DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH. (MANUFACTURING ENGINEERING)

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
Ichchhanath, Surat-395007, Gujarat, India
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MISSION & VISION STATEMENT OF INSTITUTE

Vision Statement

To be one of the leading technical institutes disseminating globally acceptable education, effective industrial training and relevant research output

Mission Statement

To be a globally accepted centre of excellence in technical education catalysing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all stakeholders

MISSION & VISION STATEMENT OF THE DEPARTMENT

Vision Statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat perceives to be globally accepted centre of quality technical education based on innovation and academic excellence.

Mission Statement

Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its under graduate students, post graduate students and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Program of M. Tech. (Manufacturing Engineering) will produce graduates who will be able to:

PEO1	processes and systems using appropriate methods and tools
PEO2	Apply manufacturing engineering education to address technical and societal problems with creativity, imagination, confidence and ethics
PEO3	Utilize communication skills in oral, written, visual and graphic modes within interpersonal, team, and group environments.
PEO4	Retain intellectual curiosity for lifelong learning and flexible response to the rapidly evolving manufacturing challenges of the 21st century

Program Articulation Matrix

Department Mission	**Mapping of PEO**			
	PEO1	PEO2	PEO3	PEO4
Department of Mechanical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat strives to disseminate technical knowledge to its under graduate students, post graduate students and research scholars to meet intellectual, ethical and career challenges for sustainable growth of humanity, nation and global community.	3	3	1	1

PROGRAM OUTCOMES (POs)

Proposed Program Outcomes (POs):

The graduates of M. Tech. (Manufacturing Engineering) will demonstrate an ability to:

PO1	Carry out independent research /investigation and development work to solve practical problems
PO2	Write and express a substantial technical report/document
PO3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PSO1	Design, analyse and develop parts using manufacturing process(es) and system(s) for innovative research and industrial application by following quality and safety standards.
PSO2	Impart solution(s) to industrial and societal problems for economic and sustainable benefits with high moral and professional ethics

COURSE STRUCTURE FOR

M. TECH. (MANUFACTURING ENGINEERING)

SEMESTER – I

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme Theory Marks	Tuto. Marks	Pract. Marks	Credits
01	MEMF101	**Core 1** Advanced Machining Processes	3	0	2	100	-	50	4
02	MEMF103	**Core 2** Sheet Metal Forming	3	1	2	100	25	50	5
03	MEMF105	**Core 3** Operations, Planning & Control	3	1	0	100	25	-	4
04		**Core Elective 1**	3	0	0	100	-	-	3
	MEMF111	1. Advanced Welding Technology							
	MEMF113	2. Computer added production planning							
	MEMF115	3. Metal Cutting and Tool Design							
	MEMF117	4. CAD for Manufacturing							
	MEMF119	5. Manufacturing Metallurgy							
05		**Core Elective 2**	3	0	0	100	-	-	3
	MEMF121	1. Industrial Robotics							
	MEMF123	2. Advanced Metrology and Computer Aided Inspection							
	MEMF125	3. Failure Analysis							
	MEMF127	4. Optimization Techniques							
	MEMF129	5. Theory of Plasticity							
06	MEMF107	Laboratory Practice	0	0	4	-	-	100	2
		Total Credits							**21**
	MEMFV01 MEMFP01	Vocational Training/ Professional Experience (Optional) (Mandatory for exit)	0	0	10	-	-	-	5

SEMESTER – II

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme Theory Marks	Tuto. Marks	Pract. Marks	Credits
01	MEMF102	**Core 4** Computer Integrated Manufacturing	3	1	2	100	25	50	5
02	MEMF104	**Core 5** Additive Manufacturing Processes	3	0	2	100	-	50	4
03		**Core Elective 3**	3	0	0	100	-	-	3
	MEMF110	1. Metal Casting							
	MEMF112	2. Finite Element Methods							
	MEMF114	3. Industrial Tribology							
	MEMF116	4. Automation in Manufacturing							
	MEMF118	5. Composite Design and Manufacturing							
04		**Core Elective 4**	3	0	0	100	-	-	3
	MEMF120	1. Surface Engineering							
	MEMF122	2. Quality Engineering and Management							
	MEMF124	3. Operations Research							
	MEMF126	4. Concurrent Engineering							
	MEMF128	5. Numerical Methods in Manufacturing							
05		**Institute Elective**	3	0	0	100	-	-	3
	MEMF130	1. Non-Destructive Testing							
	MEMF132	2. Intelligent Manufacturing Systems							
	MEMF134	3. Logistics and Supply Chain Management							
	MEMF136	4. Micro and Nano Manufacturing							
	MEMF138	5. Bio Inspired Materials							
	MEMF140	6. Design of Experiments							
06	MEMF106	**Mini Project**	0	0	4	-	-	100	2
	Total Credits								**20**
	MEMFV02 MEMFP02	Vocational Training/ Professional Experience (Optional) (Mandatory for exit)	0	0	10	-	-	-	5

SEMESTER – III

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme			Credits
						Theory Marks	Tuto. Marks	Pract. Marks	
01		MOOC Course I*	3	0	0	-	-		3
02		MOOC Course II*	3	0	0				3
03	MEMF295	Dissertation Preliminaries	0	0	14	-	-	350$	14
	Total Credits								**20**

SEMESTER – IV

Sr. No.	Code No.	Subject	L	T	P	Exam Scheme			Credits
						Theory Marks	Tuto. Marks	Pract. Marks	
01	MEMF296	Dissertation	0	0	24	-	-	600$	20
	Total Credits								**20**

$ Internal 40% and external 60%

* Swayam/NPTEL

CREDIT MATRIX

Category	Credits to be earned				
	Sem- I	**Sem - II**	**Sem- III**	**Sem - IV**	**Total**
Core Courses	13	09	-	-	22
Elective Courses	06	09	-	-	15
Laboratory Practice	02	-	-	-	02
Mini Project		02			02
MOOC Course	-	-	06	-	06
Dissertation	-	-	14	20	34
Total Credits	**21**	**20**	**20**	**20**	**81**

MEMF101	:	ADVANCED MACHINING PROCESSES	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need, classification, working and applications of advanced machining processes
CO2	Derive model for MRR and deduce relationship with various process parameters
CO3	Explain and select finishing processes and express relationship between process parameters and responses
CO4	Describe the need and working of a micro machining process and distinguish it from macro machining processes
CO5	Examine the possibility of combining different process to develop hybrid processes for more efficient Machining process
CO6	Analyse the requirement of machining/finishing according to shape, material and size of product and select the best process among various alternatives

2. Syllabus:

Introduction: Advanced Machining Processes & Mechanical Energy Based Processes	**(08 Hours)**
Evolution, need, and classification of advanced machining processes. Mechanical Energy Based Processes: USM, AJM, WJM, AWJM processes – Working Principle, equipment, Material removal rate, Process and performance parameters, Applications, Operational characteristics; Limitations	
Thermal and Electrical Energy Based Processes	**(08 Hours)**
EDM, Working Principle, equipment details, Wire Electro-Discharge Machining (WEDM), electrode / Tool – Power and control Circuits-Tool Wear -Dielectric – Flushing, Material removal rate, Process, and performance parameters such as Surface finish and accuracy, Applications. LBM, EBM, IBM, PAM processes – Working Principle, equipment, Material removal rate, Process and performance parameters, Applications, Process Capabilities, Limitations.	
Chemical and Electro Chemical Energy based Processes	**(06 Hours)**
Working principle and details of Chemical Machining (CHM), Photo-Chemical Machining (PCM), and Electro Chemical Machining ECM) - Working Principle, equipment, Material removal rate, Process and performance parameters, Applications, Tool Design	
Advanced Finishing Processes	**(07 Hours)**
Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magneto Rheological Abrasive Finishing (MRAF) - Principle of working, equipment, Material removal rate, Process and performance parameters, Applications, Limitations.	
Micro Machining Processes	**(08 Hours)**

Miniaturization, scaling laws, Principle and working of micro turning, micro milling, micro EDM, micro USM, Laser micro machining, diamond turn machining	
Hybrid Machining Processes	**(08 Hours)**
Need, Classification: Assisted Hybrid Machining Processes, Laser Assisted Machining, Vibration Assisted Machining, Electro Stream Drilling (ESD), Electrochemical Deburring (ECDe), Electro Chemical Discharge Machining (ECDM)- Working Principle, equipment description, Material removal rate, Process and performance parameters, Applications	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Jain, V.K., Advanced Machining Processes. Allied publishers, 1st Edition, 2009
2	Pandey, P.C. and Shan, H.S., Modern machining processes. Tata McGraw-Hill Education, 2003
3	Mishra P. K., Nonconventional machining, Narosa publishing house, 2011
4	Jain V. K., Introduction to micro machining, Narosa publishing house, New Delhi, 1st Edition, 2010
5	Ghosh A. & Malik A. K. , Manufacturing Science, Affiliated East–West press Pvt. Ltd., 2002

List of Practicals:

1 To study the effect of process parameters on MRR and TWR during EDM process
2 To study the effect of welding parameters during ultrasonic welding of similar/dissimilar metals
3 To study single pass and multi pass wire EDM process to cut complex geometries
4 To study the kerf and surface finish during abrasive water jet machining process
5 To study the micro milling of metal/ non-metal part
6 To study the micro turning of Brass rod
7 To study the micro EDM process using different micro electrodes
8 To study the effectiveness of hybrid ECDM process
9 To study the EDM process improvement using tool actuation
10 To study and demonstrate laser engraving process

MEMF103	:	SHEET METAL FORMING	L	T	P	Credits
			3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the sheet deformation processes and recognize load instability and tearing in sheet metal forming.
CO2	Apply the theory of plasticity and its application for analysing given sheet metal forming processes
CO3	Compute the stresses and forces during stamping and deep drawing process
CO4	Evaluate the punching forces using principles of punching and blanking process
CO5	Analyse principles, capabilities and applications of bending process and sheet hydro forming
CO6	Select suitable sheet metal forming process for given application

2. Syllabus:

Fundamentals of Metal Forming	**(04 Hours)**
Advantages of Metal Forming, cold and hot forming, various metal forming processes, Tensile Test - load–extension diagram, engineering stress–strain curve, true stress–strain curve, Anisotropy, Rate sensitivity, Effect of properties on forming	
Sheet Deformation Processes (Plane Stress)	**(10 Hours)**
Deformation in uniaxial tension, stress and strain ratios, theory of yielding in plain stress condition - Maximum shear stress, Hydrostatic stress, Tresca yield condition, Von Mises yield condition, Levy–Mises flow rule, Relation between the stress and strain ratios, Work of plastic deformation, Work hardening hypothesis, Effective stress and strain functions, Concept of Formability, formability limits and formability diagram. Factors affecting the forming limit curve.	
Load Instability and Tearing	**(09 Hours)**
Uniaxial tension of a perfect strip, Tension of an imperfect strip, Tensile instability in stretching continuous sheet - condition for local necking in uniaxial and biaxial tension.	
Analysis of Stamping and Deep Drawing Process	**(06 Hours)**
Two-dimensional model of stamping, stretch and draw ratios in a stamping, three-dimensional stamping model, Limiting drawing ratio and anisotropy, effect of strain-hardening and friction on drawing stress, redrawing and reverse redrawing of a cylindrical cup, wall ironing of deep- drawn cups, estimation of drawing force	
Analysis of Punching and Blanking Process	**(04 Hours)**
Mode of metal deformation and failure, deformation model and fracture analysis, determination of working force	

Analysis of Bending Process	(06 Hours)
Strain distribution in bending, bending without tension, bending of sheet in v-die, bending of different material behaviour like elastic perfect plastic sheet, strain hardening plastic sheet, etc. determination of work load, stock length and punch angle, springback and reverse bending, bending line construction	
Analysis of Sheet Hydroforming	**(06Hours)**
Free expansion of a cylinder by internal pressure, Forming a cylinder to a square section, Tube forming in a frictionless die, Tube forming with sticking friction (or very high friction), Constant thickness forming, Sequential hydroforming	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hill R., “The Mathematical Theory of Plasticity”, Oxford University Press, 2004
2	Hu S.J., Marciniak Z. and Duncan J.L., “Mechanics of Sheet Metal Forming”, Butterworth- Heinemann, 2002
3	Timoshenko S. P., “Theory of Elasticity”, McGraw Hill Education, 2017
4	Ghosh A. and Malik A., “Manufacturing Science”, East-West Press Pvt Ltd., 2010.
5	Dally J. W. and Riley W. F., “Experimental Stress Analysis”, McGraw-Hill Education, 1991

List of Practicals:

1. To Perform tensile test on different metal samples and plot the load-extension diagram
2. To Study the rate sensitivity of different metals by varying the strain rates during deformation.
3. To Study the temperature sensitivity of different metals by varying the temperature during deformation
4. Experiment with various metals to determine yielding using the Tresca and Von Mises yield criteria.
5. To Conduct formability tests on sheet metals
6. To Study local necking conditions in uniaxial and biaxial tension.
7. To Perform deep drawing experiments and measure the limiting drawing ratio and drawing force.
8. To Conduct punching and blanking experiments to observe deformation modes and failure mechanisms
9. To Perform bending tests on sheets using a V-die.
10. Experiment with free expansion of a cylindrical tube using internal pressure.

