M. Tech. (Manufacturing Science and Engineering)

SEMESTER-I		
S. No.	Course Title	Number of Credits
1	Tool Design in Manufacturing	3 (L)
2	Machining: Theory and Practice	2 (L) + 1 (P)
3	Plasticity and Metal Forming	3 (L)
4	CAD: Theory and Practice	1 (L) + 2 (P)
5	Advanced Casting and Welding: Science and Technology	3 (L)
6	Conventional Manufacturing Laboratory	4 (P)
7	Near Net Shape Technology (Powder Metallurgy)	2
SEMESTER-II		
1	Additive Manufacturing	3 (L)
2	Automation and AI in Manufacturing	3 (L)
3	NDT for Manufacturing	3 (L)
4	Industrial Management	3 (L)
5	Elective-I Precision Machining/Surface Engineering/Manufacturing of small and ultra-small systems	3 (L)

6	Elective-II (Systems Engineering/Selection and Design of Engineering Materials/Case Studies in Industrial Manufacturing)	3 (L)
7	Advanced Manufacturing Laboratory	4 (P)

Semester-III

Project Work + Viva-Voce

Semester-IV

Project Work + Thesis Writing + Viva-Voce

M. Tech. in Manufacturing Science and Engineering (4 Semesters)

Semester - I

1. Tool Designing in Manufacturing (L-3)

Unit 1: Tools: Role of materials in tooling and tool engineering; Analysis of various manufacturing processes w.r.t the tools required;

Unit 2: Tooling for machining and forming: Traditional and advanced machining processes; Automats and NC machining; CNC machining; Tooling for forming processes (die, punch etc.,);

Unit 3: Tooling for casting and joining: Tooling for casting (molds, patterns etc.,); Tooling for welding and mechanical joining (welding fixtures, squaring tools etc.,)

Unit 3: Inspection and gauging: Tolerances and allowances; Gage tolerances; Gage types; Magnifying or amplifying dimensions;

Unit 4: Tool designing using CMM and CAD; One example in machining, forming, casting and joining;

2. Machining: Theory and Practice (L-2 + P-1)

Unit 1: Mechanics: Geometry related to tools and cutting processes; Mechanics of chip (ductile and brittle) formation; Chip forms (geometry and properties); Built up edge formation; Chip types; Orthogonal and oblique cutting; Deviations in chip flow; Chip breakers;

Unit 2: Machining forces: Cutting force components in contact cutting (turning, milling and drilling); Merchant analysis (construction of Merchant circle diagram, cutting power consumption and specific energy requirement, analytical models for estimation of cutting forces in orthogonal and oblique cutting, measurement of cutting forces); Modelling of cutting forces in cutting processes using FEM;

Unit 3: Cutting temperature: Estimation and experimental measurement of cutting temperature; Relation between machining parameters and cutting temperature; Controlling of cutting temperature (including application of cutting fluids); Cutting tool life and failure; Modelling of thermal effects in cutting processes using FEM;

Unit 4: Machining dynamics: Machining tool vibrations, analysis methods (Chatter prediction) and vibration control; Frequency response functions and stability lobe plots; tool condition monitoring; Dynamics in high speed machining, thin-wall machining and high-performance machining; Optimization and economics;

Unit 5: Practice: Determination of chip morphology; Measurement of cutting forces in turning, milling and drilling using dynamometers; Machine condition monitoring (vibration based); Stability lobe analysis; Machining process modelling using FEM; Application of codes and standards on a given machining data;

3. Plasticity and Metal Forming (L-3)

Unit 1: Metallurgical aspects in plasticity: Slip and twinning mechanics; Temperature, strain rate, microstructure and friction effects; Stress-strain relations; Yielding and its importance; Flow stresses; Deformation mechanisms; Classification of forming processes; Examples;

Unit 2: Metal working: Hot and cold working processes; Controlling mechanical properties by working; Mechanics of metal working; Determination of flow stress; Influence of temperature, strain-rate, crystal structure, friction and lubrication in metal working processes; Working defects; Examples;

Unit 3: Rolling: Hot and cold rolling processes; Forces and geometry in rolling; Rolling load, variables, limitations and defects; Examples;

Unit 4: Forging, Extrusion and Drawing: Plane strain forging; Estimation of forging loads; Forging defects; Fundamentals of extrusion (deformation, lubrication etc.,); Extrusion defects;

