VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

M.Tech Manufacturing Engineering

Curriculum & Syllabi

(*2023-2024 batch onwards*)

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(Deemed to be University under section 3 of UGC Act, 1956)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To be a leader in imparting world class education in Mechanical Engineering, with a vision to nurture scientists and technocrats of the highest caliber engaged in global sustainable development.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To create and maintain an environment fostering excellence in instruction & learning, Research and Innovation in Mechanical Engineering and Allied Disciplines.
- To equip students with the required knowledge and skills to engage seamlessly in higher educational and employment sectors ensuring that societal demands are met.

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M. Tech Manufacturing Engineering

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment.

PO_03: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information.

PO_04: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice.

PO_05: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems.

PO_06: Having adaptive thinking and adaptability in relation to environmental context and sustainable development.

PO_07: Having a clear understanding of professional and ethical responsibility.

PO_08: Having a good cognitive load management skills related to project management and finance.

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M. Tech Manufacturing Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Manufacturing Engineering) programme, graduates will be able to

- **PSO_1:** Prepare process plan, simulate manufacturing processes and establish production systems for the physical realisation of components and products
- **PSO_2:** Conduct experimental investigations and incorporate latest technologies for improving manufacturing processes
- **PSO_3:** Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document

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M. Tech Mechanical Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

Agenda Item 67/13

To consider and approve the revised programme credit structure, curriculum and course contents of Master of Technology in Manufacturing Engineering

ANNEXURE – 17

Master of Technology in Manufacturing Engineering

School of Mechanical Engineering

Programme Credit Structure	**Credits**
Discipline Core Courses	24
Skill Enhancement Courses	05
Discipline Elective Courses	12
Open Elective Courses	03
Project/ Internship	26
Total Graded Credit Requirement	70

Discipline Core Courses **24**

		L	T	P	C
MMAE501L	Advanced Materials and Characterization	3	0	0	3
MMAE502L	Finite Element Methods in Manufacturing	3	0	0	3
MMAE502P	Finite Element Methods in Manufacturing Lab	0	0	2	1
MMAE503L	Additive Manufacturing Technology	3	0	0	3
MMAE503P	Additive Manufacturing Technology Lab	0	0	2	1
MMAE504L	Theory of Metal Forming	3	0	0	3
MMAE505L	Mechatronics and Automation	3	0	0	3
MMAE505P	Mechatronics and Automation Lab	0	0	2	1
MMAE506L	Modern Machining Processes	3	0	0	3
MMAE507L	Computer Integrated Manufacturing	3	0	0	3

Skill Enhancement Courses **05**

MENG501P	Technical Report Writing	0	0	4	2
MSTS501P	Qualitative Skills Practice	0	0	3	1.5
MSTS502P	Quantitative Skills Practice	0	0	3	1.5

Discipline Elective Courses **12**

MMAE601L	Metrology and Non-destructive Testing	3	0	0	3
MMAE602L	Optimization Techniques	2	1	0	3
MMAE603L	Micro and Nano Manufacturing	3	0	0	3
MMAE604L	Sustainable Manufacturing	3	0	0	3
MMAE605L	Supply Chain and Logistics Management	3	0	0	3
MMAE606L	Maintenance Engineering	3	0	0	3
MMAE607L	Manufacturing Information Systems	3	0	0	3
MMAE608L	Design and Analysis of Experiments	2	1	0	3
MMAE609L	Advanced Tool Engineering	3	0	0	3
MMAE610L	Casting and Welding Technology	3	0	0	3
MMAE610P	Casting and Welding Technology Lab	0	0	2	1
MMAE611L	Quality and Reliability Engineering	3	0	0	3

Open Elective Courses **03**

Engineering Disciplines | Social Sciences

Project and Internship **26**

MMAE696J	Study Oriented Project	02
MMAE697J	Design Project	02
MMAE698J	Internship I/ Dissertation I	10
MMAE699J	Internship II/ Dissertation II	12

Course Code	Course Title	L	T	P	C
MMAE501L	Advanced Materials and Characterization	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide insight into the various material classes, their mechanical properties, and their applications
2. To impart knowledge on various Materials and alloy selection.
3. To enable acquire skills in the use and selection of advanced experimental techniques for characterization of materials and application of these techniques to solving problems in materials science and engineering

Course Outcome

1. Describe the mechanical behaviour of materials, their importance and applications
2. Explain various engineering alloys in terms of specifications, applications, and heat treatment
3. Demonstrate the acquired skills in analysing the properties and applications of modern materials and alloys
4. Identify methods for use on characterization based on microscopy, microanalysis and diffraction techniques, and surface and spectroscopy analysi
5. Apply advanced lighting, thermal, chemical and imaging techniques for materials characterization particularly of the most widely used thin films, nanomaterials and advanced materials

Module:1	Mechanical Behavior of Materials	7 hours

Engineering stress - strain curve and true stress - strain curve, tensile properties, S - N curve, fatigue testing, factors affecting fatigue properties, structural features of fatigue failures, statistical nature of fatigue, low and high cycle fatigue. Impact test - Izod and Charpy tests, significance of transition - temperature curve, DBTT, factors affecting transition temperature, types of fracture, Griffith's theory of brittle fracture, size effect, effect of temperature, stress raisers and strain rate on fracture behaviour.

Module:2	Material and Alloy Selection	5 hours

Selection strategy, property limits and material indices, function objectives and constants, performance maximizing criteria, strengthening mechanisms. Material property charts: Modulus - density, strength - density, modulus - strength, specific stiffness - specific strength, fracture toughness etc. Materials selection- case studies.

Module:3	Engineering Alloy	5 hours

Cast iron, steels, alloy steels and stainless steels – an overview of phases and microstructure, types, specifications applications, heat treatment, effect of alloying elements, Aluminum, Magnesium and Titanium wrought and cast alloys used in engineering applications –Types, phases and microstructure, specifications, applications, heat treatment.

Module:4	Non-Metallic Materials	5 hours

Composite materials, ceramics, plastics -Introduction, classification, an overview of processing, their characteristic features (Mechanical, optical, electrical and thermal behaviour), types and applications.

Module:5	Modern Materials and Alloys	5 hours

Super alloys- Refractory metals - Shape memory alloys- Dual phase steels, Micro alloyed, High strength low alloy steel, Transformation induced plasticity (TRIP) steel, Maraging steel Compacted graphite iron and Creep resistant aluminium alloys, SMART materials, Metallic glass – Quasi crystal and Nano crystalline materials, metal foams

Module:6	Characterization Techniques I	8 hours

Optical Microscopy, Elements of Image Analysis and Quantitative Metallography, Scanning Electron Microscopy, Modes of Operation, Fractography, Chemical Analysis using Energy Dispersive Analysis – Transmission Electron Microscopy Principles, Thin Film and Replication Techniques, Image Contrast, Bright Field and Dark Field Imaging, Selected Area Diffraction and Chemical Analysis – Thermal Analysis Methods		
Module:7	**Characterization Techniques II**	**8 hours**
X-Ray Diffraction, Intensity of diffracted beam, Indexing of XRD patterns of cubic and non-cubic crystals, precise lattice parameter determination, Introduction to Energy Dispersive Spectroscopy (EDS)- quantification of elemental composition, Fourier transform infrared Spectroscopy (FTIR) - measurement of chemical bonding, X-ray photoelectron spectroscopy (XPS) - measurement of chemical state of the materials.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	W.D. Callister, David G. Rethwisch, (2013) Materials Science and Engineering: An Introduction, 9th ed., Wiley & Sons Michael F Ashby, “Materials Selection in Mechanical Design”, Butterworth Heinemann, 2005.

Reference Books

1.	William F. Hosford (2010), Mechanical Behavior of Materials, Cambridge University Press
2.	Dieter, G. E., & Bacon, D. (1976). Mechanical metallurgy (Vol. 3). New York: McGraw-hill.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Lab / Seminar

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE502L	Finite Element Methods in Manufacturing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To teach the mathematical and physical principles underlying the Finite Element Method (FEM)
2. To introduce the concepts of FEM and to apply in the field of Manufacturing Engineering

Course Outcome

1. Solve differential equations using various weighted residual methods and use them for finite element analysis.
2. Perform structural analysis of using 1 D and 2 D elements
3. Perform thermal analysis using 1 D and 2 D elements
4. Model various nonlinearities to perform nonlinear finite element analysis
5. Model and simulate manufacturing processes such as welding, casting, metal forming and metal cutting

Module:1	**Mathematical basis for FEM**	**6 hours**

General field problems in engineering-Discrete and continuous models characteristics – Variational formulation of boundary value problems–Minimum potential energy principle - The method of weighted residuals-Solution of large system of equations - Gaussian elimination procedures.

