DEPARTMENT OF MECHANICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY(ISM) DHANABD

SYLLABUS OF M.TECH (MECHANICAL ENGINEERING)

SPECIALIZATION: MANUFACTURING ENGINEERING

FIRST SEMESTER					
Course No.	**Course Name**	**L**	**T**	**P**	**CH**
DEPARTMENTAL CORE					
MEC502	Numerical Methods	3	0	0	9
MEC513	Thermo Production Processes	3	0	0	9
MEC514	Advances in Machining	3	0	0	9
MEC515	Theory of Metal Forming	3	0	0	9
MEC516	Unconventional Manufacturing Processes	3	0	0	9
Practicals					
MEC517	Casting, forming and welding Lab.	0	0	2	2
MEC518	Machining Lab.	0	0	3	3
	Total	**15**	**0**	**3**	**50**

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 502	Numerical Methods	3	0	0	9

Course Objective

The objective of the course is to study the numerical solution of linear and non-linear algebraic equations, solution of differentiation, integrations, PDE and ODEs.

Learning Outcomes

Upon successful completion of this course, students will:

- Be able to solve actual problems by using different Numerical methods.
- Be able to use FDM for discretization of governing equations to find the temperature distribution in the given geometry
- Be able to understand the different types of PDEs
- Be able to use the up winding for solving the flow problems.
- Be able to write the computer programming based on learning of this course

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction to Numerical Methods,	1	Numerical Methods are gradually becoming the substitute of experimental methods.
2	Solution of linear algebraic systems: Non-iterative method, Gauss elimination method, LU- factorization method, Matrix inversion method. iterative method, Gauss Seidel iterative method, Jacobi method, ill - conditioning problems, Tridiagonalization, Hoseholder's method, QR-factorization	8	This unit will help students in understanding the numerical solution methodology for linear equations
3	Solution of non-linear algebraic systems: Solution of equations by iterations, Fixed point iterations, Newton's method, Secant method, Bi-section method	5	Understanding the methods for solution of non-linear equations.
4	Numerical differentiation: Methods for first order ODEs, Euler method, Runge-Kutta methods, Methods for higher order and systems of ODEs, Euler method, Runge-Kutta methods, Stiff systems	5	This unit will help students in understanding the applications of Euler's Method, R-K2 and higher

			order R-K 4 methods
5	Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule. Numerical double integration	5	Numerical integrations will be very useful for summation and averaging. Also, students will learn about best technique for integration.
6	Introduction to partial differential equations: 1^{ST} Order PDEs, Mathematical classification second order PDEs, Characteristics.	2	Understanding the behavior of PDE equations.
7	Finite Difference Methods: Different discretization techniques of PDE equations, Backward, forward and central differencing discretization schemes, Euler's explicit, implicit and semi-implicit methods, Truncation, Discretization, Round off errors. Consistency, stability and convergence. Fourier or von-Neumann stability analysis of Finite difference schemes.	8	Understanding different types of errors, consistency, stability and convergence during solving the governing equations.
8	Applications to model problems: Parabolic equations, heat equations, Elliptic equations, Laplace and Poisson's equations. Dirichlet problems, ADI method, Neumann and Mixed problems, Hyperbolic equation, wave equation, Upwinding differencing schenie of advection terms.	5	Students may use different methods for solving the actual heat and fluid flow and wave equations,

Text Books:

1. Introductory Methods of Numerical Analysis: S.S.Sastry, 4^{th} Edition, Prentice Hall of India Pvt Ltd,
2. Computational Methods in Engineering: S.P.Venkateshan, P Swaminathan, Ane Books Pvt Ltd

Reference Books:

3. Numerical Solution of Partial Differential Equations: G.D.Smith, Oxford University Press, 1985
4. Computational Fluid Mechanics and Heat Transfer: D.A.Anderson, J.C.Tannehill and R.H.Pletcher, Hemisphere Publishing Corporation

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 513	Thermo Production Process	3	0	0	9

Course Objective
The course will enable the students to have sound theoretical and practical knowledge related to coalescence, foundry and Powder Metallurgy related practices in manufacturing domain.
Learning Outcomes
Upon successful completion of this course, students will: • Be able to have fundamental knowledge on basic manufacturing processes. • Have basic understanding of each manufacturing process parameters and its optimization procedure. • Be able to select a different manufacturing process based on requirement. • Be able to design and develop a product from scratch using commonly available raw materials. • Be capable of formulating governing equation from first principals and analyse the results.

Module	Topics	Lecture Hours	Learning Outcome
1	Metal Casting sand, Properties and Testing of Moulding Sand; Design of Pattern and Core, Gating System Design, Mould filling velocity and time including friction and velocity distribution in the conduit. Determination of solidification time of castings; Riser design and Placement.	10	Understanding the relevant properties of molding sand, gating system. Learning of the solidification time and riser design related fundamentals.
2	Casting defects, Miscellaneous casting: Dry sand casting, investment casting, pressure die casting, centrifugal casting and continuous casting. Application of reverse engineering in metal casting.	5	Appreciation of the different classes of defects and knowledge acquisition of various casting methodologies including the understanding the application of reverse engineering through casting.
3	Welding processes: Principle and type of fusion welding processes, modes of metal transfer, heat flow characteristics, welding power supply characteristics-conventional and pulsed power sources, inverter type;	8	Acquiring knowledge about the various types and principles of popular processes of coalescence. Appreciating the relevant

	Modelling of welding processes.		characteristics of power sources relevant for welding.
4	Special welding processes; Electron Beam Welding, Laser Beam Welding, Friction Stir Welding, Explosive welding and Ultra-sonic welding, Weldability of cast iron, plain carbon and low alloy steels, stainless steels, Defects and Inspection of welds- NDT; Case studies.	6	Appreciation of the revances and functioning of various modern welding process like friction stir welding, EBW, USW etc. Understanding the weldability of materials and various welding defects.
5	POWDER METALLURGY: Introduction, Sintering, Densification and Sizing; Impregnation and Infiltration. Isostatic pressing, Hot pressing and Spark plasma sintering. Porous metals and metal foams, concept of atomisation.	10	Acquiring knowledge related to various aspects of Powder Metallurgy process and their applications.

