Minor Requirements in Mechanical Engineering
Total Credit Requirement: Minimum 18

Minor in Green Technology					
Semester	**Subjects**	**L**	**T**	**P**	**Credit**
3rd	Basic Thermodynamics	3	0	0	3
4th	Green and Cleaner Technologies	3	0	0	3
4th	Renewable Energy	3	0	0	3
5th	Green Manufacturing	3	0	0	3
5th	Waste Management	3	0	0	3
6th	Mini Project	3	0	0	3

Minor in Industrial Manufacturing					
Semester	**Subjects**	**L**	**T**	**P**	**Credit**
3rd	Manufacturing Process	3	0	0	3
4th	Engineering Materials	3	0	0	3
4th	Industrial Engineering Principles	3	0	0	3
5th	Modern Manufacturing Process	3	0	0	3
5th	Quality Control and Assurance	3	0	0	3
6th	Mini Project	3	0	0	3

Minor Requirements in Mechanical Engineering

Total Credit Requirement: Minimum 18

Minor in Green Technology

SI No	Subject	Credit (L-T-P)	Semester
1	Basic Thermodynamics	3-0-0	3rd Semester
2	Green and Cleaner Technologies	3-0-0	4th Semester
3.	Renewable Energy	3-0-0	4th Semester
4	Green Manufacturing	3-0-0	5th Semester
5	Waste Management	3-0-0	5th Semester
6	Mini Project	3-0-0	6th Semester

Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Basic Thermodynamics	**3**	**3**	**0**	**0**	**3**

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Apply the first law of thermodynamics to evaluate energy conversion, heat transfer, and work interactions in both closed and open systems, assessing their performance and efficiency in real-world applications.
CO2	Estimate COP of a refrigerator and heat pump, entropy transfer, entropy of the system and universe, and entropy generation in thermodynamic processes and systems, applying the second law of thermodynamics.
CO3	Estimate the change in entropy for thermodynamic processes.
CO4	Estimate specific heats, internal energy, enthalpy, work and heat transfer for different thermodynamic processes.

Syllabus:

Module No.	Description	Contact hours
1.	**Introduction:** Concepts of Thermodynamics: Macroscopic and Microscopic concepts, System and its classification. Thermodynamic state, properties, process and cycles, Thermodynamic equilibrium, Energy interactions (Work transfer and its different modes, Heat transfer) illustrative problems	6
2.	**First law of Thermodynamics**: First law applied to non-flow as well as flow processes, Concepts of internal energy, Enthalpy, Specific heats, PMMI, Energy equations for flow systems, Application of energy equations to different engineering components such as boiler, turbine, heat exchangers, pumps, nozzles, etc.	7
3.	**Second law of Thermodynamics**: Concept of heat Engine, Kelvin Planck and Clausius statements, Refrigerator and heat pump, equivalence two statements, reversibility and irreversibility, Carnot's Carnot cycle and reversed heat engine, Carnot's and corollary of carnot's theorem, Thermodynamic scales of temperature.	7
4.	**Entropy:** Clausius theorem and inequality, Entropy change of irreversible process, Entropy Principle, Application of Entropy principles, entropy transfer mechanism, entropy generation in a closed and open systems, irreversibility, Third law of Thermodynamics.	8
5.	**Properties of Substances**: Equation of state of an ideal gas, Specific heats, Internal energy, Enthalpy and Entropy change of ideal gas, Analysis of isochoric, isobaric, isothermal, isentropic, isenthalpic processes, representation of the above processes on P-v, T-**s** planes, Determination of work, heat, entropy and enthalpy changes during the above processes, Equation of state of Real Gases, Principle of corresponding state, Compressibility Factor. Maxwell relation, specific heat relations, relations for changes in internal energy, enthalpy and entropy, Clapeyron equation.	7
	Contact Hours	36

Learning Resources:

Text Books

1. P.K. Nag, Engineering Thermodynamics, McGraw Hill Publications, 6th edition 2017
2. Cengel and Boles, Thermodynamics – An Engineering Approach, Tata McGraw HillPublications. 8th edition 2017
3. R. K. Rajput, Thermal Engineering, Laxmi Publications Ltd, 6th edition 2016

Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	GREEN AND CLEANER TECHNOLOGIES	4	3	0	0	3

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Estimate the carbon credits of various activities
CO2	Apply principles of energy efficient technologies
CO3	Interpret the importance of green fuels and its impact on environment.
CO4	Identify the importance of life cycle assessment

Syllabus:

Module No.	Description	Contact hours
1.	Greenhouse emissions, climate change and role of green and cleaner technologies, causes and effects. Diagnostics and baseline determination, climate change mitigation and adaptation strategy. Risk assessments & mitigation. Carbon accounting, carbon market, carbon capture and storage, potential carbon sequestration (forest sinks).	6
2.	Green Technology: definition, Importance, historical evolution, advantages and disadvantages of green technologies, factors affecting green technologies, role of Industry, government and institutions, industrial ecology, role of industrial ecology in green technology.	7
3.	Principles of Green Technologies, reasons for Green Technology, resource minimization, waste minimization, concepts, green reactions solvent free reactions, catalyzed (heterogeneous/homogeneous) reactions, ultrasound mediated reactions, bio catalysts etc.	7
4.	Materials for "Green" Systems: Green materials, including biomaterials, biopolymers, bioplastics, and composites. Green technologies for energy, green fuels, definition, benefits and challenges, comparison of green fuels with conventional fossil fuels with reference to environmental, economic and social impacts. Various technologies available for energy production: Wind, solar biofuels etc.	8
5.	Principles of cleaner production, barriers, role of Industry, clean development mechanism, reuse, recovery, recycle, raw material substitution, wealth from waste, case studies. Overview of cleaner production assessment steps and skills, process flow diagram, material balance, cleaner production, option generation, technical and environmental feasibility analysis, economic valuation of alternatives	7
	Contact Hours	36

Learning Resources:

Text Books:

1. Emerging green technologies, Matthew N. O. Sadiku, CRC Press, USA, 2020.
2. Green and Smart Technologies for Smart Cities, Pradeep Tomar, and Gurjit Kaur, CRC Press, USA, 2019.

Reference Books:

1. Handbook of Green Chemistry and Technology, Clark, J.H., and Macquarrie, D.J., John Wiley and Sons, USA, 2002.
2. Green Chemistry: Theory and Practice, Paul Anastas, and John Warner, Oxford University Press, USA, 2000.
3. Green Chemistry- An introductory Text, Mike Lancaster, Royal Society of Chemistry, UK, 2016, 3rd Edition.

Subject Code	Subject Title	Semester	Hours per week			Credit
	Renewable Energy	4	L	T	P	3
			3	0	0	

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Describe the environmental aspects of renewable energy resources. In Comparison with various conventional energy systems, their prospects and limitations.
CO2	Describe the use of solar energy and the various components used in the energy production with respect to CO3 applications like-heating, cooling, desalination, power generation.
CO3	Explain the conversion principles of wind and tidal energy
CO4	Acquire the basic knowledge of ocean thermal energy conversion and hydrogen energy.

Syllabus:

Module No.	Description	Contact hours
1	Introduction: Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE).	7
2	Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system.	8
3	Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and multiblade system. Vertical axis- Savonius and darrieus types.	8
4	Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.	7
5	Green Energy: Introduction, Fuel cells: Classification of fuel cells – H2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.	7
	Total Contact Hours	**36**

Learning Resources:

Text Books

1. Nonconventional Energy sources, G D Rai, Khanna Publication, Fourth Edition,
2. Energy Technology, S.Rao and Dr. B.B. Parulekar, Khanna Publication. Solar energy, Subhas P Sukhatme, Tata McGraw Hill, 2ndEdition,1996.