Drawing operation and mechanisms of rods, wires and tubes; Drawing defects (especially residual stress); Examples;

Unit 5: Sheet metal forming: Shearing, bending, stretch forming, deep drawing, and blanking operations and mechanisms therein; Forming limit criteria; Forming defects;

4. CAD: Theory and Practice (L-1 + P-2)

Unit 1: Theory: Hardware and software; Geometric modeling; Transformations; Curve representation; CAD-CAM exchange formats; Modeling (Surface and solid, assembling, and behavioral); Design (conceptual, top-down and collaborative);

Unit 2: Practice 1: Use of auto CAD commands and script files

Unit 3: Practice 2: Use of auto LISP to generate drawings

Unit 4: Practice 3: Modeling (Surface and solid, assembling, and behavioral) exercises

Unit 5: Practice 4: Exercises on assembly and manufacturing

5. Advanced Casting and Welding: Science and Technology

Unit 1: Science in Casting: Traditional casting processes (Sand, investment, plaster and die casting processes); Fluid flow and heat transfer in casting solidification; Heat transfer models for casting processes; Prediction of casting defects;

Unit 2: Advanced casting processes: Low pressure gravity die-, counter gravity sand-, and squeeze- casting processes; Thixo- and rheo- casting processes; Directional solidification of single crystal and columnar-grained castings; Metal infiltration; Casting of composites; Casting defects; Case studies;

Unit 3: Science in Welding 1: Traditional welding processes; Modelling of heat flow and distribution (stationary and moving heat sources, heat flow during welding, prediction of thermal history (steady state, transient and pseudo-steady state heat conductions), prediction of cooling rate and its effects on microstructure and mechanical properties);

Unit 3: Science in Welding 2: Solidification in fusion welding (weld pool shape and columnar grain structures, solidification microstructures, solute redistribution and peritectic solidification); Grain growth in welds; Solid-state transformations in welds; Weldability of Al, Fe, Cu, Ti based alloys;

Unit 4: Advanced welding processes: Electron beam welding, brazing (diffusion- brazing and bonding, ceramic to metal seals, vacuum brazing, controlled atmosphere brazing, laser brazing), Friction welding and friction stir welding; Ultrasonic and magnetostrictive welding;

Unit 5: Welding defects: Residual stress and distortion analysis and control in welding; Other welding defects;

6. Conventional Manufacturing Laboratory (P-4)

Experiment 1: Determination of forces in milling, grinding, drilling, and turning operations.

Experiment 2: Determination of load for forming, blanking, and bending operations.

Experiment 3: GMAW/GTAW/Friction stir welding

Experiment 4: Characterization of various defects

7. Near Net Shape Technology (L-3)

Concept of Shape, size, accuracy, tolerances and surface roughness. Economic and technological factors; improved material and energy efficiency, dimensional accuracy, product integrity and reduced manufacturing cost through near net processing.

Foundry Casting processes: Shell process, investment casting, ceramic moulding , plaster mould process, V-process, squeeze casting, rheo-casting, permanent mould casting, low pressure die casting and pressure die casting processes.

Plastic deformation processes: warm forging, flashless forging, cold forging. Super plastic forming, powder metal forging, liquid forging, rheo-forging and isothermal forging processes.

Electro forming; principles of electro deposition, production of dies and moulds by electro-forming.

Different Processes of Net shape Manufacturing, Methods of Near Net shape Manufacturing Projected Growth for Near Net shape Manufacturing

Near Net shape Machining New Advances in Net shape Forming, Net shape Components

Semester – II

1. Additive Manufacturing (L-3)

The Basics principles of additive manufacturing processes 2 The Personal Printer Revolution AM Process Workflow A Closer Look at Rep-Rap Machines Preparing Files for 3D Printing Choosing the Right Materials

Additive Manufacturing Technology-Extrusion Systems (1) Extrusion Systems (2) Sheet Lamination Jetting Direct-Write, Bioprinting , Sintering, Powder Bed Fusion, Directed Energy Deposition Photopolymerization.

Software & Methods Designing for Additive Manufacturing Software Tools vs. Requirements Pre- & Post-processing 3D Scanning & the Scanning Process Sculpting & Repairing Data AM File Formats STEP File Format More Detail on NURBS Model Validation Working with DICOM Files for 3D Printing Medical Imagery Materials.