Text books:

1. Manufacturing Engineering and Technology, Kalpakjian and Schmid, Pearson Publishers, 7th Edition, 2014

Reference books:

1. Materials and Processes in Manufacturing, Degarmo, J. T. Black, Prentice Hall of India Pvt Ltd.
2. Fundamentals of modern manufacturing processes, M. P. Groover.
3. Manufacturing Science : Ghosh and Mallick, East-West Press Private Limited
4. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 514	Advances in Machining	3	0	0	9

Course Objective
The objectives of this course is to train the students : to select suitable machines and cutting tools for different operations on a work material; to address the issues related to high cutting temperature, low tool life, effective use of cutting fluids; to understand the mechanics of metal cutting in different operations, hybrid machining process and different research areas.
Learning Outcomes

Upon successful completion of this course, students will:

- Understand the different cutting tool geometrical parameters and methods for their quantification
- Understand the principle of metal cutting process.
- Able to measure and estimate cutting force and temperature in different metal cutting operations
- Get idea of about the difficulties in metal cutting operations and the possible approaches to overcome them.

Module	Topics	Lecture Hours	Learning Outcome
1	Need and Classifications of Machining Processes; Cutting Tool Geometry in different systems: tool in hand, ASA, ORS, NRS etc. and their conversion; Cutting tool materials and selection; Drilling, milling tool geometry.	8	Students will learn the selection of proper cutting tool for a particular work material. Tool designation in different systems of reference of references and conversation of angles.
2	Mechanics of metal cutting, Orthogonal and Oblique cutting, Mechanism of chip formation and Types of chips: Turning, Drilling and Milling. Metal Cutting forces, cutting Temperature and their measurement methods, Tool Life.	12	Students will understand mechanics of chip formation in different machining process. Measurement methods of cutting forces involved. Determination of tool life, mathematical relations in machining process and their applications.
3	Advanced machining processes: high speed, cryogenic and dry machining, hard cutting, ultrasonic assisted machining.	4	Students will be able to understand how hybridization of machining process is beneficial in material removal process, machining techniques for very hard and tough materials. Effects of with and without coolant in machining.
4	Grinding processes: Grinding Wheel and types; Mechanics of Grinding, spark in and spark out, grinding stiffness, residue in grinding, grinding specific energy, and Chip Formation; Grinding Forces and Power; Grinding Temperature; Cooling and lubrication: principle and types, cutting fluids and method of application: Flood flowing, MQL, nano lubricants etc.	15	This module will teach the requirements of different grinding operations, parameters, energy consumption, forces and power requirements.

Text books:

1. Machining and Machine Tools, A.B. Chattopadhyay, Willey Publishers, 2011

References books:

1. Theory of Metal Cutting, A. Bhattacharya.
2. Materials and Processes in Manufacturing, Degarmo, J. T. Black, PHI Pvt Ltd.
3. Manufacturing Processes for Engineering Materials, Kalpakjian and Schmid, Prentice Hall.Fundamentals of Metal Machining and Machine Tools, Winston A. Knight, Geoffrey Boothroyd, CRC Press
4. Manufacturing Science : Ghosh and Mallick, East-West Press Private Limited
5. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication.Hand book of Manufacturing Engg and Technology, Edited by Andrew YC Nee, Springer, 2014

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 515	Theory of Metal Forming	3	0	0	9

Course Objective

The course will enable the students to understand the basic principles of Metal Forming Theory, to know the various types of forming processes, to know about advanced metal forming methods.

Learning Outcomes

Upon successful completion of this course, students will:

- Be able to acquire fundamental knowledge and understanding of metal forming process.
- Formulate relevant research problems, conduct experimental and/or analytical work and analyze results using modern mathematical and scientific methods
- Be able design and validate technological solutions to defined problems.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction, Theory of Plasticity: stress tensor, hydrostatic & deviator components of stress, flow	10	Decide yielding of a material according to different yield theory

	curve, true stress strain, yielding criteria, yield locus, octahedral shear stress and shear strains, invariants of stress strain, slip line field theory plastic deformations of crystals.		for a given state of stress
2	Plastic Forming of Metals-Forging: Basics of plastic forming & forging, mechanics of metal working, temperature in metal working, strain rate effects, friction and lubrication, deformation zone geometry; Forging process: classification, equipment, calculation of forging loads, forging defects, residual stresses.	7	Understanding the concept and design aspect relevant to Metal forging
3	Plastic Forming of Metals-Rolling and Extrusion: Rolling and Extrusion, classification, rolling mills, rolling of bars & shapes, rolling forces, analysis of rolling, defects in rolling, theories of hot & cold rolling, torque power estimation. Extrusion: classification, equipment, deformation lubrication and defects, analysis, hydrostatic extrusion, tube extrusion.	7	Understanding the fundamental aspects and application of rolling and extrusion process
4	Plastic Forming of Metals- Drawing and Sheet metal forming: Drawing & Sheet Metal Forming, rod & wire drawing equipment, analysis, deep drawing, tube drawing, analysis, residual stresses, sheet metal forming, methods, shearing and blanking, bending, stretch forming, deep drawing, forming limit criteria, defects, press brake forming, explosive forming.	7	Understanding the stress state and its relevance in sheet metal working processes
5	Unconventional Forming Methods: Classification; Process Principle, Applications, Equipments, Process Analysis and Die Design of Explosive Forming; Electro-Magnetic Forming ; Electro-Hydraulic Forming; Laser Beam Bending and Laser Assisted Deep Drawing; MICRO FORMING PROCESSES: Classification; Process Principle and Applications of Conventional Micro Forming Processes and Unconventional Micro-Forming Processes.	8	Application to advanced metal forming processes. This module will be useful in selection of different metal forming process in application.