REFERENCE BOOKS:

1. Principles of Energy conversion, A. W. Culp Jr., McGraw Hill, 1996
2. Non-Convention Energy Resources, Shobh Nath Singh, Pearson, 2018

Subject Code	Subject Title	Semester	Hours per week			Credit
	Green Manufacturing	5	L	T	P	3
			3	0	0	

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Interpret the basics of Green Manufacturing and its Social, Business, and Policy Environment.
CO2	Explain the Metrics for Green Manufacturing and principles of green manufacturing
CO3	Apply the knowledge of Closed-Loop Production Systems for Sustainable Factory Design.
CO4	Apply the knowledge of Environmental Implications of Nano-manufacturing and Clean Energy, Package and Supply chain.

Syllabus:

Module No.	Description	Contact hours
1	Introduction to Green Manufacturing Why Green Manufacturing, Motivations and Barriers to Green Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing. The Social, Business, and Policy Environment for Green Manufacturing: Introduction, The Social Environment—Present Atmosphere and Challenges for Green Manufacturing, The Business Environment: Present Atmosphere and Challenges, The Policy Environment—Present Atmosphere and Challenges for Green Manufacturing.	8
2	Metrics for Green Manufacturing Introduction, Overview of Currently Used Metrics, Overview of LCA Methodologies, Metrics Development Methodologies, Outlook and Research Needs. Green Supply Chain: Motivation and Introduction, Definition, Issues in Green Supply Chains (GSC), Techniques/Methods of Green Supply Chain, Future of Green Supply Chain. Principles of Green Manufacturing: Introduction, Background, and Technology Wedges, Principles, Mapping Five Principles to Other Methods and Solutions	8
3	Closed-Loop Production Systems Life Cycle of Production Systems, Economic and Ecological Benefits of Closed Loop Systems, Machine Tools and Energy Consumption, LCA of Machine Tools, Process Parameter Optimization, Dry Machining and Minimum Quantity Lubrication, Remanufacturing, Reuse, Approaches for Sustainable Factory Design.	8
4	Environmental Implications of Nano-manufacturing Introduction, Nano-manufacturing Technologies, Conventional Environmental Impact of Nano-manufacturing, Unconventional Environmental Impacts of Nano-manufacturing, Life Cycle Assessment (LCA) of Nanotechnologies. Green Manufacturing Through Clean Energy Supply: Introduction, Clean Energy Technologies, Application Potential of Clean Energy Supplying Green Manufacturing	8
5	Packaging and the Supply Chain A Look at Transportation, Introduction, Background, Recommended Method to Determine Opportunities for Improved Pallet Utilization, Discussion.	4
	Total Contact Hours	**36**

Learning Resources:

Text Books

Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007
Rodick, D, " Industrial Development for the 21st century: Sustainable development perspectives" UN New York,2007
Lawn.P, " Sustainable development indicators in ecological economics", Edward Elgar Publishing limited, 2006
Dornfeld, David (Ed), " Green manufacturing : fundamentals and applications", Springer Science & Business Media,2012
Klemes J, " Sustainability in the process industry", McGraw Hill,2011

Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Waste Management	5	3	0	0	3

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Identify waste processing methods for different types of wastes.
CO2	Analyze activities associated with the management of Hazardous wastes.
CO3	Identify various components of Regulatory and legal frameworks in waste management.
CO4	Select thermochemical conversion methods of waste to energy.

Syllabus:

Module No.	Description	Contact hours
1.	Waste Generation and Characterization Types and sources of solid wastes: Residential Waste, Commercial and Institutional Waste, Industrial Waste, Construction and Demolition Waste, an overview of various techniques for evaluation of parameters, Selection of Appropriate Technologies for waste treatment, legislations for waste management.	6
2.	Processing and Treatment of Solid Waste: Mechanical Treatment Material Recovery Facility, Recycling and Recovery, Types of Material Recovery Facilities, Design of Material Recovery Facilities, Processing and Treatment of Solid Waste.	7
3.	Hazardous waste treatment technologies: Physical, chemical, physico-chemical treatment, and thermal treatment; -Solidification, chemical fixation, encapsulation, pyrolysis and incineration. Hazardous waste disposal: Hazardous waste landfills- Site selections, design and operation. Hazardous waste reduction, recycling and reuse, remediation of hazardous waste contaminated sites Management of different Hazardous wastes: Nuclear waste, Biomedical waste, e-waste and Plastic waste.	9
4.	Waste Management Laws in India The Environmental Protection Act, The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, The Plastic Waste (Management and Handling) Rules, 2011, Bio-Medical Waste (Management and Handling) Rules, 1998, The E- Waste (Management and Handling) Rules, 2011, The Batteries (Management and Handling) Rules, 2001.	7
5.	Waste to Energy: Thermochemical conversion: incineration, pyrolysis, gasification of waste using gasifiers, environmental and health impacts of incineration; strategies for reducing environmental impacts. Energy production from wastes through incineration, energy production through gasification of wastes. Energy production through pyrolysis and gasification of wastes, syngas utilization.	7
	Contact Hours	36

