M. Tech. in
PRODUCTION ENGINEERING

(Effective from 2022-23)

DEPARTMENT OF MECHANICAL ENGINEERING

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

Vision and Mission of the Institute

VISION

To attain a distinct identity for the Institute through innovation, knowledge creation and dissemination for the benefit of the society.

MISSION

- To nurture an eco-system for continuous enhancement of value-based teaching and learning process in the emerging areas of technology.
- To train quality human and knowledge resources in the service of society.
- To develop sustainable products and technologies.

Vision and Mission of the Department

VISION

To be a centre of excellence in Mechanical, Production and Industrial Engineering education and research for the benefits of society and humanity.

MISSION

- To educate and develop competent human resources for contemporary industry, academia and research.
- To promote interdisciplinary research and innovation skills in the graduates.
- To enhance the efforts to develop sustainable products, processes and technologies by developing competent entrepreneurs for the benefit of the society.

Department of Mechanical Engineering:

Brief about the Department:

The Department of Mechanical Engineering is one of the oldest departments of the institute and was established in the year 1961. We are the largest community of excellent, energetic, and dynamic faculty, staff and students in the institute. The department is having highly qualified and experienced faculty (36 faculty members) in all streams of Mechanical Engineering. The department is broadly divided into three academic streams in which students receive outstanding education with a wide choice of specializations, electives and research areas. These three academic streams are: Design Engineering, Production and Industrial Engineering and Thermal Engineering.

The department offers eight semester (i.e. 4 year) Bachelor of Technology (B. Tech.) programmes in Mechanical Engineering and Production and Industrial Engineering. Every year 223 students are admitted through JEE (mains) and 15% of this intake is through Direct Admission to Students Abroad (DASA) scheme for the above two B. Tech. programmes. Some students are also through ICCR and MEA (Govt. of India) Schemes.

The department also offers four semester (i.e. 2 year) Master of Technology (M. Tech.) programmes in Computer Aided Design and Manufacturing, Design Engineering, Product Design and Development, Production Engineering and Thermal Engineering. Every year 125 students (25 in each specialization) are admitted through GATE in the above five M. Tech. programmes.

The department also offers Doctor of Philosophy (Ph.D.) programme in various areas of Mechanical Engineering as well as Production and Industrial Engineering. The strength of the department lies in its Ph.D. programme with more than 100 PhDs already been awarded till March, 2022. About 80 research scholars are presently pursuing their PhDs. Every year the department admits Ph.D. students equal to half of the number of faculty holding Ph.D. degree. The department is also a QIP centre for PhD and M. Tech programmes.

Today, the world of Mechanical Engineering changes under the influence of advanced computational tools, improved simulation and analysis, and entirely different manufacturing protocols. This has opened up new vistas of research in the department.

List of Programmes offered by the Department:

Program	Title of the Program
B. Tech.	Mechanical Engineering
	Production & Industrial Engineering
M. Tech.	Computer Aided Design and Manufacturing
	Design Engineering
	Product Design and Development
	Production Engineering
	Thermal Engineering
Ph.D.	Mechanical Engineering

M. Tech. – Production Engineering

Program Outcomes

PO1	Able to independently carry out research /investigation and development work to solve practical problems in Engineering.
PO2	Able to write and present a substantial technical report/document.
PO3	AbletodemonstrateadegreeofmasteryoverProductDesignandDevelopmentat a level higher than the requirements in the appropriate bachelor program.
PO4	Abletoidentifytheneedforimprovementsinexistingindustrialpractices.
PO5	Abilitytodesignanddevelopinnovativeproductstofulfiltheneedsofthesociety.

SCHEME OF INSTRUCTION

M. Tech. Production Engineering – Course Curriculum Structure

S. No.	Code	Course	Credit	L-T-P	Contact Hours
Semester-I					
1	ME21111	Materials Processes and Systems	4	4-0-0	
2	ME21112	Computer Integrated Manufacturing Systems	4	4-0-0	
3		Elective I	4	4-0-0	
4		Elective II	4	4-0-0	
5		Elective III	4	4-0-0	
		Total	**20**		
Semester-II					
1	ME22113	Advanced Machining Processes	4	4-0-0	
2	ME22211	Production Engineering Lab	4	0-0-6	
3		Elective IV	4	4-0-0	
4		Elective V	4	4-0-0	
5		Elective VI	4	4-0-0	
		Total	**20**		
Semester-III					
1	ME23661	State of the art Seminar / Special Study / Term Project	4		
2	ME23611	Thesis	16		
		Total	**20**		

Semester-IV					
1	ME24641	Thesis	20		
		Total	**20**		

Note: The distribution of thesis evaluation marks will be as follows.

1. Supervisor (s) evaluation component: 50%
2. Oral Board evaluation component: 50%

List of Electives and Minors: M. Tech. (Production Engineering)

S. No.	Code	Name
1.	ME21331	Theory of Casting and Welding
2.	ME21332	Advanced Industrial Engineering
3.	ME21333	Manufacturing of Non-Metallic Products
4.	ME21334	Optimization Methods in Engineering
5.	ME21335	Soft Computing Methods
6.	ME21336	Design and Analysis of Experiments
7.	ME21337	Additive Manufacturing Technologies
8.	ME21338	Advanced Manufacturing Systems
9.	ME21339	Tool Design
10.	ME22340	Finite Element Method in Engineering
11.	ME22341	Metal Forming Analysis
12.	ME22342	Computer Aided Design for Manufacturing
13.	ME22343	Mechatronic Applications in Manufacturing
14.	ME22344	Laser Material Processing
15.	ME22345	Computer Aided Manufacturing
16.	ME22346	Logistics and Supply Chain Management
17.	ME22347	Total Quality Management
18.	ME22348	Innovation and Intellectual Property Rights
19.		Additive Manufacturing
20.		Industry 4.0
21.		Internet of Things
22.		Artificial Intelligence

Course Code: ME21111	Materials Processes and Systems	Credits: 4-0-0:4

Prerequisites: Material Science and Engineering, Basic Manufacturing

Course Outcomes:

CO1	Students will be able to understand the properties, processing and applications of various materials for engineering applications.
CO2	Students will be able to understand the property enhancing and surface processing operations.
CO3	Students will be able to know the characterization methods for the newly developed materials and also would be able to conduct the failure analysis of the materials.
CO4	Students will be able to obtain the mechanical and metallurgical properties of the engineering materials.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	2	2	2	2