Text books:

1. Manufacturing Processes for Engineering Materials, Kalpakjian and Schmid, Prentice Hall. 5th edition, 2017
2. Manufacturing Science : Ghosh and Mallick, East-West Press Private Limited

Reference books:

3. George E Dieter, Mechanical Metallurgy, Tata McGraw Hill, 3rd Edition
4. Materials and Processes in Manufacturing, Degarmo, J. T. Black, PHI, Pvt Ltd.
5. Fundamentals of modern manufacturing processes, M. P. Groover.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 516	Unconventional Manufacturing Processes	3	0	0	9

Course Objective

To provide detailed understanding of advanced manufacturing processes. The prospect of future research will also discuss in the course which will encourage the PG students to carryout research in the advance area,

Learning Outcomes

Upon successful completion of this course, students will:

- Broad understanding of machining using different energy sources.
- Students will be able to think about the possibility of combining different process to develop more efficient machining process
- It will help the students to select the best process among various alternative.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction and classification, Theory of machining by Abrasive Jet, Abrasive water Jet, Abrasive flow; Ultrasonic machining.	8	Understanding of mechanical based unconventional processes (UMP). It will develop the ability of select the process for particular application.
2	Electrochemical Machining and grinding, polishing, sharpening, honing and turning. Chemical Machining. Electrochemical Discharge machining and Grinding; Electro-stream and Shaped Tube Electrolytic Machining.	13	Understanding of electrical and chemical based unconventional processes (UMP). The students will learn the principle of hybrid process and their applications.
3	Thermal energy methods of material processing (machining/welding/heat treatment) by Electro-discharge, Laser and Electron beam, Plasma arc and	12	Understanding of thermal based unconventional processes (UMP). The students will learn the importance of high pulse energy

	Ion beam.		source.
4	Unconventional metal forming processes: principle, working and applications, High Energy Rate Forming and Electroforming, Physical Vapour and Chemical Vapour Deposition and Plasma Spraying.	6	The students will understand the use of controlled explosive and spark energy in deformation process. The students will also learn about thin coating techniques.

Text books:

1. Fundamentals of Machining Processes (Conventional and Nonconventional Processes), Hassan Abdel-Gawad El-Hofy, CRC press, 3rd Edition, 2018

Reference books:

1. Non-traditional manufacturing processes , Gary F. Benedict, CRC press, 2015
2. Fundamentals of modern manufacturing processes, M. P. Groover.
3. Unconventional Machining, P K Mishra
4. Unconventional Machining, V K Jain
5. Unconventional Machining, Pandey and Shah

Laboratory

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 517	Casting, welding and forming Laboratory	0	0	2	2

1. Green sand preparation and testing: specimen preparation for testing permeability, clay content, grain fineness number, moisture content
2. Testing of moulding sand for compression, shear strength and hardness.
3. Sand Mould preparation and Casting of the components.
4. Permanent mould casting of metal matrix composite.
5. Analysis of metal transfer and heat distribution in welding processes.
6. Testing of welded joints as per Indian Standard.
7. Welding robot programming and execution for different welding profile:2D/3D.
8. Formability tests of sheet metal.
9. Mini project (4 classes)

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 518	Machining Laboratory	0	0	3	3

1. Measurement and analysis of Cutting Forces and temperature in turning operation.
2. Measurement Grinding stiffness in surface grinding operation
3. Measurement and analysis of Grinding Force and Estimation of Cutting Temperature.
4. Measurement and analysis of chatter in machine tools
5. Imparting geometry to different cutting tools.
6. Gear manufacturing in milling machine.
7. Helical Gear cutting using Gear Hobbing and Gear Shaping techniques and measurement of gear parameters.
8. Effect of process parameters in Electro-discharge Machining
9. Programing and profile cutting in Wire EDM
10. Experiment on Electrochemical Jet Drilling and ultrasonic machining

Semester - 2

DEPARTMENTAL ELECTIVES (ANY THREE)

Course no	Course name	L	T	P	CH
	Basket 1				
MED553	Laser Processing of Materials	3	0	0	9
MED554	Surface Engineering	3	0	0	9
	Basket 2				
MED555	Computer Aided Manufacturing and Robotics	3	0	0	9
MED556	Design of Tools, Jigs and fixture	3	0	0	9
MED529	Composite materials	3	0	0	9
	Basket 3				
MED557	Micro-Electro-Mechanical-System (MEMS)	3	0	0	9
MED558	Micro-manufacturing	3	0	0	9
MED559	Micro and Precision Engineering	3	0	0	9
	Open electives to be offered from the Department				
MEO585	Quality Engineering and Management	3	0	0	9
MEO586	Additive manufacturing	3	0	0	9
	Laboratory				
MEC560	Advanced Manufacturing Lab.	0	0	3	3

MEC561	Reverse and virtual Engineering Lab.	0	0	2	2
	Total	**15**	**0**	**5**	**50**

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED529	**Composite Materials**	3	0	0	9

Course Objective

- To learn the properties of fiber-reinforced polymer composites
- To learn the mechanical performance of laminated composites, including failure behavior.
- To model, simulate and optimize the performance of composite structures.

Learning Outcomes

Upon successful completion of this course, students will able to:

- Identify, describe and evaluate the properties of fibre reinforcements, polymer matrix materials and commercial composites.
- Develop competency in one or more common composite manufacturing techniques, and be able to select the appropriate technique for manufacture of fibre-reinforced composite products.
- Analyse the elastic properties and simulate the mechanical performance of composite laminates; and understand and predict the failure behaviour of fibre-reinforced composites
- Apply knowledge of composite mechanical performance and manufacturing methods to a composites design project

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction to composites: Brief History, Constituent Materials, Laminate , FRP, micro-mechanics & macro-mechanics, Applications	2	Understand the Composite, its advantage, classification and the terminology used for studying mechanics of composites
2	Fabrication: Liquid resin impregnation routes, Pre-Pregs methods, Consolidation of resin moulding compounds, Injection moulding and hot pressing of thermoplastics. Fabrication of metal matrix composite.	4	Understanding the manufacturing process of composite

3	Micromechanical Analysis: Assumptions, strength-stiffness, Shear , Poisson Ration	6	Develop concepts of volume and weight fraction of fiber and matrix, density and void fraction in composites
4	Elastic Properties of Unidirectional Lamina: , stress – strain relations for general anisotropic, specially orthotropic and transversely isotropic materials, Transformation Matrix	7	Find the engineering constants; Develop stress-strain relationships, elastic moduli, strengths of a unidirectional/bidirectional lamina
5	Analysis of Laminated Composites: Classical Laminate Theory, Displacement Field, Strain Displacements Relations, Constitutive Relations, Classification of Laminates and their properties.	8	Find the elastic stiffnesses of laminate based on the elastic moduli of individual laminas and the stacking sequence
6	Analysis of Laminated Plate & FEM: Classical Plate theory, Bending of composite plate, Shear deformation theories: FSDT, HSDT, Layerwise	6	Ability to analyze problems on bending, buckling, and vibration of laminated plates and beams
7	Hygrothermal Effects of Laminates , Failure Theories and Strength of Unidirectional Lamina Design of Composite structure & Example	6	Develop the relationships of mechanical and hygrothermal loads applied to a laminate to strains and stresses in each lamina