Learning Resources:

Text Books:

1. Solid Waste Technology & Management, Thomas Christensen, (2011)., John wiley & sons, USA.
2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel (2014)., 2nd Ed., CRC Press, USA
3. Thermo-chemical Processing of Biomass: Conversion into Fuels, Chemicals and Power, Robert C. Brown, John Wiley and Sons, USA, 2019.
4. Hazardous Waste Management, LaGrega M.D., Buckingham P.L. and Evans J.C., Waveland Pr Inc., 2010, Reissue Edition

Minor Requirements in Mechanical Engineering

Total Credit Requirement: Minimum 18

Minor in Industrial Manufacturing

SI No	Subject	Credit (L-T-P)	Semester
1	**Manufacturing Process**	3-0-0	3rd Semester
2	**Engineering Materials**	3-0-0	4th Semester
3.	**Industrial Engineering Principles**	3-0-0	4th Semester
4	**Modern Manufacturing Process**	3-0-0	5th Semester
5	**Quality Control and Assurance**	3-0-0	5th Semester
6	**Mini Project**	3-0-0	6th Semester

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Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Manufacturing Process	**3**	**3**	**0**	**0**	**3**

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Compare different manufacturing methods like casting, forming, machining, joining
CO2	Explain the casting process and their defects.
CO3	Explain forming process
CO4	Explain different joining process
CO5	Explain different machining process like Turning, Drilling, Milling, Shaping, Grinding

Syllabus:

Module No.	Description	Contact hours
1.	**Introduction:** Definition, importance, and classification of manufacturing processes. Basic properties of engineering materials. Comparison of manufacturing methods: casting, forming, machining, joining, additive. Criteria for process selection.	5
2.	**Casting Processes**: Sand casting: pattern types, moulding tools, core making, gating and riser design. Types: Shell molding, investment casting, die casting, centrifugal casting. Defects in casting: causes and remedies. Melting furnaces: Cupola, induction.	8
3.	**Forming Processes**: Principles of plastic deformation: stress-strain, hot vs. cold working. Forging: Open and closed die. Rolling: 2-high, 3-high, cluster mill. Extrusion: Forward and backward. Drawing: wire and tube.	7
4.	**Joining Processes**: Gas welding, Arc welding, Resistance welding, TIG, MIG welding. Brazing, soldering, adhesive bonding. Welding defects and their inspection (NDT basics). Heat-affected zones and welding metallurgy.	8
5.	**Machining Processes**: Introduction to machining and chip formation. Lathe machine: operations (turning, facing, threading, tapering). Drilling, Milling, Shaping, Grinding: operations and applications. Cutting tool materials and tool geometry. Surface finish and tolerances.	8
	Contact Hours	36

Learning Resources:

1. Ghosh and A. K. Mallik, Manufacturing Science, East West Press, 2nd edition, 2010.
2. G. K. Lal, Introduction to Machining Science, New Age International Pvt Ltd., 3rd edition 2007
3. W. A. Knight and G. Boothroyd, Fundamentals of Metal Machining and Machine Tools, CRC Press, 3rd edition 2005
4. M. C. Shaw, Metal Cutting Principles, Oxford University Press, Second Edition, 2012

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Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Engineering Materials	**4**	**3**	**0**	**0**	**3**

Prerequisites: NIL

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Analyse the failure of metals by studying the mechanical properties and different failure mechanism like fracture, fatigue and creep.
CO2	Identify crystal structures and imperfections for various materials.
CO3	Analyse Fe-Fe3C equilibrium diagram
CO4	Design proper heat treatment process to tailor material properties for ferrous alloys.
CO5	Classify different Engineering alloys, namely Copper, Aluminium, Cast iron, stainless steel and non-metallic materials.