MEMF105	:	OPERATIONS PLANNING AND CONTROL	L	T	P	Credits
			3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the elements of operations management and various transformation processes to enhance productivity and competitiveness
CO2	Analyse and evaluate various facility alternatives and their capacity decisions, develop a balanced line of production & scheduling techniques in operation environments
CO3	Plan suitable materials handling principles and Supply Chain practices in the operations.
CO4	Compute the inventory based on selected model for selected case
CO5	Develop aggregate MRP and ERP in operation environments.
CO6	Integrate Operation planning with supply chain for overall productivity rise

2. Syllabus:

Operations Planning & Control	**(04 Hours)**
Operations and Productivity, Operation strategy in a Global Environment	
Forecasting	**(04 Hours)**
Elements and steps in forecasting, Types of forecasting, Demand forecasting using qualitative and quantitative methods, Errors in forecasting	
Capacity Planning and Constraint Management	**(04 Hours)**
Process Strategies, Definition and Measurement of capacity, Adjusting capacity, Quantitative methods for capacity planning decision	
Layout and Location Strategy	**(05 Hours)**
Types of layout, Design of Layout, Factors affecting location decision, Mathematical model for facility location and layout	
Supply Chain	**(05 Hours)**
The Supply Chain's Strategic Importance Sourcing Strategies, Supply Chain Risk Managing the Integrated Supply Chain Building the Supply Base, Supplier Evaluation, Supplier Development	
Inventory Control and Management	**(06 Hours)**
Introduction, EOQ Models with and without shortage, Multi item Deterministic Model, Dynamic and Fluctuating Models, Deterministic Model with price breaks and Probabilistic inventory models, Selective Inventory control	
Aggregate Planning	**(05 Hours)**
Purpose, inputs of aggregate planning processes and strategies, Methods for aggregate,	

Aggregate planning in Services	
Materials Requirement Planning and ERP	**(06 Hours)**
Just in Time, MRP input and output, MRP structure, MRP management, Lot sizing Technique and Extension of MRP, JIT and MRP in services, JIT to Die exchange, ERP : Introduction, Implementation, Advantages	
Short Term Scheduling	**(06 Hours)**
Introduction to Scheduling and Shop floor planning and control, order sequencing rules and their performance based on different evaluation criteria, changeover costs and job sequence, mathematical models of job sequencing	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Jay Heizer, Barry Render and Chuck Munson, Amit Sachan, Operations Management, Pearson Education, 2017
2	Everett E. Adam, Ronald J. Ebert, Production and Operation Management, 5th edition, Prentice Hall of India, New Delhi,2012
3	S. N. Chary, Production & Operations Management, 6th Edition, McGraw Hill, 2019
4	R. Paneerselvam, Production & Operations Management, 3rd edition, Prentice Hall of India, New Delhi,2012
5	S. Chapman, Fundamentals of Production Planning & Control, 1st edition, Pearson Education India, 2007

MEMF111	:	ADVANCED WELDING TECHNOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the significance of welding in various industrial sectors.
CO2	Explain the characteristics of welding arc and relate it importance during welding process
CO3	Develop the concepts of various advanced welding technologies
CO4	Analyse the heat flow and metal transfer mechanism in welding
CO5	Determine the solidification mechanism of weld pool
CO6	Compile the quality of weldments by monitoring and controlling the process through advanced techniques

2. Syllabus:

Introduction	**(06 Hours)**
Welding as compared with other fabrication processes, classification, weldability, weld configuration, ASME standards for weldments, scope and applications of welding in various industrial sectors	
Physics of Welding Arc	**(08 Hours)**
Structure and characteristics of welding arc, methods of arc initiation and maintenance, arc stability, voltage distribution along the arc, cathode and anode drops, arc column, thermionic and non thermionic cathode, theories of cathode and anode mechanisms, temperature distribution in the arc, arc efficiency, heat generation at cathode and anode, effect of shielding gas on arc, isotherms of arcs, arc blow, arc welding power sources, heat sources for solid state welding.	
Advanced Welding Processes	**(12 Hours)**
Overview of arc welding processes, flux cored arc welding, plasma transferred arc welding, electro-gas and electro-slag welding, resistance welding, magnetic pulse welding. Theory and mechanism of solid state welding, technique and scope of - friction welding, fiction stir welding, diffusion welding, cold pressure welding, ultrasonic welding, electron beam welding, laser beam welding. Cladding through welding, automation in welding	
Heat Flow and Metal Transfer in Welding	**(08 Hours)**
Calculation of peak temperature, width of heat affected zone, cooling rate and solidification rates, weld thermal cycles. Forces, mechanism and types of metal transfer in various arc welding processes, factors controlling melting rate in various welding processes. Residual stresses and their measurement, weld distortion and its prevention	
Solidification of weld pool	**(05 Hours)**

Principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, grain refinement principle of weld metal, method of weld metal refinement: inoculation, arc pulsation, external excitation

Inspection and Quality Control of Weldments	**(06 Hours)**
Overview of post weld characterization, weld related discontinuities, overview of standard destructive and nondestructive testing applicable for weldments, inspection of weldments, importance of welding procedure and performance qualification, monitoring and control of welding processes, welding simulation.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Houdlecroft P.T., "Welding Process Technology", Cambridge University Press, 3rd edition, 2004
2	Bowditch, W.A., Bowditch, K. E., "Welding Technology Fundamentals", Goodheart-Willcox Co. Pub., 4th edition, 2009
3	Jeffus, L., "Welding: Principles and Applications", Cengage Learning Pub., 2016
4	Lancaster J F., "Metallurgy of Welding", Elsevier, 6th edition, 1999
5	Parmar R. S., "Welding Engineering and Technology", Khanna Publishers, 2nd edition, 2013

MEMF113	**:**	**COMPUTER AIDED PRODUCTION PLANNING**	**L**	**T**	**P**	**Credits**
			3	**0**	**0**	**03**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain different methods of computer aided process planning (CAPP) and distinguish between process planning and production planning.
CO2	Determine the forecast of a product for the given historical data using forecasting models
CO3	Solve the facility layout problems using different algorithms and create part families and machine cells in a manufacturing facility using group technology approach
CO4	Prepare material requirement plan for a product and explain enterprise resource planning (ERP)
CO5	Create schedules for multiple machines/workstations and describe the capacity planning
CO6	Explain different computer aided measurement and inspection techniques

2. Syllabus:

Introduction	**(05 hours)**
Production systems and their types -mass production, batch production and job shop production systems. Introduction to process planning in manufacturing, Role of process planning. Computer aided process planning (CAPP) - variant and generative type process planning	
Computer Aided Forecasting	**(06 hours)**
Introduction to forecasting, sources of data, demand patterns, forecasting errors, forecasting models – Quantitative: moving average, linear regression and exponential smoothing methods; Qualitative - Delphi method	
Facility Layout Planning	**(10 hours)**
Introduction to facility layout, objectives, types of facility layout- line layout, process layout, cellular layout and fixed position layout, advantages and disadvantages. Assembly line balancing, line balancing algorithms- largest candidate rule, Kilbridge and Wester method, and ranked positional weights method. Heuristics of process layout problems - computerized relative allocation of facility technique, automated layout design program and computerized relationship layout planning. Multi objective approach for facility layout planning	
Group Technology	**(06 hours)**
Introduction, benefits of group technology, part families, part classification and coding, applications of GT. Algorithms and models for Group Technology - Rank order clustering algorithm and Bond energy algorithm	

Material Requirement Planning	(06 hours)
Introduction, Objective of the MRP system, inputs to the MRP System – product structure or bill of materials (BOM), master production schedule (MPS) and inventory status file. MRP calculations. Manufacturing resources planning (MRP-II). Enterprise resource planning (ERP)	
Scheduling And Capacity Planning	**(07 hours)**
Introduction, Single machine scheduling –shortest processing time rule, weighted mean flow time rule, earliest due date rule, model to minimize total tardiness, branch and bound algorithm. Introduction to parallel processors under single machine scheduling. Flow shop scheduling – Johnson's algorithm. Job shop scheduling. Capacity planning – measure of capacity, capacity strategies, tools for capacity planning	
Computer Aided Measurement and Inspection	**(05 hours)**
Computer Aided Testing, Contact and Non-contact type inspection, Co-ordinate measuring machines (CMM), types of CMM, Applications of CMM and its Benefits, Laser viewers for production profile checks, Machine vision technology, Microprocessors in metrology	

(Total Lecture Hours: 45)

3. Books Recommended:

1	R. Panneerselvam. Production and Operations Management, 3rd Edition, PHI Learning Pvt Ltd, 2015
2	M. P. Groover. Automation production systems and computer integrated manufacturing, 5th edition, Pearson Edu Ltd, 2019
3	E. E. Adam, R. J. E Bert. Production and Operations Management, 5th Edition, Prentice Hall of India, 2015
4	J. Heizer, B. Render, C. Munson. Operations Management, Pearson Edu Ltd, 12th Edition, 2017
5	S. N. Chary. Production and operations management. McGraw Hill Education (India) Pvt. Ltd, 6th Edition, 2019

MEMF115	:	METAL CUTTING AND TOOL DESIGN	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop and calculate the relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy and temperatures associated with orthogonal cutting
CO2	Select cutting fluids, cutting tool materials and tool geometry for improving machinability and tool life for selected condition
CO3	Relate thermals aspects and form of tool wear with tool life and compute tool life under given condition
CO4	Select tool material and tool geometry for cutting tool for given application
CO5	Select suitable type of die for effective operation
CO6	Design the die and strip layout for effective utilization and increased production

2. Syllabus:

Mechanics of Metal Cutting	**(14 Hours)**
Metal cutting principles, classification and mechanism of chip formation, types of chips, chip breakers, chip thickness ratio, shear plane, shear angle, shear strain, shear strain rate, shear angle relationships, velocity relationships, force analysis in orthogonal cutting; force analysis in drilling and milling process, types of tool dynamometer.	
Thermal aspects in Machining	**(06 Hours)**
Thermal aspects in machining, temperature distribution, temperatures in primary deformation zone, temperatures in secondary deformation zone, the measurement of cutting temperatures.	
Tool Life	**(06 Hours)**
Forms of wear in metal cutting, tool life criteria for different tool materials, tool life, factors affecting tool life, tool failure, Basic requirements of tool materials and major classes of tool materials, cutting fluids, economics of machining.	
Design of Cutting Tools	**(10 Hours)**
Properties required for tooling materials, various tool materials, Jigs and fixtures, Design of cutting tools, Selection of carbide cutting tools.	
Design of Press Tools	**(08 Hours)**
Die-design fundamentals; Material of die components, Design of Blanking and Piercing die, Progressive die, Strip-layout, Deep drawing die.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	G. Boothroyd and W. A. Knight, Fundamentals of machining and machine tools, Taylor and Francis, 3rd Edition, 2006
2	M. C. Shaw, Metal Cutting Principles, Oxford University Press, 2nd edition, 2008
3	G. K. Lal, Introduction to Machining Science, New Age International Publishers, 3rd edition, 2013
4	A. B. Chattopadhyay, Machining and Machine Tools, Wiley India, 1st edition, 2013
5	Cyril Donaldson, George H. Lecain and V. C. Goold, Tool design, 4th edition, Tata-McGraw Hills, 2010