Text:

1. Mechanics of Composite Material & Structures, M Mukhopadhyay, Universities press 2013.

References:

1. An Introduction to Composite Materials, By D. Hull and Clyne, Cambridge University Press 2010
2. Engineering mechanics of composite materials, I. M. Daniel & O. Ishai, 2nd edn., oxford university press, 2006.
3. Principles of composite material mechanics, R. F. Gibson, 2nd edn. CRC Press, 2007.
4. Mechanics of Composite Material, Autar K. Kaw, CRC Press
5. Mechanics of composite materials, Rr. M. Jones, 2nd edn. Taylor & francis, 1999.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED553	Laser Processing of Materials	3	0	0	9

Course Objective
Students will learn about the applications of various types' lasers in industry/research. Laser interaction with the solids. Lasers operations in material removal, joining, forming and surface modification processes.
Learning Outcomes
Upon successful completion of this course, students will able to: • Understand the uses of laser for processing of materials • Use laser for different applications like cutting, drilling, marking etc. • Understand the principle of laser based Additive Manufacturing Process

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction to industrial lasers: He-Ne, CO2, Excimer, Nd:YAG, Diode, Fiber and Ultra-short pulse lasers and their output beam characteristics; laser beam delivery systems. Laser interaction with the materials.	6	Student will be able to understand different lasers and their applications, laser parameters and their control for engineering applications, Safety precautions.
2	Industrial & scientific applications of laser; Laser cutting, drilling, welding, marking and their process characteristics.	10	After completion of this module, the learner will understand the process physics of laser cutting, drilling, marking etc.
3	Laser surface modifications: Heat treatment, surface remelting, surface alloying and cladding, surface texturing, LCVD and LPVD.	8	This module emphasizes the application of lasers for various surface modification processes.
4	Ultra-short laser processes; pulse interaction, metallurgical considerations and micro fabrication.	6	The student will understand the laser based cold cutting process.
5	Laser additive manufacturing. Laser metal forming: Mechanisms involved including temperature gradient, buckling, upsetting. Laser peening: Laser Shock Processing.	9	This module will enlighten the applications lasers in additive manufacturing, sheet metal forming.

Text books:

1. Steen, William M., Jyotirmoy Mazumder. Laser material processing. Springer science & business media, 2010.

References books:

2. Ion, John. Laser processing of engineering materials: principles, procedure and industrial application. Elsevier, 2005.
3. Duley, Walter W. Laser processing and analysis of materials. Springer Science & Business Media, 2012.
4. Chryssolouris, George. Laser machining: theory and practice. Springer Science & Business Media, 2013.
5. Schaeffer, Ronald. Fundamentals of laser micromachining. CRC press, 2016.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED554	Surface Engineering	3	0	0	9

Course Objective
To have systematic and comprehensive understanding on various aspects related with surface engineering of metallic components.
Learning Outcomes
Upon successful completion of this course, students will able to: • Identify and design the suitable surface modification methods for different applications • Characterise the metallurgical, mechanical and tribological properties of engineered surfaces.

Module	Topics	Lecture Hours	Learning Outcome
1	Fundamentals of surface engineering: definition, scope, classification, and general principles, surface dependent properties and failures, Surface and surface energy: Structure and types of interfaces.	4	Understanding of surface properties and their influences on the performance of a component.
2	Conventional surface engineering practice: Surface engineering by material removal: like etching, grinding, polishing, etc. Surface engineering by material addition: like hot dipping, Electro-plating, carburizing, Cyaniding, etc.	6	Understanding on the fundamental of basic surface modification techniques.
3	Surface engineering by energy beams: Laser assisted microstructural modification like surface melting,	12	Understanding of thick layer coating

	hardening, shocking etc., Laser assisted compositional modification like surface alloying, surface cladding, composite surfacing etc. Surface engineering by spray techniques like Flame spray, cold spray etc.,		technology and their applications.
4	Ion beam assisted microstructure and compositional modification, Sputter deposition of thin films & coatings, PVD coating processes, Chemical vapour deposition and PECVD.	10	Understanding of thin layer coating technology and their applications.
5	Characterization of coatings and surfaces: Measurement of coatings thickness, porosity & adhesion of surface coatings, Measurement of residual stress & stability, Surface microscopy, topography and Spectroscopic analysis of modified surfaces.	7	Understanding about methods of characterization needed for evaluating the metallurgical, mechanical and tribological properties of engineered surfaces.

Text books:

1. Introduction to Surface Engineering by P. A. Dearnley, Cambridge University Press, 2017
2. Laser surface modification of alloys for corrosion and wear resistance by Chi Tat Kwok, Woodhead Publishing Limited, 2012

Reference books:

1. Surface Engineering for Corrosion and Wear Resistance by J.R. Davis, ASM international , 2001
2. ASM Hand book – Surface Engineering, ASM International, vol. 5, 9th edition, 1994

   Surface Engineering for Wear Resistances by K.G. Budinski. Prentice Hall Publisher, 1988

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED555	Computer Aided Manufacturing and Robotics	3	0	0	9

Course Objective
To provide detailed understanding of advances in manufacturing particularly in computer numerical control and robotics.
Learning Outcomes
Upon successful completion of this course, students will: • Broad understanding of Computer Numerical Control machines and working of its components. • The students will able to learn the CNC programming for the machining given engineering component design. • Students will also learn about the functioning of robots used in manufacturing environment.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction, Evolution, Benefits of CAM, Role of management in CAM.	03	Understanding of broad aspect of advances in manufacturing and its impact on productivity.
2	NC/CNC Machine Tools: NC and CNC Technology: Principles, Classification, Specifications and components, Construction Details: interpolators for machining, drives, feedback devices, tooling, adaptive control systems; CNC Applications.	12	Understanding of difference between different CNC technology, its basic components, and different sensors used in CNC machines. The students will learn the principle of interpolators, derives and sensors used in CNC.
3	CNC Programming: Types, Manual Part Programming, canned Cycles and loops, Automated Part programming. Simulation of machining process.	12	Understanding of thermal based unconventional processes (UMP). The students will learn the importance of high pulse energy source.
4	Robotics: Introduction, classification and applications, basic concepts of robot, manipulators, control and drives, robot programming, feedback devices. Technologies, Industrial robot, Kinematics of robots.	12	The students will learn the basic function of robotics and its application.