Module:2	**General theory of FEM**	**5 hours**

General theory of FEM–Procedure for FEM - Discretization of domain - Selection of interpolation polynomials–Convergence requirements- Shape functions for simplex elements.

Module:3	**FEM for one dimensional structural analysis**	**8 hours**

Element characteristic matrices and vectors for elasticity problem - Assembly of element characteristics matrices–Incorporation of boundary conditions - Solution of the equations- Post processing –Solving problems in structural mechanics using bar, truss and beam elements.

Module:4	**FEM for two dimensional solid mechanics**	**6 hours**

Plane stress, plane strain and axisymmetric stress analysis using constant strain trainable and rectangular element - Natural coordinate systems and numerical integration.

Module:5	**FEM for Heat transfer**	**6 hours**

Formulation of element equation for heat transfer considering conduction and convection loss - One dimensional, two dimensional and axisymmetric steady state heat transfer analysis using simplex elements – Introduction to transient heat transfer analysis.

Module:6	**Basic concepts of nonlinear FEM**	**6 hours**

Nonlinear problems – Analysis of material nonlinearity - Analysis of geometric nonlinearity – combined material and geometric nonlinearity – nonlinear contact conditions.

Module:7	**Applications of FEA in Manufacturing**	**6 hours**

FE analysis of casting and Weldments solidification – special considerations, latent heat incorporation - Case studies.

FE analysis of metal forming and metal cutting, chip separation criteria, incorporation of strain rate dependency- Case studies.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Reddy. J.N., An Introduction to Finite Element Method, 2020, 4th Edition, McGraw Hill, Noida, India
Reference Books	
1.	Rao. S.S., The Finite Element Method in Engineering, 2019, 6th Edition, Elsevier, Haryana, India
2	Prakash Mahadeo Dixit, Uday S. Dixit, Modeling of Metal Forming and Machining Processes: By Finite Element and Soft Computing Methods, 2010, 1st Edition, Springer-Verlag Ltd. India.
3	Reddy. J.N., An Introduction to Nonlinear Finite Element Analysis: with applications to heat transfer, fluid mechanics, and solid mechanics, 2014, 2nd Edition, OUP Oxford

Mode of Evaluation: CAT, written assignment, FAT, Seminar / Quiz			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE502P	Finite Element Methods in Manufacturing Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide experience in performing Finite Element Analysis using commercial software or by using a computer program
2. To provide capabilities to simulate simple manufacturing processes using Finite Element Analysis

Course Outcome

1. Perform finite element analysis on simple real life components
2. Simulate and Analyse simplified manufacturing processes

Indicative Experiments	
1.	Finite Element Analysis of structural problem.
2.	Finite Element Analysis of Heat transfer problems
3.	Finite Element Analysis of fluid flow problems
4.	Finite Element Analysis of nonlinear continuum mechanics problems
5.	Dynamic and normal Mode Dynamic Analysis using FEA Technique.
6.	Finite element analysis of contact analysis
7	Simulation of welding as a moving heat source problem
8	Simulation of a simple upsetting process
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Reddy. J.N., An Introduction to Finite Element Method, 2020, 4th Edition, McGraw Hill, Noida, India

Reference Books

1.	Rao. S.S., The Finite Element Method in Engineering, 2019, 6th Edition, Elsevier, Haryana, India
2	Prakash Mahadeo Dixit, Uday S. Dixit, Modeling of Metal Forming and Machining Processes: By Finite Element and Soft Computing Methods, 2010, 1st Edition, Springer-Verlag Ltd. India.
3	Reddy. J.N., An Introduction to Nonlinear Finite Element Analysis: with applications to heat transfer, fluid mechanics, and solid mechanics, 2014, 2nd Edition, OUP Oxford

Mode of assessment: Continuous assessment & FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE503L	Additive Manufacturing Technology	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.
2. Able to design and print 3D components using various printing tools.
3. Apply digital manufacturing technologies to various facets of human endeavor.

Course Outcome

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

1. Understanding the concepts, capabilities and limitations of additive technologies and their varied applications.
2. Identifying the suitable file format and data processing technique for AM systems using software.
3. Proposing suitable material and AM systems for specific requirement.
4. Applying design for additive manufacturing guidelines in designing mass customized products.
5. Suggesting the appropriate post processing technique to improve the quality of printed part.
6. Designing appropriate rapid tools for any given medical and automobile applications.

Module:1	Introduction	4 hours

Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM, Design Freedom in AM, Rapid Tooling and Reverse Engineering

Module:2	Process Planning for Additive Manufacturing	7 hours

3D model data creation, Concept of reverse engineering, Data collection, Modelling for printing, file formats: STL, OBJ, AMF, 3MF, CLI, STL file errors, Correction and printability analysis, Optimization of part orientation and support structure generation, Types of supports, Slicing parameters, Tool path generation.

Module:3	Additive Manufacturing Processes	8 hours

Basic principles of the Additive Manufacturing process, Generation of layer information, Physical principles for layer generation. Elements for generating the physical Layer, Classification of Additive Manufacturing processes, Overview of polymerization: Stereo-lithography (SL)-Photopolymerisation, Selective Laser Sintering/Melting in the Powder Bed, Layer Laminate Manufacturing (LLM), Three-Dimensional Printing (3DP), Wire and powder based Direct Energy Deposition technologies, Material Jetting, Binder Jetting, and Hybrid AM Processes.

Module:4	Materials for AM	6 hours

Multifunctional and graded materials in AM, Atomic structure and bonding, Nature of polymers, Thermoplastics and thermosetting polymers, Types of polymerizations, Properties of polymers, Degradation of polymers, Metal and Ceramic Powders, Composites, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship, and Case studies.

Module:5	Design for Additive Manufacturing	6 hours

Introduction to geometric modelling, Modelling of synthetic curves like Hermite, Bezier and B-spline, Parametric representation of freeform surfaces, Design freedom with AM, Need for design for Additive Manufacturing (DfAM), CAD tools vs. DfAM tools, Requirements of DfAM methods, General guidelines for DfAM, The economics of Additive Manufacturing, Design to minimize print time, Design to minimize post-processing.

Module:6	Post-Processing for Additive Manufacturing	6 hours

Support structure removal, Surface texture improvement, Surface treatments of Polymer & metal, Heat treatment, HIP & residual stress relieving, UV curing, Cleaning & de-powdering, Machining, Surface coating and Infiltration.		
Module:7	**Rapid Tooling & Reverse Engineering**	**6 hours**
Conventional tooling, Rapid tooling, Differences between conventional and rapid tooling, Classification of rapid tooling: Direct and indirect tooling methods, Soft, Bridge (firm) and Hard tooling methods, Rapid tooling for investment casting, Re-Engineering–Hardware and software: Contact methods, Noncontact methods, Destructive method, Point capture devices, Tracking systems, Internal measurement systems, X-ray Tomography, & Destructive systems		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	C P Paul , A N Jinoop, Additive Manufacturing – Pricniples, technologies and Applications, Mc Graw Hill Publication, 2021.
Reference Books	
1.	Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
2.	Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer Nature Singapore Pte Ltd., 2020.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Lab / Seminar

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE503P	Additive Manufacturing Technology Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.
2. Able to design and print 3D components using various printing tools.
3. Apply digital manufacturing technologies to various facets of human endeavor.

Course Outcome

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

1. Understanding the concepts, capabilities and limitations of additive technologies and their varied applications.
2. Identifying the suitable file format and data processing technique for AM systems using software.
3. Proposing suitable material and AM systems for specific requirement.
4. Applying design for additive manufacturing guidelines in designing mass customized products.
5. Suggesting the appropriate post processing technique to improve the quality of printed part.
6. Designing appropriate rapid tools for any given medical and automobile applications.

Indicative Experiments

1.	Generating a 3D CAD model by Reverse Engineering (UV-Scanner)
2.	Generating a complicated 3D model with freeform surface (Rhinoceros 7)
3.	Generating a model and storing it in .STL format. Calculating the number of triangles required to store the model in .STL format. (Rhinoceros 7)
4.	Performing the slicing operation on the .STL file generated in Problem -3. Proposing the suitable part orientation and support structure design with software (Repeiter/Cura/Pursa).
5.	Calculating the build time required to print complicated 3D model by keeping layer thickness and infill density 0.2mm and 10% respectively. (Repeiter/Cura/Pursa).
6.	Evaluating the dimensional accuracy of the part printed by FDM
7.	Evaluating the dimensional accuracy of the part printed by SLA
8.	Evaluating the dimensional accuracy of the part printed by SLS
9.	Designing a split pattern for sand casting and printing it with FDM, Producing a metal casting in foundry lab., using this 3D printed pattern.
10	Preparing the build set-up for metal 3D printer
11.	Working on process parameter (Laser power, scan speed, hatch width, hatch space, etc.)
12.	Fabrication and post processing of metal part (Support removal, surface treatment, etc.)
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	C P Paul , A N Jinoop, Additive Manufacturing – Pricniples, technologies and Applications, Mc Graw Hill Publication, 2021.

