Curriculum

M. Tech. Mechanical (Manufacturing Technology) Program

School of Technology

Pandit Deendayal Energy University

Course Structure of M. Tech. Mechanical

(Manufacturing Technology)

Approved in 2020-21 and w.e.f. Admission Batch: 2020

Program Educational Objectives (PEOs):

1. To prepare graduates with sound fundamental knowledge and futuristic research in field of thermal engineering and to make them capable of effectively analyzing and solving the problems associated in this field.
2. To prepare the graduates with core competency to be successful in industry or academia or research laboratory and motivate them to pursue higher studies in interrelated areas.
3. To prepare lifelong learner graduates by providing an academic and research environment for their successful professional career as well as to peruse higher education.
4. To prepare graduates with leadership qualities, effective communication skills, professional and ethical values.

Program Outcomes (POs)

1. **Engineering Knowledge:** Acquire advanced knowledge of thermal engineering principles and modelling methodologies commonly used in the development and analysis of Thermal systems.
2. Problem Solving Skills: Graduates will demonstrate an ability to identify, formulate and solve thermal engineering problems.
3. **Design/ Development of solutions:** An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, health and safety, manufacturability, and sustainability.
4. **Multidisciplinary Approach:** An ability to function on multidisciplinary teams.
5. **Modern tool usage:** An ability to identify, formulate, and solve engineering problems using modern tools and techniques.
6. **Communication:** An ability to communicate effectively.
7. **The Engineer and Society:** The broad education necessary to understand the impact of mechanical engineering solutions in a local, global, economic, environmental, and societal context.
8. **Life-long learning:** A recognition of the need for, and an ability to engage in life-long learning.
9. **Investigations of complex problem:** Use of Applied research including design of experiments, analysis and interpretation of data, synthesis of the information to provide valid solutions with the knowledge of contemporary issues.
10. **Project Management:** An ability to apply engineering knowledge and management principles skills to manage engineering projects.
11. **Environment and Sustainability:** An ability to design sub-systems, systems, components and processes to fulfil demand of environmental sustainability.
12. **Ethics:** Apply engineering principles toward the professional values and ethics.

Program Specific Outcomes (PSOs): At the end of the program, student will be able

1. To **analyse the problems** and **create solution** by applying engineering knowledge with a multidisciplinary approach in the area of thermal engineering, manufacturing systems and product design.
2. To analyze, interpret and provide solutions to the real life mechanical engineering problems **using engineering software/tools.**
3. **To work effectively in a team** to address **complex issues** by engaging in **lifelong learning** and following **ethical and environmental** practices

Sem I, Sem II, Sem III, Sem IV

COURSE STRUCTURE FOR M.TECH. MECHANICAL (Manufacturing Technology) FIRST YEAR

SEMESTER I			M.TECH											
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme						
								Theory			Practical		Total	
			L	T	P	C	Hrs/wk	MS	ES	IA	LW	LE/Viva	Marks	
1	20MMM501T	**Advanced manufacturing Processes-I**	3	0	0	3	3	25	50	25	--	--	100	
2	20MMM502T	**Advanced Engineering Metallurgy**	3	0	0	3	3	25	50	25	--	--	100	
3	20MMM503T	**Surface Engineering**	3	0	0	3	3	25	50	25	--	--	100	
4	20MMM506P	**Advanced Manufacturing Lab-I**	0	0	4	2	4	--	--	--	50	50	100	
5		Elective I	3	0	0	3	3	25	50	25	--	--	100	
6		Elective II	3	0	0	3	3	25	50	25	--	--	100	
		Total	**15**	**0**	**4**	**17**	**19**						600	

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like quiz, assignments etc)

LW = Laboratory work; LE = Laboratory Exam

Electives: (1) Quality Management systems (2) Manufacturing Automation (3) Micro and Nano Manufacturing (4) Advanced Welding Processes (5) Numerical Modelling of manufacturing processes (6) Computer Integrated Manufacturing (7) Design for Manufacturing (8) Simulation of Manufacturing Systems (9) Industry 4.0 (10) Sheet Metal Engineering (11) Sustainable Manufacturing (12) Manufacturing codes and standards (13) Advanced Materials and Characterizations (14) Experimental Methods (15) Finite Element and Mesh Free Methods

20MMM501T					Advanced manufacturing Processes-I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To know the importance of manufacturing.**
- **To learn different types of manufacturing processes.**
- **To understand applications of various manufacturing processes**.
- **To study advanced metal forming processes**

UNIT 1 ADVANCED CASTING **9 Hrs.**

Foundry equipment and processing, Pattern and pattern making, gating systems, Mechanism of solidification runner-riser and gating system (design and their placements), ferrous casting alloys, non-ferrous casting alloys, Casting defects. Casting techniques: Magnetic Moulding, Metal Injection Moulding, Centrifugal Casting, Evaporative Pattern Casting, Hybrid Evaporative Pattern Casting Process, Vacuum Sealed Molding Process, Ceramic Shell Investment Casting Process, Stir casting, Organic processes, Fluid sand processes, Graphite Moulding Process.

UNIT 2 ADVANCED FUSION WELDING PROCESSES **9 Hrs.**

Activated arc welding processes, Pulse gas tungsten arc welding and pulse gas metal arc welding, Cold metal transfer narrow grove welding, hot-wire arc welding, selection of electrodes, Electron Beam Welding, Laser beam welding, Hybrid welding processes. Mechanical properties of joints: hardness, tensile, corrosion, fatigue, welding economics, welding design, welding defects

UNIT 3 SOLID-STATE WELDING PROCESSES **9 Hrs.**

Comparison of fusion and solid-state welding, microstructure evolution in solid-state welding, Friction welding, Friction stir welding, Ultrasonic welding, Explosion welding, Diffusion bonding. Similar and dissimilar material welding by solid-state welding. Recent trends in solid-state welding.

UNIT 4 ADVANCED METAL FORMING **12 Hrs.**

Forging: Fundamentals- Introduction to plasticity, principle, tools, dies, classifications of forging. Rolling: Fundamentals, theory of rolling, types of rolling mills and products, forces in rolling and power requirements. Extrusion: Hot and cold extrusion, forward and backward extrusion, impact extrusion, hydrostatic extrusion. Drawing: Drawing of wires, bars and tubes. Drawing forces and power. Sheet metal forming and magnetic – pulse forming. Hydro forming.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1. Classify primary manufacturing processes.

CO2: Apply advanced knowledge of casting for different range of materials.

CO3. Compare fusion and solid-state welding processes.

C04. Evaluate joint performance of different combinations of materials.

CO5: Identify the importance of metal forming in manufacturing.

C06. Point out challenges in casting, welding, and forming.

TEXT/REFERENCE BOOKS

1. P.N. Rao, Manufacturing Technology Vol 1, Mc Graw Hill India.
2. M.P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th edition, Willey.
3. S. Kalpakjian and S.Schmid, Manufacturing Processes for Engineering Materials, 6th Edition, Pearson.
4. A. Ghosh, A. K. Mallik, Manufacturing Science, East-West Press Pvt Ltd, Second edition

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 3 Questions from each unit - each carrying 5 marks 60 Marks

Part B/Question: 1 Question from each unit- each carrying 10 marks 40 Marks

20MMM502T					Advanced Engineering Metallurgy					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To understand the importance of Metallurgy and structure – property correlations.**
- **To develop a fundamental understanding of mechanical and destructive testing.**
- **To familiarize with ferrous and nonferrous metallurgy and phase transformations.**
- **To study the fundamentals of powder metallurgy, surface hardening and metallography**

UNIT 1 STRUCTURE PROPERTY CORRELATION AND MECHANICAL & DESTRUCTIVE TESTING **10 Hrs.**

Crystal Defects Structure Property Relation: Point, line and area defects, APF, CN and strengthening mechanisms. **Mechanical properties of Metal and Alloys;** Tension test, engineering stress-strain diagram for ductile and brittle materials, compression test. Macro, Micro and Nano Hardness, Toughness, Impact Toughness and, fracture toughness testing Fatigue, creep test and anisotropy of alloys, Erichsen cupping test, Limiting Dome Height (LDH) test. **Fracture of Metals:** Brittle Fracture, Ductile Fracture, and Factors Leading to Crack Formation, Ductile-brittle Transition in Steels, Fatigue and Creep fracture. Introduction to Non Destructive Testing.

UNIT 2 FERROUS METALLURGY **12 Hrs.**

Fe-C diagram, TTT and CCT diagrams, Lever rule and its applications, structure properties of various Fe-C Alloys, Heat Treatment**:** heat treatments like annealing (recovery, re-crystallization and grain growth), normalizing, hardening and tempering. Hardenability of steels, Effect of alloying elements on mechanical properties of steel, alloy steels, tool steels, stainless steels, cast irons. Jominey end quench test.

UNIT 3 NONFERROUS METALLURGY **08 Hrs.**

Copper and the Copper-base Alloys, Aluminium and Its Alloys, Other Non-ferrous Metals and Alloys; Ni & Ti alloys, Advanced material: super alloys, cryogenic material, high temperature materials, composite material.

UNIT 4 METALLOGRAPHY & ASTM STANDARDS **10 Hrs.**

Introduction to powder metallurgy& applications, Metallurgical Microscope, Metallography, color metallography, and institute metallography, surface hardening. **ASTM standards for mechanical testing**, Numerical based on engineering stress vs. engineering strain curve, true stress vs. true strain curve, impact energy vs. temperature curve, stress amplitude vs. number of cycles in fatigue test, calculation of fatigue life and strength. Evaluating number of phases, composition of phase and amount of phases for the given condition using lever rule. Determination of ASTM grain size number, recent advances in engineering metallurgy.

Max. 40 Hrs

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 - Understand the sub disciplines of metallurgy, its application and structure property correlation.

CO2 - Develop fundamental understanding of Mechanical, Metallurgical and NDT testing.

CO3 - Familiarization with Iron- Carbon, TTT, CCT diagrams and Heat treatment.

CO4 - Understand the Metallurgy of Ferrous and Nonferrous materials.

CO5 - Knowledge of Powder Metallurgy, surface hardening and fractography.