Unit	Details	Lectures
1	Scope and classification of Engineering Materials and Manufacturing Techniques; Types, properties and uses of Metals and Alloys; Manufacturing processes for shaping – casting, deforming, sheet metal forming, particulate processing, machining, finishing, and joining.	8
2	Polymers: Classifications Plastics: Types, properties, uses and manufacturing processing techniques. Thermoplastics, Thermosets, and Elastomers Composites: Types, properties, uses and manufacturing processing techniques. Metal matrix composites, polymer matrix composites, ceramic matrix composites, FGM. Glass: Types, properties, uses and shaping processes Ceramics: Types, properties, uses and shaping processes	8
3	Superalloys: Types, properties, uses and their processing techniques. Nickel-base, Cobalt- base and iron-base superalloys, remelting, Particulate processing, casting, machining, rolling, forging and welding of superalloys Piezoelectric materials (PZT) Shape memory alloys (SMA), Micro-electro-mechanical (MEMS) materials, Nano-structured materials and processing.	8
4	Property enhancing and surface processing operations: cleaning and surface treatments: Heat treatment of metals; Surface coating technology.	6
5	Characterization: Optical/Electron Microscopy Techniques: Specimen preparation techniques; elements of phase identification, grain size determination, inclusion analysis, Image analysis, etc. Scanning Electron Microscopy: Theory and principles, construction, controls &	10

operation of scanning electron microscopy, Environmental scanning electron microscopy, High resolution SEM imaging, EDS / EDAX analysis.
Transmission Electron Microscopy: Theory and principles, construction and controls.
Electron Micro Probe Analyser: Theory and principles, Quantitative and qualitative analysis.
XRD: Principle, Crystallography and Rietveld analysis, Quantitative and qualitative analysis, Residual stress analysis, Determination of layer thicknesses, Small Angle X-ray Scattering (SAXS)
STM & AFM: Principle, sample preparation and mounting, scanning techniques, image capturing and manipulation, and analysis techniques.
Thermal Analysis: Principles and applications of thermal analysis; Dynamic Mechanical Analyzer.
Mechanical Property characterization: Principles and characterization techniques related to Tensile, compressive, hardness, fatigue and fracture toughness properties.

Texts/ References:

1	Introduction to Physical Metallurgy	Avner, S.H.	McGraw-Hill Education
2	Fundamentals of Modern Manufacturing: Materials, Processes, and Systems	Groover, M.P.	Wiley Student Edition, John Wiley and Sons
3	Engineering Design: A Materials and Processing Approach	Dieter, G.E.	McGraw-Hill Higher Education
4	Engineering Materials: Properties and Selection	Budinski, K., Budinski, M.	Pearson
5	Material Science and Engineering: An Introduction	Callister W.D. Jr., Rethwisch, D.G.	John Wiley & Sons
6	Superalloys II	Sims, C. T., Stoloff, N. S., and Hagel, W.C.	John Wiley and Sons
7	Plastic Technology: Theory, Design and Manufacture	Patton, W.J.	Reston Publishing Company
8	Materials Selection in Mechanical Design	Ashby, M.F.	Butterworth-Heinemann
9	Materials Degradation and its Control by Surface Engineering	Batchelor, A.W., Lam, L.N. and Chandrasekaran, M.	World Scientific Publishing Company

Course code: ME21112	CIM (COMPUTER INTEGRATED MANUFACTUIRNG)	Credits : 3-1-0:4

Pre-requisites: Production Engineering

COURSE OUTCOMES

S.N.	Outcomes	BT Level	BT Description
CO1	Understand and apply the basics of CAD-CAM to link with the present industrial requirement.	2	Understand
CO2	Identify the levels of integration and required devices for industrial automation and up graduation requirements.	3	Understand
CO3	Identify the parameters of capacity planning, manufacturing resource planning and their effects on current market trends.	3	Apply
CO4	Evaluate and apply the concepts of industry 4.0 environment and to develop business strategy on the basis of studied parameters.	3	Evaluate
CO5	Apply and analyse the required knowledge in developing business competencies, ethics and to develop strategy for dynamic customer's requirement.	3	Apply

Course articulation matrix

	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	3	1
CO2	2	3	3	3	3
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

Unit	Content	Lectures	CO mapping
1	**Fundamentals of Automation in Manufacturing Systems**: Manufacturing Systems: Concept Objectives, Types and Trends; Concepts of Mechanization, Automation and Integration, Concept of CAD/CAM and CIMS;	5	CO1
2	**Software Technology for CIM System:** Business Database System: File processing, Data Processing and Database Design, File Organization and Relational Analysis; Decision Support System, Personal/Distributed Computing and Local Area Network;	5	CO1
3	**Group Technology and Cellular Manufacturing:** Concept of Group Technology and its Application, classification and Coding Techniques; Clustering Techniques and Cellular Manufacturing;	4	CO2
4	**Planning and Scheduling Functions in CIM System:** Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP),	6	CO3

	Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRP-II), Just-In-time Production Systems and Concept of Enterprise Resource Planning (ERP);		
5	**Computer-Aided Process Planning:** Approaches – Variant and Generative, Feature Classification and Recognition; Process Classifications and Selections, Machines and Tool Selection, Setting Process Parameters, Process Sheet Documentation;	4	CO4
6	**Advanced Manufacturing Systems:** Lean Manufacturing systems, Agile Manufacturing systems, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems and Agent-Based Manufacturing Systems Industrial Robots, Conveyors, AGVs, Automatic Storage and Retrieval Systems.	6	CO5

Reference Books:

1	Computer-Integrated Manufacturing	James A. Rehg and Henry W. Kraebber	Pearson Education
2	Automation, Production Systems and Computer-Integrated Manufacturing	Mikell P. Groover	Pearson Education
3	CAD/CAM Principle and applications	P.N. Rao	TATA McGraw-Hill

Course code: ME21113	ADVANCED MACHINING PROCESS	Credits : 4-0-0:4

Pre-requisites: Manufacturing Science and Technology

COURSEOUTCOME

S.N.	Outcomes	BT Level	BT Description
CO1	Identify the need and understand various Advanced Machining Processes.	2	Understand
CO2	Apply the basic principles of Advanced Machining Processes for product manufacturing/development.	3	Apply
CO3	Realize the applications of Advanced Machining Processes for product development.	4	Analyse
CO4	Prepare for future olesin meeting these requirements in advanced machining environment.	5	Evaluate

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	1	2
CO2	3	2	3	2	2
CO3	3	2	3	2	3
CO4	2	2	3	3	3

Unit	Details	Lectures	CO mapping
1	**Introduction:** Description of need and classification of machining processes; Types of Studies in Machining Processes-Experimental and Theoretical. Advanced Cutting Machining: Principles, Equipments and Applications of Hard Cutting and High-Speed Cutting.	10	CO1
2	**Advanced Abrasive Machining:** Principles, Equipments and Applications of Deep Grinding and High-Speed Grinding; Concept of Ductile Regime Grinding; Working Principle and Applications of Electrolytic In Process Dressing (ELID) Grinding and Elastic Emission Machining; Process principle; Mechanism of material removal; Process Parameters; Process Capabilities; Applications of Abrasive Flow Machining,MagneticAbrasiveMachining,MagnetoRheologicalMachiningandMagneticFloatPolishing.	10	CO2

3	**Advanced Erosive Machining:** Process Principle, Applications, Equipments, Process Analysis and Tool Design of Electro-Discharge Machining(EDM);Ultra-SonicMachining(USM)andElectro-ChemicalMachining(ECM)	8	CO2, CO3
4	**Advanced Erosive Machining:** Process Principle, Applications and Equipments for Beam Machining Processes (LBM, EBM and IBM); Jet Machining Processes: (AJM, WJM, AWJM and IWJM), Chemical Machining Processes (CHM, PCM and BCM).	8	CO2, CO3
5	**Advanced Hybrid Machining:** Process Principle, Applications and Equipments for Electro-Discharge Abrasive Grinding, Electro-Chemical Abrasive Grinding, Electrolytic Magnetic Abrasive Machining, and Electro-Chemical Discharge Machining.	4	CO2, CO3, CO4

Text Books:

1	Advanced Machining Processes	V. K.Jain	Allied Publisher Bombay
2	Manufacturing Science	Ghosh and Mallik	EWP Private Ltd.