Reference Books

1.	Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.

2.	Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing, Springer Nature Singapore Pte Ltd., 2020.		
Mode of assessment: Continuous assessment / FAT / Oral examination and others			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE504L	Theory of Metal Forming	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Select suitable forming techniques for various applications
2. Calculate the forming limit for various processes

Course Outcome

Upon successful completion of the course the students will be able to

1. Demonstrate the application of the theory of plasticity and understand the mechanics, flow stress, temperature, and friction in metal forming processes.
2. Apply forging load calculations to evaluate the flow stress and their impact on the quality of the product.
3. Analyse various forces that occur in a rolling process
4. Analyse the extrusion process in terms of deformation, lubrication, and defects
5. Evaluate the wire and tube drawing processes in terms of flow stress, performance, and residual stresses
6. Determine the application of various sheet metal forming methods
7. Evaluate the flow stress and strains when forming a component by conventional and unconventional forming methods.

Module:1	**Fundamentals of Metal working**	**8 hours**

Theory of Plasticity - stress tensor – hydrostatic & deviator components of stress – flow curve – true stress strain – yielding criteria – yield locus – octahedral shear stress and shear strains – invariants of stress strain – slip line field theory plastic deformations of crystals. Classification of Forming Process, Mechanics of Metal working, Flow Stress determination, Temperature in Metalworking, Friction and Lubrication, Workability, Residual Stresses

Module:2	**Forging**	**6 hours**

Classification of forging process, Forging equipment, Forging in plain strain condition, Open and closed die forging, Calculation of forging loads in closed-die forging, Forging defects, Powder Metallurgy in forging

Module:3	**Rolling of Metals**	**6 hours**

Classification of Rolling, Rolling mills, Hot-Rolling, Cold-Rolling, Rolling of bars and shapes, Forces and Geometrical Relationship in rolling, Problems and defects in rolled products

Module:4	**Extrusion**	**6 hours**

Classification, Extrusion equipment's, Deformation, Lubrication and Defects in extrusion process, Analysis of the extrusion process, Hydrostatic extrusion, extrusion of tubing.

Module:5	**Drawing of Rods, Wires and Tubes**	**6 hours**

Rod and wire drawing, Analysis of wire drawing, Tube-drawing processes, Analysis of Tube drawing, Residual stresses in Rod, Wire and Tubes

Module:6	**Sheet-Metal forming**	**6 hours**

Forming Methods, Shearing and blanking, Bending, Stretch forming, Deep drawing, Forming Limit Criteria, Defects in formed products

Module:7	**Advances in Metal Forming**	**5 hours**

Explosive forming, Electro hydraulic forming, magnetic pulse forming, super plastic forming, electro forming – fine blanking HERF. FEM in metal forming

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. George E Dieter (2014), Mechanical Metallurgy, Third Edition Tata McGraw Hill. Education PVT Ltd

2.	Helmi A. Youssef, Hassan A. El-Hofy, Mahmoud H. Ahmed, (2011), Manufacturing Technology: Materials, Processes, and Equipment, CRC Press, Taylor & Francis Group		
Reference Books			
1.	Heinz Tschaetsch,(2005), Metal Forming Practise, Springer Berlin Heidelberg New York		
2.	B.L.Juneja, (2012), Fundamentals of Metal Forming Processes, Second Edition, New Age International,		
3.	Marciniak,Z., Duncan J.L., Hu S.J., (2006), Mechanics of Sheet Metal Forming', Butterworth-Heinemann, An Imprint of Elsevier		
4.	Hingole Rahulkumar Shivajirao. (2015), Advances in Metal Forming Expert System for Metal Forming, Springer Publications.		
	Authors, book title, year of publication, edition number, press, place		
Mode of Evaluation: CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE505L	Mechatronics and Automation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide the interdisciplinary knowledge in mechanical, electrical, and control systems for developing mechatronic components in automation.
2. To introduce sensing, actuating and control elements of a mechatronics system.
3. To provide hands on experience in automation with hydraulics, pneumatics and PLC controls.

Course Outcome

1. Select suitable elements for mechatronics application.
2. Able to select the controller for mechatronic systems for industrial control applications.
3. Select suitable drives for a mechatronic application.
4. Design a hydraulic and pneumatic circuit for a automaton applications.
5. Understand the operation and programming of CNC machines and industrial robots.
6. Explore and comprehend the newer technologies in industrial automation.

Module:1	**Elements of Mechatronics**	**5 hours**

Mechatronics key elements - applications in manufacturing- design process. Review of electronics - Mechatronics elements - sensors, signal processing and data conversion devices, relays, contactors, and timers.

Module:2	**Controllers in Mechatronic Systems**	**7 hours**

Architecture and applications of single board microprocessors, microcontrollers, PID controllers and programmable logic controllers.

Module:3	**Drives and Mechanisms**	**7 hours**

Electric drives: AC/DC motors, stepper motors, servo motors and motor drivers. Mechanisms - linear motion bearing, cam, electronic cam, indexing mechanism, magazine, and transfer system in machine tools.

Module:4	**Hydraulic Systems**	**7 hours**

Hydraulic Valves: Flow, pressure, and direction control valves. Hydraulic actuators - hydraulic pumps and power packs - Design of hydraulic circuits.

Module:5	**Pneumatic Systems**	**6 hours**

Production, distribution and conditioning of compressed air, pneumatic system components- Design of pneumatic circuits.

Module:6	**CNC Technology and Robotics**	**6 hours**

CNC machines: components and control system - part programming. Industrial Robotics- configurations, kinematics, and programming methods.

Module:7	**Mechatronics in Industrial Automation**	**5 hours**

Applications of mechatronics industrial automation - Automated material handling system, Automated assembly, and automated inspections system. Digital/smart manufacturing.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book

1. William Bolton (2018). Mechatronics: Electronic control systems in mechanical and electrical engineering, Pearson Education Ltd. UK.

Reference Books

1. Silva C WD, Khoshnoud F, Saman K. Halgamuge, Maoqing Li. (2015) Mechatronics:

	Fundamentals and Applications. United Kingdom: CRC Press.		
2.	Bradley, D. (2018). Mechatronics: Electronics in Products and Processes. United Kingdom: CRC Press.		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Seminar			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE505P	Mechatronics and Automation Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Understand the basic hydraulic and pneumatic system and their techniques
2. To understand the concept and principle operation of automation systems and their controls.

Course Outcome

1. Recognize the concepts of different hydraulic and pneumatic combination systems.
2. Understand the concepts of different electrical controls in fluid power.

Indicative Experiments	
1.	PLC programming for simple industrial control problems with logic, timers and counters, data manipulation and math instructions.
2.	Interfacing digital input and output field devices with PLC hardware.
3.	Interfacing analog field devices with PLC.
4.	Control of conveyor and material handling system using PLC system
5.	Control of AC/DC/Servo motor drives for a motion control application.
6.	PLC control of electro-pneumatic and electro-hydraulic systems.
7.	Development and analysis of fluid power circuits with AUTOMATION STUDIO software
8.	Industrial robot programming for a material handling and processing applications
9.	Development HMI and SCADA system for simple industrial application.
10.	Physical modeling and analysis of mechanical systems with MATLAB\SIMULINK \ SIMSCAPE software.
Total Laboratory Hours	**30 hours**

Text Book(s)

1. Esposito, Anthony. Fluid power with applications. Upper Saddle River, New Jersey: Prentice Hall, 2000.
2. Parr, Andrew. Hydraulics and pneumatics: a technician's and engineer's guide. Elsevier, 2011.

Reference Books

1. Johnson, James. Introduction to fluid power. Cengage Learning, 2002.
2. Watton, John. Modelling, monitoring and diagnostic techniques for fluid power systems. Springer Science & Business Media, 2007.

Mode of assessment: Continuous assessment / FAT / Oral examination and others

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE506L	Modern Machining Processes	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To understand the influence of various machining parameters on the machining processes
2. To develop models for modern machining processes to analyse the machining performances
3. To provide knowledge in applied aspects of various modern machining processes

Course Outcome

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

1. Explain the working principle, process capabilities and applications of modern machining / finishing processes
2. Develop models for estimation of cutting forces, power requirements, tool wear, material removal and surface roughness for various machining processes
3. Analyse the inter-relationship between the process parameters and machining performances
4. Select an appropriate modern machining / finishing process for manufacturing of given macro / micro components / features

Module:1	**Analysis of conventional machining**	**6 hours**

Analysis of material removal in conventional machining – shear angle solutions, stress and strain in primary deformation zone; heat generation in machining, tool wear and tool life; machinability

Module:2	**High speed machining (HSM)**	**6 hours**

Characteristics of HSM, Machine tools requirements for HSM, Cutting tool materials for HSM, Design of tools for HSM, Tool clamping systems, Applications of HSM; High performance machining

Module:3	**Unconventional machining processes – I**	**7 hours**

Water jet machining, Abrasive water jet machining, Ultrasonic machining – working principle, machining system, process variables, parametric analysis, process capabilities and applications.

