thin-Walled Open Sections: Shear Centre, Shear Centres for a Few Other Sections, Bending of Curved Beams (Winkler-Bach Formula), Deflections of Thick Curved Bars.	9
UNIT-IV	
Axisymmetric Problem Introduction, Thick-Walled Cylinder Subjected to Internal and External Pressures—Lame's Problem, Stresses in Composite Tubes—Shrink Fits, Sphere with Purely Radial Displacements, Stresses Due to Gravitation, Rotating Disks of Uniform Thickness, Disks of Variable Thickness, Rotating Shafts and Cylinders, Summary of Results for use in Problems **Energy Methods** Work, Strain Energy and Complementary Energy, Castigliano's Theorems-Method of Fictitious Loads and Statically Indeterminate Problems, Principle of Virtual Work, The Principle of Stationary Potential Energy	9
Books & References	
1. Advanced Mechanics of Materials-by P. Boresi and Richard J. Schmidt (Wiley) 2. Advanced Strength and Applied Stress Analysis by R. G. Budynas, 2nd Edition, McGraw Hill Publishing Co, 1999. 3. Theory of Elasticity, 3rd Edition by S. P. Timoshenko, J. N. Goodier,McGraw Hill Publishing Co. 1970. 4. Solid Mechanics for Engineering by P. Raymond, 1st Edition, John Willey & Sons, 2001. 5. Advanced Mechanics of Solids by L. S. Srinath ((Tata McGraw Hill).)	

MME-354	**IoT and Smart Manufacturing**	
Course category	:	Program Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Quiz, Tutorials, and Exam
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course
Course Outcomes 1. To understand the fundamentals of IoT systems. 2. To learn how IoT enables smart manufacturing. 3. To integrate sensors, data acquistion and cloud platforms. 4. To apply IoT concepts in real Industrial applications.		
Topics Covered		
UNIT-I		

Fundamentals of IoT: Introduction to IoT**,** Architecture of IoT systems**,** Sensors and actuators in manufacturing**,** Microcontrollers and embedded systems (Arduino / Raspberry Pi – overview)**,** Communication protocols: Wi-Fi**,** Bluetooth**,** MQTT (basic idea). Practice on : Interfacing sensors with microcontroller**,** Basic IoT data transmission demo	9
UNIT-II	
Smart Manufacturing Concepts: Industry 4.0 overview, Cyber-Physical Systems (CPS)**,** Smart factory architecture**,** Data acquisition systems (DAQ)**,** Machine-to-Machine (M2M) communication**,** Industrial IoT (IIoT)**. Applied study on :** CNC machine monitoring**,** Predictive maintenance**,** Smart production lines	9
UNIT-III	
Data Analytics and Cloud Integration: Data collection and storage**,** Cloud platforms (AWS / Thingspeak – overview)**,** Edge computing (basic idea) Data visualization dashboards**,** Introduction to:Big data in manufacturing**,** Machine Learning for predictive maintenance (concept only). **Hands-on:** Uploading sensor data to cloud**,** Simple data visualization project.	9
UNIT-IV	
Applications and Case Studies in Smart Manufacturing: IoT in: Additive manufacturing**,** Robotics**,** Energy monitoring systems**,** Digital Twin (basic concept) Smart supply chain, Security issues in IoT systems, Future trends in smart manufacturing. **Mini Project / Case Study:** Process optimization in manufacturing, Material or parameter optimization using DoE	9
Books & References	
1. Introduction to Industrial Internet of Things and Industry 4.0 by Sudip Misra, Chandana Roy, and Anandarup Mukherjee 2. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist . 3. Industry 4.0, Smart Manufacturing, and Industrial Engineering: Challenges and Opportunities (Edited Volume) – 4. Handbook of Smart Manufacturing: Forecasting the Future of Industry 4.0 – 5. Smart Manufacturing Technologies for Industry 4.0: Integration, Benefits, and Operational Activities	

MME-355	ADVANCED MANUFACTURING PROCESS	
Course Category	:	Program Electives(PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Explain and analyze advanced metal casting processes including gating and risering design, solidification principles, and casting defects.
2. Demonstrate knowledge of advanced welding processes and metallurgical aspects of welding.
3. Explain principles and industrial applications of modern forming techniques.
4. Describe and evaluate powder metallurgy processes and polymer/composite manufacturing techniques.