Reference Books:

1	Advanced Machining Processes	V. K. Jain	Allied Publisher, Bombay
2	Advanced Machining Processes	Hassan El-Hofy	Mc-Graw HillInc., New York
3	Nonconventional Machining	P. K. Mishra	Narosa Publishing House, NewDelhi
4	Modern Machining Processes	P. C. Pandey and H. S. Shan	TMH Limited, New Delhi
5	Advanced Methods of Machining	J. A. McGough	Chapmanand Hall, London
6	Non-Traditional Manufacturing Processes	G. F. Benedict	Marcel Dekker Inc, New York
7	Micromachining of Engineering Materials	J. A. McGough	Marcel Dekker Inc, New York
8	Micromachining of Engineering Materials	V. K. Jain	Narosa Publishing House, New Delhi

Course Code: ME 22211	Production Engineering Lab	Credits: X-X-0:X

List of Experiments:-

1. Study of Horizontal and Vertical Milling Machines. Performance Study and Measurement of Cutting Forces and Temperature in Horizontal Milling (Mechanical Workshop)
2. Study of Surface and Cylindrical Grinding Machines. Performance Study and Measurement of Grinding Forces and Temperature in Surface Grinding (Mechanical Workshop)
3. Green Sand Mould Preparation after designing of Pattern, Gating and Feeder for the given dimension of the casting. (Mechanical Workshop)
4. Study and Performance Study of GMAW (MIG) welding. (Mechanical Workshop)
5. Study about Power Press for Blanking and Deep Drawing (Mechanical Workshop)
6. Study about EDM and EDM related parameters (Machine Tool Laboratory)
7. Study about Nd: YAG Laser Beam Machine. Conducting experiment for Laser Beam Cutting and Laser Beam Drilling in metallic sheet. (Machine Tool Laboratory)
8. Demonstration and programming of CNC turning and milling (CAM Laboratory)
9. Demonstration and programming of Robot (CAM Laboratory)
10. Demonstration and study of coordinate measuring machine (CMM)/ surface roughness tester/flatness measurement (Metrology Laboratory).
11. Industrial visit related to production engineering industries.

Course Code: ME21331	Theory of Casting and Welding	Credits: 4-0-0:4

Prerequisites: Workshop, Manufacturing Science and Technology

Course Outcomes

S. No.	Outcomes	BT Level	BT Description
CO1	Understand and Identify the process requirements to manufacture a specific product by casting and welding processes.	2	Understand
CO2	Describe the moulding, gating system, feeder design and solidification mechanism and its application in various quality of the product.	3	Apply
CO3	Describe the fundamentals of welding and the mechanism of metal transfer.	2	Understand
CO4	Understand the fundamentals of different welding technology and identify the applicability for different materials	3	Apply
CO5	Assess the various potential areas in manufacturing industries where the knowledge of casting and advanced welding processes can of great use.	3	Apply

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	3	3	2	2
CO2	2	2	2	1
CO3	2	2	3	3
CO4	2	3	3	2
CO5	2	2	2	2

Unit	Details	Lectures	CO mapping
1	**Moulding and Gating Design:** Overview and Classification; Mould Parting Analysis; Pattern Design; Core Design; Gating Design and Analysis- mould filling characteristics: fluidity and turbulence, types of gating system and gating element design.	6	CO1
2	**Feeder Design and Analysis:** mould filling analysis including effect of different head losses. feeder shapes and location, risering curves, NRL method of riser design, risering of complex casting, feeding distances and riser placement, feed aid design.	8	CO2
3	**Cooling and Solidification:** Solidification of pure metals and al1oys, nucleation and growth; Progressive and Directional solidification; CFR; Mathematical treatment of solidification (solidification time and rate)-insulating mould, predominant interface resistance, constant casting surface temperature, predominant resistance in mould and solidified metal.	8	CO2
4	**Theory of Welding Process:** Overview and Classification of Welding Processes; Theory of Arc Welding- Physics of welding	4	CO1, CO3

	arc, welding power sources: constructional features, static and dynamic characteristics, duty cycle, welding arc characteristics and its relationship with power source, arc efficiency & arc blow.		
5	**Metal Transfer in Welding:** classification, forces acting on the drop, metal transfermechanisms, transition current, melting rate, effect of polarity, deposition efficiency.	6	CO3
6	**Theory of Resistance Welding:** principle of contact resistance; calculation of current, time and voltage for spot welding, choice of electrode material; electrode shapes; shunt current.	4	CO3, CO4
7	**Advanced Welding Process:** Theory of electron beam welding; ultrasonic welding; explosive welding; friction stir welding; electromagnetic pulse welding; high velocity projectile impact welding; Welding of plastic, underwater welding and welding in space; Welding of cryogenic materials; Thermal stresses and distortion in welded structures.	8	CO5

Text Books:

1	Manufacturing Science	Ghosh and Malik	East West Pres
2	Manufacturing Technology: Foundry, Forming And Welding	Rao, P. N.	Tata McGraw Hill
3	Metal Casting: Principles and Practice	Ramana Rao	New Age Publishers
4	Modern Welding Technology	Cary, Howard B.	Prentice Hall

References:

1	Solidification of Castings	R.W. Ruddle	Institute of Metals London
2	Principles of Solidifications	B. Chalmers	McGraw-Hill Publishing Co.
3	Science and Engineering of Casting Solidification	D.M. Stefanescu	Springer
4	Fundamentals of Metal casting	R. A. Flinn	Addison Wesley
5	The Physics of Welding	J. F. Lancaster	Pergamon Press
6	Principles of Welding	R.W. Messler	John Wiely & Sons

Course Code: ME21336	Design and Analysis of Experiments	Credits: 4-0-0:4

Pre-requisites: None

COURSE OUTCOME

S.N.	Outcomes	BT Level	BT Description
CO1	understand the basic principles of experimental design and statistical methods to design and analyze experiments.	2	Understand
CO2	design and analyze different factorial experiments, including two-factor and general factorial designs	2	Apply
CO3	perform analysis of variance (ANOVA) and interpret the results accurately for experiments	3	Analyse
CO4	conduct hypothesis testing and prediction in multiple regression models with the use of software tools.	3	Analyse

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	3	2	3	3
CO2	3	2	3	1	3
CO3	3	3	2	2	3
CO4	2	2	3	2	3