CO6 - Understand ASTM Standards for mechanical testing and its relevance.

TEXT/REFERENCE BOOKS

1. R.E. Reed-Hill, Physical Metallurgy Principles, Cengage Learning.
2. William D Callister, Jr., Materials Science and Engineering, Wiley India (P) Ltd.
3. RAYMOND A. HIGGINS, ENGINEERING METALLURGY, Part I APPLIED PHYSICAL METALLURGY.
4. G. E. Dieter, Mechanical Metallurgy, Third edition, Tata McGraw-Hill Education

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 15 questions each 5 marks	75 Marks
Part B/Question: 5 question each 3 marks	15 Marks
Part C/ Question: 5 question each 2 marks	10 Marks

20MMM503T					Surface Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To understand the surface deterioration of materials under service.**
- **To identify techniques for surface property modification.**
- **To understand the characterization techniques useful in determining surface properties.**
- **To enable development of better technologies for superior surface performance**.

UNIT 1 SURFACE DAMAGE **11 Hrs.**

Introduction: Purpose and Need of Surface Engineering, Surface and Sub-surface regions, Classification of Surface Modification Techniques, Scope of Surface Engineering, Role of Surface Properties, Surface Energy. **Surface Damage:** Factors causing Material Damage, Type of Wear and Mechanisms, Techniques to evaluate Damage of Wear Surfaces. **Materials:** Material Properties and Wear, Properties required for better Wear Resistance, Selection of Materials for Surface Engineering.

UNIT 2 SURFACE METALLURGY **12 Hrs.**

Surface Engineering by changing the Surface Metallurgy: Introduction, Transformation Hardening Methods, Modified Surfaces using LASER and TIG, Plastic Deformation based approaches. **Surface Engineering by changing the Composition:** Carburizing, Nitriding, Use of Plasma, LASER Alloying, Surface modification using Diffusion-based processes. **Surface Modification by Coating and Cladding:** Protection and Dilution of Coating and Cladding, Energy density and Cooling rate. Weld surfacing, LASER cladding, Thermal Spraying, Electroplating, Electroless Process. Other techniques of Coating.

UNIT 3 CHARACTERIZATION OF SURFACES **09 Hrs.**

Characterization of Engineered Surfaces: Characterization of Surface Properties, Thickness of Coatings and Films, Bond strength of Coating and substrate, Soundness of Modified surfaces by NDT, Destructive Testing of Modified Surfaces, Adhesive Wear, XRD Analysis, SEM, Compositional Analysis, EDAX Analysis, Macroscopic observation and Metallographic Examination.

UNIT 4 APPLICATIONS **08 Hrs.**

Allied Study: Nano-Sciences and Surface Engineering, Functional and nano-structured coatings and their applications in photovoltaics, bio- and chemical sensors. Surface passivation of semiconductors & effect on electrical properties. Surface engineering of polymers and composites. **Applications:** Automotive Engine components, Bio-Medical Implants etc.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Analyse the surface damage of materials for future prevention of the same.

CO2 – Examine the Surface Metallurgy techniques for altering the surface properties.

CO3 – Examine the changes in surface properties by altering the surface composition.

CO4 – Examine the Coating and Cladding techniques for altering the surface properties.

CO5 – Determine the characteristics of surfaces to ensure fidelity in application.

CO6 – Outline the allied studies associated with surface property alteration.

TEXT/REFERENCE BOOKS

1. Surface Engineering: Enhancing Life of Tribological Components, by D. K. Dwivedi, Springer
2. Introduction to Surface Engineering, by P. A. Dearnley, Cambridge University Press
3. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988
4. M. Ohring, The Materials Science of Thin Films, Academic Press
5. ASM Handbook: Surface Engineering, by Faith Reidenback, ASM-International, Metals Park, OH, 1994
6. Advanced Surface Coatings: A Handbook of Surface Engineering, by D. S. Rickerby, A. Mathews, Blackie Academic and Professional Publ. 1991.
7. Handbook of Thin-Film Deposition Processes and Techniques - Principles, Methods, Equipment and Applications, by K. Seshan, William Andrew Publishing/Noyes, 2002.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

6 questions 5 marks each 30 Marks

7 questions 10 marks each 70 Marks

20MMM506P					Advanced Manufacturing Lab-I		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Theory	Practical	Total Marks
					Continuous Evaluation	End Semester	
0	0	4	2	4	25	25	50

COURSE OBJECTIVES

- **To make students aware about the working and practical aspects of different casting processes.**
- **To enable students for making components by undergoing hands-on operation on various welding machines.**
- **To make student aware about different metal forming operations.**
- **To study micro structural analysis of welded joints**

List of Experiment

1. To perform sand casting operations
2. To study the safety aspects of welding, casting and machining operations
3. Hands on experience on Shielded metal arc welding
4. Hands on experience on Gas metal arc welding
5. Hands on experience on Gas tungsten arc welding
6. Hands on experience on Gas welding, Gas cutting
7. Hands on experience on Resistance welding spot, projection, butt welding
8. To understand the use of various welding gauge
9. Hands on experience on Soldering and Brazing.
10. To perform Friction Welding using lathe machine
11. To perform Friction Stir Welding using vertical milling machine
12. Development of macro and microstructure of welded joints and casted components.
13. To study Injection moulding of plastics

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the working principle and practical aspects of welding, casting, and forming processes.

CO2: Define the process parameters of metal forming related operations.

CO3: Analyze the effect of input process parameters for different welding processes.

CO4: Examine the working principle and create a component using solid-state welding processes.

CO5: Produce the welding and casting components.

CO6: Evaluate the performance of cast and weld component.

TEXT/REFERENCE BOOKS

1. P.N. Rao, Manufacturing Technology Vol 2, Mc Graw Hill India.
2. G.K. Lal, Introduction To Machining Science, New Age International.
3. A. Ghosh, A. K. Mallik, Manufacturing Science, East-West Press Pvt Ltd, Second edition
4. S. Kalpakjian and S.Schmid, Manufacturing Engineering & Technology, 7th edition, Pearson.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz	10 Marks
Experiment	15 Marks

COURSE STRUCTURE FOR M.TECH. MECHANICAL (Manufacturing Technology) FIRST YEAR

SEMESTER II			M.TECH										
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
								Theory			Practical		Total
			L	T	P	C	Hrs/wk	MS	ES	IA	LW	LE/Viva	Marks
1	**20MMM507P**	**Advanced Manufacturing Processes - II**	3	0	0	3	3	25	50	25	--	--	100
2	**20MMM508P**	**Additive Manufacturing**	3	0	0	3	3	25	50	25	--	--	100
3	**20MMM509P**	**Non Destructive Testing & Failure Analysis**	3	0	0	3	3	25	50	25	--	--	100
4	**20MMM510T**	**Advanced Manufacturing Lab. - II**	0	0	4	2	4	--	--	--	50	50	100
5		Elective I	3	0	0	3	3	25	50	25	--	--	100
6		Elective II	3	0	0	3	3	25	50	25	--	--	100
		Total	**15**	**0**	**4**	**17**	**19**						600

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like quiz, assignments etc)

LW = Laboratory work; LE = Laboratory Exam

20MMM507P					Advanced manufacturing Processes-II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To know the importance of metal cutting in manufacturing.**
- **To learn different types of machining related operations.**
- **To study various designing aspects of machine tool structures.**
- **To acquire knowledge of different types of non-traditional machining processes**.

UNIT 1 METAL CUTTING THEORY AND PRACTICE **13 Hrs.**

Geometry of the cutting process, Single point cutting tool geometry, Single point tool signature-Tool in hand system, ORS, NRS. Nomenclature of single and multi-point tools, Mechanics of chip formation, Thick and thin shear zone theory, Merchant's analysis, Friction in metal cutting, Chip control, Controlled contact cutting, Cutting fluids, Cutting tool materials, Machinability, Tool wear and tool life.

UNIT 2 DESIGN AND ANALYSIS OF MACHINE TOOLS **09 Hrs.**

Transmission of motion in machine tools, Design of speed and feed boxes, Design of machine tool structure, Design for strength and rigidity, Constructional features of machine tool structures, Static and dynamic stiffness, Antifriction bearings and sliding bearings, Machine tool dynamics.

UNIT 3 IMPORTANCE OF NON-TRADITIONAL MACHINING PROCESSES **09 Hrs.**

Need for advanced material removal processes, Classification of advanced machining / material Removal processes, considerations in process selection and applications. Comparison of conventional Vs. unconventional machining processes. Working principle and applications of Ultrasonic Machining Process (USM), Abrasive Flow Machining, Abrasive jet machining (AJM), Water jet and abrasive Water Jet Machining (AWJM).

UNIT 4 NON-TRADITIONAL MACHINING PROCESSES **09 Hrs.**

Role, importance, working principle and applications of Magnetic abrasive finishing and its applications, Electrical Discharge Machining (EDM), Laser Beam Machining (LBM), Electron beam machining (EBM), Electrochemical Machining (ECM), Hybrid machining processes.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1. Understand metal cutting theory.

CO2: Design machine tool structures.

CO3. Compare traditional and non-traditional machining processes.

C04. Analyze the relation between the machining parameters and machining quality.

CO5: Categorize conventional machining operations.

C06. Summarize non-traditional machining processes.