Topics Covered

UNIT-I	
Metal Casting Advanced metal casting techniques, Gating and risering, Nucleation, grain growth, and solification; Elements of gating system, design of gating system – Theoretical consideration – Directional solidification – Design of risers – Modulus – Caine's and shape factor methods, application of chills, permanent mould casting, shell moulding, die casting, vacuum die casting, squeeze casting, centrifugal casting, investment casting-die casting-continuous casting-low pressure casting, Casting defects and their remedies, Fettling and testing of casting.	**9**
UNIT-II	
Welding and Allied Processes Advanced Welding techniques: Arc welding through pulsing, Cold metal transfer welding, Plasma arc welding; Electron Beam welding; Laser beam welding etc. Welding Metallurgy: Heat flow in welding, Metallurgical transformation in and around weldment, Implication of cooling rates, Heat affected zone (HAZ), Weldability of plain carbon steels, Stainless steels, Cast iron, Aluminium and its alloys.	**9**
UNIT-III	
Advanced forming techniques Advanced forming techniques, High energy rate forming, Superplastic forming; Incremental forming; **Powder metallurgy** Powder metallurgy: Powdered metals and fabrication procedures, Preparation of powders, Compacting and sintering, Hot and cold pressing (HIP, CIP); and Polymers and composites processing	**9**
UNIT-IV	
Mechanical machining Mechanical machining – Types: Ultrasonic machining (USM), Abrasive Jet Machining (AJM), Abrasive Flow Machining (AFM), Water Jet Machining (WJM), Electro chemical machining (ECM), Electrical discharge machining (EDM), Electrical discharge wire cutting (EDWC) - Principle, analysis and applications; Electron beam machining (EBM); Plasma Arc Machining (PAM); Ion Beam Machining (IBM) - Principle, analysis and applications; Laser beam machining (LBM) - Principle, analysis and applications; and Hybrid machining processes, their advantages: ECG, ECDG, Laser assisted hybrid machining etc. **Advanced coating processes** Advanced coating processes: Physical and chemical vapour deposition, Thermal spray techniques such as plasma spraying, High and low velocity oxy-fuel coating technique, Pulsed TIG coating etc.	**9**

Books & References

1. Metal casting: Computer Aided Design and Analysis by B. Ravi, PHI Learning Pvt. Ltd. 2010
2. Advanced Welding Processes: Technologies and process control by J Norrish, Woodhead Publishing, 2006
3. Advanced Methods in Material Forming by D.Banabic, Springer, 2007
4. Powder Metallurgy: Science, Technology and Applications, P.C. Angelo, R. Subramanian, PHI Learning Pvt. Ltd. 2008
5. Nontraditional Manufacturing Processes By Gary F. Benedict, CRC Press, 1987
6. Advanced Machining Processes By Prof. Vijay Kumar Jain, Allied Publisher, 2007.

7. Advanced Machining Processes: Nontraditional and Hybrid Machining Processes By Hassan ElHof, Mc Graw Hill, 2005.
Coating and surface treatment systems for metals: a comprehensive guide to selection, by Joseph Edwards, ASM Intl.,

MME-356	**MICRO MANUFACTURING**	
Course category	:	Program Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding the need of miniaturization and classification of micro manufacturing.
2. The knowledge of different micro fabrication technologies.
3. Ability to gain the fundamentals knowledge of LIGA, micro manufacturing, bulk manufacturing, etc.
4. Ability to gain the knowledge of advanced surface finishing and polishing techniques.
5. The knowledge of behavior of materials surface by Laser micromachining, laser micro-drilling, laser micro-adjustment, and laser surface structuring etc.
6. The knowledge of metrology of micro machined components and tribological characterization.

Topics Covered

UNIT-I	
Overview of Micro Manufacturing: Introduction to meso, micro and nano manufacturing- miniaturization and applications - micro-manufacturing - classification - micro-machining: concepts and significance theory of micro-machining - chip formation -size effect in micro-machining. Challenges and Applications.	9
UNIT-II	
Micro Manufacturing Processes: LIGA, micro-stereolithography - micro-turning, micro-drilling, micro-milling, diamond turn machining - electric discharge micro-machining-ultrasonic micro-machining- laser beam micro-machining - elastic emission micro machining - focused ion beam micromachining.	9
UNIT-III	
Surface Finishing Technologies: Abrasive flow finishing, magnetic abrasive finishing, magnetorheological finishing. magnetorheological abrasive flow finishing, magnetic float polishing - Hybrid finishing processes-chemo mechanical polishing, electro discharge grinding, electrolytic in process dressing grinding.	9
UNIT-IV	
Metrology for Micro Machined Components - Optical microscopy, white light interferometry, micro CMM, scanning probe microscopy - scanning electron microscope, transmission electron microscope, atomic force microscope, Tribological characteristics -micro abrasion wear-nano indentation.	9