Unit	Content	Lectures
1	**Introduction:** Introduction, Basic Principles and Applications of Experimental Design, Statistical Methods.	8
2	**Design and Analysis of Experiments:** Sampling and Sampling Distributions, Randomized Designs, Paired Comparison Designs, Mean and Variances of Nornal Distributions. Analysis of Variance (ANOVA); Checking of Model Adequacy, Practical Interpretation of Results, Determination of Sample Size, The Random Effects Model, The Regression Approach to the ANOV A, Nonparametric Methods ANOVA.	16
3	**Advanced Experimental Designs:** Experiments with Blocking Factors; Latin Square Design, Graeco-Latin Square Design, and Balanced Incomplete Block Designs; Factorial Experiments; Two-Factor Factorial Design and General Factorial Design, Fitting Response Curves and Surfaces, Blocking in a Factorial Design. Two Level Factorial Designs; 22 and 23 Design; General 2k Design: Single Replicate and Unreplicated, Addition of Center Points, Blocking and Confounding; Factorial Design in Two Blocks; Two-Level Fractional Factorial Designs; General 2k-p Fractional Factorial Design.	12
4	**Regression Modeling and Response Surfaces:** Regression Modeling and Linear Regression Models; Hypothesis Testing in Multiple Regression, Prediction of New Response Observations, Regression Model	12

Diagnostics, Testing for Lack of Fit; Response Surface Methodology: Introduction, Method of Steepest Ascent, Analysis of a Second Order Response Surface; Experimental Designs for Fitting Response Surfaces; Experiments with Computer Models Random Effects Models Random Effects Models; Two-Factor Factorial with Random Factors and Two-Factor Mixed Model, Rules for Expected Mean Squares; Approximate F Tests; Non normal Responses and Transformations, Unbalanced Data in a Factorial Design, Analysis of Covariance, Repeated Measures.

Text Book:

1	Design and Analysis of Experiments	Douglas C. Montgomery	Wiley

Reference Books:

1	Design and Analysis of Experiments	Angela M. Dean, Daniel Voss	Springer
2	Experiments: Planning, Analysis, and Optimization	C. F. Jeff Wu, Michael S. Hamada	Wiley

Course Code: ME21339	Tool Design	Credits: 4-0-0:4

Prerequisites: Manufacturing Science and Technology- I & II

Course Outcomes

S. No.	Outcomes	BT Level	BT Description
CO1	Students will be able to understand and design cutting tools, tool holders, and cutting fluids; understand the design of dies.	2	Understand
CO2	Students will be able to understand and design of work holding devices	2	Understand
CO3	Students will be able to understand and design of drill jigs and deign of fixtures for milling, lathe etc.	2	Understand
CO4	Students will be able to understand tool design for CNC machine tools including fixture design, tool, cutting tools, tool-holding methods	2	Understand
CO5	Students will be able to understand gages and gages design	2	Understand

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5
CO1	-	1	2	2	1
CO2	-	1	2	2	1
CO3	-	1	2	2	1
CO4	-	1	2	2	1
CO5	-	1	2	2	1

Unit	Details	Lectures	CO mapping
1	**Design of Cutting Tools:** Basic Requirements, Design of single point Cutting Tools, Design of Milling Cutters, Design of Drills and Drilling, Design of Reamers, Design of Taps, Design of Inserts, Determining Shank Size for Single-point Carbide Tools, Determining the Insert Thickness for Carbide Tools, Design of Chip Breakers, and Design of form tools	16	CO1
2	**Design of Dies:** Design of Casting dies, Molding dies, and Forming dies	3	CO1
3	**Design of Work Holding Devices:** Basic requirements of work holding devices; Location: Principles, methods and devices; Clamping: Principles, methods and devices	6	CO2

4	**Design of Drill Jigs:** Definition and types of Drill Jigs, General Considerations in the Design of Drill Jigs, Drill Bushings, and Drill Jigs **Design of Fixtures:** Fixtures and Economics, Types of Fixtures, Milling Fixtures, Boring Fixtures, Broaching Fixtures, Lathe Fixtures, and Grinding	9	CO3
5	**Tool Design for NC Machine Tools:** Fixture Design for Numerically Controlled Machine Tools: Cutting Tools for Numerical Control, Tool-holding Methods for Numerical Control	6	CO4
6	**Gages and Gage Design:** Limits fits and tolerances, Geometrical tolerances-specification and measurement, Types of gages, Gage design, gage tolerances, and Material for Gages	6	CO5

References Books:

1	Fundamentals of tool design	Dufraine, W., Evans, J. W., & Hill, M.	Society of Manufacturing Engineers
2	Tool design	Donaldson, C., LeCain, G. H., Goold, V. C., & Ghose, J.	Tata McGraw-Hill Education
3	Jigs and fixtures	Joshi, P. H.	Tata McGraw-Hill Education
4	Principles of Machine Tools	G C Sen and A Bhattacharyya	New Central Book Agency
5	Machine Tool Design & Numerical Control	Mehta, N. K.	Tata McGraw Hill Education Pvt. Limited
6	Machine tool Design Handbook	Central Machine Tool Institute (CMTI)	Tata McGraw Hill
7	Machine tool structures	Koenigsberger, F., & Tlusty, J.	Pergamon Press

Course Code: ME21341	Metal Forming Analysis	Credits: 3-0-0:3

Prerequisites: Manufacturing Science and Technology, Mechanics of Materials

Course Outcomes

S. No.	Course outcomes	BT Level	BT Description
CO1	Students will be able to understand the fundamentals of metal forming and ideas in plasticity	2	Understand
CO2	Students will be able to understand the mathematical theories of plasticity help to observe experimental process of metal forming process	3	Apply
CO3	Students will be able to do both analytic treatment of metal forming process and technology aspects assist to solve the practical problem in shop floor	3	Apply
CO4	Students will be able to identify different metal forming process, equipment's, repair and maintenance methods to save manufacturing cost in industry.	2	Understand

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	1	2
CO2	3	2	2	2	3
CO3	2	3	3	3	2
CO4	2	2	2	3	3

Unit	Details	Lectures
1	Introduction to Plasticity Overview and classification of Metal Forming Processes; Criteria of Yielding and Flow Rules under complex State of Stress; Consideration of Friction and Temperatures in Metal Forming; Plastic Anisotropy and Instability.	7
2	Analysis using Equilibrium Theorem Principle of Slab Method and its application for load and power calculation in Forging of hollow disc, Drawing of tubes and non-circular wires; Extrusion through curved dies, Rolling with flat rolls and angular rolls.	9
3	Analysis using Limit Theorem Understanding of Upper Bound Theorem and its applications for plane strain Forging, axisymmetric Upsetting, plane strain Drawing, plane strain and axisymmetric Extrusion.	8
4	Analysis using Slip Line Theorem: Theory of slip lines-Velocity equations, velocity and stress discontinuities, Hencky's theorem, construction of slip line fields and hodograph; Application of slip line field technique in plane strain Forging, Indentation by flat and wedge shape punch, and plain strain Drawing	8

Text/Reference Books:

1 Introduction to Engineering Plasticity Lal and Ready Narosa Pub. House, ND
2 Metal Forming Processes and Analysis B. Avitzur McGraw Hill Inc

3	Fundamentals of Metal Forming Processes	Juneja	New Age Inc. Publisher
4	Plasticity for Mechanical Engineers	Johnson and Mellor	Nostrand Co. London
5	Mathematical Theory of Plasticity	Hill	Oxford University Press, Oxford

Course Code: ME22345	Computer Aided Manufacturing	Credits: 4-0-0:4

Prerequisites: Manufacturing Science and Technology.