Text books:

1. Computer control of Manufacturing system, Yoram koren, McGraw Hill Publication, Reprint 2005

Reference books:

2. Industrial Robotics Technology, Programming, and Application, M. P. Groover et al, Tata McGraw-Hill Publication. 2018

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED556	Design of Tools, Jigs and Fixtures	3	0	0	9

Course Objective
Students will learn about tooling and job holding requirements during different manufacturing operations. Another objective is to understand the design and selection criteria for jigs and fixtures for bulk and sheet metal processes.
Learning Outcomes
Upon successful completion of this course, students will: • Be able to acquire fundamental knowledge on tool design and clamping methods in different industrial environmental applications. • Formulate mathematical and scientific methods associated with design of a mechanical system. • Finally, it will be helpful in customizing design and development of a new system as per the requirement.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction: Tool design methods; tool making practices: hand finishing and polishing, screws and dowels, hole location and jig boring practices. Tooling materials tool steel, cast iron, non-metallic tooling material, heat treatment and factor affecting the heat treatment.	10	Understanding the different tool design methods and factors affecting the design criteria.
2	Design of cutting tools: Basic Requirement of The Cutting Tools, Metal Cutting Tools and classification. Gauges and gauge design: fixed gauges, gauge tolerance, selection of materials for gauge.	9	Characterizing the cutting tools and its specification criteria in different applications
3	Locating and clamping methods, Classification of jigs, design of drill jigs and milling fixtures, other fixtures: Turning, Grinding, Broaching, Welding and Modular Fixtures,	10	Application of jigs and fixtures in conventional manufacturing processes,
4	Design of sheet metal blanking and piercing dies, sheet metal bending, forming and drawing dies, tool design for numerical control machine tools.	10	Design and application of dies in sheet metal operations

Text books:

1. Donaldson C, LeCain GH, Goold VC, Ghose J. Tool design. Tata McGraw-Hill Education; 2012

References books:

1. Venkataraman, K. *Design of jigs, fixtures and press tools*. John Wiley & Sons, 2015.
2. Jones, Ernest James Henry, and Harold Clifford Town. *Production engineering: jig and tool design*. Newnes, 2013.
3. Reid, D. "Fundamentals of tool design, Society of manufacturing engineers." *Publications development department* (1991).

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED557	Micro- Electro-Mechanical Systems (MEMS)	3	0	0	9

Course Objective
To enable students to obtain real life exposure in fabrication and uses of MEMS technology.
Learning Outcomes
Upon successful completion of this course, students will: • Understand the benefits and consequences of scaling in MEMS. • Understand properties and crystallography of each elements of MEMS system. • Design and understand bulk micromachining and fabrication technologies. • Understand noise and different challenges in MEMS.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction, material selection and classification, their characteristic features. Concept of scalability, perception of micron-based dimensions and their real-life significances, challenges of scalability and mass manufacturing related to MEMS, case studies.	15	Understanding the concept of MEMS and their special purpose applications.
2	Surface micromachining processes for MEMS fabrication. Inspection, quality control and microscopic analysis of the micro machined products. MEMS based sensors & actuators: Working Principle, sensitivities. Latest applications of those actuators in	12	Acquiring awareness of the manufacturing processes related to MEMS. Appreciation of the working principle of various MEMS based

	cell phones, biomedical instrumentation and aerospace technology, case studies.		devices and their latest applications.
3	Principles of electro mechanics applied in MEMS, mathematical assessment of the sensitivities and electromechanics features of MEMS, Modelling and design techniques for MEMS based devices, preliminary exposure to software used for modelling.	6	Appreciating the mathematical modelling and subsequent assessment of electromechanics features of MEMS and the relevant software.
4	Packaging issues related to MEMS, Reliability assessment and measurement techniques for MEMS, precision, accuracy, uncertainties of MEMS based devices, exposure to distribution fitment for predicting the performance.	6	Acquiring knowledge about packaging challenges and uncertainties related to MEMS.

Text books:

1. MEMS, N. P. Mahalik, Tata McGraw-Hill Publications, 2007
2. MOEMS: Micro-Opto-Electro-Mechanical Systems, M. Edward Motamedi, SPIE Publications, 2005

Reference books:

1. MEMS: Introduction and Fundamentals by Mohamed Gad-el-Hak
2. MEMS mechanical sensors by Stephen Beeby
3. Microsensors, MEMS, and smart devices by Julian W. Gardner, V. K. Varadan, Osama O. Awadelkarim
4. MEMS and microsystems: design, manufacture, and nanoscale engineering- Tai-Ran Hsu
6. Micromachining – V.K.Jain, Narosa Publishing house

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED558	Micro Manufacturing	3	0	0	9

Course Objective
Principle of mechanics of manufacturing in macro and micro are entirely different. Materials change behaviour if processed at micro level. The present course based on the mechanical/chemical behaviour changes during micromachining/manufacturing. Therefore, tool based micro machining and unconventional micromachining processes have been explored.
Learning Outcomes

Upon successful completion of this course, students will:

- Learn the fundamental and process mechanics of micromachining.
- Understand of mechanics at micro level machining.
- Able to Differentiate between micro and macro machining, visualize micro machining process.
- Understand application and advancements in the micro machining process.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction and classification of micromachining; Mechanical type micro machining processes: Abrasive jet micromachining (AJMM), Ultrasonic micromachining, abrasive water jet micro machining (AWJMM)	9	Acquired knowledge about different micro-machining processes.
2	Magnetorheological finishging (MRF), Magnetorheological abrasive flow finishing (MRAFF), Magnetic float polishing (MFP)	7	Acquired knowledge about super finishing processes.
3	Chemical and electrochemical type advanced machining processes: Electrochemical micromachining (EDMM), electrochemical micro deburring, Chemical and photochemical micro-machining. Abrasive based nano finishing processes: Abrasive flow finishing (AFF), Chemo-mechanical polishing (CMP), Magnetic abrasive finishing (MAF)	10	Understanding about the capabilities of different micro-manufacturing processes.
4	Thermo electric type micro-machining process: Electric discharge micromachining (EDMM), wire EDM, EDDG, ELID, Laser beam micro machining (LBMM), Electron beam micromachining (EBMM)	7	Understanding about the capabilities of different advanced micro-manufacturing processes.
5	Traditional mechanical micro-machining processes: Micro turning, micro milling, micro drilling	6	Understanding about the capabilities of traditional micro-manufacturing processes.