TEXT/REFERENCE BOOKS

1. P.N. Rao, Manufacturing Technology Vol 2, Mc Graw Hill India.
2. G.K. Lal, Introduction To Machining Science, New Age International.
3. S. Kalpakjian and S.Schmid, Manufacturing Engineering & Technology, 7th edition, Pearson.
4. E. J. A. Armarego, R. H. Brown, The machining of metals, Prentice-Hall
5. A. Ghosh, A. K. Mallik, Manufacturing Science, East-West Press Pvt Ltd, Second edition

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 3 Questions from each unit - each carrying 5 marks 60 Marks

Part B/Question: 1 Question from each unit- each carrying 10 marks 40 Marks

20MMM510T					Advanced Manufacturing Lab – II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	4	2	4	--	--	--	25	25	50

COURSE OBJECTIVES

- **To make students aware about the working and practical aspects of different CNC machines used for operations such as Lathe, Milling, Drilling, Grinding, Shaper and Grinding Machines.**
- **To enable students for making components by undergoing hands-on operation on the CNC machines.**
- **To make student aware about different non-conventional processes.**
- **To illustrate different NDT techniques with practical exposure.**

List of Experiment

1. To study basics and advanced functions of CNC Lathe machine and to prepare a job by performing Hands-on-experiment
2. To study basics and advanced functions of CNC Milling machine and to prepare a job by performing Hands-on-experiment
3. To study basics and advanced functions of CNC Drilling machine and to prepare a job by performing Hands-on-experiment
4. Study and performance of ultrasonic welding machine.
5. Study and performance of wear testing equipment.
6. Study and performance of Hot-tensile equipment.
7. To study the operation and perform analysis on optical microscope.
8. To study the advanced functions of Wire-cut EDM Machine and prepare a Job by performing hands-on-experiment
9. To study the advanced functions of Spark erosion EDM Machine and prepare a Job by performing hands-on-experiment.
10. To study the advanced functions of ECDM Machine and prepare a Job by performing hands-on-experiment.
11. To study and carry out the Visual testing as per ASNT procedure.
12. To study and carry out the Magnetic Particle testing as per ASNT procedure.
13. To study and carry out the liquid penetrant testing as per ASNT procedure.
14. To study and carry out the Ultrasonic testing as per ASNT procedure.
15. To have a hands-on surface roughness tester and prepare a comparative analysis.
16. Introduction and hands-on on 3d Printing machine.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the working principle and practical aspects of CNC machining used for machining operations.

CO2: Apply the principles of machining to prepare a component using the CNC machines

CO3: Analyze the effect of input process parameters for different CNC operations.

CO4: Examine the working principle and create a component using non-conventional machining processes

CO5: Analyse the different NDT techniques used for assessment.

CO6: Evaluate the performance of 3d printing by making a component.

TEXT/REFERENCE BOOKS

1. P.N. Rao, Manufacturing Technology Vol 2, Mc Graw Hill India.
2. G.K. Lal, Introduction To Machining Science, New Age International.
3. S. Kalpakjian and S.Schmid, Manufacturing Engineering & Technology, 7th edition, Pearson.
4. V.!K.!Jain,!Advanced!Machining!Processes,!Allied!Publishers!Mumbai.!!
5. Baldev Raj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa Publishing, 1997.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz	10 Marks
Experiment	15 Marks

20MMM508P					Additive Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To provide fundamentals of additive manufacturing (AM) with recent development and applications**
- **To study role of CAD models and CAM programming in AM with Reverse engineering.**
- **To provide knowledge of different AM processes for various materials based on ASTM standards.**
- **To develop experimental based learning with case study related to AM processes.**

UNIT 1 INTRODUCTION TO AM **09 Hrs.**

Introduction to additive manufacturing (AM): Overview – History – Need- Classification of AM processes- current development of new additive manufacturing processes- Process chain (Pre-processing and Post-processing). **Applications of AM:** AM applications in various Industries. AM in Industry 4.0.

UNIT 2 CAD FOR AM **09 Hrs.**

CAD design for AM: CAD model preparation – Part orientation and support generation – Model slicing –Tool path generation (preparatory (G) and miscellaneous (M) code generation) – Softwares for AM Technology. STL file generation, Design for AM, Regenerative design in AM, Reverse Engineering, 3D scanning.

UNIT 3 AM PROCESSES **14 Hrs.**

AM Processes: Fused deposition modelling (FDM)- Principle, process, advantages and applications Stereolithography (SLA)-Binder Jetting-Material jetting-Powder bed fusion AM processes involving sintering and melting- Principle, process, advantages and applications-Directed energy deposition-Sheet lamination: Principle, process, advantages and applications, Micro- and nano-additive manufacturing processes.

UNIT 4 MATERIALS IN AM **8 Hrs.**

Material Science Aspects and case study: Different materials used in AM- polymers, metals, multiple materials, multifunctional and graded materials. A case study based on experimental development of 3 D components. Mini Project

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand fundamentals of process chain of Additive manufacturing (AM) with classification of AM process.
CO2: Apply various designing and slicing techniques that enable AM and create programming for tool path.
CO3: Understand fundamentals of polymer material based AM processes.
CO4: Analyze the characteristics of liquid, powder and solid based AM process.
C05: Explain different materials used for building three dimensional AM components.
CO6: Create AM components by applying fundamental knowledge of different AM process.

TEXT/REFERENCE BOOKS

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.
3. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003.
4. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from each unit, each carrying 10 marks 40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks 60 Marks

20MMM509P					Non-Destructive testing and failure analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To introduce and familiarize the different Non-destructive testing techniques and its importance in manufacturing.**
- **To understand basic working principle and its allied aspects for different widely used NDT techniques.**
- **To enable the students for doing Failure analysis of a component and make them aware about different tools used.**
- **To make student aware about the latest advancement in the codes and standards followed in NDT as well as advanced tools pertaining to Industry 4.0 in NDT.**

UNIT 1 FAILURE ANALYSIS 9 Hrs.

Failure Analysis – I: Failure analysis – methodology; approaches, tools and techniques of failure analysis; modes of failure; failure data retrieval; procedural steps for Investigation of a failure for failure analysis. **Failure Analysis – II:** Improvements (design, material) derived from failure analysis; two case studies; application of fracture mechanics concepts to design for safety. **Techniques for Failure identification:** Optical Microscopy, X-RAY Diffraction, Electron microscopy

UNIT 2 MANUFACTURING DEFECTS 9 Hrs.

Manufacturing DEFECTS : Origin - types - process induced defects, - significance – remedial Measures, e.g. Micro cracks, Hot cracking - cold cracking -lamellar tearing - reheat cracking. **Introduction to NDT:** Introduction to Non-Destructive Testing (NDT), its relevance, importance and key features. Classification of NDT techniques and its various applications. Selection of NDT techniques and their importance in the field of reliability analysis as well as remaining life assessment (RLA). Brief introduction to 16 methods of NDT and brief introduction to 6 widely used NDT techniques. **Visual examination:** Fundamentals of defects, root causes of defects, tools and techniques for visual observation. Acceptance standards and application.

UNIT 3 INSPECTION 12 Hrs.

LPT, MPT: Liquid penetrant testing – procedure; penetrant testing materials, penetrant testing method – sensitivity; application and limitations; magnetic particle testing; definition and principle; magnetizing technique, procedure, equipment sensitivity and limitation; Application & Acceptance Standards **RADIOGRAPHY:** Basic principle, electromagnetic radiation in film, radiographic imaging, inspection techniques, applications, limitations, real time radiography, safety in Industrial radiography. Application & Acceptance Standards. **Ultrasonic Techniques:** Ultrasonic transducers, inspection methods, technique for normal beam inspection, flaw characterization technique, ultrasonic flaw detection equipment modes of display, immersion testing, advantage, limitations; Application & Acceptance Standards

UNIT 4 CODES & STANDARD 9 Hrs.

Eddy current testing: Principle, instrument techniques, sensitivity application, limitation; ultrasonic testing – basic properties of sound beam, Application & Acceptance Standards **Acoustic emission testing:** Principles of AET and techniques, its application, Acceptance standards. **Codes & Standards:** Introduction to codes and standards, necessity, importance and various codes worldwide. Introduction to ASME codes and its various sub-sections. Requirements of ASME Sec-V code and its interpretation. **Introduction to various codes and standards across the world such as ISO, ASTM, ASNT, etc.** Use of automation, AI and Industry 4.0 in testing techniques and its case studies

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the basic concept of Failure analysis and apply it for remaining life assessment.
CO2: Discuss the various defects in manufacturing, basis of NDT and principles of visual testing.
CO3: Explain the various methods of NDT such as LPT, MPT and its relevance in manufacturing.
CO4: Discuss the NDT method of RT and UT and its application on real life manufacturing scenario.
CO5: Evaluate the advanced NDT technique such as AET and ECT for manufacturing applications.
CO6: Discuss the different codes and standards of NDT and use of industry 4.0 tools for Non-destructive testing.

TEXT/REFERENCE BOOKS

1. Baldev Raj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa Publishing, 1997.
2. Das A.K., 'Metallurgy of Failure Analysis', TMH, 1992.
3. Hull., 'Non-Destructive Testing', ELBS Edition, 1991
4. Halmshaw R., - 'Non-Destructive Testing', Edward Arnold, 1989

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 Questions from all units, each carrying 10 marks 80 Marks
Part B/Question: 4 Questions from all units, each carrying 5 marks 20 Marks

COURSE STRUCTURE FOR M.TECH. MECHANICAL (Manufacturing Technology) 2nd Year

SEMESTER III			M.TECH.											
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme						
			L	T	P	C	Hrs/wk	Theory			Practical		Total
								MS	ES	IA	LW	LE/Viva	Marks
	20MT611	Seminar				4		40	60	--			100
	20MT612	Project				14		40	60	--			100
	20MT613	Industrial Internship											PP/NP
		Total				18							200

20MT611					Seminar					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	4	2	04	-	-	-	-	-	50

COURSE OBJECTIVES

- Students can gain skills of group interaction, skills of integrative discussion, critical evaluation and exploring and mining a text through seminar.
- Students can develop the technical writing skill

Seminar

Each student must present any technical topic for 15 mins followed by an evaluation by a teacher for 10 minutes using evaluation criteria. All other students must attend and can give suggestions. Each student must give minimum two presentations per semester.

