



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
(2022-2023 batch onwards)



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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, leading to nurturing of scientists and technologists of highest caliber who would engage in sustainable development of the globe.

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.



M. Tech Manufacturing Engineering

PROGRAMME OUTCOMES (POs)

PO_1: Having an ability to apply mathematics and science in engineering applications.

PO_2: 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_3: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information.

PO_4: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice.

PO_5: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems.

PO_6: Having adaptive thinking and adaptability in relation to environmental context and sustainable development.

PO_7: Having a clear understanding of professional and ethical responsibility.

PO_8: 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

PSO1: Prepare process plan, simulate manufacturing processes and establish production systems for the physical realisation of components and products.

PSO2: Conduct experimental investigations and incorporate latest technologies for improving manufacturing processes.

PSO3: Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document.



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M. Tech Manufacturing 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.

Master of Technology in Manufacturing Engineering
School of Mechanical Engineering

Programme Credit Structure	Credits	Discipline Elective Courses	12
Discipline Core Courses	24	MMAE601L Metrology and Non-destructive Testing	3 0 0 3
Skill Enhancement Courses	05		
Discipline Elective Courses	12	MMAE602L Optimization Techniques	2 1 0 3
Open Elective Courses	03	MMAE603L Micro and Nano Manufacturing	3 0 0 3
Project/ Internship	26	MMAE604L Sustainable Manufacturing	3 0 0 3
Total Graded Credit Requirement	70	MMAE605L Supply Chain and Logistics Management	3 0 0 3
Discipline Core Courses	24	MMAE606L Maintenance Engineering	3 0 0 3
	L T P C	MMAE607L Manufacturing Information Systems	3 0 0 3
MMAE501L Advanced Materials and Characterization	3 0 0 3	MMAE608L Design and Analysis of Experiments	2 1 0 3
MMAE502L Finite Element Methods in Manufacturing	3 0 0 3	MMAE609L Advanced Tool Engineering	3 0 0 3
MMAE502P Finite Element Methods in Manufacturing Lab	0 0 2 1	MMAE610L Casting and Welding Technology	3 0 0 3
MMAE503L Additive Manufacturing Technology	3 0 0 3	MMAE610P Casting and Welding Technology Lab	0 0 2 1
MMAE503P Additive Manufacturing Technology Lab	0 0 2 1	MMAE611L Quality and Reliability Engineering	3 0 0 3
MMAE504L Theory of Metal Forming	3 0 0 3		
MMAE505L Mechatronics and Automation	3 0 0 3	Open Elective Courses	03
MMAE505P Mechatronics and Automation Lab	0 0 2 1	Engineering Disciplines Social Sciences	
MMAE506L Modern Machining Processes	3 0 0 3		
MMAE507L Computer Integrated Manufacturing	3 0 0 3	Project and Internship	26
Skill Enhancement Courses	05	MMAE696J Study Oriented Project	02
MENG501P Technical Report Writing	0 0 4 2	MMAE697J Design Project	02
MSTS501P Qualitative Skills Practice	0 0 3 1.5	MMAE698J Internship I/ Dissertation I	10
MSTS502P Quantitative Skills Practice	0 0 3 1.5	MMAE699J Internship II/ Dissertation II	12