Books & References

1. Advanced manufacturing processes, Hassan Abdel, Gabad El Hoffy, McGraw Hill.
2. V.K. Jain, Advance Machining Processes, Allied Publisher Bombay.
3. Ghosh and Mallik, Manufacturing Science, EWP Private Ltd.
4. Pandey P.C., Shan H.S., Modern machining processes, Tata McGraw-Hill Education.
5. Weller E.J., Non-traditional machining processes, Society of Manufacturing Engineers, Publications.
6. The Science and Engineering of Micro-fabrication, Stephen P. Campbell, Oxford University press.

MME-357	ADDITIVE MANUFACTURING		
Course Category		:	Program Elective (PE)
Pre-requisites		:	NIL
Contact Hours/Week		:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits		:	4
Course Assessment Methods		:	Continuous assessment through tutorials, attendance, home assignments, Quizzes, one Minor test and One Major Theory examination.
Course Outcomes		:	The students are expected to be able to demonstrate the following knowledge and skills after completing this course

1. Ability to understand the fundamental of Additive manufacturing and its varieties like liquid based, solid based and powder-based AM technologies, their potential to support design and manufacturing.
2. Ability to understand the various types of Pre-processing, processing, post-processing errors in AM and to acknowledge the various types of data formats and software's used in AM.
3. Ability to demonstrate the applications of AM in design analysis, aerospace, automotive, biomedical and other fields and research challenges associated with AM.

Topics Covered	
UNIT-I	
Introduction: Need for Additive Manufacturing, Development of AM systems, AM Process Chain, commonly used Terms, Impact of AM on product development, Virtual prototyping, Rapid tooling, Rapid prototyping to AM, Classification of AM process, Advantages and Limitations, Applications of AM-Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Medical and Bioengineering, Web Based Rapid Prototyping Systems etc.	9
UNIT-II	
Liquid-based AM Systems: Stereo lithography Apparatus (SLA): Working principle, Pre-build process, part building and post building processes, photo polymerization SL resin, part quality and process planning, recoating issues, advantages, limitations and applications. Case studies. Solid Ground Curing (SGC): Working principle, Process, Applications, Advantages and Disadvantages, Case studies. Polyjet: working principle, Process, Applications, Advantages and Disadvantages, Case studies. **Solid-based AM Systems:** Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies. Fused Deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Case studies. Multi-Jet Modelling (MJM): working principle, Process, Applications, Advantages and Disadvantages, Case studies.	9
UNIT-III	
Powder Based AM Systems: Selective laser sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Case studies. Laser Engineered Net Shaping (LENS): Process, working principle, Applications, Advantages and Disadvantages, Case studies. **Other Additive Manufacturing Systems:** Three-dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based, and powder based 3DP systems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballistic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.	9
UNIT-IV	
AM Data Formats: Reengineering for Digital Representation, STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Mesh Refining by Sub division Techniques.	9

AM Software's: Need for AM software, Features of various AM software's , Slicing Software, Hands-on Practice of AM softwares.	

Textbooks	
1.	Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
2.	Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
3.	Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
Reference books	
1.	Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

MME-358	**Green manufacturing**	
Course Category	:	Program Elective (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Able to understand the basic concept, challenges and policy for green manufacturing,
2. Able to understand principle of green manufacturing and green supply chain..
3. Acquire the knowledge about Life Cycle of Production Systems.
4. Ability to know about Environmental Implications of Nano-manufacturing and clean enegry.