Syllabus:

Module No.	Description	Contact hours
1	**Mechanical Property measurement:** Tensile, compression and torsion tests, relations between true and engineering stress-strain curves, yielding and yield strength, ductility, resilience, toughness, Hardness: Rockwell, Brinell and Vickers and their relation to strength **Fracture of Metals**: Ductile fracture, Brittle fracture, Ductile and Impact Testing, Toughness and Impact testing **Fatigue of Metals**: Cyclic stress, SN curve, endurance and fatigue limits, Fatigue life calculations Creep and Stress rupture of metals: Creep of metals, Creep test	8
2	**Crystal Structures and Imperfection in solids** Crystal Structures: Crystal systems and Bravais Lattice, Principal Metallic Crystal Structure (SC, BCC, FCC, HCP), Miller Indices and direction for Crystallographic Planes in Cubic unit cell, Crystal structure analysis by X ray diffraction Imperfection in solids: Point, line, interfacial and volume defects; deformation by twinning, Stacking faults.	8
3	**Heat Treatment of Plain Carbon Steel** Iron-Carbon equilibrium diagram, Microstructure changes during phase transformation. Transformation in plain carbon steel: TTT diagram, Effect of Alloying elements in Alloy Steel, Different heat treatment processes: Hardening, Tempering, Annealing, Normalizing, Case Hardening, Cyaniding, Nitriding, Flame and Induction Hardening.	8
4	**Engineering Alloys** Cast iron: General Properties, Types of cast iron, Stainless steel: Ferritic, Martensitic and Austenitic stainless steel, Copper Alloy: General properties of copper, Production of Copper, Classification of Copper Alloy, Wrought Copper alloy, Aluminium Alloy: General properties of Aluminium and its production, Wrought Aluminium Alloys,	6

	Aluminium Casting Alloys	
5	**Non-Metallic Materials** Classification of non-metallic materials, Rubber: classification, Properties, processing and applications, Plastics: Thermosetting and Thermoplastics, General purpose Thermoplastics (Polyethylene, Polypropylene, Polystyrene), Engineering thermoplastics (Nylons, Polycarbonate, Acetals), Ceramics: Properties and applications, Processing of Ceramics, Glasses: Glass transition temperature, Structure and composition of glasses, Composites: Properties and applications, Fibers for Reinforced Plastic Composite Materials (Glass fibers, carbon fibers)	6
	Total Contact Hours	**36**

Suggested Books and Other Study Materials

1. William D. Callister Jr. and David G. Rethwisch, Materials Science and Engineering: An Introduction Wiley, 9th Edition 2013
2. James F. Shackelford, Introduction to Materials Science for Engineers, Pearson, 8th Edition, 2020
3. William F. Smith and Javad Hashemi, Foundations of Materials Science and Engineering, McGraw-Hill Education, 2009
4. S.L Kakani and Amit Kakani, Material Science, New Age International Private Limited , 2016
5. V. Raghavan, Materials Science and Engineering, Prentice Hall India Learning Private Limited, 6th Edition 2015

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Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Industrial Engineering Principles	**4**	**3**	**0**	**0**	**3**

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Describe the scope, objectives, and applications of Industrial Engineering in different industries
CO2	Apply the techniques of work study to analyze and improve workplace efficiency.
CO3	Develop appropriate plant layouts and material handling strategies.
CO4	Design effective production planning and control systems to manage production flow.