MEMF117	:	CAD FOR MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand and describe geometric transformation techniques in CAD.
CO2	Design surface models for given engineering applications.
CO3	Develop mathematical equation to represent curves
CO4	Create model of a given engineering component using solid modeling techniques
CO5	Design and analyse a given engineering component or assembly
CO6	Describe and create interfacing design and drafting for an application with CAD standards

2. Syllabus:

Introduction	**(05 Hours)**
Basics of Computer Aided Design, Introduction to Computer graphics, DDA and Bresenham's algorithm for generating various figures and Basics of CAD hardwares.	
2D/3D Transformation	**(06 Hours)**
2D Transformation of geometries and 3D Transformations for Translation, Rotation, Scaling, Symmetry, Reflection, and Homogeneous Transformations, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.	
Representation of Curves	**(06 Hours)**
Representation of curves – Explicit and Implicit Equations Parametric and non-parametric Curves, Splines, Bezier, B-Splines and generation of surfaces.	
Solid Modeling	**(08 Hours)**
Introduction to Drafting and modelling of solids, Coordinate system, Fundamentals of solid modeling, Customization, 3D sketches, Datum features, Modeling operation Strategyand creating features, Geometric constraints, Modeling aids & tools, Generalized, views, Presentation of dimensioning / tolerances/symbols & annotation, Associatively, Parent child relationship, Parametric design, Programming techniques in drafting/ modeling/analysis, Concept of computer animation, Properties calculation Hidden line and surface removal.	
Surface Design & Analysis	**(08 Hours)**
Different approaches of creating and assembly. Surface design, and Surface analysis	
CAD Standards	**(04 Hours)**
Standards in CAD, Graphics and computing standards, Data exchange standards, Exchange format, Design database, Interfacing design and drafting, Mechanical assembly.	
Applications of CAD in Manufacturing	**(08 Hours)**
Introduction to CAD tools and softwares, Role and applications of CAD in manufacturing domains like machining, forming, tool design, die design, assembly, 3D printing, etc.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Hearn Donald & Baker M. Pauline, “Computer Graphics”, Prentice-Hall of India Pvt. Ltd., 2nd Edition, 1997
2	David F. Rogers & J. Alan Adams, “Mathematical Elements for Computer Graphics” McGraw Hill, 2nd Edition, 1990
3	Zeid Ibrahim, “CAD/CAM - Theory and Practice”, McGraw Hill, International Edition, 1998
4	McMohan Chris, “CAD/CAM: Principles, Practice and Manufacturing ”, Prentice Hall, 1999
5	Rao, P.N. “CAD/CAM: Principles and Applications”, McGraw Hill Publication, 2nd Edition

MEMF119	:	MANUFACTURING METALLURGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the mechanism of solidification of metals and alloys
CO2	Explain and distinguish various deformation mechanisms under different conditions
CO3	Determine heat treatment required for given conditions
CO4	Identify the equilibrium condition under different phase transformation using TTT or CCT diagram
CO5	Perform mechanical testing of given part
CO6	Understand metallurgical aspects of manufacturing processes

2. Syllabus:

Liquid Metallurgy Processing	**(10 Hours)**
Introduction, Nucleation in pure metals, undercooling, recalescence, homogeneous nucleation, heterogeneous nucleation, growth and interface stability, cooling curve and solidification structures of pure metal, single crystals, equiaxed microstructures, cooling curve and solidification structures of solid solutions, Constitutional Undercooling, Solute redistribution during solidification, Cellular Structures, dendritic structures, segregation during cooling, eutectic phase solidification, off-eutectic alloys, peritectic alloys, solidification of ingot and casting, gas solubility and gas porosity, solidification during quenching from the melt (metal glasses).	
Plastic Deformation of Metals	**(10 Hours)**
Metallic crystal structure, SC, FCC, BCC, HCP, miller indices, single crystal vs polycrystal, Segregation of Impurities Line and Points Defects in Crystals Elasticity, yield criteria, and plasticity; defects in crystals; elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions; strengthening mechanisms; tensile, fatigue and creep behaviour; superplasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness.	
Solid State Phase Transformation	**(08 Hours)**
Phase equilibria involving eutectoid and peritectoid transformations, TTT and CCT diagrams, hardenability, Heat Treatment of Ferrous and Non Ferrous Alloys viz., annealing, normalizing, quenching, tempering and precipitation hardening.	
Fundamental Mechanical Properties	**(08 Hours)**
Tensile Strength, Hardness Tests Impact Tests, creep, fatigue, fracture toughness and formability Other Destructive Tests, Non-destructive Tests.	
The Industrial Shaping of Metals	**(09 Hours)**
Sand Casting, Die Casting and Allied Processes, Fusion and Non Fusion Welding	

Processes, Hot-working Processes, Cold-working Processes, Sintering from a Powder, Machinability of Metals and Alloys

(Total Lecture Hours: 45)

3. Books Recommended:

1	Balasubramaniam R., Callister's Materials Science and Engineering, 8th Ed., Willy, 2010
2	Askeland R.D. and Askeland D., Materials Science and 2010 Engineering, Ceneage, 2010
3	Ghosh A. and Mallick A. K., Manufacturing Science, Affiliated East West Press, 2001
4	Porter, D.A., Easterling, K.E., and Sherif, M.Y., "Phase Transformations in Metals and Alloys", 3rd Ed., CRC Press, 2009
5	Rajan, T.V., Sharma, V.P., Sharma, A., "Heat Treatment Principles and Technique", Prentice- Hall, 2006

MEMF121	:	INDUSTRIAL ROBOTICS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify suitable actuator and sensor to monitor and control a given product or process
CO2	Describe the evolution, classification, structures and drives for robots
CO3	Select suitable pneumatic/hydraulic or electro-pneumatic/electro-hydraulic system for a given task
CO4	Design and analyse robot cell layout for given application
CO5	Develop PLC programs using suitable language for a given task.
CO6	Apply AI and Expert systems for robot programing of given task or cell layout

2. Syllabus:

Introduction	**(02 Hours)**
Robot Definition, Applications, Robot Anatomy, Robot Classifications and Technical Speciation's, Serial robots and Parallel robots.	
Robot Sensors & Actuators	**(06 Hours)**
Contact and non-contact sensors; Position, Velocity, Acceleration and Force/Torque sensors; Robot vision and their interfaces Pneumatic, Hydraulic and Electric Actuators, Stepper Motors, DC and AC motors, Selection of Motors, Gearboxes and Robot End-effectors	
Transformations	**(06 Hours)**
DOF of a Robot; Understanding Pose or Configuration; Homogeneous transformation matrix, Denavit - Hartenberg (DH) Parameters, Forward Kinematics, Tools and Base Calibration. Velocity Relations and Robot Jacobean, Force and Velocity Ellipsoids, Inverse Kinematics.	
Introduction to Robot Statics & Control	**(06 Hours)**
Gravity Compensation, Effect of external forces. Introduction to Robot Dynamics; Euler-Lagrange Formulation, Obtaining generalized equation of motion. Transfer functions and Block Diagram Representation, Proportional, Integral and Derivative Control	
Pneumatic/Hydraulic Systems and Circuit	**(06 Hours)**
Introduction to pneumatic/Hydraulic Systems and Their Components, Various types of valves, and their applications. Pneumatic/Hydraulic Circuit Design Approach and Examples. Pneumatic/Hydraulic Circuit Sequence, Limit Switches, Limitations of Pneumatic/Hydraulic Systems. Basics of Electro-Pneumatic and Electro-Hydraulic/Electro-Hydraulic Systems and Their Components, Circuit Design, Relay Control and Sequence Control Applications with Example	
Robot Cell Design and Application	**(05 Hours)**
Robot work cell design and control, Safety in Robotics, Robot cell layouts, Multiple Robots and machine interference, Robots cycle time analysis, Industrial application of	

robots	
PLC, Robot Programming, Artificial Intelligence and Expert System	**(14 Hours)**
Introductions to PLCs, Inputs and Outputs and their types. Interfacing of I/O devices with a PLC. Programming Languages and Introduction sets, Ladder Logic and Applications Methods of Robot Programming, Characteristics of task level languages lead through programming methods, Motion interpolation, Artificial intelligence, Basics, Goals of artificial intelligence, AI techniques, Problem representation in AI, Problem reduction and solution techniques, Application of AI and ES in Robots	

(Total Lecture Hours: 45)

3. Books Recommended:

1	John J Craig, Introduction to Robotics: Mechanics and Control, Prentice Hall, 3rd edition, 2004
2	Subir Kumar Saha, Introduction to Robotics, McGraw Hill, 2nd edition, 2014
3	Stamatios Manesis, and George Nikolakopoulos, Introduction to Industrial Automation, CRC Press, 2nd edition, 2018
4	W. Bolten, Mechatronics, Pearson Publishers, 4th Edition, 2010
5	Saeed B Niku, "Introduction to Robotics: Analysis, Systems, Applications ",Pearson Education India, PHI, 2nd edition, 2003

MEMF123	:	ADVANCED METROLOGY AND COMPUTER AIDED INSPECTION	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Suggest suitable techniques to minimize measurement errors and uncertainty
CO2	Identify suitable methods and devices for dimensional metrology of given part
CO3	Calculate limits, fits and tolerances and design limit gauges for given condition
CO4	Assess surface roughness and form errors for given surface
CO5	Identify devices for computer aided inspection of given form and part
CO6	Deduce requirement of laser metrology for given application

2. Syllabus:

Basic Concepts of Measurement	**(03 Hours)**
Generalized measurement system, Classification of measurements, Classification of measurement, Calibration, Measuring instruments and their properties.	
Uncertainty Analysis	**(03 Hours)**
Measurement and error, Type A and Type B categories of uncertainty, Combined type A and type B, Evaluation of uncertainty.	
Measurement of Length and Angle	**(05 Hours)**
Length measurement, Angle measurements, Direct and indirect methods, Standards for length measurement, Length measuring instruments, Angle measuring instruments, Setting errors with sine-bar, Measurement of angles over 45^0 , Internal taper measurements.	
Limits, Fits and Tolerances	**(07 Hours)**
Need for limit systems, Interchangeability, types of interchangeability, Limits and fits, Tolerance dimensions, Terns and definitions, Published standards for limits and fits system, Types of fits, Design of limit gauges, Geometric tolerances key aspects, symbols, Tolerance frame, Datum symbols, Tolerance feature and Interpreting drawing.	
Form Metrology	**(06 Hours)**
Measurement of roughness, waviness, flatness, roundness, cylindricity, radius, screw, gear, Methods of improving accuracy & surface finish, Influence of forced vibration on accuracy, Dimensional wear of cutting tools and its influences on accuracy.	
Amplifying Devices	**(04 Hours)**
Tool Maker's microscope, Profile projector, Comparators: Mechanical, Pneumatic, optical, electric and electronic.	
Computer Aided Metrology	**(10 Hours)**
Coordinate measurement machine (CMM), Applications, Advantages, Type of CMM & applications, Constructional features of CMM, Probes touch trigger probe and non contact trigger probers, Operation and Programming, Examination of surface texture, Possible sources of error in CMM, Image Analysis and Computer Vision.	