Technical writing

1	Definitions, structure and types of reports	4 Hrs
2	Importance of references, glossary and bibliography. How to write and insert them in reports.	6 Hrs
3	Use and types of charts and illustrations in report writing	6 Hrs
4	Various report writing techniques	6 Hrs
5	Computer aided report writing practices	4 Hrs
		26 Hrs

COURSE OUTCOMES

On outcome of the course would be as follows:

CO-1: Shy or reserved students find voice.
CO-2: Students are highly motivated to research and prepare for discussion
CO-3: Group sharing provides a more in-depth understanding of the text
CO-4: Students develop the skills for report writing.
CO-5: Students learn the standard process to write a publication quality report or research article
CO-6: Familiarization of various software tools for report writing

References:

1. Malcolm Goodale, Professional Presentations, Cambridge University Press (2009)
2. MK Rampal and S L Gupta, Project report writing, Galgotia Publishing Company, New Delhi (2010)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50

Part A: Writing skill 25 marks
Part B: Presentation 25 Marks

20MT612					Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	0	13	-	-	-	-	50	50	100

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Undertake** problem identification, formulation and solution by considering ethical responsibility

CO2 – **Demonstrate** a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – **Formulate** and develop a hardware/software based prototype model

CO4 – **Achieve** skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – **Identify** and **apply** appropriate steps to solve problems they have met during implementation of their project

CO6 – **Design** engineering solutions to complex problems utilizing as system approach

COURSE STRUCTURE FOR M.TECH. MECHANICAL (Manufacturing Technology) 2nd Year

SEMESTER IV			M.TECH.											
Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme						
			L	T	P	C	Hrs/wk	Theory			Practical		Total	
								MS	ES	IA	LW	LE/Viva	Marks	
	20MT621	Seminar				4		40	60	--			100	
	20MT622	Project and Dissertation				24		40	60	--			100	
		Total				28							200	

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like quiz, assignments etc.)

LW = Laboratory work; LE = Lab. Exam

20MT621					Seminar					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	4	2	04	-	-	-	-	-	50

COURSE OBJECTIVES

- Students can gain skills of group interaction, skills of integrative discussion, critical evaluation and exploring and mining a text through seminar.
- Students can develop the technical writing skill

Seminar

Each student must present any technical topic for 15 mins followed by an evaluation by a teacher for 10 minutes using evaluation criteria. All other students must attend and can give suggestions. Each student must give minimum two presentations per semester.

Technical writing

1	Definitions, structure and types of reports	4 Hrs
2	Importance of references, glossary and bibliography. How to write and insert them in reports.	6 Hrs
3	Use and types of charts and illustrations in report writing	6 Hrs
4	Various report writing techniques	6 Hrs
5	Computer aided report writing practices	4 Hrs
		26 Hrs

COURSE OUTCOMES

On outcome of the course would be as follows:

CO1: Shy or reserved students find voice.
CO2: Students are highly motivated to research and prepare for discussion
CO3: Group sharing provides a more in-depth understanding of the text
CO4: Students develop the skills for report writing.
CO5: Students learn the standard process to write a publication quality report or research article
CO6: Familiarization of various software tools for report writing

References:

3. Malcolm Goodale, Professional Presentations, Cambridge University Press (2009)
4. MK Rampal and S L Gupta, Project report writing, Galgotia Publishing Company, New Delhi (2010)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50

Part A: Writing skill 25 marks
Part B: Presentation 25 Marks

20MT622					Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	0	13	-	-	-	-	50	50	100

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Undertake** problem identification, formulation and solution by considering ethical responsibility

CO2 – **Demonstrate** a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – **Formulate** and develop a hardware/software based prototype model

CO4 – **Achieve** skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – **Identify** and **apply** appropriate steps to solve problems they have met during implementation of their project

CO6 – **Design** engineering solutions to complex problems utilizing as system approach

20MMM505T					Quality Management systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To introduce and familiarize different aspects of quality and its perspective in industry.**
- **To aware students about the various QC tools and techniques used in manufacturing industry.**
- **To introduce the different ISO standards, its application and benefits of the ISO**
- **To empower students about various aspects of quality control and assurance.**

UNIT 1 QUALITY MANAGEMENT **10 Hrs.**

Definitions of quality, explaining basic concepts, Overview of historical development. Management theory, Statistical quality control, Integrated quality control, Contemporary developments in the field of quality management, the role of quality control in the modern enterprise, Evolution of Quality Management, Concepts of Product and Service Quality, Dimensions of Quality, Deming's, Juran's, Crosby's Quality, Philosophy, Quality Cost

UNIT 2 QC TOOLS **10 Hrs.**

Introduction to Process Quality Graphical and statistical techniques for Process Quality Improvement Graphical tools for data representation 7 QC tools Sampling, sampling distribution, and hypothesis Testing, Regression Control charts Process capability analysis Measurement system analysis of Variance (ANOVA) Design and Analysis of Experiment (DOE) Acceptance sampling plan TQM Leadership Lean and JIT Quality Philosophy Benchmarking Process failure mode and effect analysis (PFMEA) Service Quality Six sigma for Process Improvement ISO 9001 and QS 9000 Quality Audit Quality Circles.

UNIT 3 QUALITY FUNCTION DEPLOYMENT **9 Hrs.**

Quality Function Deployment Robust Design and Taguchi Method Design Failure Mode & Effect Analysis Product Reliability Analysis Six Sigma in Product Development

Lean manufacturing: Lean logic, lean implementation requirements, lean layout and design flow, lean applications for line flow, lean services, case studies in lean manufacturing, Just-in-time (JIT), characteristics of JIT, implementation of JIT, the Toyota Production System: elimination of waste and respect for people, push vs. pull systems, use of Kanban, case studies on pull vs push systems.

UNIT 4 INSPECTION AND QUALITY **10 Hrs.**

Introduction to Inspection and Quality Control, Dimensions and Tolerances, Selection of Gauging Equipment, Gauge Control, Quality Control and Quality Assurance, Statistical Quality Control, Total Quality Management, Quality Standards. Basics of project management and it role in quality management. Philosophy of industries in quality management.

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO 1: To understand the concept of quality and evaluate the different theories of quality.
CO 2: To apply the tools and techniques of Quality control on real life industry scenario.
CO 3: To Understand the concept of different ISO standards and its application.
CO 4: To discuss the different techniques for product development and enhancement of efficiency.
CO 5: To explain the concept of Lean manufacturing and its application in shop floor.
CO 6: To understand the concept of quality assurance and quality control.

TEXT/REFERENCE BOOKS

1. D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 3rd Edition.
2. Mitra A., Fundamentals of Quality Control and Improvement, PHI, 2nd Ed., 1998.
3. J Evans and W Linsay, The Management and Control of Quality, 6'th Edition, Thomson, 2005
4. Bester field, D H et al., Total Quality Management, 3rd Edition, Pearson Education, 2008.
5. D. C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 6th Edition,2004
6. D. C. Montgomery and G C Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, 4th Edition.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 8 Questions from all units, each carrying 10 marks	80 Marks
Part B/Question: 4 Questions from all units, each carrying 5 marks	20 Marks

20MMM511T					Manufacturing Automation					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To know the basics of Automation in Manufacturing.**
- **To develop in depth knowledge of automation process in manufacturing environment.**
- **To address the business concepts and methods of smart factory.**
- **To introduce Industry 4.0**

UNIT 1 AUTOMATION IN MANUFACTURING **11 Hrs**

Automation in Manufacturing: Features, Advantage and Disadvantages, Factory and Manufacturing, the Manufacturing Environment. **Fundamental Concepts:** Analog and Digital Signals, Input and Output Data, Numbering System, Electrical Power, Hydraulics and Pneumatics, Continuous, Synchronous and Asynchronous Processes, Documentation and File Formats, Safety, Overall Equipment Effectiveness

UNIT 2 COMPONENTS AND HARDWARE **10 Hrs**

Components and Hardware: Controllers, Operator Interfaces, Sensors, Power Control, Distribution and Discrete Controls, Actuators and Movement, AC and DC Motors, Mechanisms and Machine Elements, Structure and Framing. **Machine Systems:** Conveyors, Indexers and Synchronous Machines, Part feeders, Robots and Robotics, Material Handling Systems

Process Systems and Automated Machinery: Chemical Processing, Packaging, Metal, Plastic, Ceramic and Glass processing, Assembly machines.

UNIT 3 SENSORS **10 Hrs**

Sensors: Introduction, Need, Features, Position, velocity and acceleration sensors, proximity and range sensors, touch and slip sensors, tactile sensors, force sensors and torque sensors. **Actuators:** Introduction, Function, Features, Types, Mechanical, Electric, Hydraulic, Pneumatic Actuators. **Machine and System Design:** Requirements, Quoting, Procurement, Design, Fabrication, Start-up and Debug, FAT and SAT, Installation, Support.

UNIT 4 BUSINESS SYSTEMS **09 Hrs**

Business Systems: Automation related Businesses-Manufacturers, OEMs, Distributors, Machine Builders, System Integrators, Consultants, Department and Functions, Systemization. Industry 4.0, Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories

Application: Case-studies for Automation in Manufacturing

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define the scope and importance of Automation in Manufacturing
CO2: Analyze the importance and working of various components involved in Automation
CO3: Develop automation for Machine systems and processes
CO4: Summarize the technologies allied with Automation
CO5: Apply the automation principal for designing the process.
CO6: Examine the feasibility and commissioning of an Automation process in a factory, along with the commercial aspects

TEXT/REFERENCE BOOKS

1. Industrial Automation-Hands On, Frank Lamb, McGraw Hil
2. Manufacturing Automation, Yusuf Altintas, Cambridge University Press
3. Handbook of Design, Manufacturing & Automation: R.C. Dorf, John Wiley and Sons
4. Industrial Automation, W.P. David, John Wiley and Sons
5. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, PHI.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20MMM512T					Micro and Nano Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To understand the requirements for micro/nano manufacturing**
- **To introduce various mechanical micro machining techniques**
- **To provide basics of various micro/nano finishing processes**
- **To introduce micro/nano fabrication methods**

UNIT 1 INTRODUCTION TO PRECISION ENGINEERING **9 Hrs.**

Introduction to Precision engineering, macro milling and micro drilling, Micro-electromechanical systems – merits and applications. Introduction to Bulk micromachining, Surface micromachining- steps, Micro instrumentation – applications, Micro Mechatronics, Nan finishing – finishing operations. Introduction to Nanotechnology. Carbon Nano-tubes – properties and structures, Molecular Logic Gates and Nano level Biosensors - applications