Module:4	**Unconventional machining processes – II**	**8 hours**

Electrochemical machining, Electric discharge machining, Laser beam machining, Electron beam machining, Ion beam machining - working principle, machining system, process variables, parametric analysis, process capabilities and applications.

Module:5	**Hybrid machining processes**	**5 hours**

Electro chemical grinding, Electro chemical honing, Electrical discharge grinding, Electro chemical discharge grinding, Laser assisted machining, Cryogenic assisted machining

Module:6	**Advanced Finishing Processes**	**5 hours**

Abrasive flow finishing, Magnetic abrasive finishing, Magneto rheological finishing, Magneto float polishing, elastic emission machining and chemo-mechanical finishing - working principle, machine tool set up, process variables, process performance and applications.

Module:7	**Micro and ultraprecision machining**	**6 hours**

Introduction to micro fabrication, micro-turning, micro-milling, micro-drilling, micro EDM, micro-WEDM, micro ECM.

Ultra Precision turning and grinding, mechanism of ductile cutting, chip formation, tools for ultraprecision machining, recent developments.

Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Boothroyd G., and Knight W.A., (2005), Fundamentals of Metal Machining and Machine Tools, CRC Press, Third Edition
2.	Pandey, P.S. and Shah.N., “Modern Manufacturing Processes”, Tata McGraw Hill, 2017.
Reference Books	
1.	McGeough,J.A.,"Advanced methods of Machining",Springer,2011
2.	Benedict,G.F.,"Non Traditional manufacturing Processes",CRC press,2011
3.	Kapil Gupta, Paulo Davim, High Speed Machining”, Elsevier, Academic Press, 2020
4.	Jain V.K, (2010), Introduction to Micromachining, Narosa Publishers
Mode of Evaluation: CAT, assignment, seminar, FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE507L	Computer Integrated Manufacturing	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. Develop an understanding of classical and state-of-the-art production systems, control systems, management technology, cost systems, and evaluation techniques.
2. Develop an understanding of computer-integrated manufacturing (CIM) and its impact on productivity, product cost, and quality.
3. Obtain an overview of computer technologies including computers, database and data collection, networks, machine control, etc, as they apply to factory management and factory floor operations.

Course Outcome

1. Understand the effect of integrated and intelligent manufacturing automation strategies in a collaborative environment to derive production metrics.
2. Analyze automated technologies and systems in a manufacturing flow lines and assembly systems
3. Design a computer-based production monitoring system for a typical production system
4. Develop Intelligent process planning systems for rotational and prismatic parts/
5. Understand the knowledge of basics, drivers and enablers of Industry 4.0 which leads to smart connected factory.

Module:1	Concept of CIM	5 hours

Manufacturing and its types – Definition of CIM, Elements of CIM, Benefits of CIM, Needs of CIM: Hardware and software. Concurrent Engineering: Definition, Sequential Engineering Versus Concurrent Engineering, Benefits of Concurrent Engineering, Characteristics of concurrent Engineering.

Module:2	CIM Technologies and Systems	6 hours

Design for Manufacturability (DFM): Component Design, Design for Assembly. Computer-Aided Process Planning: Variant and Generative Process Planning, Material Requirements Planning (MRP), Manufacturing Resource Planning (MRP -II), Cellular Manufacturing, Programmable Logic Controllers, Flexible Manufacturing Systems: Physical Components of an FMS, FMS benefits and limitations of FMS.

Module:3	Integrated and intelligent product and process design	7 hours

Intelligent CAD systems, integrating product and process design, manufacturing analysis and CAD/CAM integration, design methodology for automated manufacture, the impacts of intelligent process control on product design, and fuzzy knowledge-based controller design. Knowledge based system for material selection – Intelligent process planning system. Intelligent system for equipment selection -Intelligent system for project management & factory monitoring.

Module:4	Computer Monitoring	7 hours

Types of production monitoring systems-structure model of manufacturing process-process control & strategies direct digital control-supervisory computer control-computer in QC – contact inspection methods non-contact inspection method - computer-aided testing - integration of CAQC with CAD/CAM.

Module:5	Product Lifecycle Management	7 hours

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM).PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications- Case studies based on top few commercial PLM/PDM tools.

Module:6	**Cloud-based design and manufacturing**	**5 hours**
Evolution of design and manufacturing systems, Characteristics and requirements for cloud-based design and manufacturing systems, Cloud-based design and manufacturing example scenario, Cloud-Based Desktop Factory.		
Module:7	**Industry 4.0 a connected factory**	**6 hours**
Introduction to Industry 4.0, Basic principles and technologies of a Smart Factory, Cyber-Physical Production Systems, Digital Twins in Production, Augmented Reality in Manufacturing, Interoperability: Communication systems and standards for Industry 4.0 and cloud applications, cyber security in networked production environments.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Mikell Groover, (2016), Automation, Production Systems and Computer-Integrated Manufacturing, 4th. Ed., ISBN # 0-13-349961-8, Pearson, New Jersey

Reference Books

1.	.C. Chang, R. Wysk and H.P. Wang, (2009), Computer aided Manufacturing, Third Edition, Pearson Education
2.	Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006
3.	Mahapatra, P.B.,” Computer-Aided Production Management”, Prentice-Hall of India Pvt. Limited, 2004

Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ‘,’ to separate the evaluations. Eg. CAT, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE601L	Metrology and Non-destructive Testing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Describe the evolution of quality standards and metrology
2. Describe key points and timelines for the evolution of the quality system as we know it today
3. To prepare the graduates with a strong foundation in basic science, engineering and technology so as to become effective innovators and entrepreneurs in addressing engineering challenges in the field of non-destructive testing.

Course Outcome

1. The student will reproduce the fundamental knowledge on metrology techniques.
2. The student will apply statistical process control and acceptance sampling procedures in a manufacturing environment to improve quality of processes / products.
3. The student will identify suitable metrological methods for measuring the components.
4. The student will understands the inspection procedures for detection, evaluation and analysis of defects in engineering components to meet the need of quality through codes and standards for public safety and human life.
5. The student will investigate and find solutions for complex engineering components and structures using theoretical and practical knowledge acquired in NDT.
6. The student will obtain in-depth knowledge and hands on experience in conventional and advanced techniques in the field of non-destructive testing at the national and global levels.

Module:1	Introduction to Metrology	6 hours

Introduction to Metrology, Fundamental principles and definitions, measurement standards / primary and tertiary standards, distinction between precision and accuracy. Limits, fits and tolerances, Tolerance grades, Types of fits, IS919, GO and NO GO gauges- Taylor's principle, design of GO and NO GO gauges, filler gauges, plug gauges and snap gauges.

Module:2	Comparators	7 hours

Comparators-Constructional features and operation of mechanical, optical, electrical/electronics and pneumatic comparators, advantages, limitations and field of applications. Principles of interference, concept of flatness, flatness testing, optical flats, optical interferometer and laser interferometer. Surface Texture Measurement - importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters- Ra, Ry, Rz, RMS value etc., surface roughness measuring instruments – Tomlinson and Taylor Hobson versions, surface roughness symbols.

Module:3	Thread Measurement	6 hours

Screw Thread Measurement - Two wire and three wire methods, floating carriage micrometer.

Gear Measurement - Gear tooth comparator, Master gears, measurement using rollers and Parkinson's Tester. Special Measuring Equipments - Principles of measurement using Tool Maker's microscope profile projector & 3D coordinate measuring machine

Module:4	Liquid Penetrant Testing and Magnetic Particle Testing	6 hours

Liquid Penetrant Testing Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables –selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing – calibration- Interpretation and evaluation of test results - dye penetrant process applicable codes and standards. Magnetic particle testing, Basic theory of magnetism, Magnetization

methods, Field indicators, Particle application, Inspection. Advantages and limitations of techniques.		
Module:5	**Ultrasonic Testing**	**6 hours**
Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations – contact testing, immersion testing, couplants– Data presentation A, B and C scan displays, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates, alarms and attenuators, detectability of defects.		
Module:6	**Radiographic Testing and Safety**	**6 hours**
X-ray film – structure and types for industrial radiography – sensitometric properties – use of film, characteristic curves (H & D curve) – latent image formation on film – radiographic exposure, reciprocity law, photographic density – X-ray and gamma ray exposure charts – exposure time calculations – film handling and storage – Effect of film processing on film characteristics – Processing defects and their appearance on films – control and collection of Unsatisfactory radiographs – Automatic film processing.		
Module:7	**Thermographic NDE**	**7 hours**
Introduction and fundamentals to infrared and thermal testing– Heat transfer – Active and passive techniques – Lock in and pulse thermography– Contact and non-contact thermal inspection methods– Heat sensitive paints – Heat sensitive papers –- thermally quenched phosphors liquid crystals – techniques for applying liquid crystals – other temperature sensitive coatings – Inspection methods – Infrared radiation and infrared detectors–thermo mechanical behavior of materials– IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures– Case studies.		
Module:8	**Contemporary Issues**	**1 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Gupta, I.C., Engineering Metrology, Dhanpat Rai & Sons, 2004.
2.	Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.
3.	B.Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3rd edition (2007).
Reference Books	
1.	N.V. Raghavendra and L. krishnamurthy, Engineering Metrology and Measurements, Oxford university press 2013.
2.	C. Hellier, Handbook of Non-Destructive Evaluation, McGraw-Hill Professional, 1st edition (2001).

Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ',' to separate the evaluations. Eg. CAT, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course code	Course Title	L	T	P	C
MMAE602L	Optimization Techniques	2	1	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To understand the role of optimization in engineering design and its importance.
2. To introduce the different optimization algorithm in linear programming and non-linear programming.
3. To introduce the non-traditional optimization algorithm in non-linear problem.

Course Outcome

Upon completion of this course, the student shall be able to:

1. Formulate unconstrained and constrained optimization problems for engineering applications and derive optimality conditions.
2. Apply suitable methods for solving unconstrained and constrained non-linear optimization problems.
3. Apply quadratic programming approach to solve quadratic functions with equality constraints covering wide range of applications.
4. Interpret the nature of posynomial function and apply geometric programming approach in solving engineering design problems.
5. Justify and apply genetic algorithm for solving optimization problems.
6. Analyze and implement artificial neural networks for various manufacturing engineering applications.

Module:1	**Classical Optimization**	**6 hours**

Introduction, engineering applications of optimization-classification of optimization problems-Single variable optimization-Multivariable optimization with no constraints-Multi variable optimization with equality and in equality constraints: Lagrange multipliers method, Kuhn-Tucker conditions

Module:2	**Unconstrained Nonlinear Optimization**	**6 hours**

Direct Search methods: Pattern directions, Hook and Jeeves' method, Powell's method-Indirect search methods: Gradient of a function, Cauchy method, Fletcher-Reeves method.

Module:3	**Constrained Non-linear Optimization**	**8 hours**

Characteristics of a constrained optimization problem - Direct methods: Cutting plane method, methods of feasible directions – Indirect methods: Interior and exterior penalty function methods

Module:4	**Quadratic Programming**	**5 hours**

Introduction-applications-necessary conditions-solution to quadratic programming problem using Wolfe's method

Module:5	**Geometric programming**	**5 hours**

Introduction - Solution from differential calculus point of view-Solution from arithmetic-geometric inequality point of view

Module:6	**Genetic algorithms**	**6 hours**

Basic concepts- working principle – encoding – different methods – fitness function – reproduction-different methods. Genetic modelling-inheritance- Crossover mutation-convergence of genetic algorithm.

Module:7	**Artificial Neural Networks**	**7 hours**

Basic concepts-Neural network Architectures-Single layer feed forward network-Multilayer feed forward network-Recurrent Networks-Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network-Kohonen Self organizing maps-ART

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Singiresu S. Rao, (2019), Engineering Optimization - Theory and Practice, John Wiley & Sons, Inc. 5th Edition.
Reference Books	
1.	Arora, R.K., (2015). Optimization: algorithms and applications. Chapman and Hall/CRC.
2.	S.Rajasekharan, G.A.VijayalakshmiPai,(2017), Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications, Prentice Hall India, 2nd Edition.
3.	Kalyanmoy Deb, (2012), Optimization for Engineering Design: Algorithms and Examples, PHI Learning Pvt. Ltd., 2nd edition

Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ',' to separate the evaluations. Eg. CAT, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE603L	Micro and Nano Manufacturing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To comprehend the principles of various micro and nano manufacturing processes, basic machine tools and recent developments in micro and nano manufacturing technologies
2. To inspire the students for developing the models of micro and nano machining processes.
3. To impart knowledge about nano finishing and metrology for newly developed micro components used in industries and research organizations.

Course Outcome

1. Classify the basic micro machining processes
2. Analyze the various conventional and advanced micro machining processes
3. Describe the microfonishing concepts and application.
4. Discuss the process of Micro-fabrication, forming and micro welding.
5. Distinguish the recent trends and applications of micro casting and micro molding

Module:1	**Introduction**	**8 hours**

Introduction to Micro-manufacturing, Classification of Micromanufacturing Processes, Scaling Laws – Types of Scaling laws - Scaling in Geometry, Scaling in Mechanics, Scaling in Adhesive Forces, Scaling in Electrostatic Forces, Scaling in Electromagnetic Forces, Scaling in Fluid Mechanics, Scaling in Heat Transfer; Salient Features of Micro-Machining - Workpiece microstructure effect, Tool design effect - Crystallographic Orientation Effect, Edge Radius Effect and Minimum Chip thickness.

Module:2	**Conventional and Advanced Micromachining Processes**	**6 hours**

Microturning, Micromilling, Microgrinding, Diamond Turning, Micro- and Nano-manufacturing by Focused Ion Beam, Electric discharge micromachining, Electrochemical micromachining, Abrasive water jet micromachining and laser beam micro machining

Module:3	**Micro and Nanofinishing processes**	**6 hours**

Abrasive Flow finishing – Magnetic Abrasive Finishing – Magneto rheological finishing – Magneto Rheological abrasive flow finishing - Magnetic Float polishing – Elastic Emission Machining – chemomechanical Polishing.

Module:4	**Microjoining and allied processes[**	**6 hours**

Introduction to microjoining, Laser Microwelding, Electron Beams Microwelding and Applications .

Module:5	**Microforming Processes**	**6 hours**

Introduction to Microforming ,Micro- and Nanostructured Surface Development by Nano Plastic Forming and Roller imprinting. Micro-hydroforming, Microextrusion , Microbending with Laser

Module:6	**Microcasting and Micromolding**	**5 hours**

Microcasting, Micromolding, Net Shape Manufacture of Freestanding Ceramic Micro components through Soft Lithography.

Module:7	**Metrology for Micro/Mesoscale Manufacturing**	**6 hours**

Sensor integration for process monitoring, Robotics in Micromanufacturing and Micro robotics, Optical Coherence Tomography for the characterization of Micro-parts and Structures. Acoustic emission-based tool wear compensation– Machining of Micro gear, micro nozzle, micro pins – Applications.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)
1. J. Paulo Davim, Mark J. JacksonNano and Micromachining,John Wiley & Sons, 2013 2. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006. 3. V.K.Jain, Micro-manufacturing Processes, CRC Press, 2012. 4. Yi Qin, Micro-manufacturing Engineering and Technology, William Andrew, 2015 5. Kapil Gupta, Micro and Precision Manufacturing, Springer, 2017 6. *Non-traditional Micromachining Processes Fundamentals and Applications* edited by Golam Kibria, B. Bhattacharyya and J. Paulo Davim, Springer.
Reference Books
1. N. P. Mahalik, Micromanufacturing & Nanotechnology, Springer, 2010. 2. Mark J. Jackson, Microfacbrication & Nanomanufacturing, 1st ed., CRC Press, 2005. 3. Manas Das, V. K. Jain and P. S. Ghoshdastidar, Nanofinishing Process using Magnetorheological Polishing Medium, Lambert Academic Publishing, 2012. 4. Richard Leach, Characterisation of Areal Surface Texture, 1st ed., Springer-Verlag Berlin Heidelberg, 2013. 5. Richard Leach, Optical Measurement of Surface Topography, 1st ed., Springer-Verlag Berlin Heidelberg, 2011.
Authors, book title, year of publication, edition number, press, place
Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ‘,’ to separate the evaluations. Eg. CAT, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE604L	Sustainable Manufacturing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide practical level understanding of key factors in sustainable manufacturing
2. To impart knowledge on sustainable models and frameworks
3. To inculcate the practice of sustainability in manufacturing

Course Outcome

Upon completion of this course, Students will be able to:

1. Identify key requirements in sustainable manufacturing
2. Apply sustainability concepts in manufacturing systems
3. Demonstrate the life cycle analysis and costing in production process
4. Map the possibilities in remanufacturing and circular economy in manufacturing
5. Implement sustainability assessment in firms

Module:1	**Sustainability**	**5 hours**

Concept of sustainability, Sustainable Development goals, manufacturing operations, resources in manufacturing. Concept of triple bottom line, environmental, economic and social dimensions of sustainability. Need for sustainable manufacturing.