LASER Metrology	(07 Hours)
Types of laser, Laser in engineering metrology, methods of laser metrology, Laser interferometer, Laser alignment telescope, Laser micrometer, On-line and in-process measurements of small diameter, large displacement, Roundness and surface roughness using LASER, Micro profile and topography measurements, Testing of machine tools.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	J. F. W. Galyer and C. R. Shotbolt, Metrology for Engineers, Thomson Learning, 5th Edition, 1993
2	I. C. Gupta, A Text Book of Engineering Metrology, Dhanpat Rai and Sons, 4th Edition, 2018
3	M. Mahajan, A text-book of Metrology, Dhanpat Rai & Co, 2014
4	R. K. Jain, Engineering Metrology, Khanna Publishers, 19th edition , 2015
5	C. Dotson, Dimensional Metrology, Delmar Cengage Learning, 1st Edition, 2009

MEMF125	:	FAILURE ANALYSIS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify and illustrate sources of failures during manufacturing, services and maintenance
CO2	Analyse the type of failures in the components by applying fracture mechanics principles
CO3	Suggest and explain different types of failure analysis tools for industrial solution
CO4	Compute extent of failure using different industrial engineering tools
CO5	Identify suitable NDT techniques applied for failure analysis of industrial problem
CO6	Design and implement failure analysis strategies to diagnose failure indications, identify failure mechanisms, and determine reasons of failure in components

2. Syllabus:

Introduction	**(06 Hours)**
Need and scope of failure analysis and prevention, Engineering disasters and understanding failure, Fundamental sources of failures: Examples of different deficient designs.	
Fundamental Sources of Failures	**(07 Hours)**
Imperfections in base metals , Improper manufacturing processes and Improper service conditions, Poor assembly, Service and maintenance.	
Industrial Engineering Tools for Failure Analysis	**(12 Hours)**
Pareto diagram, Fish bone diagram, Fault tree analysis, Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd,, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA)	
NDT & DT for Failure analysis:	**(06 Hours)**
Non-destructive testing for failure analysis, Destructive testing, selection, preservation, cleaning & sectioning of samples, Macroscopy of fracture surfaces-I, Macroscopic of fracture surfaces- II, Determination of Type of Fractures and chemical analysis	
General Procedures for Failure Analysis and case studies	**(14 Hours)**
Types of Failure and Stress, Ductile and Brittle Fractures, Fatigue Failures, Wear Failures, Corrosion Failures, Elevated-Temperature Failures, use of fracture mechanics and fracture toughness principles in failure analysis and analysis findings and report/recommendation writing. Simulated test and analysis of evidences and results. Different case studies: Failure analysis of welded joints in different sectors, Failure analysis of 3D Printed polymer parts, Failure analysis of manufacture defects induced tubes, failure analysis of deep drawing dies in manufacturing of automotive parts and aerospace components	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Brett A. Miller, Roch J. Shipley, Ronald J. Parrington, and Daniel P. Dennies, Failure analysis and prevention, ASM Handbook, 2002
2	Gordon W Powell, Salah E Mahmoud, Metals Hand Book Volume 11: Failure Analysis and Prevention ASM Hand book 9th Edition, 1986
3	Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei,_Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries, Butterworth- Heinemann Publications 2015.
4	Jones DRH, Failure analysis of Case studies II, Pergaman Publications, 2001.
5	Govil AK, Reliability Engineering, Tata McGraw-Hill, 1983

MEMF127	:	OPTIMIZATION TECHNIQUES	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the concept of optimization, related terms and formulate mathematical models for practical problems based on the information provided
CO2	Use linear programming to solve real life linear programming problems
CO3	Solve transportation and transhipment problems, travelling salesman problem and integer programming
CO4	Determine solutions that will be deployed in real world situations after conducting sensitivity and post optimality analysis
CO5	Apply classical methods to solve nonlinear programming problems
CO6	Use evolutionary algorithms to solve complex engineering problems where classical methods are not suitable

2. Syllabus:

Introduction	**(05 Hours)**
Introduction to Optimization, Linear Programming – Formulation, Graphical method, simplex method and special cases	
Sensitivity and Post Optimality Analysis	**(08 Hours)**
Sensitivity Analysis and post optimality analysis of linear programming problems – changes in resources and objective function, changes affect feasibility and optimality, duality, dual simplex algorithm, generalize simplex algorithm	
Special Types of Linear Programming Problems	**(06 Hours)**
Transportation problems, Transshipment problems, Travelling salesman problems, Integer programming	
Introduction to MATLAB and Solving Linear and Nonlinear Problems using MATLAB	**(07 Hours)**
Introduction to MALAB, creating and manipulating vectors and matrix, user defined function, special built-in function to create special vectors and matrices, symbolic math, built-in function to solve linear programming problems	
Nonlinear Programming Problems	**(05 Hours)**
Nonlinear Programming problems: Graphical method, convex function and convex region, necessary and sufficient conditions, Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, solving nonlinear problems using MATLAB	
Evolutionary Algorithms	**(14 Hours)**
Introduction to evolutionary algorithm, introduction to multi-objective optimization, genetic algorithms, differential evolution algorithm, Particle swarm optimization, tabu search, simulated Annealing technique, solving real life engineering problems using MATLAB.	

(Total Lecture Hours: 45)

3. **Books Recommended:**

1	Hillier, Frederick S. "Introduction to operations research.", 1967
2	Taha, Hamdy A. Operations research: an introduction. Vol. 790. Upper Saddle River, NJ, USA: Pearson/Prentice Hall, New Jersey, 2011
3	Rao S.S., “Optimization Theory & Applications”, Wiley Eastern, USA, 1990.
4	Vasuki, A. Nature-Inspired Optimization Algorithms. CRC Press, Florida, 2020
5	Malik A. K. , Yadav S. K. , Yadav S. R., “Optimization Techniques”, I.K. International Publishing House ,India, 2013

MEMF129	:	THEORY OF PLASTICITY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe basic concepts of plasticity and plastic deformation mechanism in metals.
CO2	Develop analytical modeling and skills of engineering application related to plastic deformation
CO3	Apply empirical equations for equilibrium of given conditions
CO4	Analyse and compute the yielding of a material according to different yield theory for a given state of stress
CO5	Apply plasticity concepts to given problems of metal forming
CO6	Compute stress and strain for given conditions

2. Syllabus:

Basic Theory	**(08 Hours)**
Introduction to Tensor, Concept of Stress and Strain, Principle Stresses & Strains, Stress & Strain Invariants, Deviatoric Stress & Strain, Octahedral Normal and Shear Stresses and Strains, Spherical Stress, Plane Stress and Plane Strain, Strain Rate and Strain Rate Tensor, Cubical Dilation, Stress Transformation, Compatibility and Constitutive Equation, Generalized Hooke's Law.	
Theory of Plasticity	**(13 Hours)**
Theory of Plastic Flow, Plastic Deformation of Metals: Crystalline Structure in Metals, Crystal Imperfections, Dislocation Geometry and Energy, Dislocation Mechanics, Mechanism of Plastic Deformation, Factors Affecting Plastic Deformation, Strain Hardening, Recovery, Recrystallization and Grain Growth, Flow Figures or Luder's Cubes. Differential Equations of Equilibrium, Equivalent Stress and Strain, 3D Stress Analysis, Idealised Stress-Strain Diagrams for different material models, Empirical Equations, Levy-VonMises Equation, Prandtl-Reuss and Saint Venant theory, Experimental Verification of Saint Venant's.	
Yielding Criteria in Plasticity	**(12 Hours)**
Introduction, Yield or plasticity Conditions, Significance of the Theories of Failure, Von Mises's, Tresca's and Anisotropic Yield Criteria, Geometrical Representation, Halgh-Westergard Stress Space Representation of Yield Criteria, Yield Surfaces of Tresca's and Von Mise's, Yield Locus (Two Dimensional Stress Space), Experimental Evidence for Yield Criteria, Plastic Flow of Anisotropic Material, Bauschunger Effects, Isotropic and Kinematic Hardening, Advanced Anisotropic Criteria in Sheet Metals like Barlat or BBC Yield Criteria.	
Applications of Plasticity	**(12 Hours)**
Introduction to Bending of Beams, Stages of Plastic Yielding, Analysis of Stresses, Linear and Nonlinear Stress Strain Curve, Introduction to Torsion Bars, Plastic Torsion of a Circular Bar, Elastic Perfectly Plastic Material, Elastic Work Hardening of Material,	

Theory and application of Slip Line Field, Basic Equations for Incompressible Two Dimensional Flows, Continuity Equations, Stresses in Conditions of Plain Strain, Convention for Slip Lines, Geometry of Slip Line Field, Properties of the Slip Lines, Construction of Slip Line Nets, Simple Problems of Forging Extrusion, Drawing and Indentation, Bound Theorem and Application.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Chakraborty J., Theory of Plasticity, Elsevier, 3rd Edition , 2006
2	Sadhu Singh, Theory of Plasticity and Metal Forming Process, Khanna Publishers, 3rd edition 2008
3	L S Srinath, Advanced Mechanics of Solids, McGraw Hill Education, 3rd edition, 2009
4	Valentin Molotnikov, Antonina Molotnikova, Theory of Elasticity and Plasticity, Springer International Publishing, 2021
5	H. Jane Helena. Theory of Elasticity and Plasticity, Prentice Hall India Pvt. Limited, 2017

MEMF107	**:**	**LABORATORY PRACTICE-I**	**L**	**T**	**P**	**Credits**
			0	**0**	**4**	**02**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand and demonstrate operation of identified machine/instrument/equipment
CO2	Perform given practical task independently on machine/instrument/equipment
CO3	Analyse and evaluate the observations of identified practical task
CO4	Represent results graphically and deduce conclusions therein
CO5	Demonstrate practical skills to work on identified problem
CO6	Demonstrate skills of team effort and coordination through group practical performance

Practicals:

Students will perform practicals in various laboratories. The indicative list (but not limited to) of practicals is as under:

1. To understand the effect of selected welding process parameters on weld bead geometry and welded joint characteristics.
2. To understand microstructural characterization techniques for as weld and post weld heat treated weldments.
3. To understand cladding approach through plasma transferred arc welding process
4. To understand the correlation of virtual/reality-based welding with actual welding.
5. Evaluation of the effect of process parameters on cutting force during given machining process
6. Estimation of chip reduction co-efficient and shear angle during orthogonal cutting
7. Preparation of single point cutting tool with a given tool geometry
8. Estimation of tool life of a single point cutting tool
9. Evaluation of dimensional and geometrical accuracy on a given part using CMM
10. Mechanical testing of a given part (machined part/welding part/ composite)

MEMF102	:	COMPUTER INTEGRATED MANUFACTURING	L	T	P	Credits
			3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe different types of Automation and CIM.
CO2	Develop the CNC Program for the given geometry for Drilling, Milling and Turning machines
CO3	Develop the part program using APT
CO4	Analyze the production flow based on part classification, identification and coding.
CO5	Evaluate the different types of flexibilities in manufacturing
CO6	Explain and evaluate types and steps of computer aided process planning