Discipline Core Courses

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					
<ol style="list-style-type: none"> To provide insight into the various material classes, their mechanical properties, and their applications To impart knowledge on various Materials and alloy selection. 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					
<ol style="list-style-type: none"> Describe the mechanical behaviour of materials, their importance and applications Explain various engineering alloys in terms of specifications, applications, and heat treatment Demonstrate the acquired skills in analysing the properties and applications of modern materials and alloys Identify methods for use on characterization based on microscopy, microanalysis and diffraction techniques, and surface and spectroscopy analysis 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					
<ol style="list-style-type: none"> To teach the mathematical and physical principles underlying the Finite Element Method (FEM) To introduce the concepts of FEM and to apply in the field of Manufacturing Engineering 					
Course Outcome					
<ol style="list-style-type: none"> Solve differential equations using various weighted residual methods and use them for finite element analysis. Perform structural analysis of using 1 D and 2 D elements Perform thermal analysis using 1 D and 2 D elements Model various nonlinearities to perform nonlinear finite element analysis 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 triangle 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, 4 th Edition, McGraw Hill, Noida, India		
Reference Books			
1.	Rao. S.S., The Finite Element Method in Engineering, 2019, 6 th 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, 1 st 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, 2 nd 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						
<ol style="list-style-type: none"> To provide experience in performing Finite Element Analysis using commercial software or by using a computer program To provide capabilities to simulate simple manufacturing processes using Finite Element Analysis 						
Course Outcome						
<ol style="list-style-type: none"> Perform finite element analysis on simple real life components 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, 4 th Edition, McGraw Hill, Noida, India					
Reference Books						
1.	Rao. S.S., The Finite Element Method in Engineering, 2019, 6 th 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, 1 st 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, 2 nd 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
MMAE503P	Additive Manufacturing Technology Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<ol style="list-style-type: none"> 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. Able to design and print 3D components using various printing tools. Apply digital manufacturing technologies to various facets of human endeavor. 					
Course Outcome					
<p>Upon successful completion of the course, the students will be able to</p> <ol style="list-style-type: none"> Understanding the concepts, capabilities and limitations of additive technologies and their varied applications. Identifying the suitable file format and data processing technique for AM systems using software. Proposing suitable material and AM systems for specific requirement. Applying design for additive manufacturing guidelines in designing mass customized products. Suggesting the appropriate post processing technique to improve the quality of printed part. 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 – Principles, 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
MMAE503L	Additive Manufacturing Technologies	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<ol style="list-style-type: none"> 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					
<p>Upon successful completion of the course, the students will be able to</p> <ol style="list-style-type: none"> 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, Modeling 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: Stereolithography (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 – Principles, 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
MMAE504L	Theory of Metal Forming	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<ol style="list-style-type: none"> 1. Select suitable forming techniques for various applications 2. Calculate the forming limit for various processes 					
Course Outcome					
<p>Upon successful completion of the course the students will be able to</p> <ol style="list-style-type: none"> 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 Rahul Kumar 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					
<ol style="list-style-type: none"> To provide the interdisciplinary knowledge in mechanical, electrical, and control systems for developing mechatronic components in automation. To introduce sensing, actuating and control elements of a mechatronics system. To provide hands on experience in automation with hydraulics, pneumatics and PLC controls. 					
Course Outcome					
<ol style="list-style-type: none"> Select suitable elements for mechatronics application. Able to select the controller for mechatronic systems for industrial control applications. Select suitable drives for a mechatronic application. Design a hydraulic and pneumatic circuit for a automaton applications. Understand the operation and programming of CNC machines and industrial robots. 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					
<ol style="list-style-type: none"> Understand the basic hydraulic and pneumatic system and their techniques To understand the concept and principle operation of automation systems and their controls. 					
Course Outcome					
<ol style="list-style-type: none"> Recognize the concepts of different hydraulic and pneumatic combination systems. 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					
<ol style="list-style-type: none"> To understand the influence of various machining parameters on the machining processes To develop models for modern machining processes to analyse the machining performances 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:					
<ol style="list-style-type: none"> Explain the working principle, process capabilities and applications of modern machining / finishing processes Develop models for estimation of cutting forces, power requirements, tool wear, material removal and surface roughness for various machining processes Analyse the inter-relationship between the process parameters and machining performances 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					
<ol style="list-style-type: none"> 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					
<ol style="list-style-type: none"> 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