UNIT 2 MECHANICAL MICROMACHINING **11 Hrs.**

Introduction to mechanical micromachining, Micro drilling – process, tools and applications. Micro turning- process, tools and applications, Diamond Micro turning – process, tools and applications. Micro milling and Micro grinding – process, tools and applications. Introduction to Non-conventional micro-nano manufacturing. Process, principle and applications – Abrasive Jet Micro Machining, WAJMM. Micro EDM, Micro WEDM, Micro EBM – Process principle, description and applications. Micro ECM, Micro LBM - Process principle, description and applications

UNIT 3 MICRO AND NANO FINISHING PROCESSES **10 Hrs.**

Introduction to Micro and Nano Finishing Processes. Magnetorheological Finishing (MRF) processes, Magnetorheological abrasive flow finishing processes (MRAFF) – process principle and applications. Force analysis of MRAFF process, Magnetorheological Jet finishing processes. Working principle and polishing performance of MR Jet Machine. Elastic Emission Machining (EEM) – machine description, applications. Ion Beam Machining (IBM) – principle, mechanism of material removal, applications. Chemical Mechanical Polishing (CMP) – Schematic diagram, principle and applications

UNIT 4 MICRO FABRICATION **10 Hrs.**

Introduction to Micro Fabrication: basics, flowchart, basic chip making processes. Introduction to Nanofabrication, Nanofabrication using soft lithography – principle, applications – Examples (Field Effect Transistor, Elastic Stamp). LIGA Process. Laser Micro welding – description and applications, Defects. Electron Beam Micro-welding – description and applications. Introduction to micro and nano measurement, defining the scale, uncertainty. Scanning Electron Microscopy – description, principle. Optical Microscopy – description, application. Scanning Probe Microscopy. Introduction to On-Machine Metrology.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand various mechanical micro machining methods
CO2 – Compare macro mechanical machining and micro mechanical machining methods
CO3 – Understand various micro/nano fabrication techniques
CO4 – Judge application of micro and nano finishing
CO5 – Point out application of micro fabrication
CO6 – Compare different micro and nano measurement methods

TEXT/REFERENCE BOOKS

1. V.K. Jain, Micro-manufacturing Processes CRC Press, 2012
2. Nitaigour Premchand Mahalik, Micro-manufacturing and Nanotechnology, 2006
3. Mark. J. Jackson, Micro-fabrication and Nano-manufacturing – Pulsed water drop micromachining CRC Press, 2006
4. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 Questions from all units carrying 2.5 marks each 20 Marks

Part B/Question: 2 Questions from each unit carrying 10 marks 80 Marks

20MMM513T					Advanced Welding Processes					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To Understand fundamental of arc, resistance, beam and solid state welding processes**
- **To review welding for metal joining, hard facing & cladding and additive manufacturing**
- **To study welding metallurgy of ferrous, non-ferrous and dissimilar materials**
- **To review automation, robotics and virtual simulator systems for welding operations**
- **To distinguish various welding defects and weldability tests**

UNIT 1 ADVANCED ARC WELDING PROCESSES **15 Hrs.**

Fusion Welding Processes: Principles of operation, process characteristics and applications of SMAW, SAW, GMAW, PAW, and GTAW; Beam welding processes: Electron beam welding (EBW). Laser beam welding (LBW); Resistance welding processes: Spot, Projection and seam welding, Modes of metal transfer; Fundamental differences between soldering, brazing and welding. Effects of shielding gases, welding current, welding voltage, speed on the weld bead shape. Activated Flux TIG welding processes, Metal Core Arc Welding, Flux Core Arc Welding, Narrow gap welding, Hybrid Welding processes. Underwater welding & repair. Electro slag and electro gas welding.

UNIT 2 SOLID STATE WELDING PROCESSES **5 Hrs.**

Introduction to solid state welding processes , fundamental difference between fusion and solid state welding processes, classifications, principal, variable, advantages, applications, limitation. Solid state welding processes for dissimilar metal joining. Friction stir processing for super plasticity and surface composites. Friction surfacing. Hybrid FSW.

UNIT 3 WELDABILITY **10 Hrs.**

Welding Defects under various welding fusion welding processes, Weldability Tests, Destructive and non-destructive testing of welds and welding defects and significance. Welding Standards and codes. Weldability issues of Carbon steels, Weldability issues of Stainless Steel, Weldability issues of alloy steels. Weldability issues of copper and copper based alloys, Weldability issues of Al and Al based alloys, Weldability issues of Nickel and nickel based alloys.

UNIT 4 CLADDING, AUTOMATION AND ADDITIVE MANUFACTURE **5 Hrs.**

Various cladding and hard facing processes, various types of automation, virtual weld simulator and robotics system applicable in advanced welding processes. Importance of health and safety in various welding processes. Welding processes for additive manufacturing includes wire and arc additive manufacturing, cold metal transfer and friction stir welding for additive manufacturing.

Max. 40 Hrs

COURSE OUTCOMES:

On completion of the course, student will be able to

CO1 - To apply advanced concepts of welding and its relevance in manufacturing.
CO2 - To compare and contrast various welding processes
CO3 - To understand the concepts of dissimilar metal welding and its relevance
CO4 - To analyse welding defects and its relevance
CO5 - To review the existing codes and standards of ASME
CO6 - To differentiate the effects of welding variables

TEXT/REFERENCE BOOKS

1. Welding Hand Book, Volume I and IV , 8th Edition , American Welding Society,
2. ASM Metal hand book, "Welding, Brazing and Soldering, Vol 6 A/B.
3. J Vora, V J Badheka, Advances in Welding Technologies for Process Development ,CRC Press, 2019
4. Robert W Messler, Jr, Principles of Welding- processes, Physics, Chemistry, and Metallurgy, John Wilesy and Sons, Inc. 1999.
5. Nasir Ahmed 'New Development in Advance Welding', Wood head publishing Limited, England, 2007
6. John Norrish, 'Advance Welding Processes- Technologies and Process Control' Wood head publishing Limited, England, 2006

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 15 questions each 5 marks	75 Marks
Part B/Question: 5 question each 3 marks	15 Marks
Part C/ Question: 5 question each 2 marks	10 Marks

20MMM514T					Numerical Modelling of manufacturing processes					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To provide fundamental knowledge of advanced manufacturing processes and heat transfer and fluid flow.**
- **To derive governing equations for mass, momentum and energy with classification of differential equations**
- **To provide knowledge of different numerical methods to solve governing equations.**
- **To explain modelling steps for modelling software to develop a model for manufacturing process.**

UNIT 1 FUNDAMENTALS OF MANUFACTURING PROCESSES **08 Hrs.**

Fundamentals of Manufacturing Processes: Basics of manufacturing processes - casting, forming, welding, machining, Influence of process variables on manufacturing processes, need of optimization of process parameters, Need and role of numerical modelling. Basics of heat transfer and fluid mechanics required for modelling.

UNIT 2 FUNDAMENTAL OF NUMERICAL MODELLING **10 Hrs.**

Fundamental of Numerical Modelling: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.

Mathematical Representation of physical problems: Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions.

UNIT 3 NUMERICAL METHODS **14 Hrs.**

Numerical Methods: Classification and overview of Numerical Methods, Finite Difference method: Taylor series expansion, finite difference scheme for elliptic, parabolic, and hyperbolic partial differential equations. Finite Volume Method: Different types of finite volume grids; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem. Finite Element Method - Rules for forming interpolation functions – Shape Functions, Application to fluid flow and heat transfer problems.

UNIT 4 INTRODUCTION AND APPLICATION OF NUMERICAL MODELLING SOFTWARE **07 Hrs.**

Introduction and Application of numerical modelling software: Geometric modelling, mesh generation, boundary and initial conditions, computational approach, analysis. **Case study:** Numerical modelling of various advanced manufacturing processes. Mini Project

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand fundamental knowledge of advanced manufacturing processes and requirement of optimizing manufacturing processes using numerical modelling techniques.

CO2: Apply the fundamentals of heat transfer and fluid mechanics in numerical modelling

CO3: Derive and apply the conservation equations to represent the physical system in mathematical form

C04: Derive different types of differential equations to represent physical problems.

CO5: Understanding various numerical methods to solve different governing equations.

CO6: Apply numerical analysis to develop model for manufacturing process.

TEXT/REFERENCE BOOKS

1. S Kalpakjian, Manufacturing processes for engineering materials, 3rd Edition, Addison Wesley Longman, 1997.
2. V. K. Jain, Advanced Machining Processes, Allied Publishers Mumbai J Schey, Introduction to Manufacturing processes, 3rd Edition, Tata McGraw Hill, 2000.
3. Henk Kaarle Versteeg, Weeratunge Malalasekera: An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Ltd., 2007
4. Computational Fluid Dynamics, John D. Anderson Jr., McGraw Hill Book Company.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from each unit, each carrying 10 marks	40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks	60 Marks

20MMM515T					Computer Integrated Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To provide the basics & advances in computer integrated manufacturing.**
- **To study technologies associated with CIM.**
- **To implement Computer Aided Process Planning and Quality Control.**
- **To study various models of CIM and concepts of JIT and Lean production**

UNIT 1 PRODUCT DEVELOPMENT **10 Hrs.**

Introduction: Basic Concepts, Nature and Role of Elements of CIM, CIM Wheel, Evolution of CIM, CIM Hardware and CIM Software, Challenges and Trends. Product Development through CIM: Product Development Cycle, Sequential Engineering, Concurrent Engineering, Implementation of Concurrent Engineering, Characteristics of Concurrent Engineering, Value Engineering, Product Life Cycle Management.

UNIT 2 FLEXIBLE MANUFACTURING SYSTEMS AND ROBOTS IN CIM **10 Hrs.**

Group Technology: Introduction, Basic GT Layouts, Process Layouts, Product Layouts, Designing layouts, Coding System, Opitz System, MICLASS System. Flexible Manufacturing System: Introduction, Dedicated Manufacturing System, Flexible Manufacturing System, Major Elements of FMS, Materials handling system, Cell Technology and FMS, Automated Guided Vehicles, Automated Storage and Retrieval system. FMS scheduling, and sequencing, FMS simulation CNC Machine Tools: Introduction, Types of CNC Machines, Features of a CNC machine, Functions Available in a standard CNC system, Standard Controllers, CNC Programming, Direct Numerical Control, Virtual Machining. Robots in CIM: Introduction, Types of Robots, Robot Anatomy, Robot Components, Capabilities, Robot Configurations, Robot Motions, Specifications of a Robot, Robot Programming, Tooling, Control System, Integration of an Industrial Robot into a CIM system, Applications.