2. Syllabus:

Introduction to CIM	**(04 Hours)**
Introduction to automation, Types of automation, Automation principles and strategies, Definition of CIM, CIM wheel, Evolution of CIM, Benefits of CIM, CIM hardware and software, Nature and role of the elements of CIM system, Development of CIM.	
Computer Aided Manufacturing	**(18 Hours)**
Components of NC/CNC system, Specification of CNC system, Classification of CNC machines, Constructional details of CNC machines, Axis designation, CNC control loops. Basic programming terms, Programming formats, Preparatory command, Miscellaneous functions, Machine zero, work zero and tool zero, Work offsets, Tool length offset and setup methods, Cutter radius offset, Machine zero return, Part programming for milling - linear and circular interpolation, subprogram, fixed/canned cycles, mirrors commands, machining large hole pattern, polar coordinates, round and rectangular pocket machining and cycles, subroutines, mirror, Part programming for lathe - lathe cycles, with and without tool nose radius feature, repetitive fixed cycle	
Part Programming with Automatically Programmed Tools (APT)	**(05 Hours)**
Computer aided part programming, APT: Geometry, motions and auxiliary commands, drill cycle commands, programming for geometry and drill cycle and hole pattern	
Group Technology	**(08 Hours)**
Definition, implementation considerations, benefits and applications, G.T. methods - visual search method, production flow analysis, Parts classification and coding, Design and manufacturing attributes, Concept of composite component, Rank order clustering, machine cell formation, Cell group tooling, Design rationalization, possibilities of integration with CAD/CAM.	
Flexible Manufacturing System	**(07 Hours)**
Introduction, General Considerations for FMS, types of FMS, Flexibilities, their measurements, Computer control in FMS, Automated material handling systems, AGVs, Automatic storage and retrieval systems, Manufacturing cells, cellular v/s	

flexible manufacturing	
Computer Aided Process Planning	**(03 Hours)**
Introduction to CAPP, Route card, Manual and computer aided process planning, steps, and types	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Krar, S.F. and Gill, A., CNC: Technology and Programming, McGraw-Hill, 1989
2	Groover, M.P., Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 5th Edition, 2019
3	P. Radhakrishnan, S. Subramanyan, and V. Raju, CAD/CAM/CIM, New age International publishers, 3rd edition, 2011
4	P. N. Rao, CAD/CAM Principles and Applications, Tata McGraw Hill, 2nd Edition, 2006.
5	S. Kant Vajpayee, Principles of Computer Integrated Manufacturing, PHI, New Delhi, 1st edition, 1998

List of Practicals:

1. Demonstration of CNC Milling machine with user interface and calculate the Co-ordinates of given geometry in absolute and increment mode for cutter path.
2. Introduction of G codes and M codes and write the CNC part programming for a given geometry using Linear, Circular interpolation. (Using FANUC Controller)
3. Write the CNC part programming for a given geometry using Mirror and Subroutine. (Using FANUC Controller)
4. Write the CNC programming for a given geometry using Polar Co -ordinate for drilling cycles.
5. Write the CNC part programming for a given geometry using Tool Radius Compensation and Repeat loop for Peck Drilling Cycle. (Using FANUC Controller)
6. Introduction and programming of all canned cycle of Milling machine. (Using FANUC controller)
7. Demonstration and study of CNC Lathe machine with sample programming.
8. Write CNC programming for given geometry (Lathe) using stock removal cycles (Using FANUC controller)
9. Demonstration of FMS setup. (AS / RS, AGV, CNC Lathe, CNC Milling, Robot & CMM setup
10. Demonstration of Advance manufacturing Machines like EDM (Electro Discharge Machine), Micro Machine, Vision Measuring System.

MEMF104	:	ADDITIVE MANUFACTURING PROCESSES	L	T	P	Credits
			3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify additive manufacturing processes and explain generic steps in additive manufacturing
CO2	Explain principle, and mechanism of solid based, liquid based and powder based additive manufacturing processes
CO3	Select a suitable additive manufacturing process for a given material and application
CO4	Identify software related issues in additive manufacturing; and post processing aspects including defects and part quality
CO5	Design and optimize a given part following guidelines and rules for part building
CO6	Elaborate state of art in additive manufacturing

2. Syllabus:

Introduction	**(04 Hours)**
Definition, classification, stages of generic additive manufacturing process, benefits, applications, process selection, evaluation, benchmarking, future growth and opportunities	
Solid Based Processes	**(06 Hours)**
Basic principle and working of Fused Deposition Modelling process, liquification, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Multi jet process, typical materials and applications, safety considerations	
Liquid Based Processes	**(06 Hours)**
Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, typical materials and applications, safety considerations	
Powder Based Processes	**(07 Hours)**
Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, process parameters, typical materials and applications, safety considerations	
Additive Manufacturing Data Formats, Pre-processing & Post processing	**(08 Hours)**
Additive manufacturing file formats, Defects and Issues in Data Formats; Pre-processing - Part orientation and support structure generation, Model Slicing, Contour Generation, Tool Path Generation, Build File preparation, Machine Set-up; Post Processing – Product quality evaluation, support structure removal, Improvement of finish, geometry and aesthetics	
Design For Additive Manufacturing	**(08 Hours)**
Core concepts and objectives, Principles of design for manufacturing and assembly, Constraint approach to design for additive manufacturing: Guidelines and rules for part building, Topology optimization and generative design, exploring design freedom, design tools	

Recent Trends in Additive Manufacturing	(06Hours)
Composite 3D printing, Bio 3D printing of tissues and organs, Clay and Concrete 3D printing, 3D food printing, 3D printing in space, 4D printing.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	I. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer Publisher, 2nd Edition, 2015
2	C. K. Chua, K. F. Leong, C. S. Lim, Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010
3	C. P. Paul, A. N. Anoop, Additive Manufacturing – Principles, Technologies and Applications, Mc Graw Hill Education (I) Pvt. Ltd., 1st edition, 2021
4	A. Bandyopadhyay and S. Bose, Additive Manufacturing, CRC Press, 2nd edition, 2015
5	Diegel, Olaf, Axel Nordin, and Damien Motte. A Practical Guide to Design for Additive Manufacturing. Springer Singapore, 1st edition, 2019

List of practicals:

1. To study the STL file preparation of a given CAD model using selected software
2. To 3D print a given part using filament extrusion process
3. To 3D print a given part using photo polymerization process
4. To fabricate polymer filament and study its suitability for 3d printing
5. To study the effect of infill pattern and infill density on mechanical strength of a given 3D printed part
6. To prepare cellular structures using different additive manufacturing techniques
7. To fabricate fiber reinforced polymer composite part using composite 3D printing process
8. To study of the post-processing techniques for 3D printed components
9. To study clay 3D printing process
10. To prepare report on demonstration of laser based additive manufacturing process

MEMF110	:	METAL CASTING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the fundamentals and steps involved in metal casting
CO2	Determine suitable strategy for melting and solidification of metal for sound casting
CO3	Explain designing of gating and riser system.
CO4	Analyze the metallurgical aspects of the solidified metals
CO5	Understand Inspection, quality control and testing of cast products.
CO6	Select suitable casting process for given industrial application

2. Syllabus:

Introduction	**(03 Hours)**
Casting as a process of Manufacturing, foundry industry in India, challenges for foundry industry in India, important industrial sectors using casting	
Moulding Processes, Equipment and Mechanization	**(07 Hours)**
Different types of moulds, moulding materials and moulding processes, pattern and other mould making equipments, forces acting on moulds, mould factors in metal flow, moulding factors in casting design, different types of binders and their use in mould and core making	
Melting of Metals and Alloys for Casting	**(07 Hours)**
Brief mention of various melting units, melting and post melting treatments, , Cupola, Charge Calculations, Other Furnaces, Inoculation Practice for Gray and Ductile Iron, Degassing, Ladles, Casting Cleaning melting practices as adopted for a few metals and alloys such as Al, Cu, steels.	
Solidification of Metals and Alloys	**(09 Hours)**
Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Time of solidification and Chowrinov rule, concept of directionality in solidification Significance and practical control of cast structure	
Principles of Gating and Risering	**(08 Hours)**
Feeding characteristics of alloys, types of gates and risers, time of solidification and Chvorinov rule, Wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification, yield of casting and prescription for its augmentation.	
Special Casting Methods	**(06 Hours)**
Shell Moulding, Precision Investment Casting, Permanent Mould Casting, Die Casting, Vacuum Die Casting, Low Pressure Die Casting, Centrifugal Casting, Continuous Casting, Squeeze Casting, Slush Casting, Vacuum Casting, Thixocasting, centrifugal casting, full mould casting, quick casting , evaporative pattern casting.	
Casting Defects & Quality Control	**(05 Hours)**

A detailed analysis of casting defects, their causes and prescription of remedial measures. Non-Destructive Testing (NDT): Dye Penetrant Testing, Fluorescent Powder Testing, Magnetic Particle Inspection, Radiographic Inspection, Ultrasonic Testing, Eddy Current Inspection.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ramana Rao, T. V., Metal Casting, Principles and Practice, New Age International (P) Ltd. 2nd Edition, 2019
2	Mahi Sahoo, Principle of Metal Casting, Mcgraw Hill, 3rd Edition, 2017
3	Jain, P. L., Principles of Foundry Technology, Tata McGrawHill Edu. 4th edition, 2006
4	Hein, R. W., Loper, C.R. and Rosenthal, P.C., Principles of Metal Casting, Tata-Mc Graw Hill. 1st Indian edition, 2017
5	Scrope Kalpakjian, "Manufacturing processes for Engineering Materials", Addision, Wesley, 3rd edition, 1997

MEMF112	:	FINITE ELEMENT METHODS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental concepts of the theory of the finite element method.
CO2	Develop element characteristic equation and generation of global equation
CO3	Devise suitable boundary conditions to a global equation for bars, trusses and beams
CO4	Evaluate the governing FE equations for solving 1D and 2D problems
CO5	Apply the FE method for identified problems
CO6	Perform finite element analyses and evaluate the results of a select set of manufacturing processes

2. Syllabus:

Introduction to Finite Element Method	**(05 Hours)**
Relevance of finite element analysis in design, Modeling and discretization, Interpolation, Elements, Nodes and degrees-of-freedom, Applications of FEA. One-Dimensional Elements and Computational Procedures: Bar elements, Beam elements, Bar and beam elements of arbitrary orientation, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Solution of equations, Mechanical loads and stresses, Thermal loads and stresses.	
Truss, Beam and 2-D Elements	**(08 Hours)**
Interpolation and shape functions, Element matrices, Linear triangular elements (CST), Quadratic triangular elements, Bilinear rectangular elements, Quadratic rectangular elements, Solid elements, Higher order elements, Development of Truss equations, Development of beam equations, Nodal loads-stress calculations.	
Isoperimetric Elements	**(08 Hours)**
Bilinear quadrilateral elements, Quadratic quadrilaterals, Hexahedral elements, Numerical integration, Quadrature, Static condensation, Load considerations, Stress calculations, Examples of 2D and 3D applications.	
Finite Elements in Structural Dynamics Applications	**(10 Hours)**
Solid and Structural Mechanics Applications: One dimensional problems static analysis of trusses, Analysis of plates, Solid of revolution. Dynamic analysis: Dynamic equations, Mass and damping matrices, Natural frequencies and modes, Damping, Model methods, Ritz vectors, Component mode synthesis, Direct integration techniques, Explicit and implicit methods, Analysis by responses spectra	
Heat Transfer and Fluid Mechanics Applications	**(07 Hours)**
Heat Transfer, Element formulation, Reduction -nonlinear problems, Transient thermal analysis, Acoustic frequencies and modes, fluid structure interaction problems, Plane incompressible and rotational flows.	
FEA Applications in Manufacturing	**(07 Hours)**

FE analysis of casting and Weldments solidification–special considerations, latent heat incorporation, FE analysis of metal forming and metal cutting.