Module:2	**Standards**	**7 hours**

Environmental impact assessment methods - CML, EI 95 and 99, ISO 14001, EMS and PAS 2050 standards, environmental impact parameters. Sustainability assessment-concept models and various approaches, product sustainability and risk assessment-corporate social responsibility.

Module:3	**Life Cycle Analysis**	**7 hours**

Life cycle analysis-tools for LCA, optimization for achieving sustainability in manufacturing, value analysis, analysis for carbon footprint-software packages for sustainability analysis, Life Cycle Cost Analysis

Module:4	**Remanufacturing**	**6 hours**

Remanufacture and disposal - Environmental conscious- quality function deployment- R3 and R6 cycles – Remanufacturing case studies, EoL Waste valorization techniques, Industrial symbiosis, Circular economy-strategies.

Module:5	**Sustainable Manufacturing**	**6 hours**

Environmental Impacts of Manufacturing, Cutting tool sustainability, Minimum Quantity Lubrication in Machining.

Module:6	**Design for Sustainability**	**6 hours**

Environmentally conscious quality function deployment (ECQFD), Life Cycle Design, Facilitating Disassembly, System Design for Eco-efficiency, Environmental Complexity and Designing Activity, Product Lifetime Optimisation

Module:7	**Process Sustainability**	**6 hours**

Sustainable Consumption and Production, Selecting Low Impact Resources and Processes, Extending the Lifespan of Materials, Process analysis – Sustainability assessment - Gaps identification for implementation – Energy studies – Case studies.

Module:8	**Contemporary Issues**	**2 hours**
Total Lecture hours:		**45 hours**

Text Books

1. S.Vinodh, Sustainable Manufacturing Concepts, Tools, Methods and Case Studies, Published October 27, 2020 by CRC Press
2. Kapil Gupta, Sustainable Manufacturing, Elsevier Science Publishing Co Inc, 2021,

	Springer Publications			
Reference Books				
1.	Dornfeld, David.(2012), Green Manufacturing, Springer-Verlag, New York			
2.	Davim, J.P.(2010), Sustainable Manufacturing, John Wiley & Sons.			
3.	Gupta, S.M. and Lambert, A.J.D.(2008), Environment Conscious Manufacturing, CRC Press			
Mode of Evaluation: CAT, Written assignment, Quiz, FAT.				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE605L	Supply Chain and Logistics Management	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To introduce various supply chain and logistics principles and systems.
2. To demonstrate the application of supply chain and logistics concepts, methodologies, and techniques to solve real-life problems.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Demonstrate the importance of value proposition and effective use of emerging information technologies in the operations of supply chain and logistics
2. Address the problems of inventory management in a holistic approach using suitable models and strategies
3. Apply the transportation and warehouse systems for improving the performance of SC
4. Evaluate SC network based on drivers and total cost approach
5. Analyse the performance of SC
6. Foresee the importance of global supply chains and trends

Module:1	Supply Chain and Logistics Management	5 hours

Introduction and Development- Integrated Supply Chain - Value Perspectives – Generalized Model – Applications – SC Processes – SC Value Proposition – Strategy – Responsiveness – Barriers – Global Applications

Introduction – Value Proposition – Integrated Logistics – Logistical Operations – Integration Objectives – Logistical System Arrangements – Flexible Operations – SC Synchronization.

Module:2	Information System	6 hours

Introduction – Evolution – IS Functionality – Different levels – IS Framework – IS Modules – Enterprise Resource Planning – Enterprise SC Operations – Enterprise Planning and Monitoring – Communication Technology – Blockchain – Logistics Operations System

Module:3	Inventory Management	7 hours

Introduction – Functionality - Definitions – Costs – Planning Inventory – Managing Uncertainty: Demand, Performance Cycle, Safety Stock, Fill Rate - Inventory Management Policies: Control, Reactive, Planning, Collaborative Replenishment, Postponement – Inventory Management Practices: Classification, Segmentation

Module:4	Transportation and Warehouse Management Systems	7 hours

Introduction – Functionality and Participants – Modal Structure – Specialized Services – Economics and Pricing – Transportation Management Systems – Documentation

Strategic Warehousing – Arrangements – Decisions – Operations: Primary and Secondary – Systems – Packaging for efficiency

Module:5	Network Design	7 hours

Network – Warehouse Requirements: Drivers for Procurement, Manufacturing, Customer Relationship and Warehouse – Total Cost Integration: Transportation and Inventory – Formulation of Strategy – Application – Strategy Drivers

Module:6	Performance Measurement	5 hours

Objectives – Operational Assessment: Functions, Customer Relationships, Metrics – Benchmarking – Financial Assessment: Analysis, Model and Reporting

Module:7	**Global Supply Chain and Trends**	**6 hours**
Introduction – Global Economics – Integration: Logistics and Strategies – Sourcing: Guidelines and Characteristics – Compliance End-to-End SCM – Managing Risk and Complexity – Managing Threats and Environmental Challenges		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Donald J. Bowersox, David J. Closs, M. Bixby Cooper, and John C. Bowersox (2020), Supply Chain Logistical Management, 5th edition, McGraw Hill Education
Reference Books	
1.	John J. Coyle, C. John Langley, Jr. , Robert A. Novack, and Brian J. Gibson (2017), Supply Chain Management: A Logistics Perspective, 10th edition, Cengage learning, New Delhi
2.	Sunil Chopra, Peter Meindl, and D.V. Kalra (2017), Supply Chain Management: Strategy, Planning & Operations, 6th edition, Pearson Education (Singapore) Pvt. Ltd.
3.	David Simchi-Levi, Philip Kaminsky, and Edith Simchi-Levi, (2022), Designing & Managing the Supply Chain: Concepts, Strategies & Case Studies, 4th edition, McGraw-Hill Education

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE606L	Maintenance Engineering	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To enable the student to understand maintenance principles, functions and practices followed in industry
2. To understand basic concepts of maintenance categories like Preventive maintenance, condition monitoring and repair methods for some basic machine elements.
3. To have an introductory idea about maintenance management

Course Outcome

Upon successful completion of the course the students will be able to

1. Demonstrate the methods and techniques for planning, scheduling, carry out and analyze maintenance.
2. Understand the maintenance function and its objectives and know how to prepare report about the maintenance function
3. Demonstrate the basic knowledge of various condition monitoring methods in accordance with the established procedures
4. Develop step-by-step procedure for conducting a failure analysis of failed machine components
5. Predict appropriate condition monitoring (CM) techniques and instruments
6. Apply the replacement plan of parts on any machine in an economical way.

Module:1	Principles and Practices of Maintenance Planning	6 hours

Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability

Module:2	Maintenance Policies – Preventive Maintenance	6 hours

Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle - Principles and methods of lubrication – TPM. Failure Modes Effects and Criticality Analysis (FMECA), Implementation of FMECA for Machinery Maintenance, Risk Priority Number for FMECA.

Module:3	Condition Monitoring	6 hours

Condition Monitoring – Cost comparison with and without CM – Vibration Monitoring, Noise Monitoring, Thermography Wear Debris Analysis, Machine Tool Condition Monitoring

Module:4	Engineering Failure Analysis	6 hours

Introduction, Overview of Failure Analysis, Failure Modes, Failure Analysis - Manufacturing and Installation Defects, Assembly at Factory/Installation at Site, Failure Investigation Procedure.

Module:5	Maintenance Organization, Economics, Optimization Models	6 hours

Maintenance organization – Maintenance economics-Introduction to maintenance optimization models: Age replacement, Block replacement models

Module:6	Repair Methods For Basic Machine	6 hours

Repair methods for beds, slideways, spindles, gears, lead screws and bearings

Module:7	Repair methods for Material handling equipment	6 hours

Repair methods for Material handling equipment, Some examples - Upkeep Of Equipment Maintenance Records

Module:8	Case Studies	3 hours

Bend Pulley Failure Analysis, Root Cause Analysis of Torsion Shaft Failure, Failure Analysis of a Conveyor System Support Structure, Vibration Measurements on a Motor-Multistage Gearbox drive set.

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Amiya Ranjan Mohanty, Machinery Condition Monitoring Principles and Practices, (2017) ISBN 9781138748255, CRC Press
2.	A. Davies, (2012), Hand book of condition monitoring Techniques and methodology – Springer science & Business Media
3.	Donald J. Bowersox and David J. Closs,(2006), Logistical Management: The Integrated Supply Chain Process, TMH
Reference Books	
1.	Chopra, S. and Meindl, P., (2014), Supply Chain Management: Strategy, Planning & Operations, 6th edition, Pearson Education (Singapore) Pvt. Ltd
2.	Edward J Bradi, John J Coyle: (2010), A Logistics Approach to Supply Chain Management, Cengage learning, New Delhi
Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ‘,’ to separate the evaluations. Eg. CAT, Quiz and FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE607L	Manufacturing Information Systems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide an importance of databases and its application in manufacturing systems that prepare students for their engineering practice by organization by conversant with order policies, data base terminologies, designing, manufacturing considerations.
2. Define and explain basic terms in the area of manufacturing, as well as structure, design, configuration and practical use of IT systems for manufacturing.
3. To provide specialist knowledge in the area of manufacturing information systems, as an upgrade of the basic knowledge about information systems provided in the core courses.