Text books:

1. Introduction to micromachining, VK Jain, Narosa Publisher, New Delhi 2nd edition

Reference books:

2. Micromachining methods, JA Mc Geough, Champan and Hall, London

3. Micro manufacturing processes, VK Jain CRC Press
4. Advanced machining processes, VK Jain, Allied Publisher New Delhi

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED559	Micro and Precision Engineering	3	0	0	9

Course Objective

To impart the knowledge about the tooling and job holding requirements during different machining operations. Design considerations for jigs and fixtures for macro and micro components.

Learning Outcomes

Upon successful completion of this course, students will:

- Learn about the precision machine tools/ macro and micro components.
- Understand handling and operating of the precision machine tools.
- Learn to work with miniature models of existing machine tools/robots and other instruments.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction to Microsystems, design, and material selection, micro-actuators: hydraulic, pneumatic, electrostatic/ magnetic etc. for medical to general purpose applications. Micro-sensors based on Thermal, mechanical, electrical properties; micro-sensors for measurement of pressure, flow, temperature, inertia, force, acceleration, torque, vibration, and monitoring of manufacturing systems.	11	Get introduced to the fundamental of micro and precision engineering.
2	Fabrication processes for micro-systems: additive, subtractive, forming process, Examples of microsystems: Micro-pumps, micro-turbines, micro engines, micro-robot, and miniature biomedical devices	10	Acquired a completed idea about fabrication processes for micro-system.

3	Introduction to Precision engineering, Machine tools, holding and handling devices, positioning fixtures for fabrication/ assembly of microsystems. Precision drives: inch worm motors, ultrasonic motors, stick-slip mechanism and other piezo-based devices.	5	Understand about the basic elements of Precision engineering.
4	Precision machining processes for macro components: diamond turning, fixed and free abrasive processes, finishing processes.	6	Acquired a completed idea about the components of Precision engineering.
5	Metrology for micro systems, Surface integrity and its characterization.	7	Understanding about metrological and characterization methods.

Text books:

1. Davim, J. Paulo, ed. *Microfabrication and Precision Engineering: Research and Development*. Woodhead Publishing, 2017
2. Gupta K, editor. Micro and Precision Manufacturing. Springer; 2017

References books:

1. Dornfeld, D., and Lee, D. E., Precision Manufacturing, 2008, Springer.
2. H. Nakazawa, Principles of Precision Engineering, 1994, Oxford University Press.
3. Whitehouse, D. J., Handbook of Surface Metrology, Institute of Physics Publishing, Philadelphia PA,1994.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEO585	Quality Engineering and Management	3	0	0	9

Course Objective
The Objective of the course is to improve quality and productivity of products and services in order to compete and excel in the international market
Learning Outcomes
Upon successful completion of this course, students will: • Be able to understand quality of products and services • Be able to solve actual quality related problems by using statistical quality control techniques. • Be able to learn about aspects of quality management techniques.

- Be able to solve problems related to quality management in the industry.
- Be able to understand and use various quality management and associated standards as well as software in the industries.

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction to Quality Engineering and Management	1	This unit will help learn basics of quality of products and services.
2	Control Charts: Types, Types of sampling and Acceptance Sampling plans, Normal Distribution curve, Process Capability Analysis.	9	This unit will help students in controlling deviations in the dimensions of quality characteristics of products and processes.
3	Definition and Evolution of quality, Contribution of Deming and Taguchi	6	Understanding of various definitions and history of quality and about quality experts
4	Quality Costs, Quality Function Deployment, Business Process Re-engineering, Quality Management, Total Quality Management: definition, philosophy, principles, vision, mission	7	This unit will help students in understanding quality improvement methodology.
5	Quality tools and techniques - Seven Tools of Quality, Seven Quality Management Tools, Six Sigma, Benchmarking, JIT, Poka-Yoke, 5S Campaign, Kaizen, Quality Circles	7	This unit will help in learning basic statistical tools and various quality management concepts and techniques for application in the industries
6	Management Systems - Quality Management Principles as per ISO 9000, ISO 9001, ISO 14001, ISO 45001, their importance and case studies, introduction to SPSS/TQM Software.	9	This unit will help students to learn about international quality, environmental as well as occupational health and safety management standards and SPC/TQM software in order apply in the industries.

Text books:

1. 'Statistical Quality Control', by D. C. Montgomery. John Wiley & Sons, Inc., 7th Ed. 2013
2. 'Total Quality Management', Dale H. Besterfield et al, Pearson Education Reprint 2011

References books/ Standards:

3. ISO 9000: 2015 Quality Management System-Fundamentals and Vocabulary
4. ISO 9001:2015 Quality Management System- Requirements with guidance for use
5. ISO 14001: 2015 Environmental Management System- Requirements with guidance for use
6. ISO 45001:2018 Occupational Health and Safety Management System - Requirements with guidance for use
   for use

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEO586	Additive Manufacturing	3	0	0	9

Course Objective
To provide detailed understanding of additive manufacturing processes. The prospect of future research will also discuss in the course which will encourage the PG students to carryout research in the advance area,
Learning Outcomes
Upon successful completion of this course, students will: • Broad understanding of Additive Manufacturing processes using different technologies. • Students will be able to think about the possibility of combining different process to develop more efficient AM process. • It will help the students to select the best process among various alternative.