UNIT 3 COMPUTER AIDED PROCESS PLANNING AND QUALITY CONTROL **10 Hrs.**

Computer Aided Process Planning: Basics of Production Planning and Control, Automated Process Planning, Computer Aided Process Planning, Variant Process Planning, Generative Process Planning, Artificial Intelligence, Process Planning Systems, Material Requirements Planning (MRP), Manufacturing Resource Planning (MRP II). Computer Aided Quality Control: Introduction, Total Quality Management (TQM), QC and CIM, Inspection and Testing, Statistical Process Control, Objectives of CAQC, Role of Computer in QC, Coordinate measuring machine, Non-contact Inspection Methods, Computer Aided Inspection using Robots, Integrated Computer Aided Inspection Systems, Flexible Inspection System. Shop Floor Data Collection Systems: Shop Floor Control, Shop Floor Data Collection, Types of Data Collection Systems, Data Input Techniques, Automatic Data Collection systems, Allied Technologies, Data Acquisition Systems (DAS).

UNIT 4 COMPUTER INTEGRATED MANUFACTURING MODELS AND SIMULATION IN MANUFACTURING **10 Hrs.**

JIT and Lean Production: Just-in-Time production, Kanban System, Automation, Lean Manufacturing-Principle, Basic Characteristics, Agile Manufacturing. CIM Models: Introduction, ESPRIT-CIM OSA Model, the NIST-AMRF Hierarchical Model, the Siemens Model of CIM, the IBM concept of CIM. Simulation in Manufacturing: Introduction, Types of Simulation, Techniques of Simulation, Simulation process for Manufacturing Systems analysis.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define the fundamentals of group technology and flexible manufacturing systems.

CO2 - Understand the principles of various casting processes.

CO3 - Analyze the potential of CIM implementation on a shop floor.

CO4 - Apply principles of CNC and robots on a shop floor

CO5 - Explain the different characteristics of computer aided planning and quality control

CO6 – Develop a systematic and automated shop floor with basic and advanced technologies associated with CIM

TEXT/REFERENCE BOOKS

1. CAD/CAM/CIM by P. Radhakrishnan, S. Subramanyan, V. Raju, New age International Publishers, New Delhi
2. CAD/CAM Theory and Practices by Zeid Ibrahim, McGraw Hill International Edition
3. Automation, Production Systems and Computer Integrated Manufacturing by Mikell P Groover, Pearson Education
4. Computer Integrated Manufacturing by A. ALAVUDEEN, N. VENKATESHWARAN, PHI Learning engineering and Technology, Wesley Publishing Co.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from all units together - each carrying 5 marks 20 Marks

Part B/Question: 2 Questions from each unit each carrying 10 marks 80 Marks

20MMM504T					Design for Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To know importance of manufacturing processes and their relative characteristics during the design stage.**
- **To develop design of a product suiting the manufacturing process.**
- **To address the various design guidelines for different manufacturing processes.**
- **To introduce qualitative Guidelines for Design for assembly**

UNIT 1 ROLE OF MANUFACTURING IN DESIGN **10 Hrs.**

Introduction: Design, Manufacture and Role of Manufacturing in Design, Industrial Design, Engineering Design, Production Design, Manufacturing functions, Classification of Manufacturing processes, Manufacturing process selection, Design for Manufacture, Design for Assembly, Role of Standardization, Mistake-proofing, Early estimation of Manufacturing cost, Computer Methods for DFMA. **Tolerances and Mechanical Properties**: Inter-changeability of parts, Tolerances-Introduction, Types, Standards, Surface finish, Mechanical and Physical Properties of Materials, Engineering materials and their specific properties

UNIT 2 DESIGN FOR VARIOUS MANUFACTURING PROCESSES **10 Hrs.**

Design for various Manufacturing Processes: Introduction, Design of Castings-Guidelines for the Design of Castings, Producing Quality Castings, Design of Forgings-DFM Guidelines for Closed-Die Forging, Computer-Aided Forging Design, Design for Sheet-Metal Forming, Sheet Metal Stamping, Sheet Bending, Stretching and Deep Drawing, Computer-Aided Sheet Metal Design, Design of Machining-Machinability, Guidelines for Machining, Design of Welding-Joining Processes, Welding Processes, Welding Design, Cost of Joining, Residual Stresses in Design, Origin of Residual Stresses, Residual Stress Created by Quenching, Other Issues Regarding Residual Stresses, Relief of Residual Stresses, Design for Heat Treatment-Issues with Heat Treatment, DFM for Heat Treatment, Design for Plastics Processing- Injection Molding, Extrusion, Blow Molding, Rotational Molding, Thermoforming, Compression Molding, Casting, Composite Processing, DFM Guidelines for Plastics Processing.

UNIT 3 METAL CASTING PROCESSES **10 Hrs.**

Metal Casting Processes: Introduction, Sand Casting, Investment Casting, Die Casting, Other Processes, Qualitative Guidelines for Casting. **Die Casting-Total Relative Part Cost**: Overview, Relative Tooling Cost, Worksheet for Relative Tooling Cost, Processing Costs, Production yield and Effective Cycle Time, Surface finish, Part Tolerances. **Sheet Metal Forming**: Introduction, Stamping Processes, Stretch forming, Spinning, Stamping Dies, Stamping Presses, Process Planning, DFM guidelines for Stamped Parts. **Stamping-Relative Tooling Cost**: Estimating the relative cost of stamped parts, Die Construction Cost, Determination of Active Stations for Shearing and local features, Determination of Active Stations for Wipe forming and Side-action features, Number of Bend stages, Relative Die-Construction costs, Relative Die-Material cost for Progressive Dies, Worksheet for Relative Tooling Cost-Stamping. **Stamping-Total Relative Part Cost**: Relative Processing Cost, Determining press tonnage, Press Selection, Determining the relative Cycle time, Relative Material Cost, Total Relative Part Cost, Worksheet for Relative Processing Cost-Stamping.

UNIT 4 DESIGN FOR ASSEMBLY **10 Hrs.**

Design for Assembly: Assembly processes, Qualitative Guidelines for Design for Assembly, Total Assembly cost, Summary of DFA Guidelines, Reducing Part Count. **Design for X**: Concept, Implementing a DFX Strategy, X-Assembly, Environment, Manufacture, Quality, Reliability, Safety, Serviceability, Tolerances

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1. Define the scope and importance of Manufacturing process and their relative characteristics
CO2. Analyse the importance of designing the product for manufacturing.
CO3. Develop the product for manufacturing process
CO4. Summarize the technologies allied with Manufacturing
CO5. Apply the principal for designing the process.
CO6. Examine the various design guidelines for different manufacturing processes

TEXT/REFERENCE BOOKS

1. Engineering Design by George Dieter and Linda Schmidt, McGraw Hill
2. Design for Manufacturing-A Structured Approach by Corrado Poli, Butterworth Hienemann
3. Design for Manufacturing and Assembly-Concepts, Architectures and Implementation by O. Molley, S. Tilley and E. A. Warman, Springer-Science
4. Product Design for Manufacture and Assembly by G. Boothroyd, P. Dewhurst and W. A. Knight, CRC Press
5. Design for Manufacturability Handbook by James G. Bralla, McGraw Hill

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks 20 Marks

20MMM516T					Simulation of Manufacturing Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks 80 Marks

COURSE OBJECTIVES

- **To know the basics of modeling and simulation.**
- **To develop in depth knowledge of simulation process in manufacturing environment.**
- **To introduce various simulation languages**
- **To address the simulation concepts and methods of smart factory simulation.**

UNIT 1 PRINCIPLE OF COMPUTER MODELING AND SIMULATION **10 Hrs.**

Principle of Computer Modeling and Simulation: Nature of computer modeling and simulation. Limitations of simulation, areas of applications. **System and Environment**: Components of a system -discrete and continuous systems, Models of a system –a variety of modeling approaches. Statistical Models In Simulation: Discrete distributions, continuous distributions. **Discrete Event Simulation**: Concepts in discrete event simulation, manual simulation using event scheduling, single channel queue, multiple server queues, simulation of inventory problem.

UNIT 2 RANDOM NUMBER GENERATION **10 Hrs.**

Random number generation, techniques for generation of random numbers, tests for random numbers. Probability distributions used in simulation. Data collection for simulation experiments, analyzing input data, goodness of fit tests.

UNIT 3 INTRODUCTION TO SIMULATION LANGUAGES **10 Hrs.**

Introduction to simulation languages (like GPSS/H, Simpy or similar. Need for simulation Languages – Comparisons & Selection of Languages – GPSS – ARENA - Study of any one of the languages, modeling using simulation software (like Arena or similar). Selection of simulation software, simulation packages

Input modeling: Estimation of parameters, Fit tests of distributions.

UNIT 4 DESIGN AND EVALUATION OF SIMULATION EXPERIMENTS **10 Hrs.**

Design and Evaluation of Simulation Experiments: Output data analysis for single system: Statistical analysis for terminating and non-terminating simulations, Comparing alternative system configurations. Verification, validation and credibility of simulation models, Simulation of manufacturing and material handling systems. **Simulation of Manufacturing and Material Handling systems**. Monte Carlo simulation, Case studies

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define modeling, optimization and simulation, as it applies to the study.