Course Outcomes

S. No.	Outcomes	BT Level	BT Description
CO1	Students will be able to understand the NC and CNC Technology and will be able to write part programs for drilling, lathe and milling machine operations.	3	Apply
CO2	Students will be able to understand the features of Programmable Logic Controllers (PLC) and able to program the PLCs.	3	Apply
CO4	Students will be able to understand FMS and its elements including material handling systems.	2	Understand
CO5	Students will be able to understand the features, programming and applications of Industrial Robots	2	Understand
CO6	Students will be able to understand the features and application of automated inspection through CMM	2	Understand

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5
CO1	-	1	2	2	2
CO2	-	1	2	2	2
CO3	-	1	2	2	-
CO4	-	1	2	2	-
CO5	-	1	2	2	2
CO6	-	1	2	2	-

Unit		Lectures	CO mapping
1	**Introduction of CAM:** Concepts and Objectives; Evolution and Benefits; Role of management **NC/CNC Machine Tools:** NC and CNC Technology: Types, Classification, Specification and components, Construction Details, Controllers, Sensors and Actuators, CNC hardware: Re circulating ball screw, anti-friction slides, step/servo motors. Axis designation, NC/CNC tooling. Fundamentals of Part programming, Types of format, Part Programming for drilling, lathe and milling machine operations, subroutines, do loops, canned Cycles, parametric sub routines.	8	CO1
2	**Programmable Logic Controllers:** Relay Device components, Programmable controller architecture, programming a programmable controller, tools for PLC logic design.	12	CO4

3	**Flexible Manufacturing System:** Introduction & Component of FMS, Needs of FMS, general FMS consideration, Objectives, Types of flexibility and FMS, FMS lay out and advantages. Automated material handling system: Types and Application, Automated Storage and Retrieval System, Automated Guided Vehicles, Cellular manufacturing, Tool Management, Tool supply system, Tool Monitoring System, Flexible Fixturing, Flexible Assembly Systems.	8	CO5
4	**Robot Technology:** Introduction: Robot Anatomy, Laws of Robot, Human System and Robotics, Coordinate system, Specifications of Robot. Power sources, actuators and Transducers, Robotic Sensors, Grippers, Robot Safety, Robot Programming and Robot Applications, Economic Considerations of Robotics system, Robot Kinematics and Dynamics, Robot Arm Dynamics. Concepts of Computer Vision and Machine Intelligence.	5	CO6
5	**Material Handling and Storage:** Overview of material handling equipments, automated material handling equipments – AGVs, conveyor systems, performance analysis of material handling systems, automated material storage systems – ASRS and carousel storage, analysis of automated storage systems.		
6	**Automated quality Control Systems:** Computer-aided quality control, Programming and applications of CMM		

References Books:

1	Automation, Production System & Computer Integrated Manufacturing	M.P. Groover	Pearson
2	CAD/CAM Principles and Applications	P N Rao	McGraw Hill Education (India)
3	CAD/CAM/CIM	P Radhakrishnan, S. Subramanyan, V. Raju	New Age International Publishers
4	Numerical Control and Computer Aided Manufacturing	P. N. Rao, N. K. Tewari, T. K. Kundra	McGraw Hill Education
5	Computer Control of Manufacturing Systems	Yoram Koren	McGraw Hill Education
6	Computer-Aided Manufacturing	T.C. Chang, R.A. Wysk and H.P. Wang	Pearson Education India
7	Programmable Logic Controllers	Frank D. Petruzella	McGraw Hill

Course Code: ME22347	Total Quality Management	Credits: 4-0-0:4

Course Outcomes

CO1	Students will be able to understand the concept of Quality and its importance.
CO2	Students will be able to know the basic concepts of Total Quality Management, its principle and its implementation.
CO3	Students will be able to apply TQM tools for quality improvement.
CO4	Students will be able to apply Statistical quality control tools and Quality Design concept for Parameter and Tolerance Design.
CO5	Students will be able to understand the Quality systems and its implementation in the organization.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	2	2	2	2
CO5	1	3	3	1	1

Unit	Details	Lectures
1.	Introduction: Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.	6
2.	TQM Principles: Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDCA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development	6
3.	TQM tools : Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs	6
4.	Statistical analysis for quality and experimental design, The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Control Charts- General theory of Control Charts, Shewhart control chart for process control; Control Charts for variables such as X, R Control Charts for charts for attributes such as c and p charts; Acceptance control chart; Cumulative Sum Control Charts; Concept of six sigma.	6
5.	Quality Design- Design of experiment concept, System, Parameter and Tolerance Design; Concept of Robust Design, Taguchi Concept - Orthogonal Arrays and S/N ratio	6
6.	Quality system, Need for ISO 9000 Certification and Other Quality Systems, ISO 9000:2015 - Quality Management System;	6

	ISO/IEC 27001:2013-IT - Information Security Management Systems; ISO 14001:2015 – Environmental Management Systems. Case studies and discussion of practical industrial and service problems	
7.	Performance measures, basic concepts and strategies , cost of quality, improvement action and plan, Quality Awards.	4

Texts/ References:

1	Total Quality Management	Dale H. Besterfiled	Pearson Education
2	Introduction to Total Quality: Quality Management for Production, Processing and Services	Goetsch and Davis	Prentice Hall
3	Total Quality Management	Suganthi and Samuel	PHI
4	The Management and Control of Quality	James R. Evans and William M. Lindsay	South-Western (Thomson Learning)
5	Juran's quality handbook	Joseph M. Juran	McGraw Hill

Course Code: ME21332	Advanced Industrial Engineering	Credits: X-0-0:X

Production Planning and Control: Introduction to PPC and Preplanning; Planning: The Production Order, Quantities in Batch Production, Batch-size Determination under Boundary Conditions, Machine Capacity, Scheduling, Batch Production Scheduling; Control: Elements of Control Procedure, Computer-Assisted Production Control, Inventory Control, Quality Control, Production Cost Control.

Productivity : Productivity and Production, Measurement of Productivity, Productivity Index, Means of Increasing Productivity, Improving Productivity by Reducing Work Content, Productivity Improvement Procedure, "Six lines of Attack" to Improve Productivity, Productivity and Fatigue.

Equipment Replacement Policy: Reasons for replacement of Equipments, Methods of Replacement Analysis, Replacement Models, Development of Systematic Equipment Replacement Programme, Advantages of Sound Equipment Replacement Programme.

Materials Management and Purchasing: Definitions, Objectives, Functions of Materials Management, Factors Promoting Economies in Materials Management, Purchasing, Duties, Functions and Responsibilities of Purchasing Department, Buying Techniques/Tenders, Purchasing Procedure, Methods of Purchasing, Purchasing Organization.

Job Analysis, Job Evaluation, Merit Rating: Definitions, Objectives and Principles of Job Evaluation, Procedure for Installing Job Evaluation, Methods of Job Evaluation, Merit Rating, Selection of Factors in Setting up Rating Method, Methods of Merit Rating.