Syllabus:

Module No.	Description	Contact hours
1	**Introduction to Industrial Engineering:** Definition and Scope of Industrial Engineering, Historical Development and Contribution to Industry, Objectives and Functions of Industrial Engineering, Productivity Concepts: Factors Affecting Productivity, Productivity Measurement Techniques, Systems Approach in Industrial Engineering, Role and Responsibilities of an Industrial Engineer in Manufacturing and Service Sectors.	8
2	**Work Study:** **Method Study:** Objective and Procedure of Method Study, Recording Techniques: Flow Process Chart, Two-Handed Process Chart, Operation Process Chart, Principles of Motion Economy, Micro-Motion Study and SIMO Chart **Work Measurement:** Techniques of Work Measurement: Time Study, Work Sampling, PMTS, Standard Time Determination, Allowances and Rating Factors, Performance Rating and Synthetic Data	10
3	**Plant Layout and Material Handling** Definition and Need for Plant Layout, Objectives and Principles of Effective Layout, Types of Plant Layout: Product Layout, Process Layout, Fixed Position Layout, Cellular Layout, Computerized Layout Techniques (Brief Introduction to CRAFT, CORELAP) Material Handling Principles, Selection of Handling Equipment (Conveyors, Cranes, Hoists, AGVs, etc.), Relationship Between Layout and Material Handling.	10
4	**Production Planning and Control** Introduction and Objectives of PPC, Functions of PPC: Forecasting, Capacity Planning, Aggregate Planning, Routing and Scheduling Techniques, Job Shop and Flow Shop Scheduling, Gantt Charts, Critical Ratio Method, Dispatching and Follow-up Activities Line Balancing: Concepts, Objectives, Heuristic Approaches.	8
	Total Contact Hours	**36**

Learning Resources:

1. Niebel, B.W. & Freivalds, A., Methods, Standards, and Work Design, McGraw-Hill Education
2. Buffa, E.S. & Sarin, R.K., Modern Production/Operations Management, Wiley India
3. S.S. Rao, Facilities Planning and Layout, PHI Learning
4. I.L.O. (International Labour Organization), Introduction to Work Study, ILO Publications
5. Mahajan, M., Industrial Engineering and Production Management, Dhanpat Rai & Co.

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Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Modern Manufacturing Process	**5**	**3**	**0**	**0**	**3**

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Explain the need for and classification of advanced and non-traditional manufacturing techniques.
CO2	Describe the principles, equipment, and parameters involved in mechanical process.
CO3	Describe different electrochemical and chemical-based processes.
CO4	Describe the principles, equipment, and parameters involved in thermal metal removal processes.
CO5	Analyze additive manufacturing processes and their industrial applications.

Syllabus:

Module No.	Description	Contact hours
1.	**Introduction:** Trends in modern manufacturing; characteristics and classification of modern manufacturing methods, considerations in the process selection.	4
2.	**Mechanical Processes:** Introduction, principle, process description, process capabilities, material removal mechanism, parametric analysis, tool design, limitations, and applications of Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) processes.	7
3.	**Electrochemical & Chemical Processes:** Fundamental principle, process description, process capabilities, mechanism of material removal, surface finish and accuracy, limitations, and applications of Electrochemical Machining (ECM), Electrochemical Grinding (ECG), Electrochemical deburring, Electrochemical honing and Chemical Machining (C M) processes.	7
4.	**Thermal Metal Removal Processes:** **Electrical Discharge Machining (EDM):** Working principle, process description, process capabilities, power circuits, mechanism of material removal, selection of tool electrode and dielectric fluid, limitations, and applications. Wirecut electro discharge machining, powder mixed electro discharge machining process **Laser Beam Machining (LBM):** Working principle, type of lasers, machining applications of lasers, mechanism of material removal, shape and material, applications and limitation. **Electron Beam Machining (EBM):** Generation and control of electron beam, EBM systems, process analysis & characteristics, mechanism of material removal, shape and material, applications and limitations. **Plasma Arc Machining (PAM) and Ion Beam Machining (IBM):** Process principle, analysis and characteristics of process, mechanism of material removal, shape and material, applications and limitations.	12
5.	**Additive Processes:** Introduction to additive manufacturing processes; classification; laminated object manufacturing process; adhesive manufacturing process; digital manufacturing process.	5
	Contact Hours	36