(Total Lecture Hours: 45)

3. Books Recommended:

1	R. D. Cook, Concepts and Applications of Finite Element Analysis, 4th Edition, John Wiley and Sons, 2007
2	D. L. Logan, A first course in the finite element method, 5th Edition, Cenage Learning, 2012
3	J. N. Reddy, An Introduction to the Finite Element Method, 5th edition, McGraw Hill, 2017
4	T. R. Chandrupatla and A. D. Belagundu, Finite Elements in Engineering, 4th Edition, Pearson, 2015
5	O. C. Zienkiewicz, R. L. Taylor and J. Z. Zhu, The finite element method its basis and fundamentals, 7th edition, Elsevier, 2013

MEMF114	:	INDUSTRIAL TRIBOLOGY	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the lubrication and wear behaviour under different conditions
CO2	Identify and select suitable type of lubrication system for a given problem
CO3	Design and evaluate the performance parameters for sliding element bearings.
CO4	Design and evaluate the performance characteristics of rolling element bearings.
CO5	Select suitable strategy for instrumentation and inspection of selected feature/part
CO6	Compute relevant features in given system to ensure proper lubrication

2. Syllabus:

Surfaces, Friction and Wear	**(10 Hours)**
Topography of Surfaces, Surface features, Surface interaction, Theory of Friction, Sliding and Rolling Friction, Friction properties of metallic and non -metallic materials, Friction in extreme conditions, Wear, types of wear, Mechanism of wear, wear resistance materials, Surface treatment, Surface modifications, Surface coatings.	
Lubrication Theory	**(09 Hours)**
Lubricants and their physical properties lubricants standards, Lubrication Regimes in Hydrodynamic lubrication, Reynolds Equation, Thermal, inertia and turbulent effects, Elasto hydrodynamic (EHD) magneto hydrodynamic lubrication, Hydro static lubrication, Gas Lubrication, Solid lubrication.	
Design of Fluid Film Bearings	**(09 Hours)**
Design and performance analysis of thrust and journal bearings, Full, Partial, Fixed and pivoted journal bearings design, Lubricant flow and delivery, Power loss, Heat and temperature of steady and dynamically loaded journal bearings, Special bearings, Hydrostatic Bearing design.	
Rolling Element Bearings	**(09 Hours)**
Geometry and kinematics, Materials and manufacturing processes, Contact stresses, Hertzian stress equation, Load divisions, Stresses and deflection, Axial loads and rotational effects, Bearing life capacity and variable loads , ISO standards, Oil films and their effects, Rolling Bearings Failures	
Tribo Measurement and Instrumentation	**(08 Hours)**
Surface Topography measurements, Electron microscope, friction and wear measurements, Laser method, Instrumentation, International standards, Bearings performance measurements, Bearing vibration measurement	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Bharat Bhushan, Introduction to Tribology, Johan Wieley & Sons, New York, 2nd edition, 2013
2	Basu S. K., Sengupta S. N. , Ahuja B. B., " Fundamental of Tribology", PHI Learning Pvt, Ltd, New Delhi, 2009
3	G. Stachowiak and A. Batchelor. Engineering Tribology, ~~3r~~Elsevier Science, 3rd Edition, 2011
4	R. Gohar and H. Rahnejat. Fundamentals of Tribology, World Scientific Publishing Company, 3rd Edition, 2018
5	Harish Harani, Fundamentals of Engineering Tribology, Cambridge, 1st edition, 2017

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MEMF116	:	AUTOMATION IN MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe importance of automations in manufacturing
CO2	Describe principles of automations and mechatronics in various manufacturing systems
CO3	Select suitable sensors, mechanism and microprocessor for an automation system
CO4	Explain and select suitable drives and systems for an automation system
CO5	Design and develop automated systems for manufacturing and material handling
CO6	Perform basic Programming's related to automation

2. Syllabus:

Introduction	**(03 Hours)**
Introduction: Importance of automation in the manufacturing industry. Use of mechatronics. Systems required.	
Design of Automated system	**(04 Hours)**
Design of an automated system: Building blocks of an automated system, working principle and examples	
Fabrication	**(06 Hours)**
Fabrication: Fabrication or selection of various components of an automated system. Specifications of various elements. Use of design data books and catalogues	
Sensors	**(05 Hours)**
Sensors: study of various sensors required in a typical automated system for manufacturing. Construction and principle of operation of sensors.	
Microprocessor technology	**(05 Hours)**
Microprocessor Technology: signal conditioning and data acquisition, use of microprocessor or micro controllers. Configurations. Working.	
Electrical Drives	**(03 Hours)**
Electrical drives – types, selection criteria, construction and operating principle.	
Mechanisms	**(04 Hours)**
Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts	
Hydraulic Systems	**(06 Hours)**
Hydraulic systems: hydraulic power pack, pumps, valves, designing of hydraulic circuits.	
Pneumatic Systems	**(04 Hours)**
Pneumatic systems: configurations, compressors, valves, distribution and conditioning	
CNC Technology	**(05 Hours)**
CNC technology: basic elements, interpolators and programming.	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman, Singapore,1999
2	Gaonkar, R. S., Microprocessor architecture, programming,and applications with the 8085, Penram International Publishing (India), Delhi, 2000
3	Rothbart, H. A., CAM Design Handbook, McGraw-Hill, 2004.• Norton, R. L., Cam Design and Manufacturing Handbook, Industrial press Inc, 2002
4	Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001
5	Rao, P. N., CAD/CAM Principles and Applications, Tata McGraw Hill, New Delhi, 2010

MEMF118	:	COMPOSITES DESIGN AND MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the perspectives and applicability of composites over the other class of materials
CO2	Identify suitable fibers and reinforcements in composite for identified properties
CO3	Identify suitability of various manufacturing processes for composites
CO4	Categorize the allied issues of composites
CO5	Determine the macro-mechanical and micro-mechanical analysis of laminates
CO6	Elaborate the failure and design criteria for laminates

2. Syllabus:

Introduction	**(05 Hours)**
Introduction, classification, characteristics of composite materials, basic terminology, properties of constituents and composites, merits and demerits with other class of materials, applications, present statistics, future perspectives, related organizations/associations.	
Fundamentals of various fibers and reinforcements	**(07 Hours)**
Fiber terminology, glass fibers, aramid fibers, ultra-high molecular weight polyethylene (UHMWPE) fibers, carbon and graphite fibers, woven fabrics, reinforced mats, chopped fibers, prepreg. Polymer-matrix composites, metal-matrix composites, ceramic-matrix composites. Reinforcement forms –short fiber composites, textile composites, hybrid composite. Importance of curing, adhesive bonding and integrally cocured structures	
Manufacturing processes for composites	**(12 Hours)**
Classifications, open mold processes, closed mold processes, lay-up processes, vacuum-bag molding, pressure-bag molding, thermal expansion molding, autoclave molding, filament winding, pultrusion, pulforming, automated tape laying, compression molding, resin transfer molding, continuous laminating. Defects in manufacturing of composites, its causes and remedies. Manufacturing issues of small, big and complex components of composites – Case studies	
Allied issues of composites	**(06 Hours)**
Joining of composite materials, machining and cutting of composites, recycling of composites, material selection guidelines, nondestructive evaluation of polymer composite, interface- statistical distribution of fiber strength, standard mechanical tests for composite and constituents. Case studies for joining, cutting, recycling and testing of composites.	
Macromechanical and micromechanical analysis of laminates	**(07 Hours)**
Stress strain relationship for different type of materials, engineering constants for lamina, strength failure theories, hygrothermal stresses and strain. Concept of volume and weight fraction of fiber & matrix, density and void fraction, fiber packing. Evaluation of elastic modulies, ultimate strength of lamina, experimental evaluation using standard test methods, semi empirical models for prediction. Laminate – Code for laminate and	

stacking sequence, strength, stiffness and hygrothermal properties of laminate. Evaluation of elastic moduli, coefficient of thermal and moisture expansion for laminate	
Failure analysis and design of laminates	**(08 Hours)**
Failure criteria for laminate – Design of laminated composite structure and components, importance of constituents and their selection, stiffened structure, stiffener types, stiffener design, laminate joints, sandwich composite, environmental effects, inter laminar stresses, impact resistance, fracture resistance, fatigue resistance	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Gibson R.F., "Principles of composite material mechanics", McGraw-Hill Inc, 4^{th} edition, 2016
2	Jones R. M., "Mechanics of composite materials", CRC Press, 2^{nd} edition, 2015
3	Bhargava A.K. and Sharma C.P., "Mechanical behaviour and testing of materials", PHI publication, New Delhi, 1^{st} edition, 2011
4	Kaw A. K, "Mechanics of composite materials", Taylor and Francis, 2^{nd} edition, 2005
5	Harris B., "Engineering composite materials", Maney publication, 2^{nd} edition, 1999

MEMF120	:	SURFACE ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Decide the surface preparation methods suitable for different substrate materials
CO2	Demonstrate the ability to use the core concepts of engineering application in material degradation by corrosion, wear and its prevention
CO3	Describe the importance & role of surface modifications to achieve several technological properties
CO4	Explain importance of specific coating technique, characterization & its applications on specific engineering components
CO5	Select surface engineering technique for specific wear mechanisms and corrosion control
CO6	Propose suitable surface engineering technique to control material degradation

2. Syllabus:

Introduction	**(04 Hours)**
Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coating.	
Wear	**(06 Hours)**
Adhesive wear, Abrasive and erosive wear, Wear induced by mechanical fatigue of the worn surface, Melting wear, fretting wear and diffusive wear, Analytical models of wear, Wear resistant materials, Fatigue, fracture and creep.	
Corrosion	**(06 Hours)**
Corrosion of metals in aqueous media: Electrochemistry and aqueous corrosion, Electrochemical corrosion of machinery and structures, Corrosion inhibitors, Materials factors in aqueous corrosion. Oxidative reactions of metals with oxygen, sulphur and other halogens.	
Discrete Coatings	**(06 Hours)**
Introduction, Coatings of organic compounds, Electrochemical coatings, Plasma and thermal spraying, plasma-transferred arc the D gun, Vacuum-based coating methods, Friction surfacing, weld overlays and explosive bonding, Advanced coating techniques.	
Integral Coatings and Modified Surface Layers	**(09 Hours)**
Introduction, Thermally or mechanically modified surface layers: Induction hardening, Laser and electron beam surface hardening, Shot-peening, Thermochemical methods of coating: Galvanization and hot-dipping, Carburizing, Carbonitriding, Nitriding, Nitrocarburizing & Boronizing, Advanced surface modification technologies: Plasma Nitriding and Plasma Carburization, Surface alloying by laser and electron beam, Ion implantation	

Characterization of Surface Coatings	(07 Hours)
Introduction, Measurement of surface roughness and coating thickness, Hardness and micro hardness analysis, Adhesively testing, Microstructural evaluation, Chemical analysis, Residual stress analysis, Corrosion testing.	
Control of Materials Degradation	**(07 Hours)**
Introduction, Methodology of analysing materials degradation, Selection of optimal surface engineering technology, Control of wear by surface engineering, Principles of coating selection for wear resistance, Selection of specific surface engineering techniques for specific wear mechanisms, Control of corrosion by surface engineering, Control of fatigue and fracture by surface engineering	

(Total Lecture Hours: 45)

3. Books Recommended:

1	T Burakowski and T. Wierzchon, Surface engineering of metals, CRC Press, 1st edition, 1998
2	A. W. Batchelor, L. N. Lam and M. Chandrasekaran, Materials degradation and its control by surface engineering, Imperial college press, 3rd edition, 2011
3	L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko, Coated Metal: Structure and Properties of Metal-Coating Compositions, Springer, Germany, 1st edition, 2002
4	M. Ohring, Materials Science of Thin Films, Academic Press, 2nd Edition, 2002
5	D. K. Dwivedi, Surface Engineering: Enhancing life of tribological components, Springer, 1st edition, 2018

MEMF122	:	QUALITY ENGINEERING AND MANAGEMENT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain different concepts of quality, system reliability & maintenance and its application to the design and manufacturing activities
CO2	Apply statistical concepts and techniques for designing of products and process controls
CO3	Describe and apply reliability analysis concepts to selected applications
CO4	Describe and apply the factorial design and surface response method for experimental design.
CO5	Formulate, analyze, design and synthesize open-ended quality engineering problems using various statistical process control tools and quality management tool
CO6	Select and apply newer concepts and initiatives for quality improvement