Value Analysis: Concepts, Definition and Objectives and Applications of Value Analysis, Techniques of Value Analysis and Value Engineering.

Management by Objectives, Exception and Information System.

References:

1. Elements of Production, Planning and Control by Samuel Eilon, Universal Publishing Co.
2. Industrial Engineering and Management: a New Perspective by P.E. Hicks, McGraw-Hill
3. Handbook of Industrial Engineering: Technology and Operations Management by Gavriel Salvendy, John Wiley & Sons.
4. Maynard's Industrial Engineering Handbook by Harold Maynard & K. Zandin, McGraw-Hill
5. Industrial engineering and Production Management by M. Mahajan, Dhanpat Rai & Co.
6. Industrial Engineering and Management by C. Natha Muni Reddy, New Age International

Course Code: ME21333	Manufacturing of Non-Metallic Products	Credits: X-0-0:X

Polymers: Classification; Characteristics of Thermoplastics and Thermosetting plastics; Injection and Extrusion molding; Compression and Transfer molding; Blow and Rotational molding; Calendaring and Thermoforming; Lamination and pultrusion.
Rubber: Characteristics; Additives applications; Stages in raw rubber and latex rubber technology; Processing of rubbers; Manufacturing techniques for tires, belts, hoses, foot wears, cellular products and cables. Manufacture of latex based products.
Glass: Characteristics; Glass forming machines; hollow wares flat glasses, fiberglass, bulbs, bottles, heat absorbing glasses, amber glass and their manufacturing methods, general plant layouts for manufacture of different types of glasses.
Ceramics: Classification; Characteristics of traditional ceramics, structural ceramics, fine ceramics, bio ceramics, and ceramic super conductors. Ceramic processing techniques: hot pressing; hot isostatic pressing (HIP); Sintering, injection molding, slip casting, tape casting, gel casting and extrusion.
Composites: Requirements of reinforcement and matrix; Manufacturing of composites: Casting, Solid state diffusion, Cladding, HIP, Liquid metal infiltration, Liquid phase sintering; Preparation of molding compounds and prepregs; hand layup method; autoclave method; filament winding method; compression molding; reaction injection molding; knitting; braiding.

References:-

1. Polymer Science and Technology- Plastics, Rubber, Blends, and Composites by Ghosh, TMH Rubber Processing Technology, Materials and Principles, J.L. White, Hanser Publishers
2. Glass Engineering Handbook by E. B. Shand, McGraw-Hill
3. Introduction to ceramics by Kingery, Bowen and Uhlmann, John Wiley & Sons publishers
4. Handbook of Composites by George Lubin, Springer

Course Code: ME21334	Optimization Methods in Engineering	Credits: X-0-0:X

Introduction: Terminologies, Design Variables and Constraints, Objective Function, Variable Bounds, and Problem Formulation.
Linear Programming: Simplex Method, Duality in Linear Programming. Single Variable Optimization Problems: Optimality Criterion, Bracketing Methods: Exhaustive Search Method, Bounding Phase Method, Region Elimination Methods: Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method.
Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method. Multivariable Optimization Algorithms: Optimality Criteria, Unidirectional Search, Direct Search Methods: Box Method, Hooke-Jeeves Pattern Search Method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method, Conjugate Gradient Method, Variable-metric (DFP) Method.
Constrained Optimization Algorithms: Kuhn Tucker Conditions, Transformation Methods: Penalty Function Method, Method of Multipliers (MOM), and Sensitivity Analysis. Specialized Algorithms: Integer Programming: Penalty Function Method, Branch and Bound Method, Geometric Programming.
Non-Traditional Optimization Algorithms: Genetic Algorithms, Simulated Annealing, Tabu Search, Ant Colony Optimization, Particle Swarm Optimization; Applications to Engineering Optimization Problems.

References:

1. Optimization for engineering design: algorithms and examples by Kalyanmoy Deb, Prentice-Hall of India Private Limited, New Delhi
2. Multi-Objective Optimization using Evolutionary Algorithms by Kalyanmoy Deb, Wiley India Pvt. Ltd., New Delhi.
3. Engineering optimization: Theory and Practice by S.S Rao, Fourth Edition, New Age International (P) Limited Publishers, New Delhi.
4. Engineering optimization - methods and applications by Ravindran, Ragsdell, and Reklaitis, John Wiley & Sons, Inc.

Course Code: ME21335	Soft Computing Methods	Credits: X-0-0:X

Introduction to soft computing; Neurons and neural networks, Single layer perceptron's, Multilayer feed-forward neural networks; Learning processes, Radial basis function networks; Recurrent neural networks, Principal component analysis, Applications of neural networks. Introduction to Fuzzy logic, Operations on fuzzy sets, Fuzzy relations, Fuzzy implications, Introduction to fuzzy logic controllers (FLC), Construction of data base and rule base of FLC, Inference mechanisms, Defuzzification methods, Applications of fuzzy systems; Genetic algorithms and its applications.

References:

1. Neural Networks: A comprehensive Foundation by Haykin, Pearson Education.
2. Introduction to artificial neural systems by J. M. Zurada, Jaico Publishing House.
3. An Introduction to Fuzzy Logic for Practical Applications by Tanaka and Niimura, Springer.
4. Fuzzy logic with engineering applications by T. J. Ross, Wiley India Pvt. Ltd.
5. Multi-Objective Optimization using Evolutionary Algorithms by K. Deb, Wiley India Pvt. Ltd. An Introduction to Genetic Algorithms by T M. Mitchell, MIT Press.
6. Practical Genetic Algorithms by Haupt and Haupt, Wiley.

Course Code: ME21337	Additive Manufacturing Technologies	Credits: X-0-0:X

Traditional manufacturing v/s AMTs: Computer aided design (CAD) and AM; AM process chain, Application level: Direct processes Rapid Prototyping, Rapid Tooling, Rapid Manufacturing; Indirect Prototyping and Tooling, Indirect Manufacturing; Simultaneous Engineering and Additive Manufacturing Technologies (AMT); Support structure in Additive Manufacturing; Generation of the physical layer model; Virtual Prototyping. Tessellation (STL format) and tessellation algorithms. Defects in STL files and repairing algorithms. Slicing and various slicing procedures. Accuracy and Surface quality in Additive Manufacturing. Effect of part deposition orientation on accuracy, surface finish, build time, support structure, cost etc. Various Rapid tooling techniques. Introduction to Reverse Engineering; Reverse engineering and Additive Manufacturing.

Materials Science for AM: Different materials used for AM. Use of multiple materials, malti-functional and graded materials in AM. Role of solidification rate. Evolution of non equilibrium structure. Structure property relationship. Grain structure and microstructure.

AM Technologies: Powder based AM processes involving sintering and melting (selective laser sintering, laser engineered net shaping, electron beam melting, high energy beam involvement). Printing processes (droplet based 3D printing) Solid based AM processes extrusion based fused deposition modeling (FDM), Laminated object manufacturing (LOM) Stereolithography. Micro and nanoadditive manufacturing process.