Learning Resources:

1. P. C. Pandey and H. S. Shan, Modern Machining Processes, Tata Mcgraw Hill,New Delhi, 2003.
2. P. K. Mishra, Nonconventional machining, Narosa publishing house, 2011
3. V. K. Jain, Advanced Machining processes, Allied publishers, New Delhi, 2008.
4. G. Benedict, Nontraditional manufacturing processes, Marcel Dekker, New York, 1st Edition, 1987.
5. J. A. McGeough, Advanced methods of machining, Chapman & Hall, London, 1st Edition, 1988
6. Ghosh and A. K. Mallik, Manufacturing Science, East-West Press, New Delhi, 2006.
7. D. T. Pham and S. S. Dimov, Rapid manufacturing, Springer-Verlag, 1st Edition, 2001.

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Subject Code	Subject Title	Semester	Hours per week			Credit
			L	T	P	
	Quality Control and Assurance	5	3	0	0	3

Course Outcome (CO): After completion of the course, the students will be able to

CO	Statement of course outcomes
CO1	Explain quality concepts, dimensions, and philosophies.
CO2	Apply control charts and process capability tools for statistical process control.
CO3	Design acceptance sampling plan using OC curves and risk analysis.
CO4	Apply quality assurance frameworks such as TQM, Six Sigma, and ISO standards.
CO5	Use quality tools like Pareto charts, fishbone diagrams, and FMEA to solve quality problems.
CO6	Implement inspection methods, metrology practices, and testing protocols.

Syllabus:

Module No.	Description	Contact hours
1	**Introduction to Quality:** Definition of quality: Product and service quality, Dimensions of quality: Performance, reliability, durability, aesthetics, serviceability, etc., Evolution of quality management: Craftsmanship to TQM, Quality control (QC), Quality assurance (QA), Quality management (QM), Cost of Quality (COQ): Prevention, appraisal, internal and external failure costs, Contributions of Deming (PDCA, 14 points), Juran (Quality trilogy), Crosby (Zero Defect)	6
2	**Statistical Quality Control (SQC) :** Variability in processes: Common vs. special causes, Control Charts for Variables: $\bar{X}$ – R, $\bar{X}$ – S charts, Control Charts for Attributes: p, np, c, u charts, Rules for identifying out-of-control processes, Process Capability Index: Cp, Cpk, Cpm, Machine capability study	8
3	**Acceptance Sampling** Introduction and need for acceptance sampling, Lot-by-lot inspection and sampling plan types: single, double, multiple, Operating Characteristic (OC) curves, Producer's risk (α), Consumer's risk (β), AOQL, LTPD, ASN, MIL-STD sampling tables (introductory)	6
4	**Quality Assurance Systems and Standards** Introduction to Quality Assurance (QA), Total Quality Management (TQM): Principles and implementation, BIS, ISO 9001:2015 Quality Management System, Documentation, Quality Manual, Procedures, Work Instructions, Internal Quality Audits, Six Sigma Methodology: DMAIC & DMADV, Quality Function Deployment (QFD), House of Quality	8
5	**Quality Tools and Techniques** Check Sheet, Histogram, Cause-and-Effect (Ishikawa/Fishbone), Pareto Diagram, Control Charts, Scatter Diagrams, Flowcharts	7
6	**Inspection and Testing** Types and levels of inspection (incoming, in-process, final), Destructive and Non-Destructive Testing (NDT), NDT Techniques: Visual, Ultrasonic, Radiography, Magnetic Particle, Dye Penetrant, Measurement systems and Calibration, Metrology in quality assurance, Surface roughness, flatness, roundness inspection	
	Total Contact Hours	**36**

Learning Resources:

1. **Montgomery, D. C.** – Introduction to Statistical Quality Control, Wiley.
2. **Besterfield, D. H.** – Quality Control, Pearson.
3. **Juran, J. M.** – Juran's Quality Handbook, McGraw-Hill.