Topics Covered

UNIT-I	
Introduction to Green Manufacturing Why Green Manufacturing, Motivations and Barriers to Green Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing. The Social, Business, and Policy Environment for Green Manufacturing: Introduction, The Social Environment—Present Atmosphere and Challenges for Green Manufacturing, The Business Environment: Present Atmosphere and Challenges, The Policy Environment—Present Atmosphere and Challenges for Green Manufacturing.	9
UNIT-II	
Metrics for Green Manufacturing Introduction, Overview of Currently Used Metrics, Overview of LCA Methodologies, Metrics Development Methodologies, Outlook and Research Needs. **Green Supply Chain:** Motivation and Introduction, Definition, Issues in Green Supply Chains (GSC),Techniques/Methods of Green Supply Chain, Future of Green Supply Chain. **Principles of Green Manufacturing:** Introduction, Background, and Technology Wedges, Principles, Mapping Five Principles to Other Methods and Solutions.	9
UNIT-III	
Closed-Loop Production Systems Life Cycle of Production Systems, Economic and Ecological Benefits of Closed Loop Systems, Machine Tools and Energy Consumption, LCA of Machine Tools, Process Parameter Optimization, Dry Machining and Minimum Quantity Lubrication, Remanufacturing, Reuse, Approaches for Sustainable Factory Design.	9
UNIT-IV	

Environmental Implications of Nano-manufacturing Introduction, Nano-manufacturing Technologies, Conventional Environmental Impact of Nano-manufacturing, Unconventional Environmental Impacts of Nano-manufacturing, Life Cycle Assessment (LCA) of Nanotechnologies. Green Manufacturing Through Clean Energy Supply: Introduction, Clean Energy Technologies, Application Potential of Clean Energy Supplying Green Manufacturing	9

Textbooks

1. David Dornfeld "Green Manufacturing Fundamentals and Applications", Springer, 2013
2. J. Paulo Davim "Green Manufacturing Processes and Systems" Springer-Verlag Berlin Heidelberg, 2013

MME-359	**SENSORS, ACTUATORS AND DRIVES**	
Course category	:	Program Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 0
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding of measurement and measuring instruments, sensors, and transducers.
2. The knowledge of measurements of displacement, pressure, strain, temperature, force, torque with different principles.
3. The knowledge of different micro fabrication techniques.
4. Able to understand the fundamentals of micro manufacturing, bulk manufacturing, etc.
5. The knowledge of different types of actuators such as pneumatic actuators, hydraulic actuators single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors and servo motors.
6. The knowledge of different actuation materials such as piezo electric and shape memory alloys etc.

Topics Covered

UNIT-I	
Brief overview of measurement: Measurement systems, measurement variables, Introduction to Instruments, Simple instrument model, Modifying and Interfering Inputs, characteristics of instruments, Static characteristics, Accuracy, Precision, Resolution, sensitivity, linearity, and stability etc., Dynamic characteristics, speed of response, fidelity, lag, dynamic errors etc., calibration of instruments.	9
UNIT-II	
Sensors: Classification of sensors, Measurement of physical quantities with working principles, displacement sensors, position sensors, motion sensors, tactile and proximity sensors, strain gauge sensors, force sensors, temperature sensors. Optical encoder, ultrasonic transducers etc.	9

UNIT-III	
Micro-fabrication technologies: Miniaturization, need of miniaturization, classification of micro-fabrication, Ion-implantation, Diffusion, Photolithography, Introduction to micro-fabrication technologies, Bulk micromachining, surface micromachining, LIGA, assembly, and packaging. Piezoelectric actuator: characterization, operation, and application; shape memory alloys.	9
UNIT-IV	
Pneumatic and hydraulic actuation systems: definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves and valve selection. **Electrical actuation systems:** Electric motors; single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors and servo motors, solid-state switches, solenoids.	9

Books & References

1. Measurement, Instrumentation, and Sensors Handbook. John G. Webster, Editor-in-chief, CRC Press 1999).
2. Handbook of modern Sensors. Jacob Fraden, AIP Press, Woodbury (1997).
3. An Introduction to Microelectromechanical Systems Engineering. Nadim Maluf, Artech House Publishers, Boston (2000).
4. Fundamentals of Microfabrication. Marc Madou, CRC Press, Boca Raton (1997).
5. Micromachined Transducers. Gregory Kovacs, "", McGraw-Hill, New York (1998).
6. Measurement Systems – Application and Design. E. O. Deobelin and D. Manik, Tata McGraw-Hill (2004).
7. Principles of Industrial Instrumentation. D. Patranabis, Tata McGraw-Hill, eleventh reprint (2004).
8. Instrument Engineers' Handbook: Process Measurement and Analysis. B. G. Liptak, CRC (2003).