Module	Topics	Lecture Hours	Learning Outcome

1	Introduction to Additive Manufacturing and classification. Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	4	Understanding the evolution and need of AM processes. It will develop the ability of select the process for particular application.
2	Introduction to 3D-printing, Stereolithography apparatus (SLA), Fused deposition modelling (FDM), Laminated Object Manufacturing (LOM))	6	Understanding the basic principle of curing type, extrusion and layer deposition type AM processes. The students will learn the pros & cons of these processes and their applications.
3	Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	12	Understanding of thermal based AM processes (UMP). The students will learn the importance of controlled high energy source to manufacture the complex profile components.
4	Pre-Processing in Additive Manufacturing: Preparation of 3D-CAD model, Reverse engineering and Reconstruction of 3D-CAD model, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	11	The students will understand the use of pre requirement of AM process. Basic knowledge about the software requirement and processing of drawing.
5	Post-Processing in Additive Manufacturing: Support material removal, improvement of surface texture, accuracy and aesthetic; property enhancements.	6	The students will learn about the post processing requirements of different AM processes.

Text books:

1. Gibson, I, Rosen, D W., and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2015

Reference books:

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
2. Chua C.K., Leong K.F., and Lim C.S., “Rapid prototyping: Principles and applications”, Third Edition, World Scientific Publishers, 2010

3. Gebhardt A., “Rapid prototyping”, Hanser Gardener Publications, 2003
4. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007
5. Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006
6. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
7. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, “Laser Cladding”, CRC Press, 2004

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 560	Advanced Manufacturing Engg. Lab.	0	0	3	3

1. Simulation of various machining operations using CAM packages.
2. Profile cutting with CNC milling machine and Lathe.
3. CNC Programming for machining in different planes using machining centre.
4. Programming of material handling systems (ASRS, AGV, Robots) in FMS environment.
5. Work space analysis of manipulator.
6. Demonstration of system devices such as motors, feedback devices controller etc.
7. Demonstration of CMM, surface profilometer, micro hardness tester.
8. Experiment on micro-EDM/ECM/ECDM
9. Experiment on micro-milling/drilling
10. Experiment on profile cutting/drilling using laser

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 561	Reverse and virtual Engg. Lab.	0	0	2	2

1. Solid modelling and slicing of an engineering component
2. Fabrication of the component through 3D printer and dimensional analysis
3. Programing practices on virtual instrumentation
4. Data acquisition from various sensors using virtual programming and hardware
5. Experiments of sensors used in factory-light sensor, hall sensor, LVDT
6. Experiments of sensors used in factory-Load-cell, strain gauge, proximity, accelerometer
7. Simulation of casting process
8. Simulation of forming process
9. Simulation of metal machining process
10. Simulation of additive manufacturing

3RD Semester					
Course No.	**Course Name**	**L**	**T**	**P**	**CH**
MEC 569	Thesis Unit 1	0	0	0	9
MEC 570	Thesis Unit 2	0	0	0	9
MEC571	Thesis Unit 3	0	0	0	9
MEC 572	Thesis Unit 4	0	0	0	9
	Total	**0**	**0**	**0**	**36**

4TH Semester

Course Nos.	Course Names	L	T	P	CH
MED573	Advanced Optimization Technique	3	0	0	9
MED574	Research Methodology & Statistics	3	0	0	9
MEO587	Advanced Manufacturing systems				
MEC 575	Thesis Unit 5	0	0	0	9
MEC 576	Thesis Unit 6	0	0	0	9
	Total	**6**	**0**	**0**	**36**

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 573	Advanced Optimization Techniques	3	0	0	9

Course Objective

- To understand theory of different optimization methods to solve various types of engineering problems.
- To understand physical engineering problem and to construct mathematical formulation towards solving it by selecting proper optimization techniques.
- To understand both computer programming and heuristic approaches to solve optimization problems.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding formulation of engineering optimization problem, specially mechanical engg.
- have an understanding about solving the real life/ industrial /engineering/ environmental/ social problems using conventional optimization methods, that helps to take decision.
- be able to write MATLAB code for single and multivariable engineering problems.
- be able to understand and write MATLAB code for nontraditional optimization technique like GA, ANN, fuzzy logic to solve different engineering problems with single objective function and multi-objective function.

Module	Topics	Lecture Hours	Learning Outcome
1	Basic Concepts: optimization problem formulation.	2	Understanding the types and basic concept of engineering optimization problem formulation. Especially real life/ industrial /engineering/ environmental/ social problems.
2	Single variable optimization algorithms: Exhaustive search method, bounding phase method, Interval halving method, Fibonacci method, golden search method, Newton Rapshon method, bisection method, secant method. Formulation of engineering problem with single variable. Computer programming to solve the single variable problem	6	This unit discuss about different types of classical single variable optimization algorithms. Student will learn to write MATLAB code for these algorithms also.
3	Multivariable optimization algorithms: Unidirectional search, direct search methods: simplex search, gradient based methods: Cauchy's Steepest Descent	8	This unit discuss about different types of classical multivariable unconstrained optimization

	method Formulation of engineering problem with multiple variable. Computer programming to solve Multivariable optimization algorithm		algorithms. Student will learn to write MATLAB code for these algorithms also.
4	Constrained optimization algorithms: Linear programming, nonlinear programming penalty function method, method of multipliers, sensitivity analysis, direct search for constrained minimization. Formulation of engineering problem with constrained multiple variable. Related computer Programming.	6	Student will learn constrained optimization algorithms and their computer programming.
5	Nontraditional optimization: Introduction to Genetic algorithm (GA), Artificial Neural Network (ANN), fuzzy logic etc with single objective function. Computer programming, other evolutionary algorithms. Formulation of engineering problem and solve with Nontraditional optimization.	9	This unit demonstrates basics of Nontraditional optimization techniques. Use of Nontraditional optimization like GA, ANN, fuzzy logic with single objective function to solve different engineering problem.
6	Multi-Objective Optimization: Introduction to linear and nonlinear multi-objective problems, Use of Evolutionary Computations to solve multi objective optimization with computer programming in MATLAB	8	This unit demonstrates Nontraditional optimization techniques to solve different engineering problem with multi objective function.

Text Books:

1. Deb, K. Optimization for engineering design: algorithms and examples. Prentice Hall of India, New Delhi. 2nd Edition 2012

Reference Books:

1. K.Deb, Multiobjective optimization using Evolutionary Algorithm. Wiley. 1st Edition, 2001.
2. Rao, S.S. Engineering Optimization: Theory and Practice. Wiley. 3rd Edition, 2014
3. Ravindran, A., Ragsdell, K. M., Reklaitis, G. V. Engineering Optimization: Methods and Applications, Willey, 2nd Edition, 2013
4. Rardin, Ronald L. Optimization in operations research. Prentice Hall.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 574	Research Methodology and Statistics	3	0	0	9

Course Objective

To illustrate to the students a) the basic concepts of research, b) how a scientific research problem has to be formulated and tackled and c) important statistical tools necessary to analyze the collected data for a meaningful research outcome.