Course Outcome

Upon successful completion of the course the students will be able to

1. To create simple to moderately complex manufacturing information system for manufacturing industry
2. Evaluate critically the role of management information systems for design, engineering and manufacturing
3. Demonstrate an appreciation of the complex relationship between information systems and organization
4. Explain system analysis and design tools
5. Apply decision support systems for various issues.

Module:1	Repetitive Manufacturing	5 hours

Run Schedule Quantities, Material Usage, Reporting Point Statistics, Header Master Data – Bill of material(BOM) -BOM Header-BOM Positions

Module:2	Integration and Routing	7 hours

Production Planning (PP) and Material Management – PP and Sales and Distribution PP and Financial Accounting & Controlling(FICO) - pp and project system, PP and quality management, PP and maintenance- Routing Group Header-Routing Group Sequence-Routing Group Operations-Production Order Header-Production Order Position

Module:3	Product master	6 hours

Finished products (FERT)/ Externally produced- material type (ROH –BOM) Types of BOMs- Work centers – Categories- Standard routing - Task lists-Production version - Lot sizes -Production orders – Types- Material availability – Rules - Capacity check - Categories

Module:4	Scheduling and Costing	6 hours

Scheduling - Types - Costing - Formulas -Releasing - Reservations -Goods issue - Material docs- Confirmation - Variance -Goods receipt - Inventory -Settlement - Actual -Technical completion -Automate release process - Automate GI process -Automate GR process

Module:5	Production Types	7 hours

Make to stock production -Make to order production -Planning with final assembly -Plan to procure. no production - Plan to produce & sell - Planning with Planned Independent Requirement (PIR) -Plan with Variant configuration -Master production scheduling - Material requirement planning - Consumption-based planning.

Module:6	Production Planning	6 hours

Introduction -Sales operation plan-Long-term planning- By-products in production -Co product in production - Scrap in production process- Produce with Batches- Production with QM -Production with WM - Production with (handling unit management) HUM

Module:7	Configuration	6 hours

Produce with Variant Configuration (VC)-Production with MES - Production with shop floor

data - Production with serial numbers - Repetitive manufacturing -PP-PI (process industry)- Process management - PCS Interface		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Dickersbach Jörg Thomas and Gerhard Keller. Production Planning and Control with SAP ERP. Galileo Press, 2011.
2.	Weber, Björn. First Steps in the SAP Production Processes (PP). Espresso Tutorials GmbH, 2018.
3.	Akhtar, Jawad. Production Planning with SAP S/4HANA. Rheinwerk Publishing, 2021.
Reference Books	
1.	Lawlor, William. Common SAP R/3 Functions Manual. Springer, 2004.
2.	Gerald, Bastin, Nigel King, and Dan Natchek. Oracle E-Business Suite Manufacturing & Supply Chain Management. McGraw-Hill Prof Med/Tech, 2002.

Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ‘,’ to separate the evaluations. Eg. CAT, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE608L	Design and Analysis of Experiments	2	1	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To impart knowledge on the principles and methods of statistical analysis of experimental designs.
2. To provide knowledge on process/product optimization through statistical concepts.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply the principles of experimental designs
2. Design an experiment, develop the statistical model and check its adequacy
3. Analyze the sources of variation in an experimental design
4. Create a factorial/fractional-factorial design with suitable resolution
5. Develop the regression models and response surfaces for process prediction and optimization

Module:1	**Experiments with a Single Factor**	**7 hours**

Basic Principles and Guidelines of Design of Experiments - Hypothesis Testing - Confidence Intervals - Choice of Sample Size - Single Factor Experiments: ANOVA - Model Adequacy Checking - Determining Sample Size - Comparing Pairs of Treatment Means - Introduction to DOEA software.

Module:2	**Randomized Block Designs**	**5 hours**

Randomized complete block design - Latin square designs - Graeco-Latin square design - Balanced incomplete block designs.

Module:3	**Factorial Designs**	**7 hours**

Two-factor factorial Design - General Factorial Design - Fitting Response Curves and Surfaces - Blocking in a Factorial Design - 2^k factorial design - Addition of center points to 2^k factorial design - Blocking and Confounding in 2^k factorial design

Module:4	**Two-level Fractional Factorial Designs**	**7 hours**

The One-Half and One-Quarter Fraction of the 2^k Design - General 2^{k-p} Fractional Factorial Design - Alias structures in fractional factorials - Resolution

Module:5	**Robust Design**	**5 hours**

Comparison of classical and Taguchi's approach - Orthogonal designs - S/N ratio - Application to Process and Parameter design.

Module:6	**Fitting Regression Models**	**6 hours**

Simple linear regression models - Estimation of regression parameters - Multiple Linear Regression Model - Model Adequacy Checking

Module:7	**Response Surface Methods and Designs**	**6 hours**

Method of steepest ascent - Analysis of a second-order response surface - Experimental designs for fitting first-order and second-order response surfaces

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book				
1.	Douglas C. Montgomery, (2020), Design and Analysis of Experiments, John Wiley & Sons, Inc., 10th edition			
Reference Books				
1.	Philip J. Rose, (2000), Taguchi Techniques for quality Engineering, Prentice Hall			
2.	Charles R. Hicks, Kenneth V. Turner (1999) Jr., Fundamental concepts in the Design of Experiments, Oxford University Press, 5th edition			
Mode of Evaluation: CAT, Assignment, Quiz, FAT				
Recommended by Board of Studies		27-07-2022		
Approved by Academic Council		No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE609L	Advanced Tool Engineering	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To develop competency in understanding different cutting tools and its working principles.
2. To select proper material for the design of the tool, dies and fixtures.
3. To enable the students to analyze and optimize the design of tools, dies, jigs and fixtures

Course Outcome

1. Understand the design considerations in different cutting and forming tools.
2. Design of various cutting tools, holding tools.
3. Select appropriate work holding devices based geometry of workpiece.
4. Design and analyze different dies and press tools.
5. Design of tool holding and workpiece holding for various unconventional machining processes.
6. Design of tools and work holding for non-manufacturing applications.

Module:1	Introduction to Tool Design and Tool Engineering	4 hours

Tool Design, Objectives, Tool engineering, tool classification, tool design in manufacturing, challenges and requirements, standards in tool design, tool drawings, fits and tolerances, tooling Materials

Module:2	Design of Cutting tools	6 hours

Basic Requirements, Design of Single Point Cutting Tools, Design of Milling Cutters, Design of Drills, Reamers, Taps and Inserts, Determining Shank Size for Single-Point Carbide Tools, Determining Insert Thickness for Carbide Tools, Design of Chip Breakers and Design of Form Tools.

Module:3	Design of Locators and Clamps	7 hours

Introduction to locating and clamping devices, difference between jigs and fixture, advantages of jigs and fixture, materials used in jigs and fixture, locating principle, locating methods and devices, standard parts, clamping – analysis of clamping forces, tolerance and error analysis. Consideration of Safety factor while designing of Jig Fixture and Gauge.

Module:4	Design of Fixtures	7 hours

Introduction to fixtures, Economics of fixtures, Types of fixtures & Application – overview, Vise fixtures, milling fixtures ,boring fixtures, broaching fixtures , Lathe fixtures, grinding fixtures, welding fixture, indexing fixture, Design of fixtures for the given components.

Module:5	Design of Jigs	6 hours

Introduction to drill jigs, Economics of drill jig, General considerations in design drill jigs , types of drill jigs, Drill bushings, Method of constructions , clearance – handling clearance, swarf and cutting fluid clearances, burr grooves Methods of inserting bushes, Design of Drill jigs for given components.

Module:6	Design of Press Tools Dies	7 hours

Press Working Terminologies, Types of presses, Computation of press capacity, mechanical and automatic feed, Introduction to Inverted Dies, function of various parts of Inverted dies, Compound dies, Progressive dies, function of various parts of Compound dies and progressive dies, Design of compound, progressive and Inverted Dies.

Module:7	Design of Forming Dies	6 hours

Introduction to forming dies, Selection of material for Dies, Draw Dies, Bending dies – Forging dies – Extrusion dies - Drawing dies - Design and drafting; Casting Dies and Welding dies –Manufacturing methods of forming and Drawing Dies.