2. Syllabus:

Introduction	**(03 Hours)**
Introduction to quality control and the quality system, Some philosophies and their impact on quality, Cost of quality, Quality audit.	
Statistical Quality Control	**(14 Hours)**
Statistical Concepts and Data analysis: Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling; Control Charts: Statistical Process Control using control charts, Control charts for attributes and variables. Process capability analysis: Concepts and procedures of Process capability. Acceptance Sampling: Acceptance sampling for attributes and variables	
Reliability Analysis	**(03 Hours)**
Reliability: Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, Graphical representation of Fd, Z and R. Generalization in graphical form, integral form, Hazard models, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA).	
Experimental Design	**(08 Hours)**
Experimental Design : Fundamentals of experimental Design, Single, Multi factor and 2^k factor experiments, Two level fractional factorial design, Response surface method. Quality loss function. Taguchi method: Taguchi method, Design of experiments using orthogonal array, Data analysis from Taguchi and Multi levelfactor design	
New Quality Concepts and Initiatives	**(12 Hours)**
New Quality Concepts and initiatives : Total Quality Management (TQM) and its	

techniques, New Seven Management Tools, and Industrial Case studies on Costs of Quality, Five S, kaizen, Quality Circles, Quality Function Deployment (QFD), Poka Yoke, Total Productive Maintenance (TPM), Lean Manufacturing, Six Sigma, Lean Six Sigma, etc. Quality Management through Software	
Quality Standards	**(03 Hours)**
Quality Standards and Business Excellence Models: Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies.	
World Class Manufacturing	**(02 Hour)**
Manufacturing Excellence World Class Manufacturing (WCM) – Modeland elements of WCM	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Amitra Amitava, Fundamentals of Quality Control and Improvement, 2nd Ed., PrenticeHall of India, 2011
2	K. Krishnaiah and P. Shahabudeen, Aplied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012
3	Dale H. Besterfield, Carol Besterfield-Michna, Mary Besterfield-Sacre, Glen H. Besterfield, Hemant Urdhwareshe, Rashmi Urdhwareshe, Total Quality Management, , Pearson Education, 2012
4	George W. Cobb, Introduction to Design and Analysis of Experiments, John Wiley & Sons, 2015
5	D.C. Montogomery, Design and Analysis of Experiments, John Wiley & Sons, 8^{th} Edition, 2013

MEMF124	:	OPERATIONS RESEARCH	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyse a given system with constraints and express it in mathematical form
CO2	Formulate and solve mathematical problem using linear and non linear programing
CO3	Explain different queuing situations and find optimal solutions using applicable model
CO4	Analyse given network using PERT/CPM
CO5	Decide optimal solution under uncertainty using fuzzy and non fuzzy concepts
CO6	Simulate real life probabilistic situations using Monte Carlo simulation technique

2. Syllabus:

Linear Programming	**(10 Hours)**
Introduction, Linear Programming Problem (LPP), Standard Form of an LPP, Matrix Form of LPP. Solution of a LPP: The Simplex Method, Big M Method and Two-Phase Method. The Dual Simplex method. Duality in Linear Programming and Sensitivity Analysis. The Transportation and Transhipment Model and Sequencing Models.	
Integer Programming	**(04 Hours)**
Integer Programming Formulations. The Cutting Plane Algorithm. Branch and Bound Technique.	
Dynamic Programming	**(05 Hours)**
Characteristic of Dynamic Programming, Formulation, Applications of Dynamic Programming - Capital Budgeting Problem, Shortest Path Problem, Cargo Loading Problem, etc. Solution of Linear Programming Problem Through Dynamic Programming	
Non- Linear Programming	**(05 Hours)**
Introduction, Lagrangean Method, Kuhn-Tucker Conditions, Graphical Method, Quadratic Programming. Separable Programming. Geometric Programming	
Network Analysis	**(05 Hours)**
PERT and CPM Networks, Cost Analysis and Crashing the Network. Updating and Resource Scheduling	
Queuing Theory	**(06 Hours)**
Introduction, Terminologies of Queueing System, Classification of Queueing Models: Probabilistic and Deterministic. Assumptions and Limitations of Queueing Models	
Decision Analysis and Games	**(06 Hours)**
Decision Making Under Certainty – Analytical Hierarchy Process. Introduction to Fuzzy Numbers, Triangular and Trapezoidal Fuzzy Numbers, Membership Function, Fuzzy	

Decision Making. Terminologies of Game Theory, Game with Pure and Mixed Strategies. Dominance Property. Graphical Method and Linear Programming Approach for Game Theory	
Simulation	**(04 Hours)**
Simulation Concepts, Introduction, Advantages and Limitations of Simulation Techniques. Monte Carlo Simulation. Generation of Random Numbers. Applications of Simulation	

(Total Lecture Hours: 45)

3. Books Recommended:

1	P. K. Gupta and D. S. Hira, Operations Research, Third Edition, S. Chand and Company Ltd., New Delhi, 5th edition, 2005
2	J. K. Sharma, Operations Research –Theory and Applications, Macmillan Publishers India Ltd., 4th Edition, 2009
3	F. S. Hillier and G. J. Lieberman, Introduction to Operations Research- Concepts and Cases, Tata Mcgraw Hill, 9th Edition, 2010
4	N. D. Vora, Quantitative Techniques in Management, McGraw Hill Education (India) Private Limited, 4th Edition, 2014
5	H. Taha, Operations Research, Pearson, 10th edition, 2016

MEMF126	:	CONCURRENT ENGINEERING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Support the multi-disciplinary integrated product development teams and Plan and implement a new product development program
CO2	Apply appropriate concurrent engineering tools and techniques to design and develop environment-friendly products by leveraging both manufacturing cost and lifecycle cost
CO3	Determine the customer needs and ensure that the product design is robust and meets the professional standards with better quality
CO4	Design and develop the products with high reliability, maintainability and availability
CO5	Apply the information technology tools for collaborative product design and development.
CO6	Demonstrate the applications of concurrent design of structures, products and components.

2. Syllabus:

Introduction	**(07 Hours)**
Motivation, definition, and philosophy of Concurrent Engineering (CE); sequential and concurrent processes; Principles of CE; Organizing for CE; CE teams and team dynamics; Role of CAD/CAM/CAE/CIM and automation in CE; Managing product development projects; Decomposition of product development stages; Benefits of CE; Implementation issues of CE	
Concurrent Engineering Tools and Techniques	**(22 Hours)**
Design for manufacturing (DFM), Design for assembly (DFA); Factors influencing form design; Casting and machining considerations; Design for manufacturing and Assembly (DFMA) guidelines and examples; Lifecycle design of products with circular economy concept; Design for environment (DFE) with examples; Design for (-to-) cost; Design for X (DFX); Value engineering. Design for quality; Taguchi's methods for designing robust products; Design of Experiments (DOE) with examples; Design optimization; Quality function deployment (QFD) with examples. Design for reliability, maintainability and availability with examples; Failure modes and effects analysis (FMEA); Fault tree analysis (FTA); Rapid prototyping methods; Design simulation; Virtual and augmented reality environments for CE	
Role of Information Technology in Concurrent Engineering	**(08 Hours)**
Information technology (IT) components and functions; Artificial Intelligence for IT operations used for product design; Collaborative product development; Collaborative product commerce, Cloud IoT for CE	
Selected Applications of Concurrent Engineering	**(08 Hours)**

Design of aerospace and naval structures made of composite materials; Design of automotive components; Design of medical devices; Design of electronic products; Design of white goods parts

(Total Lecture Hours: 45)

3. Books Recommended:

1	B. Prasad. Concurrent Engineering Fundamentals I & II, Prentice Hall, New Jersey, 1995, 1996
2	I. Moustapha. Concurrent Engineering in Product Design and Development, New Age International, New Delhi, 2006
3	G. Boothroyd, P. Dewhurst, and W. Knight. Product Design for Manufacture and Assembly, 3rd Edition, Routledge, Boca Raton, 2010
4	J. R. Hartley. Concurrent Engineering: Shortening Lead Times, Raising Quality, and Lowering Costs, 4th Edition, Routledge, Boca Raton, 2017
5	K. T. Ulrich, S. D. Eppinger, and M. C. Yang. Product Design and Development, 7th Edition, McGraw Hill Education (India), Noida, 2020

MEMF128	:	NUMERICAL METHODS IN MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain and compute errors in computer programing
CO2	Develop and analyse transcendental and algebraic equations
CO3	Apply optimality criterion on given real life problem
CO4	Develop regression models using different methods
CO5	Solve identified problems through given differential equations
CO6	Apply different equations and schemes to solve partial differentiation equations

2. Syllabus:

Error Analysis	**(07 Hours)**
Introduction to numerical analysis, Significant figures, round-off, precision and accuracy, approximate and true error, truncation error and Taylor series, machine epsilon, data uncertainties, error propagation, removal of errors in computer programming.	
Transcendental & Algebraic Equations	**(08 Hours)**
Bracketing & open Methods- Bisection, False Position, Newton- Raphson Method, Secant Method. Gauss Elimination, Gauss Jordon applications, Gauss Seidal, LU decomposition, Matrix Inversion	
Single variable optimization	**(08 Hours)**
Single variable optimization: Optimality Criterion, Bracketing methods - Exhaustive Search Method, Bounding Phase Method, Region Elimination Method - Interval Halving Method, Fibonacci Search Method, Golden Section Search Method, Point Estimation Method - Successive quadratic estimation method, Gradient based methods: - Newton Raphson Method, Bisection Method, Secant Method, Cubic Search Method, Root Finding Method using Optimization Technique	
Regression Analysis	**(08 Hours)**
Least Square Method, Linear Regression, Polynomial Regression, Fourier Regression, &Nonlinear Regression. Interpolation- Newton's Forward and backward Interpolation, Newton's Divided Difference Interpolation, Lagrange's Interpolation, Gauss's Central Difference Interpolation. Newton Cotes Integration formulas-Trapezoidal, Simpson, Romberg, Gaussian Quadrature, Numerical Differentiation-Finite Difference Method.	
Solution to Differential Equations	**(07 Hours)**
Types of Differential equations, Picard's Series Method, Taylor Series Method, Euler's Method, Modified Euler's Method, Runge - Kutta Method, Predictor Corrector Method, Milnes Method, and Application to Initial & Boundary value Problems.	
Partial Differentiation Equations	**(07 Hours)**
Introduction to PDE Elliptic, Parabolic & Hyperbolic Equation. Finite Difference Schemes, Forward, Backward, Central Difference, Application to Laplace & Poisson's Equation,	

Iterative & Relaxation Techniques, Laplacian Operator in Cartesian, polar and other coordinate systems. Solution of Parabolic Equations, Implicit & Explicit Schemes, Crank Nicholson, ADI scheme. Solution of Hyperbolic Equations.

(Total Lecture Hours: 45)

3. Books Recommended:

1	Steven C. Chapra, Reymond P. Canale, Numerical Methods for Engineers, Tata McGraw Hill Publications, 2010
2	E. Balagurusamy, Numerical Methods, Tata McGraw Hill Publications, 1999
3	E. Kreyszig, Advanced Engineering Mathematics, Tenth Ed., John Wiley and Sons, 2010
4	Kalyanmoy Deb, Optimization for Engineering Design - Algorithms and Examples, PHI Pvt. Ltd.
5	R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition (second Indian Reprint 2012),Brooks/Cole, 2011.