Learning Outcomes

On successful completion of the course, the students will

- Learn various types of research process, methodologies to identify, design and execute a research problem based on scientific and statistical tools;
- Learn various types of sample design techniques and its classification, characteristics of a good sample design and how to select a sampling procedure for data collection;
- Learn various types of measurement scales, sources of error in measurement and technique of developing measurement tools to evaluate the collected data;
- Learn various methods of data collection and the reliability and validity of the collected data;
- Learn various ways to prepare and present report for dissemination of research outcome;
- Learn various statistical tools necessary for designing a sample, analyzing the data and making scientific conclusion(s) out of the collected data to arrive at a research outcome.

Module	Topics	Lecture Hours	Learning Outcome
1	Research Process, Types of Research, Problem identification and Hypothesis formulation	5	Basic ideas on research processes, Definition of various types of research, Knowledge on what constitute a research and how to identify a research problem, Knowledge on the formulation of hypothesis for research
2	Research Design: General Designs of Research, Randomized and Correlated Groups Design.	5	Meaning of research design, Ideas on the need for research design, Knowledge on the features of a good research problem design, Important concepts relating to research design, Ideas on different research design

			methodologies, Ideas on the basic principles of experimental designs
3	Sampling Design, Measurement and Scaling, Methods of Data Collection, Reliability and Validity	5	Ideas on the Implications of a Sample Design and its classification, Knowledge on the criteria of selecting a sampling procedure and characteristics of a good sample design, Ideas on measurement scales and sources of error in measurement, Knowledge on technique of developing measurement tools, Ideas on the meaning of scaling and important scaling techniques, Ideas on the methods of data collection and the reliability and validity of the collected data.
4	Data Presentation and Report Preparation, Introduction to Qualitative and Quantitative Research Methods.	3	Ideas on Data presentation and report preparation techniques, Sensitizing the students on the very important issues of plagiarism, Preliminary ideas on the qualitative and quantitative research methodologies and their mutual difference.
5	Frequency Distribution, Presentation of Data, Measures of Central Tendency, Measures of Dispersion, Skewness	3	Ideas and knowledge on frequency distribution, cumulative frequency distribution, constructing histograms, Knowledge on the measures of central tendency (Mean, Median and Mode), Various measures of dispersion of the data.
6	Probability Distributions, Discrete and continuous random variable, Binomial, Poisson, Normal and Standard Normal distributions.	6	Learn about Experiment, Outcomes, and Sample Space, Calculation of Probability, Ideas on Marginal and Conditional Probabilities, Learn about Mutually Exclusive, Independent and Complementary

			Events, Learn about Bay's Theorem, Learn about discrete and continuous random variables and how to calculate their mean and standard deviation, Learn about Binomial, Poisson, Normal and Standard Normal distributions.
7	Sampling and Estimation, Sampling Distribution, Estimation of the mean and proportion, Hypothesis tests about the mean and proportion of a population, t-test and z-test, Estimation and hypothesis testing about two different populations.	6	Learn about sampling and estimation methods, hypothesis testing regarding the properties of the population from the sample statistics (sample mean and variance), Learn about Student's t-distribution and z-distribution and t-test and z-tests, Knowledge on estimation and hypothesis testing about two different populations
8	Hypotheses testing: χ^2- test, Analysis of Variance, Correlation and Regression analysis.	6	Learn about the Chi-Square distribution, Goodness-of-Fit test, Learn about making contingency tables, Learn about testing independence or homogeneity of populations, Learn to infer about the population variance, F-Distribution and one-way ANOVA, Learn about simple linear regression models and analysis.

Textbook:

1. 'Research Methodology - Methods and Techniques' C R Kothari and Gaurav Garg New Age International (P) Limited Publishers 4rth Edition, 2019 New Delhi
2. 'Applied Statistics and Probability for Engineers' D C. Montgomery and George C. Runger 6 th Edition, 2016

References:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, SAGE Publications Ltd; Fifth edition 2018.
2. Introductory Statistics, Prem S. Mann, 7th Edition, John Wiley and Sons Inc., 2010, Danvers, MA.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEO 587	Advanced Manufacturing Systems	3	0	0	9

Course Objective
The course will provide the advances in manufacturing system and their implementation issues.
Learning Outcomes
On successful completion of the course, the students will • Able to design different plant layouts • Able to form cells for cellular manufacturing system • Understand the concept of modern manufacturing systems

Module	Topics	Lecture Hours	Learning Outcome
1	Introduction to Manufacturing systems, Classification of Manufacturing systems. Analysis of single station, assembly line and job shop problems.	6	Understanding the various types of manufacturing systems.
2	Group Technology: Concepts, merits, demerits and applications, Opitz classification system and production flow analysis. Cellular Manufacturing: Principle of cell formations, applications, different methods of cell formations. Case Studies.	12	Appreciating group Technology and Cellular Manufacturing in the perspective of modern day manufacturing processes and their role in the enhancement of the productivities.
3	FMS: Concepts of FMS, components, FMS layouts. Analysis of Flexible Manufacturing systems., CIM: Concepts, applications	11	Understanding the concept of Flexible Manufacturing Process and the application of Computer

			Integrated Manufacturing System
4	Lean Manufacturing: concepts, implementation methodology, case studies. Agile Manufacturing: Definition, agility, method of implementation, relationship between lean and agile manufacturing. Case Studies.	10	Understanding the concept of Lean and Agile Manufacturing and their applications in a competitive environment with special reference to the case studies.

Text books:

1. Automation, Production Systems, and Computer-integrated Manufacturing, M. P. Groover, Pearson Education, 4th Edition, 2016

Reference books:

1. Materials & processes in Manufacturing, Degarmo, J. T. Black.
2. Lean Manufacturing System & Cell Design, J. T. Black.
3. Cellular Manufacturing Systems Design, planning and control by Singh, N., Rajamani, Divakar