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	Donaldson, C., LeCain, G. H., Goold, V. C., & Ghose, J. (2017). Tool design. Tata McGraw-Hill Education., Fifth Edition.	
Reference Books		
1.	Joshi, P. H. (2017). Jigs and fixtures. Tata McGraw-Hill Education, Third Edition	
2.	Balachandran, V. (2015). Design of Jigs, Fixtures and Press Tools	
3.	Hoffman, E. (2012). Jig and fixture design. Cengage Learning.	
4.	PSG College of Technology, Coimbatore - Design Data Handbook.	
Mode of Evaluation: CAT / written assignment / Quiz / FAT / Project / Seminar / group discussion / field work (include only those that are relevant to the course. Use ‘,’ to separate the evaluations. Eg. CAT, Quiz and FAT		
Recommended by Board of Studies	27-07-2022	
Approved by Academic Council	No. 67	Date 08-08-2022

Course Code	Course Title	L	T	P	C
MMAE610L	Casting and Welding Technology	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To enable students to acquire knowledge on foundry and casting processes.
2. To teach students about various casting and welding processes.
3. To impart knowledge on contemporary developments and issues in foundry and welding industries.

Course Outcome

Upon successful completion of the course the students will be able to

1. Discriminate the knowledge of principles, operations and applications of different casting and welding processes.
2. Analyze the effects of process parameters on the quality of cast and weld products.
3. Identify the techniques for the evaluation of cast and weld components
4. Apply the knowledge of welding in Heavy Engineering and nuclear industries
5. Identify heat treatment processes for various applications and relate to casting processes in industries

Module:1	Casting Design	6 hours

Heat transfer between metal and mould – Design considerations in casting – Designing for directional solidification and minimum stresses – Principles and design of gating and risering – Thermal characteristics of the mould.

Module:2	Casting Metallurgy	6 hours

Solidification of pure metal and alloys – Freezing of pure metals and alloys – Shrinkage in cast metals – Progressive and directional solidification – Degasification of the melt – Castability of steel, Cast Iron, Al alloys, Babbit alloy and Cu alloy

Module:3	Recent Trends in Casting and Foundry Layout	6 hours

Shell moulding, precision investment casting, CO2 moulding, centrifugal casting, Die casting, Continuous casting, Counter gravity low pressure casting, Squeeze casting and semisolid processes. Layout of mechanized foundry – sand reclamation – material handling in foundry pollution control in foundry – Computer aided design of casting.

Module:4	Heat Flow in Welding	6 hours

Significance, theory of heat flow cooling rate determination, selection of welding parameters based on heat flow analysis, residual stresses and distortion. Joint design, analysis of fracture and fatigue of welded joints.

Module:5	Stresses in Welding	6 hours

Welding stress and distortion, residual stress, causes of residual stress, effect of weld thermal cycle and shrinkage on residual stresses, Reaction stresses, stresses generated by phase transformation, Measurement techniques of residual stresses in weld metals.

Module:6	Heat Treatment	6 hours

Pre-heat and post weld heat treatment, Methods of Pre-heating, Advantages and limitations of pre-heating. Pre & post weld heat treatment for carbon steel, cast iron.

Module:7	Welding Metallurgy	7 hours

Basic Metallurgy of fusion welds, general theory of solidification of metals and alloys, homogeneous and heterogeneous nucleation, Effect of welding parameters on grain

structure, properties of weld metals, fusion boundary zone, heat affected zone, properties of heat affected zone.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Carrry B., Modern Welding Technology, Prentice Hall Pvt Ltd., 2002.
2.	Heineloper & Rosenthal, Principles of Metal Casting, Tata McGraw Hill, 2000
3.	Lancaster J. F. – Metallurgy of Welding – George Alien & Unwin Publishers,1980.
Reference Books	
1.	Schwariz, M.M. – Source book on innovative welding processes – American Society for Metals (OHIO), 1981.
2.	P.N. Rao, Manufacturing Technology Foundry, Forming and Welding, TMH-2003; 2nd Edition, 2003

Mode of Evaluation: CATs / Digital assignments / Quizes / FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE610P	Casting and Welding Technology Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To enable students to acquire practical knowledge on foundry and casting processes.
2. To teach students about the measurement of moulding sand properties.
3. To study the effect of welding parameters on joint characteristics.
4. To provide knowledge of underlying principles, mechanisms related to fusion-joining technologies.
5. To study the effect of FSW parameters and its effect on joint characteristics.

Course Outcome

Upon successful completion of the lab course the students will be able to

1. Understand the principles of casting and welding.
2. Acquire practical knowledge on fusion and solid state welding processes.
3. The students gain the knowledge about the importance of heat input and its effect on microstructure.
4. The students can understand the working principle of FSW process and its parameters.

Indicative Experiments

1.	Determination of permeability, shear strength and compression strength of the given foundry sand
2.	Determination of the grain fineness of the given foundry sand
3.	Determination of clay content for the given moulding sand sample and also to study the variation of compression strength for various moisture contents
4.	Prepare the mould for the given pattern with the core using two boxes and three - box moulding process
5.	Determination of flowability for the given foundry sand
6.	Foundry melting practice – demonstration
7.	To study the microstructure of weld metal and HAZ of aluminium alloys performed under GTAW process (Heat input).
8.	To study micro hardness testing across weld metal and HAZ of welded steel.
9.	To study the effect of FSW process parameters on the butt welding of aluminium alloy. (Tool rotational speed, Axial load and travel speed)
10	Effect of SMAW welding parameters on butt joining of stainless steel.
11	Effect of shielding gases on the performance characteristics of GMAW process.
12.	To study the microstructure of weld metal and HAZ of dissimilar welded mild steel and stainless-steel joint.
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Jain P. L., ‘Principles of Foundry Technology’, 3rd Edition, Tata McGraw Hill, 1995
2.	J. Norrish: Advanced Welding Processes, Woodhead publishing. 2006.

Reference Books

1.	Srinivasan N. K., ‘Foundry Technology’, Khanna Publications, 1986
2.	Richard L Little, Welding and welding technology, Mc Graw Hill, 2020

Mode of assessment: Internal assessment / FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE611L	Quality and Reliability Engineering	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide knowledge on the various techniques to assess and improve the quality and reliability of the product and process.
2. To impart the underlying concepts, methods and applications of Quality and Reliability in industries.

Course Outcome

Upon successful completion of the course the students will be able to

1. Find the applications of quality and reliability concepts.
2. Solve the quality and reliability issues in the industrial applications.
3. Improve the quality and reliability of a product and process.

Module:1	**Quality Control**	**5 hours**

Evolution of quality control - Quality control vs. assurance - Quality planning - Cost of quality - Economics of quality - Quality loss function.

Module:2	**Statistical Process Control**	**6 hours**

Causes of variations - Process control charts for variables - Process control for attributes - Cusum charts - Multi-vari charts - Process capability analysis using control charts - Process capability (Cp, Cpk, Pp, Ppk) - Six Sigma.

Module:3	**Acceptance sampling**	**6 hours**

Acceptance sampling- fundamental - OC curve - sampling plans for attributes – single – double - multiple and sequential - sampling plans for variables - MIL-STD-105D - MIL-STD-414E and IS2500 standards.

Module:4	**Strategic tools and Techniques**	**6 hours**

Quality function deployment - Deming's PDCA cycle – Poka-Yoke - Failure modes & effects analysis – Benchmarking - 5S concepts.

Module:5	**Experimental Design and Optimization**	**7 hours**

Fundamentals – factorial experiments – random design, Latin square design – Taguchi method – Loss function – experiments – S/N ratio and performance measure – Orthogonal array.

Module:6	**Reliability**	**7 hours**

Reliability definition – quality and reliability– life cycle curve - reliability mathematics – Reliability functions – MTBF – MTTF - Hazard rate – measures of reliability – system reliability – series –parallel – mixed configuration systems – system with standby component.

Module:7	**Reliability Improvement**	**6 hours**

Analysis of downtime – Repair time distribution – System repair time – Maintainability prediction – Measures of maintainability – Inspection decisions –System Availability.

Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Amitava Mitra, "Fundamentals of Quality Control and Improvement", 2016, Fourth Edition, Wiley.

Reference Books

1. Douglus C. Montgomery, "Introduction to Statistical Quality Control", 2019, Eighth Edition Wiley-India.
2. Charles E. Ebeling, "An introduction to Reliability and Maintainability Engineering" 2019,

	Third Edition, Tata McGraw Hill.		
Mode of Evaluation: CAT / written assignment / Quiz / FAT.			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE696J	Study Oriented Project				02
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcome:

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content	(Project duration: One semester)

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE697J	**Design Project**				**02**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

1. Students will be able to design a prototype or process or experiments.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcome:

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model or process or experiments.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content **(Project duration: One semester)**

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE698J	**Internship I/ Dissertation I**				**10**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

Course Outcome:

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work.
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.
3. A consciousness of the ethical aspects of research and development work.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAE699J	Internship II/ Dissertation II				12
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:

Upon successful completion of this course students will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022