Mathematical models for AM: Transport phenomena models: temperature, fluid flow and composition, buoyancy driven flow, surface tension driven free surface flow (study of molten pool). Case studies: Numerical Modeling of fusion based AM process, Powder bed melting based process, Droplet based printing process. Residual stress, part fabrication time, part fabrication cost, optimal orientation and optimal layer thickness. Defect in AM and role of transport phenomena on its formation. Simulations (choice of parameter, experimental data and comparison between simulation and experiments) Model validation for different aspects.

References:-

1. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing byIan Gibson, David W. Rosen, Brent Stucker, Springer
2. Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, Andreas Gebhardt, Hanser Publishers, 2011.
3. Laser Assisted Fabrication of Materials by Majumdar and Manna, Springer Series in Material Science.
4. Laser Induced Materials and Processes for Rapid Prototyping by Fuh and Wong, Kluwer Academic Press.
5. Numerical modeling of the additive manufacturing (AM) processes of titatium alloy,Zhiqiang Fan and Frank Liou.
6. Rapid Prototyping: Principles and Applications by Chua, Leong and Lim, World Scientific

Course Code: ME21338	Advanced Manufacturing Systems	Credits: X-0-0:X

Introduction to Production and Layout System: Types of production systems, Types of plant Layout, advantages and disadvantages of various production systems and Layout.
Lean, Agile and Quick Response Manufacturing (QRM): Introduction, benefits from Lean, Agile and Quick Response Manufacturing, Difference between Lean, Agile and Quick Response Manufacturing.
The Methodology for Transforming your organization in Lean: Understanding products, processes, and Demand, Line lay out and work station Identification with process linking and balancing, The Kanban Strategies, Managing inventory with Kanban system. Project Management for Implementation: Team establishment, The lean implementation milestones checklist, Managing the Lean Manufacturing Line.
Agile Manufacturing Enterprise Design: Enterprise Design, The Enterprise Design Process, Interdisciplinary Design, Management Accounting and Investment Appraisal. Agile Manufacturing Implementation: Skill And Knowledge Enhancing Technologies For Agile Manufacturing, Enablers of Agile Manufacturing, Agile Enterprise design strategies Implementation Framework, Issues, Problems, and Future Developments.
Rethinking Production and Materials Management for QRM: Reorganizing production, Structured methodology for implementing cellular Manufacturing, creative thinking for cellular manufacturing, capacity and lot sizing decisions, Materials and production planning in QRM Enterprise, The new Material control and Replenishment system for QRM, QRM approach to supplier relation; Rethinking office operation for QRM: Principles of quick response for office operations, Tools to implement quick response for office cell (Q-ROC) and system dynamics principle for quick response.
QRM in Product Introduction: Extending QRM to new product introduction.
Creating QRM enterprises: Management Support, Organization structure, performance measurement, cost system, and steps to implement QRM.
Reconfigurable Manufacturing system (RMS): Components, capabilities and challenges of Reconfigurable manufacturing system, technologies enabling reconfiguration. Concepts of Holonic Manufacturing Systems, Agent-Based Manufacturing Systems, Web-based Manufacturing, e-manufacturing, customized manufacturing, Virtual Manufacturing.

References:

1. Lean Manufacturing Implementation: A Complete Execution Manual for Any Size Manufacture by Dennis P. Hobbs, J. Ross Publishing, Inc.
2. Agile Manufacturing: The 21st Century Competitive Strategy by A Gunasekaran, Elsevier publication,
3. Quick Response Manufacturing: A Companywide Approach to Reducing Lead Times by Rajan Suri, Productivity Press
4. It's About Time: The Competitive Advantage of Quick Response Manufacturing by Rajan Suri, Productivity Press
5. How To Implement Lean Manufacturing by Lonnie Wilson, McGraw-Hill Professional

Course Code: ME22340	Finite Element Method in Engineering	Credits: X-0-0:X

Introduction: Concept of Finite Element Method (FEM), History, FEM based Packages, Applications of FEM, Approaches of FEM-Galerkin's and Raleigh-Ritz, Step by Step Procedure of FEM Applications.

FEM for 1-D and Radially Symmetric Scalar Field Problems: General Governing Equation and Boundary Conditions for descibing steady state problems of Heat Transfer, Solid Mechanics, Fluid Dynamics, Electrostatics and Magnetostatic; Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 1-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions; Finite Element Formulation of Transient Problems.

FEM for Plane (2-D) and Axisymmetric SINGLE VARIABLE Problems: General Governing Equation and Boundary Conditions for descibing steady state problems of Heat Transfer, Solid mechanics, Fluid Dynamics, Electrostatics and Magnetostatics; Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 2-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions; Finite Element Formulation of Transient Problems.

FEM for Plane (2-D) and Axisymmetric MULTI-VARIABLE Problems: Governing Equation and Boundary Conditions for describing steady state Plane and Axisymmetric Elastic Stress Analysis Problems: Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 2-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions.

FEM for 3-D Problems: Governing equation and Boundary conditions for describing steady state Heat Transfer and Elastic Stress Analysis Problems, Finite Element Formulation following the steps of Integral Formulation, Discretization and Polynomial Approximation using Standard 3-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions.

Software Practices: Finite Element Analysis on a software system for finding solution of FEM based real life Problems.

References:

1. An Introduction to Finite Element Method by J.N. Reddy, TMH, New Delhi
2. The Finite Element Method in Engineering by S.S. Rao, Butterworth Heinemann, Boston
3. Introduction to Finite Elements in Engineering by Chandrupatla and Belegundu, PHI, New Delhi
4. The Finite Element Method for Engineers by Huebner, Dewhirst, Smith and Byrom, John Wiley and Sons, Singapore
5. The Finite Element Method Using MATLAB by Kwon and Bang,CRC Press, New York

Course Code: ME22342	Computer Aided Design for Manufacturing	Credits: X-0-0:X

Introduction to CAD/CAM/CAE for manufacturing. Prototyping cycle for product design, manufacture and life management. Competitive design and manufacturing cycles for rapid product realization. CAD tools and industry adoption of standards.
Introduction to geometric modelling. Basic modelling and representation of lines, curves, surfaces and solids. Constructive Solids Geometry. Surface modelling techniques. Solids Modelling. Boundary Representation. Spatial enumerative techniques. Object representation. Object validation. Constraints and feature modelling. Feature based data representation. Object visualization. Texturing. Ray tracing and related algorithms. Assembly modelling. Feature based analysis.
Disassembly analysis. Manufacturing analysis. Dimensioning, Tolerance and fits representation and analysis. Product manufacturing planning. Design Structure matrix. Data extraction for product design analysis. Elements of primary processes CAD modelling – Casting, Rapid prototyping etc. Tools for automated generation of cutter path from CAD representation in secondary processes. Rapid Prototyping and machine data generation from CAD models. Elements and data structures for standards based data exchanges – IGES, STEP, STP etc. Web-based product visualization and collaboration. Web based manufacturing planning.
Advanced topics: • Surface generation methods – algorithm examples. • Cutter path generation software development. • Development of interaction methods to exchange C

References:

1. Geometric Modeling by Michael E. Mortenson, Industrial Press Inc.
2. CAD/CAM Theory and Practice by I. Zeid, Tata-McGraw Hill, 2006
3. Computer-Aided Engineering Design by B Sahay and A Saxena, Springer
4. Computational Geometry for Design and Manufacture by Faux and Pratt, John Wiley

Course Code: ME22343	Mechatronic Applications in Manufacturing	Credits: X-0-0:X

Introduction to mechatronic systems and components: Review of integration of mechatronics at different levels, Principles of basic electronics, Digital electronics review: number system, gates, flip-flops, counters, registers, tristate concept, TTL and CMOS circuits, memories. Embedded electronics, Basics of Microcontroller & Microprocessors architecture and instruction set, machine cycles, interrupts, instruction set, memory and I/O interfacing, programming techniques, Timer/Counters, Serial Interfacing and communications, Interfacing to keyboards and displays, Standard busses. Microcontrollers and their applications, integrated circuits, sensors, actuators, and other electrical/electronic hardware in mechatronic systems.
Microprocessor based measurement and control: D/A and A/D conversion, data acquisition systems, encoders, interfacing of motors and transducers. Selection of mechatronic components, namely sensors like encoders and resolvers. Stepper and servomotors; Solenoid like actuators; Transmission elements like Ball screw and Controllers. Analysis of mechatronic systems with applications to motion control, robotics, CNC systems, and others. Case studies of applications in process and discrete manufacturing.

References:

1. Mechatronics: Principles, Concepts and Applicationsby Mahalik, TMH New Delhi
2. Mechatronics: electronic control systems in mechanical and electrical engineering by Boltan, W., Longman, Singapore
3. Mechatronics by HMT, Tata McGraw-Hill, New Delhi

Course Code: ME22344	Laser Material Processing	Credits: X-0-0:X

Introduction: Concept of laser, basic mechanisms in lasers; Properties of laser; Types of laser, gas, liquid and solid state lasers; Pulsed and CW lasers.
Laser-Material Interaction: Interaction of laser with metals, ceramics, polymers, composites and other materials; Laser heating fundamentals.
Laser Forming: Process principle, analysis and applications of Laser forming processes such as Bending and Deep drawing.
Laser Machining: One, two and three dimensional laser machining; Process principle, analysis and applications of laser Drilling, Cutting, Turning, and Milling processes Laser assisted machining (LAM).
Laser Welding: Principles, Significance of laser welding variables; Laser welding of various materials including steel, aluminium and its alloys and titanium and its alloys.
Laser Heat Treatment: One dimensional thermal heating and cooling of metals; Mechanisms of hardening in steel and cast irons.
Lasers in Surface Engineering Applications: Laser glazing; Laser alloying; Microstructural considerations in laser rapid heating process.

References:

1. Steen W. M., Laser Material Processing, Springer
2. Bass, M., “Laser Materials Processing”, North Holland Publishing Co., Amsterdam
3. Chryssolouris, G., “Laser Machining- Theory and Practice”, Springer Verlog, NYork Inc.
4. Luxon, J. T. and Parker, D. E., Industrial Lasers and Their Applications”, Prentice-Hall, Englewood Cliffs, NJ.

Course Code: ME22346	Logistics and Supply Chain Management	Credits: X-0-0:X

Introduction to Logistics and Supply Chain Management; C 1 oncepts, Drivers and obstacles; Planning Demand and supply in a supply chain-Demand forecasting; Aggregate Planning; Management of Inventory in global supply Chain; Role of Information Technology in supply chain; E-Business and the Supply chain; Factors influencing logistics and decision; Bench making and performance measurement; Supply chain risk and Reverse logistics and Green Supply Chain.

References:

1. Supply Chain Management by John T. Mentzer, SAGE Publication.
2. Supply Chain Management: Strategy, Planning, and Operation by Chopra, Meindl and Kalra,
3. Business Logistics/Supply Chain Management by Ballou &Srivastava, Pearson Education.
4. Supply Chain Logistics Management by Bowersox, Closs, Cooper, Tata McGraw-Hill
5. Logistics and Supply Chain Management by Martin Christopher, Financial Times Prentice
6. Supply Chain Management: Text and Cases by Janat Shah, Pearson Education
7. Textbook of Logistics & Supply Chain management by D.K. Agrawal, Macmillan.

Course Code: ME22348	Innovation and Intellectual Property Rights	Credits: X-0-0:X

Introduction:- Historical and philosophical background of patents and other intellectual property, Need to protect inventor interests, IPR: meaning and significance, The types of intellectual property, Introduction to the leading International Instruments concerning Intellectual Property Rights: the Berne Convention, Universal Copyright Convention, The Paris Convention, Patent Co-operation Treaty, TRIPS, The World Intellectual Property Organization (WIPO) and the UNESCO.

Overview of patents:- copyrights, trademarks and trade secrets The construction of a Patent, Legal fundamentals of patent protection for useful inventions, Patent proliferation, requirements for getting a patent, Indian Patent Law Copyright in context, The terms of copyright, Legal fundamentals of copyright protection, Critical differences between patent and copyright protection, Indian Copyright Law. Trademarks defined, The economic function of trademarks, Legal fundamentals of trademark protection, Indian Trademarks Law. Trade secrets defined, Legal fundamentals of trade-secret protection.

Key Business Concerns in Intellectual Property Rights:- Intellectual Property as an Instrument of Development, Commercialisation of Intellectual Property Rights by Licensing, Determining Financial Value of Intellectual Property Rights, Negotiating Payments Terms in Intellectual Property Transaction, Intellectual Property Issues in the Sale of Business, Legal Auditing of Intellectual Property, Due Diligence of Intellectual Property Rights in a Corporate Transaction, Intellectual Property and market failure.

Infringements and Case studies related to IPR:- Infringement defined, Determination of Infringement, Defences to Infringement, Research exemption, invalidity, misuse, failure to mark, laches and estoppel, and first sale doctrine; Rights and obligations among co-inventors, co-authors, employers, and licensees.

References:

1. Intellectual Property Rights- A Primer by R. Anita Rao & V. Bhanoji Rao, Eastern Book Company Lucknow.
2. Intellectual Property and Open Source: A Practical Guide to Protecting Code by Van Lindberg, SPD Pvt. Ltd.
3. Intellectual Property Management in R&D Collaborations: The Case of the Service Industry Sector by Martin A. Badder,Physica-Verlag Heidelberg, New York.
4. Law of Copyright and Industrial Designs by P. Narayanan, Eastern law House, Delhi.
5. Intellectual Property by W.R. Cornish, Sweet & Maxwell, London.
6. Principles of Intellectual Property by N.S. Gopalakrishnan& T.G. Agitha, Eastern Book Company, Lucknow.

Course Code: MEXXXXX	Additive Manufacturing	Credits: X-0-0:X

Course Code: MEXXXXX	Industry 4.0	Credits: X-0-0:X

Course Code: MEXXXXX	Internet of Things	Credits: X-0-0:X

Course Code: MEXXXXX	Artificial Intelligence	Credits: X-0-0:X