Materials for Manufacturing Multiple Materials Metal AM Processes & Materials Composite Materials Biomaterials, Hierarchical Materials & Biomimetics Ceramics & Bio-ceramics Shape-Memory Materials, 4D Printing & Bio-active materials Advanced AM Materials

Selection of Right Manufacturing Process Injection Moulding Casting Mould-making Module

Applications of AM Direct Digital Manufacturing Distributed Manufacturing Mass Customization Biomedical Applications Aerospace & Automotive Applications Architectural Engineering Food & Consumer Applications Personalized Surgery Art, Fashion, Jewelry, Toys & Other Applications

2. Automation and Artificial Intelligence in Manufacturing (L-3)

Automation In Production System, Principles And Strategies Of Automation, Basic Elements Of An Automated System, Advanced Automation Functions, Levels Of Automations. Flow Lines & Transfer Mechanisms, Fundamentals Of Transfer Lines.

Overview Of Material Handling Systems, Principles And Design Consideration, Material Transport Systems, Storage Systems, Overview Of Automatic Identification Methods.

Components, Classification And Overview Of Manufacturing Systems, Manufacturing Cells, GT And Cellular Manufacturing, FMS, FMS And Its

Industrial Control Systems, Process Industries Versus Discrete-Manufacturing Industries, Continuous Versus Discrete Control, Computer Process And Its Forms.

Machine Learning – Concept of Artificial Intelligence, Conceptual Learning, Artificial Neural Networks – Biological Neuron, Artificial Neuron, Types of Neural Networks, Applications in Manufacturing.

Automated Process Planning – Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) – Manufacturing system design. Equipment Selection Problem, Modelling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

Suggested Reading:

Intelligent Manufacturing Systems/ Andrew Kusiak/Prentice Hall.

Artificial Neural Networks/ Yagna Narayana/PHI/2006

Automation, Production Systems and CIM / Groover M.P./PHI/2007

3. NDT for Manufacturing (L-3)

Introduction of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT., Visual inspection – Unaided and aided.

Surface NDT techniques

Liquid Penetrant Testing – Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Bulk /Volumetric NDT Techniques

Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation. Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations – contact testing, immersion testing, couplants– Data presentation A, B and C scan displays, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates, alarms and attenuators, detectability of defects.

NDT Case studies for different types of manufacturing techniques and products casting, metal processing, welding.

Books:

Baldev Raj, T.Jayakumar, M.Thavasimuthu “Practical Non-Destructive Testing”, Narosa Publishing House, 2009.

Ravi Prakash, “Non-Destructive Testing Techniques”, 1st revised edition, New Age International Publishers, 2010

ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.

Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005

Charles, J. Hellier," Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.

ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

4. Industrial Management(L-3)

Introduction to Management, Entrepreneurship and organization – Nature and Importance of Management, Functions of Management, Taylor's Scientific Management Theory, Fayol's Principles of Management, Maslow's Theory of Human Needs, Douglas McGregor's Theory X and Theory Y, Herzberg's Two-Factor Theory of Motivation, Systems Approach to Management, Leadership Styles, Social responsibilities of Management

Organizational Structures Departmentation and Decentralization, Types of Organization structures – Line organization, Line and staff organization, functional organization, Committee organization, matrix organization, Virtual Organization, Cellular Organization, team structure, boundary less organization, inverted pyramid structure, lean and flat organization structure and their merits, demerits and suitability.

Operation management: product design process- Process selection-Types of production system (Job, batch and Mass Production),-Plant location-factors- Urban-Rural sites comparison- Types of Plant Layouts-Design of product layout- Line balancing(RPW method) Value analysis-Definition-types of values- Objectives- Phases of value analysis- Fast diagram

Volume analysis, costing, investment appraisal, accounting and bookkeeping, budgeting, financing, financial analysis, pricing and management control are discussed as support for and a background to decision-making. Insights into the company and it's environment, leadership, entrepreneurship, organisation, strategic planning, learning and marketing are given as a basis for understanding structure of the industrial company's prerequisites.

5. Elective-I (L-3)

(Precision Machining/Surface Engineering/Manufacturing of small and ultra-small systems)

6. Elective –II (L-3)

(Systems Engineering/Selection and Design of Engineering Materials/Case Studies in Industrial Manufacturing)

7. Advanced Manufacturing Laboratory (P-4)

Semester-III

Project Work + Viva-Voce

Semester-IV

Project Work + Thesis Writing + Viva-Voce