MEMF130	:	NON DESTRUCTIVE TESTING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the basic concept of NDT and its industrial applications
CO2	Select appropriate NDT technique to identify given defect.
CO3	Identify internal flaw in the part and suggest measures to eliminate it
CO4	Analyse available data using modern tools and softwares
CO5	Introduce environmental friendly solutions to the industrial problem through NDT
CO6	Identify and overcome limitations of NDT technique through alternative techniques

2. Syllabus:

Introduction to NDT, Liquid Penetrant Test	**(07 Hours)**
Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.	
Ultrasonic Testing	**(07 Hours)**
Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection , Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing , Advantages and limitations	
Thermography	**(06 Hours)**
Basic principles, Detectors and equipment, techniques, applications.	
Radiography	**(06 Hours)**
Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.	
Eddy Current Test	**(06 Hours)**
Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations.	
Acoustic Emission	**(06 Hours)**
Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.	
Magnetic Particle Inspection	**(07 Hours)**
Principle of MPT, Procedure used for testing a component, sensitivity, limitations	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Peter J. Shull , Non-destructive Evaluation: Theory, Techniques and Applications, Marcel Dekkar, 1st edition, 2002
2	Ravi Prakash, Non Destructive Testing Techniques, New Age International Publishers, 1st edition, 2010
3	Sadashiva, Non Destructive Testing, Notion Press, 1st edition, 2021
4	ASM Metals Hand Book, Non Destructive Testing and Quality Control, Vol. 17, ASM, 1989.
5	Mix Paul, Introduction to NDT: A training guide, John Wiley and Sons, 2nd edition, 2005

MEMF132	:	INTELLIGENT MANUFACTURING SYSTEMS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need and capability of AI based manufacturing system
CO2	Identify the characteristics and components of knowledge based expert systems
CO3	Apply probability and fuzzy logic for machine thinking
CO4	Apply the ANN modeling to identified manufacturing problem
CO5	Develop the knowledge based GT for selected automation system
CO6	Design an intelligent system for various manufacturing systems

2. Syllabus:

Concepts of Artificial Intelligence	**(09 Hours)**
Origin of Artificial Intelligence, Human and machine Intelligence, Branches of artificial intelligence, Programming in AI environment, Emergence of expert systems, Applications in Engineering and Manufacturing , Intelligent Manufacturing Systems – System components, System Architecture and Data Flow and System Operation	
Knowledge Based Systems/Expert Systems	**(12 Hours)**
Expert systems: Expert system process, characteristics and components of expert systems, Knowledge Acquisition: Knowledge acquisition phases, Methods of extracting knowledge from experts, Knowledge acquisition meetings, Group knowledge acquisition, Knowledge Representation: Characteristics of knowledge, Knowledge representation models, Concepts of knowledge sets and Reasoning models. Expert system justification and future directions for expert systems	
Machine Learning	**(10 Hours)**
Machine Learning – Concept, Artificial Neural Networks, Biological and Artificial Neuron, Types of Neural Networks, Applications in manufacturing, Use of probability and fuzzy logic for machine thinking	
Knowledge Based Group Technology	**(09 Hours)**
Group Technology: Models and Algorithms – Visual method, Coding method, Cluster analysis method , Knowledge based group technology – Group technology in automated manufacturing system, Structure of knowledge based system for group technology (KBSGT) – Database, Knowledge base, Clustering algorithm.	
Industrial Applications of AI	**(05 Hours)**
Intelligent system for design, equipment selection, scheduling, material selection, maintenance, facility planning and process control	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Michael Negnevitsky, Artificial Intelligence: A guide to Intelligent systems, Pearson, 3rd edition, 2020
2	A. B. Badiru, Expert Systems Applications in Engineering and Manufacturing, Prentice-Hall, New Jersey, 1992
3	Andrew Kussiak, Intelligent Manufacturing Systems, Prentice Hall, 1990
4	Kishan Mehrotra, Elements of Artificial Neural Network, Penram International Publishing Pvt Ltd; 2nd edition, 2009
5	Rajendra Akerkar, Knowledge based Systems, Jones & Bartlett, 1st edition, 2009

MEMF134	:	LOGISTICS AND SUPPLY CHAIN MANAGEMENT	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the elements and functions of supply chain, role of drivers and demand forecasting
CO2	Describe the increasing significance of logistics and its impact on both costs and service
CO3	Build strategic framework to analyse supply chain of selected industries
CO4	Apply various techniques for managing inventory and transport network for selected situations
CO5	Apply suitable pricing and revenue management using information technology tools
CO6	Develop criteria to achieve improved performance by integrating and optimizing the logistics and supply-chain process

2. Syllabus:

Logistics and Supply Chain Management	**(04 Hours)**
Logistics Management-An Introduction, Key actors, Classification of Logistics Applications, Total logistics cost, Logistics to supply chain Management	
Building a Strategic Framework to Analyze Supply Chains	**(06 Hours)**
Historical evolution of supply chain, Understanding the supply chain, supply chain performance: achieving strategic fit, supply chain drivers and metrics and case studies.	
Designing the Supply Chain Network	**(07 Hours)**
Designing distribution networks and applications to e-business, network design in the supply chain, network design in an uncertain environment, and case studies	
Planning Demand and Supply in a Supply Chain	**(07 Hours)**
Demand forecasting strategy in a supply chain, aggregate planning in a supply chain, sales and operation planning: Planning supply and demand in a supply chain, and case studies	
Planning and Managing Inventories in a Supply Chain	**(08 Hours)**
Managing economies of scale in a supply chain: cycle inventory, managing uncertainty in a supply chain: safety inventory, determining the optimal level of product availability, and case studies	
Designing and Planning Transportation Networks	**(05 Hours)**
Transportation strategy in a Supply Chain and case studies	
Managing Cross-Functional Drivers in a Supply Chain	**(08 Hours)**
Sourcing decisions in a supply chain, pricing and revenue management in a supply chain, information technology in a supply chain, coordination in a supply chain, and case studies	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Sunil Chopra and Peter Meindel. Supply Chain Management: Strategy, Planning, and Operation, Pearson Education, 2010
2	Martin Christopher. Logistics and Supply Chain Management: Strategies for Reducing cost and Improving Services, Pearson Education, 2010
3	David Simchi Levi, Philip kaminsky, and Edith Simchi Levi. Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies. Irwin McGrawHill, 2000
4	Bowersox, Supply Chain Logistics Management, McGraw Hill Education, 4th edition, 2018
5	Raghuram and Rangaraj, Logistics and Supply chain management: Cases and concepts, Laxmi Publications, 1st edition, 2015

MEMF136	:	MICRO AND NANO MANUFACTURING	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify and describe micro and nano manufacturing processes based on applications
CO2	Explain and select suitable micro machining/ micro forming/ MEMS processes based on given parameters and constraints
CO3	Explain and select suitable MEMS/NEMS technique for identified application.
CO4	Distinguish between the requirements for micro and nano manufacturing processes
CO5	Recommend a suitable nano- manufacturing process for a given application.
CO6	Propose suitable metrological technique for measuring micro and nano features.

2. Syllabus:

Introduction	**(03 Hours)**
Introduction to miniaturization and its needs, scaling laws, micro products and design considerations, classification, selection of micro machining processes, applications	
Micro Machining Processes	**(14 Hours)**
Evolution and Principle of micromachining, micro turning, micro milling, micro grinding, ultrasonic micro machining, abrasive jet micro machining, micro electro discharge machining, micro electro chemical machining, laser micro machining	
Micro Forming Processes	**(09 Hours)**
Micro scale plastic deformation, size effect, micro deep drawing, micro extrusion, micro punching, micro blanking, micro fabrication using bulk metallic glasses, flow induced defects.	
MEMS and NEMS Techniques	**(07 Hours)**
Classification, principle and working, photo lithography, chemical etching, LIGA, materials	
Introduction to Nano Manufacturing	**(08 Hours)**
Transition from nano technology to nano manufacturing; diamond turn machining; nano joining, nano soldering, nano welding, mechanical bonding, fastening; chemical vapor deposition, scanning tunnelling microscopy, nano lithography	
Abrasive Based Nano Finishing Processes	**(04 Hours)**
Abrasive flow finishing, chemo-mechanical polishing, magnetic abrasive finishing, magnetorheological finishing, magnetorheological abrasive flow finishing, magnetic float polishing, hybrid nanofinishing: chemo-mechanical magnetorheological finishing, electrochemical magnetic abrasive finishing	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Kei Cheng & Dehong Heo, Micro Cutting : Fundamentals and Applications, John Willey & Sons, 2013
2	V K Jain, Micromanufacturing Processes, CRC Press, 2013
3	Mark J. Jackson, Micromachining with Nanostructured Cutting Tools, Springer, 2013
4	N. Maluf and K. Williams, Introduction to MEMS Engineering, 2nd edition, Artechhouse, 2004
5	V K Jain, Nanofinishing Science and Technology, CRC Press, 2017

MEMF138	:	BIO INSPIRED MATERIALS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need and applications of biomaterials
CO2	Identify biomaterials from desired properties for medical applications
CO3	Identify suitable metallic and ceramic materials for identified application
CO4	Identify the requirements for cardiovascular and orthopaedic implants
CO5	Select suitable material for tissue engineering and regeneration
CO6	Explain the effect of degradation of materials in biological environment

2. Syllabus:

Introduction to Biomaterials	**(05 Hours)**
Introduction to materials at the interface with biological sciences, Brief historical background, Requirement of biomaterials, classification of biomaterials, Class of materials used in the body, application of biomaterials, tissue engineering	
Desired properties in biomaterials for medical applications	**(04 Hours)**
Performance of biomaterials, Properties: Biocompatibility, nontoxic, mechanical properties (strength, wear, fatigue) Corrosion resistance, Osseointegration	
Permanent Metallic implant bio materials	**(05 Hours)**
Stainless steels, Co-Cr alloys, Ti based alloys, Ta based alloys. **Biodegradable Metals:** Mg based alloys, Zn based alloys, Fe based alloys, Limitation of biomaterials	
Ceramic Materials	**(07 Hours)**
Ceramic implant materials, alumina, yittria stabilized zirconia, hydroxyapatite glass ceramics carbons, restorable ceramics, composites. **Polymeric implant materials**: Polymers in biomedical use, polyethylene, polypropylene, acrylic polymer, hydrogels, polyurethans, polyamides, biodegradable synthetic polymers, silicon rubber, microorganisms in polymeric implants, polymer sterilization	
Dental Materials	**(06 Hours)**
Tooth composition and mechanical properties, impression materials, bones, liners, and varnishes for cavities, filling and restorative materials, oral implants, use of collagen in dentistry	
Cardiovascular and Orthopedic implants	**(06 Hours)**
Artificial heart, aorta and valves, geometry of circulation, vascular implants, cardiac pace makers, bone composition and properties, fracture healing, joint replacement, knee joint repair, bone regeneration with restorable materials	
Tissue Engineering Materials and Regeneration	**(06 Hours)**
Substrate scaffolds materials, cellular aspects, viability, stem cells, bladder regeneration, cartilage regeneration, skin regeneration, regeneration in cardiovascular system	

Degradation of Materials in the biological environment	**(06 Hours)**
Chemical and biochemical degradation of polymers, degradation effects on metals and ceramics, pathological classification of biomaterials	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoen and Lemons, Second Edition: Elsevier Academic Press, 2004
2	Biological Performance of Materials: Fundamentals of Biocompatibility, Jonathan Black, Marcel Dekker, Inc., New York and Basel, 1981
3	Park J.B. and Bronzino J.D., Biomaterials: Principals and Applications, CRC Press, 2003
4	Park J.B. and Lakes R.S., Biomaterials: An Introduction, 3rd edition, Springer press, 2007
5	Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing, 2007

MEMF140	:	DESIGN OF EXPERIMENTS	L	T	P	Credits
			3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate objective(s) and identify key factors in designing experiments for a given problem
CO2	Develop appropriate experimental design to conduct experiments for a given problem
CO3	Identify randomization, replication, blocking and degree of freedom based on given parameters and their levels
CO4	Analyze experimental data to derive valid conclusions
CO5	Optimize process conditions by developing empirical models using experimental data
CO6	Design robust products and processes using parameter design approach

2. Syllabus:

Fundamentals of Experimentation	**(05 Hours)**
Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation	
Fundamentals of Design of Experiments	**(06 Hours)**
Basic principles – randomization, replication, blocking, degree of freedom, confounding, selection of quality characteristics, Signal to Noise ratio	
Simple Comparative Experiments	**(07 Hours)**
Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA; understanding main effect and interaction effect	
Experimental Designs	**(07 Hours)**
Practical methodology for DoE, Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data	
Response Surface Methodology	**(10 Hours)**
Concept, linear model, steepest ascent, second order model, regression	
Taguchi's Parameter Design	**(10 Hours)**
Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis	

(Total Lecture Hours: 45)

3. Books Recommended:

1	Ross P.J., Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, New York, 1st edition, 2008
2	Montgomery D.C, Design and Analysis of Experiments, John Wiley & Sons, New York, 7th Edition, 2008
3	Jiju Antony, Design of Experiments for Engineers and Scientists, Elsevier, 2nd edition, 2018
4	Colin Hardwick, Practical Design of Experiments, Create Space Independent Publisher, 1st edition, 2013
5	Madhav Phadke, Quality Engineering using Robust Design, Pearson Education, 1st edition, 1989