Discipline Elective Courses

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					
<ol style="list-style-type: none"> 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					
<ol style="list-style-type: none"> 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 understand 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.	Doebelin 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					
<ol style="list-style-type: none"> To understand the role of optimization in engineering design and its importance. To introduce the different optimization algorithm in linear programming and non-linear programming. To introduce the non-traditional optimization algorithm in non-linear problem. 					
Course Outcome					
<p>Upon completion of this course, the student shall be able to:</p> <ol style="list-style-type: none"> Formulate unconstrained and constrained optimization problems for engineering applications and derive optimality conditions. Apply suitable methods for solving unconstrained and constrained non-linear optimization problems. Apply quadratic programming approach to solve quadratic functions with equality constraints covering wide range of applications. Interpret the nature of posynomial function and apply geometric programming approach in solving engineering design problems. Justify and apply genetic algorithm for solving optimization problems. 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. 5 th 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, 2 nd 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					
<ol style="list-style-type: none"> To comprehend the principles of various micro and nano manufacturing processes, basic machine tools and recent developments in micro and nano manufacturing technologies To inspire the students for developing the models of micro and nano machining processes. To impart knowledge about nano finishing and metrology for newly developed micro components used in industries and research organizations. 					
Course Outcome					
<ol style="list-style-type: none"> Classify the basic micro machining processes Analyze the various conventional and advanced micro machining processes Describe the micro finishing concepts and application. Discuss the process of Micro-fabrication, forming and micro welding. 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)			
<ol style="list-style-type: none"> 1. J. Paulo Davim, Mark J. Jackson Nano 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. <i>Non-traditional Micromachining Processes Fundamentals and Applications</i> edited by Golam Kibria, B. Bhattacharyya and J. Paulo Davim, Springer. 			
Reference Books			
<ol style="list-style-type: none"> 1. N. P. Mahalik, Micromanufacturing & Nanotechnology, Springer, 2010. 2. Mark J. Jackson, Microfabrication & 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:					
<ol style="list-style-type: none"> To introduce various supply chain and logistics principles and systems. To demonstrate the application of supply chain and logistics concepts, methodologies, and techniques to solve real-life problems. 					
Course Outcome:					
<p>Upon successful completion of the course the students will be able to</p> <ol style="list-style-type: none"> Demonstrate the importance of value proposition and effective use of emerging information technologies in the operations of supply chain and logistics Address the problems of inventory management in a holistic approach using suitable models and strategies Apply the transportation and warehouse systems for improving the performance of SC Evaluate SC network based on drivers and total cost approach Analyse the performance of SC 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, 5 th 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, 10 th edition, Cengage learning, New Delhi	
2.	Sunil Chopra, Peter Meindl, and D.V. Kalra (2017), Supply Chain Management: Strategy, Planning & Operations, 6 th 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, 4 th 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					
<ol style="list-style-type: none"> To enable the student to understand maintenance principles, functions and practices followed in industry To understand basic concepts of maintenance categories like Preventive maintenance, condition monitoring and repair methods for some basic machine elements. To have an introductory idea about maintenance management 					
Course Outcome					
Upon successful completion of the course the students will be able to					
<ol style="list-style-type: none"> Demonstrate the methods and techniques for planning, scheduling, carry out and analyze maintenance. Understand the maintenance function and its objectives and know how to prepare report about the maintenance function Demonstrate the basic knowledge of various condition monitoring methods in accordance with the established procedures Develop step-by-step procedure for conducting a failure analysis of failed machine components Predict appropriate condition monitoring (CM) techniques and instruments 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, MTTTR 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					
<ol style="list-style-type: none"> 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. Define and explain basic terms in the area of manufacturing, as well as structure, design, configuration and practical use of IT systems for manufacturing. 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					
<ol style="list-style-type: none"> To create simple to moderately complex manufacturing information system for manufacturing industry Evaluate critically the role of management information systems for design, engineering and manufacturing Demonstrate an appreciation of the complex relationship between information systems and organization Explain system analysis and design tools 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:					
The objectives of this course are to:					
<ol style="list-style-type: none"> 1. Introduce the student to the principles and methods of statistical analysis of experimental designs. 2. Provide knowledge on process/product optimization through statistical concepts. 					
Course Outcome :					
Upon the completion of the course, the students will be able to					
<ol style="list-style-type: none"> 1. Identify the Principles and Guidelines of Design of Experiments 2. Analyze the Randomized Block Designs 3. Analyze the Factorial Designs 4. Explain the comparison of classical and Taguchi's approach in Design of Experiments 5. Solve the problems by Regression Analysis. 6. Analyze the importance of response Surface Methodology in Design of Experiments 					
Module:1	Experiments with a Single Factor	7 hours			
Basic Principles and Guidelines of Design of Experiments - Single Factor Experiments – ANOVA - Model Adequacy Checking - Determining Sample Size - Comparing Pairs of Treatment Means - Introduction to DOAE 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 levels - 2k factorial designs - Confounding and Blocking in factorial designs					
Module:4	Fractional Factorial Designs	7 hours			
The One-Half and One-Quarter Fraction of the 2k Design - General 2k-p Fractional Factorial Design – 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	Regression Analysis	6 hours			
Introduction - Simple Linear Regression Analysis - Multiple Linear Regression Model - Model Adequacy Checking					
Module:7	Response Surface Methodology	6 hours			
Response surface methodology, parameter – optimization - robust parameter design and its application to control of processes with high variability					
Module:8	Contemporary Issues	2 hours			
Total Lecture hours:					45 hours
Text Book(s)					

1.	Douglas C. Montgomery, (2017), Design and Analysis of Experiments, John Wiley & Sons, Inc., 9th edition		
Reference Books			
1.	Philip J. Ross, (2000), Taguchi Techniques for quality Engineering, Prentice Hall		
2.	Angela Dean, Max Morris, John Stufken, Delrek Bingham (2015), Handbook of Design and Analysis of Experiments, Chapman & Hall/CRC Publishers.		
3.	K. Krishnaiah, P. Shahabuddeen (2012) Applied Design of Experiments and Taguchi Methods, PHI Publications.		
Tutorial			
1.	Module 1	2 hours	
2.	Module 2	2 hours	
3.	Module 3	2 hours	
4.	Module 4	2 hours	
5.	Module 5	2 hours	
6.	Module 6	2 hours	
7.	Module 7	3 hours	
Total tutorial hours			15 hours
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
MMAE609L	Advanced Tool Engineering	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<ol style="list-style-type: none"> To develop competency in understanding different cutting tools and its working principles. To select proper material for the design of the tool, dies and fixtures. To enable the students to analyze and optimize the design of tools, dies, jigs and fixtures 					
Course Outcome					
<ol style="list-style-type: none"> Understand the design considerations in different cutting and forming tools. Design of various cutting tools, holding tools. Select appropriate work holding devices based geometry of workpiece. Design and analyze different dies and press tools. Design of tool holding and workpiece holding for various unconventional machining processes. 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					
<ol style="list-style-type: none"> To enable students to acquire knowledge on foundry and casting processes. To teach students about various casting and welding processes. 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					
<ol style="list-style-type: none"> Discriminate the knowledge of principles, operations and applications of different casting and welding processes. Analyze the effects of process parameters on the quality of cast and weld products. Identify the techniques for the evaluation of cast and weld components Apply the knowledge of welding in Heavy Engineering and nuclear industries 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, Babbitt alloy and Cu alloy					
Module:3	Recent Trends in Casting and Foundry Layout	6 hours			
Shell moulding, precision investment casting, CO ₂ 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.	Carry 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.	Schwarz, 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					
<ol style="list-style-type: none"> To enable students to acquire practical knowledge on foundry and casting processes. To teach students about the measurement of moulding sand properties. To study the effect of welding parameters on joint characteristics. To provide knowledge of underlying principles, mechanisms related to fusion-joining technologies. 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					
<ol style="list-style-type: none"> Understand the principles of casting and welding. Acquire practical knowledge on fusion and solid state welding processes. The students gain the knowledge about the importance of heat input and its effect on microstructure. 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					
<ol style="list-style-type: none"> To provide knowledge on the various techniques to assess and improve the quality and reliability of the product and process. 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					
<ol style="list-style-type: none"> Find the applications of quality and reliability concepts. Solve the quality and reliability issues in the industrial applications. 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

Project and Internship

Course Code	Course Title	L	T	P	C
MMAE696J	Study Oriented Project				02
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives:					
<ol style="list-style-type: none"> 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:					
<ol style="list-style-type: none"> 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:					
<ol style="list-style-type: none"> 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:					
<ol style="list-style-type: none"> 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:							
<ol style="list-style-type: none"> 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)			
<ol style="list-style-type: none"> 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					
<ol style="list-style-type: none"> 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)		
<ol style="list-style-type: none"> 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	

Skill Enhancement Courses

Course code	Course Title	L	T	P	C
MENG501P	Technical Report Writing	0	0	4	2
Pre-requisite	Nil	Syllabus version			
		1.0			
Course Objectives					
1.To develop writing skills for preparing technical reports. 2. To analyze and evaluate general and complex technical information. 3. To enable proficiency in drafting and presenting reports.					
Course Outcome					
At the end of the course, the student will be able to 1.Construct error free sentences using appropriate grammar, vocabulary and style. 2. Apply the advanced rules of grammar for proofreading reports. 3. Interpret information and concepts in preparing reports. 4. Demonstrate the structure and function of technical reports. 5. Improve the ability of presenting technical reports.					
Indicative Experiments					
1.	Basics of Technical Communication General and Technical communication, Process of communication, Levels of communication				
2.	Vocabulary & Editing Word usage: confusing words, Phrasal verbs Punctuation and Proof reading				
3.	Advanced Grammar Shifts: Voice, Tense, Person, Number Clarity: Pronoun reference, Misplace and unclear modifiers				
4.	Elements of Technical writing Developing paragraphs, Eliminating unnecessary words, Avoiding clichés and slang Sentence clarity and combining				
5.	The Art of condensation Steps to effective precis writing, Paraphrasing and summarizing				
6.	Technical Reports: Meaning, Objectives, Characteristics and Categories				
7.	Formats of reports and Prewriting: purpose, audience, sources of information, organizing the material				
8.	Data Visualization Interpreting Data - Graphs - Tables – Charts - Imagery - Info graphics				
9.	Systematization of Information: Preparing Questionnaire Techniques to Converge Objective-Oriented data in Diverse Technical Reports				
10.	Research and Analyses: Writing introduction and literature review, Reference styles, Synchronize Technical Details from Magazines, Articles and e-content				
11..	Structure of Reports Title – Preface – Acknowledgement - Abstract/Summary – Introduction - Materials and Methods – Results – Discussion - Conclusion - Suggestions/Recommendations				
12.	Writing the Report: First draft, Revising, Thesis statement, Developing unity and coherence				
13.	Writing scientific abstracts: Parts of the abstract, Revising the abstract Avoiding Plagiarism, Best practices for writers				
14.	Supplementary Texts Appendix – Index – Glossary – References – Bibliography - Notes				
15	Presentation				

	Presenting Technical Reports Planning, creating and digital presentation of reports		
Total Laboratory hours :			60 hours
Text Book(s)			
1.	Raman, Meenakshi and Sangeeta Sharma, (2015). Technical Communication: Principles and Practice, Third edition, Oxford University Press, New Delhi.		
Reference Books			
1.	Aruna, Koneru, (2020). English Language Skills for Engineers. McGraw Hill Education, Noida.		
2.	Rizvi, M. Ashraf (2018) Effective Technical Communication Second Edition. McGraw Hill Education, Chennai.		
3.	Kumar, Sanjay and Pushpalatha, (2018). English Language and Communication Skills for Engineers, Oxford University Press.		
4.	Elizabeth Tebeaux and Sam Dragga, (2020). The Essentials of Technical Communication, Fifth Edition, Oxford University Press.		
Mode of Evaluation : Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies		19-05-2022	
Approved by Academic Council		No. 66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
MSTS501P	Qualitative Skills Practice	0	0	3	1.5
Pre-requisite	Nil	Syllabus version			
		1.0			
Course Objectives:					
<ol style="list-style-type: none"> To develop the quantitative ability for solving basic level problems. To improve the verbal and professional communication skills. 					
Course Outcome:					
At the end of the course, the student will be able to					
<ol style="list-style-type: none"> Execute appropriate analytical skills. Solve problems pertaining to quantitative and reasoning ability. Learn better vocabulary for workplace communication. Demonstrate appropriate behavior in an organized environment. 					
Module:1	Business Etiquette: Social and Cultural Etiquette; Writing Company Blogs; Internal Communications and Planning: Writing press release and meeting notes	9 hours			
Value, Manners- Netiquette, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body– Make it relevant to your audience.					
Module:2	Time management skills	3 hours			
Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines					
Module:3	Presentation skills – Preparing presentation; Organizing materials; Maintaining and preparing visual aids; Dealing with questions	7 hours			
10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions.					
Module:4	Quantitative Ability-L1–Number properties; Averages; Progressions; Percentages; Ratios	11 hours			
Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, increase and Decrease or Successive increase, Types of ratios and proportions.					
Module:5	Reasoning Ability - L1 – Analytical Reasoning	8 hours			
Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations, Ordering / ranking / grouping, Puzzle test, Selection Decision table.					
Module:6	Verbal Ability -L1 – Vocabulary Building	7 hours			

Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies.			
		Total Lecture hours:	45 hours
Reference Books			
1.	Kerry Patterson, Joseph Grenny, Ron McMillan and Al Switzler, (2017).2 nd Edition, Crucial Conversations: Tools for Talking when Stakes are High .McGraw-Hill Contemporary, Bangalore.		
2.	Dale Carnegie,(2016).How to Win Friends and Influence People. Gallery Books, New York.		
3.	Scott Peck. M, (2003). Road Less Travelled. Bantam Press, New York City.		
4.	SMART, (2018). Place Mentor, 1 st edition. Oxford University Press, Chennai.		
5.	FACE, (2016). Aptipedia Aptitude Encyclopedia. Wiley publications, Delhi.		
6.	ETHNUS, (2013). Aptimithra. McGraw – Hill Education Pvt .Ltd, Bangalore.		
Websites:			
1.	www.chalkstreet.com		
2.	www.skillsyouneed.com		
3.	www.mindtools.com		
4.	www.thebalance.com		
5.	www.eguru.ooo		
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Course Code	Course Title	L	T	P	C
MSTS502P	Quantitative Skills Practice	0	0	3	1.5
Pre-requisite	Nil	Syllabus version			
		1.0			
Course Objectives:					
<ol style="list-style-type: none"> To develop the students' advanced problem solving skills. To enhance critical thinking and innovative skills. 					
Course Outcome:					
At the end of the course, the student will be able to					
<ol style="list-style-type: none"> Create positive impression during official conversations and interviews. Demonstrate comprehending skills of various texts. Improve advanced level thinking ability in general aptitude. Develop emotional stability to tackle difficult circumstances. 					
Module:1	Resume skills – Resume Template; Use of power verbs; Types of resume; Customizing resume	2 hours			
Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout-Understanding different company's requirement, Digitizing career portfolio.					
Module:2	Interview skills – Types of interview; Techniques to face remote interviews and Mock Interview	3 hours			
Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds.					
Module:3	Emotional Intelligence - L1 – Transactional Analysis; Brain storming; Psychometric Analysis; SWOT analysis	12 hours			
Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure ,Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways, SWOT analysis.					
Module:4	Quantitative Ability - L3–Permutation - Combinations; Probability; Geometry and menstruation; Trigonometry; Logarithms; Functions; Quadratic Equations; Set Theory	14 hours			
Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram.					
Module:5	Reasoning ability - L3 – Logical reasoning; Data Analysis and Interpretation	7 hours			

Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data Interpretation-Advanced, Interpretation tables, pie charts & bar charts.			
Module:6	Verbal Ability - L3 – Comprehension and Critical reasoning		7 hours
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument.			
Total Lecture hours:			45 hours
Reference Books			
1.	Michael Farra and JIST Editors,(2011).Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Jist Works, Saint Paul, Minnesota.		
2.	Flage Daniel E, (2003).The Art of Questioning: An Introduction to Critical Thinking. Pearson, London.		
3.	David Allen, (2015).Getting Things done: The Art of Stress-Free productivity. Penguin Books, New York City.		
4.	SMART, (2018). Place Mentor 1 st edition. Oxford University Press, Chennai.		
5.	FACE, (2016).Aptipedia Aptitude Encyclopedia. Wileypublications, Delhi.		
6.	ETHNUS, (2013).Aptimithra. McGraw-Hill Education Pvt Ltd, Bangalore.		
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