CO2: Analyse manufacturing systems for decision support

CO3: Expose students to a wide range of applications for simulation methods and models, and to integrate them with their introduction to operations management

CO4: Develop the practical skills necessary to design, implement and analyze discrete-event simulation systems

CO5: Analyse the basic theory underlying discrete-event simulation methodologies,

CO6: Apply the simulation theory in order to enable a critical understanding of simulation output in managerial environments and build the foundations necessary to quickly adapt to future advances in simulation technology

TEXT/REFERENCE BOOKS

1. Jerry banks, John S Carson, Barry L Nelson and David M Nicol, Discrete Event System Simulation, 4th edition, Pearson Education Asia, 2006
2. Averill M. Law and W David Kelton, Simulation Modeling and Analysis, 3rd Edition, McGraw Hill, 2000
3. W David Kelton, Randoll P Sadowski and Debroah A Sasowski, Simulation with ARENA, McGraw Hill, 2002
4. Schriber, T. J., An Introduction to Simulation Using GPSS/H, Wiley

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks 20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks 80 Marks

20MMM517T					Industry 4.0					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To provide fundamentals of Industry 4.0 with recent development and applications**
- **To understand the basics of Industry 4.0 and its different pillars**
- **Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world**
- **Appreciate the power of Cloud Computing in a networked economy**
- **Understand the opportunities, challenges brought about by Industry 4.0**

UNIT 1 INTRODUCTION TO INDUSTRY 4.0 **10 Hrs.**

Introduction to Industry 4.0: The Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0 in manufacturing sector, The Journey so far: Developments in USA, Europe, China and other countries, Comparison of Industry 4.0 based manufacturing and Today's manufacturing, Trends of Industrial Big Data and Predictive Analytics for Smart manufacturing, Summary **Mini project, Seminar, Case Studies on Unit 1**

UNIT 2 ROAD TO INDUSTRY 4.0 **10 Hrs.**

Road to Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Predictive Analytics, Summary. Related Disciplines, System and Technologies for enabling Industry 4.0: Cyberphysical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Related Disciplines, Cyber Security, Summary. **Mini project, Seminar, Case Studies on Unit 2**

UNIT 3 ROLE OF DATA AND INFORMATION IN FUTURE MANUFACTURING INDUSTRIES **10 Hrs.**

Role of data, information, knowledge and collaboration in future manufacturing industries: Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0, Summary. **Other Applications and Case Studies:** Industry Internet of Things in manufacturing industries- Additive Manufacturing, Rapid Manufacturing, Flexible manufacturing system, Computer aided inspection, Automated Storage and retrieval System, CNC machines and machining centers, Automated Guided Vehicles, Production planning, Robotics case studies, Summary. **Mini project, Seminar, Case Studies on Unit 3**

UNIT 4 BUSINESS ISSUES IN INDUSTRY 4.0 **9 Hrs.**

Business issues in Industry 4.0: Opportunities and Challenges, Future of Works and Skills required for manufacturing engineers and Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world, Survival of manufacturing industries, Summary. **Mini project, Seminar, Case Studies on Unit 4**

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define the concept of Industry 4.0.
CO2: Explain the science behind smart factories, smart devices and smart products
CO3: Identify the various systems used in manufacturing plant
CO4: Elaborate the basics of cloud computing in Industry 4.0
CO5: Analyze the opportunities and challenges of Industry 4.0
CO6: Apply case study based in the era of Industry 4.0

TEXT/REFERENCE BOOKS

1. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things 1st ed. Edition, Publisher: Apress; 1st ed. edition (June 28, 2016)
2. Fran Yáñez, The Goal is Industry 4.0: Technologies and Trends of the Fourth Industrial ; Revolution Paperback – November 28, 2017, Publisher: Independently published
3. Gilchrist, Alasdair. Industry 4.0: the industrial internet of things. Apress, 2016. Apress
4. Klaus Schwab, The Fourth Industrial Revolution Publisher :,Currency (January 3, 2017)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 6 Questions from each unit, each carrying 10 marks 60 Marks
Part B/Question: 4 Questions from each unit each carrying 10 marks 40 Marks

20MMM518T					Sheet Metal Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **Fundamental understanding of metal forming process**
- **To understand the application of forging, rolling, extrusion and drawing processes**
- **To understand sheet metal forming processes.**
- **To familiarize with the recent advances in sheet metal forming processes**

UNIT 1 FUNDAMENTALS OF METAL FORMING **07 Hrs.**

Fundamentals of Metal Forming: Forming – fundamentals, classification, Stress-strain behaviour of materials, Stress and strain, Mohr's circles, stress-strain relations – elastic, strain energy, yield criteria, anisotropy, plasticity, flow rate,.

UNIT 2 FORGING AND ROLLING **14 Hrs.**

Forging and Rolling: Principle – classification – equipment – tooling – processes parameters and calculation of forces during forging and rolling processes – Ring compression test – Post forming heat treatment – defects (causes and remedies) – applications.

Extrusion and Drawing Processes: Classification of extrusion processes – tool, equipment and principle of these processes – influence of friction – extrusion force calculation – defects (causes and remedies) – Rod/Wire drawing – tool, equipment and principle of processes – defects – Tube drawing and sinking processes.

UNIT 3 SHEET METAL FORMING PROCESSES **09 Hrs.**

Sheet Metal Forming Processes: Classification – conventional and HERF processes – presses – types and selection of presses – for mability studies – FLD, Limiting Draw ratio – processes: Deep drawing, spinning, stretch forming, plate bending, Rubber pad forming, bulging and press brake forming – Explosion forming, electro hydraulic forming, Magnetic pulse forming.

UNIT 4 RECENT ADVANCES **09 Hrs.**

Recent Advances: Super plastic forming – Electro forming – fine blanking – Hydro forming – Peen forming – Laser Forming – Micro forming – Single point incremental forming, P/M forging – Isothermal forging – high speed hot forging – near net shape forming high velocity extrusion – CAD and CAM in forming.

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Explain the theory, application, and technology of material and metal forming

CO2 – Apply fundamental of metal forming and sheet metal working

CO3 – Judge the tooling requirements of various sheet metal forming processes

CO4 – Analyze the design consideration of each product produced using forming technology

CO5 – Classify different sheet metal forming processes

CO6 –.Understand recent developments in sheet metal forming processes

TEXT/REFERENCE BOOKS

1. Mechanical Metallurgy, S.I. Metric edition, George E. Dieter, McGraw Hill Book Company.
2. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M.Caddell, PTR Prentice-Hall(USA)
3. Metal Forming Analysis, R.H.Wagoner and J.L.Chenot, Cambridge University Press, New York, U.S.A.
4. Nagpal G.R. "Metal forming processes", Khanna publishers, New Delhi, 2004
5. Metal Forming Practice, Heinz Tschaetsch, Springer-Verlag Berlin Heidelberg.
6. Serope Kalpakjian, Steven R Schmid, "Manufacturing Process for Engineering Materials", 4th Edition, Pearson Education, 2003.
7. Rao, P.N. "Manufacturing Technology", TMH Ltd., 2003
8. Edward M.Mielink, "Metal working science Engineering, McGraw Hill, Inc, 2000.
9. Metal Hank book Vol.14, "Forming and Forging", Metal Park, Ohio, USA, 1990

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 Questions from all units carrying 2.5 marks each 20 Marks

Part B/Question: 2 Questions from each unit carrying 10 marks 80 Marks

20MMM519T					Sustainable Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To provide basic understanding of design of experiments**
- **To understand the importance of lean techniques for green manufacturing**
- **To introduce the importance of renewable energy sources to achieve green manufacturing**
- **To introduce the simulation of smart green factory**

UNIT 1 CONCEPT OF SUSTAINABILITY **10 Hrs.**

Concept of sustainability, manufacturing, operations, processes, practices Resources in manufacturing, five Ms, system approach to manufacturing. Basic experimental design, factor identification, quantification, comparison, selection Introduction to simulation modeling and analysis. Overview of modeling and decision making, modeling pitfalls, good modeling practices. Simulation models for manufacturing, validation, verification, output analysis Concepts of optimization, numerical optimization through simulation Approaches for process factors optimization.

UNIT 2 LIFE CYCLE ANALYSIS **10 Hrs.**

Life Cycle Analysis: remanufacture and disposal, tools for LCA. Optimization for achieving sustainability in unit manufacturing. Green manufacturing Lean models, value analysis, carbon footprint, analysis for carbon footprint Green manufacturing: sustainability framework Green manufacturing techniques: factors effecting sustainability. Green manufacturing techniques: dry and near-dry machining, edible oil based cutting fluids Green manufacturing techniques: cryogenic machining for eco-efficiency Green manufacturing techniques: improving work environment**.**

UNIT 3 SUSTAINABLE MANUFACTURING **10 Hrs.**

Sustainable manufacturing Social aspects of Sustainable manufacturing: Modern approaches for Sustainable Manufacturing Toxic substances in industry, and need of Renewable Sources of Energy – Bio energy based manufacturing, Industry Symbioses for reducing Carbon footprint. Concept of lean manufacturing, Lean techniques for green manufacturing Waste assessment, strategies for waste reduction in green manufacturing.

UNIT 4 SIMULATION FOR SUSTAINABLE MANUFACTURING **09 Hrs.**

Simulation for sustainable manufacturing Building a smart green factory: simulation techniques Building a virtual green factory: assessment of a facility greenness Sustainability in Education: Filling the gaps in engineering education Sustainability in Entrepreneurship: Job market qualification demand.

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Distinguish factors affecting a process through design of experiments

CO2 – Explain various green manufacturing techniques to fulfil the needs of the present without compromising the ability of future generations to meet their own needs

CO3 – Summarize different optimization technique through simulation

CO4 – Appraise the importance of lean technique for green manufacturing

CO5 – Judge factors affecting sustainability in manufacturing sector

CO6 – Defend the need for renewable energy sources

TEXT/REFERENCE BOOKS

1. Montgomery Douglas, 2017. Design of Experiments, John Wiley and Sons, Inc.
2. Dornfeld, D.A. ed., 2012. Green manufacturing: fundamentals and applications. Springer Science & Business Media.
3. Seliger, G., Khraisheh, M.M. and Jawahir, I.S. eds., 2011. Advances in sustainable manufacturing. Springer Science & Business Media.
4. Klemes, J., 2011. Sustainability in the process industry. McGraw-Hill.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 Questions from all units carrying 2.5 marks each 20 Marks

Part B/Question: 2 Questions from each unit carrying 10 marks 80 Marks

20MMM520T					Manufacturing codes and standards					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To understand the importance of codes and standards pertaining to Industry**
- **To analyse the working of ISO standards within industry**
- **To understand the mechanism of working of the codes and standards in manufacturing industry**.
- **To introduce ASME codes**

UNIT 1 INTRODUCTION TO CODES AND STANDARDS **09 Hrs.**

Different Codes and standards: Introduction to different structural codes, need for codes, evolution of these codes. Description of codes such as IS standards, ASME, ASTM, etc. Introduction to ASME: Different codes of ASME such as section II, IV, VIII, IX, its scope, implications and salient features. The codes pertaining to pressure vessels.

UNIT 2 ASME CODES **15 Hrs.**

ASME Section – II : Origin, Introduction, scope, Sub - division A, B and C, the applications, implication and their salient Features. Nomenclature of base material consumable and non-consumable used in structural applications.

ASME Section - V: Introduction, codes of Non-Destructive Testing (NDT), scope, implications and applications. Selecting the extent and its relevance, importance and key features. Classification of NDE techniques and its various applications.

ASME section – IX: Introduction, scope, implications and applications. Welder qualification ways and its requirements.

UNIT 3 PRESSURE VESSEL CODES **06 Hrs.**

Introduction to ASME section – VIII: Origin, Introduction, scope, Sub - division I, II and II the applications, implication and their salient Features. The rules for selection of pressure vessels codes and its methods.

UNIT 4 ISO STANDARDS **09 Hrs.**

Introduction to ISO standards: Different standards, relevance, need, implications and applications of different standards such as 9001, 22000, 14000 and concepts of quality management systems.

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO 1: To understand different type of codes and its existence.
CO 2: To apply different ASME section II and V codes in real time manufacturing case studies.
CO 3: To summarize ASME section IX standards and its implications.
CO 4: To analyse the existing codes and standards of ASME section VIII existing industry requirements.
CO 5: To understand the concept of section IX.
CO 6: To apply the knowledge of ISO standards in the industrial firms.

TEXT/REFERENCE BOOKS

1. AWS D1.1 Structural Welding Code
2. API 5L
3. API 1104
4. ASME Section VIII – Division 1,2
5. ASME Section IX
6. ASME Section II Part A and C

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 Questions from all units, each carrying 10 marks 80 Marks
Part B/Question: 4 Questions from all units, each carrying 5 marks 20 Marks

20MMM521T					Advanced Materials and Characterizations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To know modern materials with their applications.**
- **To develop understanding of importance of characterization of materials.**
- **To identify the various microstructural features in different alloys.**
- **To familiarize measurement and analysis of wear and corrosion**

UNIT 1 ADVANCED MATERIALS **10 Hrs.**

Need, manufacturing and processing, properties, applications. Super alloys, nanostructured alloys, shape memory alloys, micro alloying, nanocomposites, superplastic alloy, SMART materials, nonmetallic- composites, plastics, ceramics. Microstructural evolutions during manufacturing or processing, relation between microstructure and properties, macro, micro and nano scale behavior, chemical components quantitative distribution, crystal orientations and its quantifications, material failure analysis.

UNIT 2 OPTICAL AND ELECTRON MICROSCOPY **9 Hrs.**

Role of etchant, basic principle, instrumentations, three-dimensional images, specimen preparations, applications. SEM: electron sources, modes of operation, fractography, chemical analysis using energy dispersive analysis, specimen preparations, applications.

UNIT 3 EBSD, XRD AND TEM **10 Hrs.**

Crystal lattice structure and orientations, grain size and its boundaries distributions, dislocation densities, texture, specimen preparations, applications. Generation of X-rays, principles of diffraction, X - ray generation, Instrumentation, Types of analysis, Elements of Image Analysis and Quantitative Metallography X-Ray Diffraction. TEM: Basic principles, Thin Film and Replication Techniques, Image Contrast, Bright Field and Dark Field Imaging, applications.

UNIT 4 THERMAL, WEAR AND CORROSION MEASUREMENTS AND ANALYSIS **9 Hrs.**

Instrumentation, experimental parameters, different types used for analysis, differential thermal analysis, differential scanning calorimetry, applications. Corrosion friction and wear measurements: basic principle, instrumentations, specimen preparation, applications.

Max. 38 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1. Understand significance on advanced materials and characterizations.

CO2: Distinguish various characterization techniques.

CO3. Compare various materials and their mechanical properties.

C04. Apply fundaments of characterization and develop understanding on microstructure features and their effect on the properties of materials.

CO5: Develop skills of specimen preparations of the various characterization techniques.

C06. Evaluate material performance based on microstructural characteristics of advanced materials.

TEXT/REFERENCE BOOKS

1. W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley & Sons, 2007.
2. 2. William F.. Smith, Javad Hashemi, and Francisco Presuel-Moreno. Foundations of materials science and engineering. Mcgraw-Hill Publishing, 2006
3. ASM Handbook: Materials Characterization, ASM International.
4. Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 3 Questions from each unit - each carrying 5 marks 60 Marks

Part B/Question: 1 Question from each unit- each carrying 10 marks 40 Marks

20MMM522T					Experimental Methods					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To gain knowledge of strategy of conducting experimentation**
- **To gain an insight of the factors influencing the experiment**
- **To gain the knowledge of how to reduce the number of experiments through fractional factorial**
- **To appreciate the Taguchi's philosophy of quality loss function**
- **To use software (both open and commercial software) for statistical analysis**

UNIT 1 STRATEGY OF EXPERIMENTATIONS **7 Hrs.**

Applications of experiment methods, basic principles, design guidelines, statistical design and problems Fundamentals of Statistics, Plots, Statistical Inference of Single Sample, Hypothesis Testing, Z- Test, t-Test, Statistical Inference of Two Samples, Confidence levels.

UNIT 2 COMPARATIVE EXPERIMENTS **8 Hrs.**

P-Values, variations, correlations, central limits, significance, confidence limits, distribution test, analysis of variance, goodness of fit, Inference of Variances of two Normal Distributions, Analysis of the fixed effects model, model adequacy checking, practical interpretation of results, the regression approach to the analysis of variance (ANOVA), Use of Commercial Software for statistical design

UNIT 3 FACTORIAL ANALYSIS **15 Hrs.**

Block design, Latin square design, Graeco-latin square design, 2^k and 3^k design with and without replicates, Fractional Factorial Designs, Regression Models, Residual Analysis, Introduction to Response Surface Methodology, Use of Open and Commercial software for statistical design

UNIT 4 TAGUCHI'S METHODOLOGIES **10 Hrs.**

Introduction, Quality through product and process optimization, Taguchi's philosophy of loss function, Signal to Noise ratio, Taguchi Design of Experiments, ANOVA, Case Studies

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the experimentation philosophy through the fundamentals of statistics.
CO2 - Evaluate Hypothesis testing, significance and confidence limits, goodness of fit
CO3 - Evaluate ANOVA for experimental problems
CO4 - Analyze analysis of variance and blocking
CO5 - Develop statistical design using Factorial Design
CO6 - Formulate Taguchi's principle of quality and philosophy of experimentation

TEXT/REFERENCE BOOKS

1. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
2. Lehmann, Erich L., and Joseph P. Romano. Testing statistical hypotheses. Springer Science & Business Media, 2006.
3. Walpole, Ronald E., et al. Probability and statistics for engineers and scientists. Vol. 5. New York: Macmillan, 1993.
4. Ranjit K. Roy-Design of Experiments Using The Taguchi Approach 16 Steps to Product and Process Improvement-Wiley-Interscience (2001)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions (10 Marks each) 40 Marks
Part B/Question: 5 Questions (12 Marks each) 60 Marks

20MMM523T					Finite Element and Mesh Free Methods					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- **To learn the theory and characteristics of finite element and meshfree methods.**
- **To formulate the stiffness matrix for linear, quadratic and higher order elements for 1D, 2D and 3D cases.**
- **To learn and solve problems of beam, truss, frame, grid, plates, dynamic, thermal and fluid using variational and displacement methods.**
- **To study mesh free methods for solving engineering problems**

UNIT 1 INTRODUCTION **12 Hrs.**

Introduction to Finite Element Method, Basic Concepts and Steps in FEM formulations, Discretization, General Applications of the Method, Comparison with other numerical methods, Integral formulations and Variation methods: Need of weighted Integral forms, Differential equations and Functional forms, Galerkin Methods, Point Collocation methods, Weak Formulations, Rayligh-Ritz Methods, Concept of Interpolation

UNIT 2 FINITE ELEMENT ANALYSIS OF ONE AND TWO DIMENSIONAL PROBLEMS **11 Hrs.**

Linear, Quadratic and Higher order Elements, Beam Elements, Truss, Frame and Grid Elements, Triangular, Quadrilateral and rectangular element, Natural Coordinates and Coordinates transformations, Connectivity of Elements

UNIT 3 APPLICATIONS OF FINITE ELEMENT ANALYSIS **8 Hrs.**

Dynamic Analysis using Finite Elements, Plane Elasticity Problem using FEM

UNIT 4 MESHLESS FINITE ELEMENT METHODS **8 Hrs.**

Introduction to Meshfree Methods, Comparison with FEM, Solution procedure of Meshfree methods, Meshfree Shape function constructions: Polynomial shape functions, Application to some simple problem

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Recall the fundamental theory of FEM and concepts behind formulation methods in FEM.

CO2 – Explain the role and significance of variational methods considering linear, quadratic, and cubic shape functions and theory of mesh free methods.

CO3 - Modify the real world problems to 1D, 2D and 3D cases of finite element analysis by applying various FEA elements such as bars, beams, plane and iso-parametric elements.

CO4 – Analyse the bars, trusses, beams, heat transfer, fluid flow, and dynamic problems using suitable boundary conditions to a local as well as global equations.

CO5 – Estimate the deflections, stresses, and strains induced during failure of various components.

CO6 – Formulate and simulate various mechanical components subjected to different loading conditions using FEM.

TEXT/REFERENCE BOOKS

1. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill Publication(2003)
2. L.S. Segerlind, Applied Finite Element Analysis, John Wiley & Sons
3. S.S. Rao, The Finite Element Method in Engineering, Pergamon
4. G.R.Liu and Y.T.Gu, An introduction to Meshfree Methods and their programming, Springer.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks