Master of Technology

in

Mechanical Engineering
(Manufacturing and Automation)

Course Structure & Syllabus

Department of Mechanical Engineering
National Institute of Technology Hamirpur
Hamirpur (HP) – 177005, India

Course Structure of M. Tech. Mechanical Engineering (Manufacturing & Automation)

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	ME-651	Advanced Engineering Materials and Characterization	4	0	0	4	4
2	ME-652	Computer Aided Manufacturing	4	0	0	4	4
3	ME-653	Advanced Machining Processes	4	0	0	4	4
4	ME-7MN	Programme Elective- I	4	0	0	4	4
5	ME-7MN	Programme Elective –II	4	0	0	4	4
6	ME-654	Manufacturing Engineering Lab-I	0	0	4	4	2
Total			**20**	**0**	**4**	**24**	**22**

Programme Elective-I & II: List of Programme Electives is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	ME-661	Additive Manufacturing Technologies	4	0	0	4	4
2	ME-662	Industrial Robotics	4	0	0	4	4
3	ME-663	Manufacturing Automation	4	0	0	4	4
4	ME-7MN	Programme Elective -III	4	0	0	4	4
5	ME-70N	Institute Elective	4	0	0	4	4
6	ME-664	Manufacturing Engineering Lab-II	0	0	4	4	2
Tota			**20**	**0**	**4**	**24**	**22**

Programme Elective-III & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	ME- 798	M. Tech. Dissertation	--	18
Total				**18**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	ME- 799	M. Tech. Dissertation	--	18
Total				**18**

Annexure

(A) List of Programme Electives

Programme Elective-I:

S. No.	Course No.	Programme Elective
1.	ME-771	Theory of Plasticity and Advanced Metal Forming
2.	ME-772	Theory of Casting and Welding
3.	ME-773	Optimization Methods in Engineering

Programme Elective-II:

S. No.	Course No.	Programme Elective
1.	ME-781	Computer-Aided Geometric Design
2.	ME-782	Inspection and Quality Control in Manufacturing
3.	ME-783	Production and Operation Management
4.	ME-784	Smart Manufacturing

Programme Elective-III:

S. No.	Course No.	Programme Elective
1.	ME-791	Laser Material Processing
2.	ME-792	Mechatronics
3.	ME-793	Machining Science and Technology

(B) List of Institute Elective Courses

S. No.	Course No.	Institute Elective (Interdisciplinary)
1.	ME-701	Thermal Managements of Electronic Systems
2.	ME-702	Measurement and Data Acquisition System
3.	ME-703	Optimization Methods in Engineering
4.	ME-704	Soft Computing Methods in Engineering
5.	ME-705	Fault Diagnosis and Signal Processing
6.	ME-706	Introduction to Design of Experiments
7.	ME-707	Logistics and Supply Chain Management

Advanced Engineering Materials and Characterization

Course Code: **ME-651**

Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge of materials and their characteristics.
- To introduce the students to the mechanical, surface and wear characterizations of materials.
- To impart the knowledge of different techniques of material characterizations.

Course Content

Introduction and Classification of Engineering Materials: Structure and manufacturing properties of Materials, Ferrous Metal and alloys, High strength low-alloy (HSLA) steels, high strength steels, Stainless Steels, Tool and die steels, Non-Ferrous Metals and alloys: Aluminum alloys, Magnesium alloys, Copper alloys, Nickel alloys, Titanium alloys, Super alloys; Ceramic, Glass and Polymers: Structure, Properties and Applications; Special Metals and alloys: Shape Memory alloys, Amorphous alloys, Nanomaterials, Metal Foams, Rare earth Metals, High Temperature Materials, Piezoelectric materials, Biomaterials. Composite Materials: Introduction composites, Metal Matrix Composites (MMCs), Polymer Matrix Composites, Ceramic Matrix Composites, Manufacturing processes (in brief) of composites. Macro mechanical analysis of lamina, Micromechanical analysis of lamina: Volume and mass fraction, density and void content, Evaluation of Elastic moduli, Ultimate strength of unidirectional lamina. Special cases of laminates: symmetric, cross-ply, angle ply and antisymmetric laminates, failure criteria and failure modes. Mechanical Characterization of Materials: Elastic modulus – Stress-strain curves - Tensile test of material – properties evaluation, Compression, Torsion, Bending, Hardness measurement tests, Toughness tests, Residual stresses, Fatigue – Endurance limit, Fatigue test; Creep, High-temperature deformation, Plasticity, yield strength, strengthening mechanisms in materials, Creeps and stress relaxation, Fracture of materials – Mechanisms of Ductile and Brittle fracture. Surface and Wear Characterization of Materials: Surface structure and Properties, Surface Texture and Roughness, Measurement techniques for Surface Roughness, Introduction to surface treatments, and coatings. Friction, Wear, types of wear, Adhesion and Abrasion theory of friction and wear. Introduction to Material Characterization Techniques: X-ray diffraction (XRD) technique; Microscopy techniques: optical microscopy (OM), scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), Principles and applications of thermal analysis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand and explain various advanced materials used in various applications.

CO2: Design and fabricate composites for different engineering applications for research and industries

CO3: Conduct mechanical tests on different compositions of materials.

CO4: Understand and implement the concept of surface characteristics of materials.

CO5: Compare the principle and operation of different characterization tools.

Books and References

1. Manufacturing Processes for Engineering Materials by Serope Kalpakjian, Pearson Publication
1. Introduction to Manufacturing Processes by Mikell P. Groover Wiley Publication
2. Material Science and Engineering: An Introduction, by W. D. Callister, John Wiley & Sons, 2002.
3. Mechanical Metallurgy, by G. Dieter, McGraw Hill, 1996.
4. Mechanical Behavior of Materials by William S. Hosford

Computer-Aided Manufacturing

Course Code: **ME-652**

Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge of NC machines, CNC control, and part programming.
- To impart the knowledge of writing NC part programming for various machining operations.
- To impart knowledge of Group Technology, FMS and material handling.

Course Content

CNC Machine Tools and Programming: Basis and need of CNC machines: NC, CNC and DNC systems. Constructional details of CNC machines, CNC machining centre, Tooling For CNC Machines: Tooling requirements of CNC machine, pre-set and qualified tools, work and tool holding devices in CNC machines, Programming For 2 Axis Control Systems- Manual part programming for a CNC Lathe/ Turning centre, using tool nose radius compensation, do loop, subroutines and fixed cycles; Programming for 3 Axis Control System- Manual part programming for CNC Milling/CNC machining centre, using tool radius compensation, tool offsets, do loop, subroutines and fixed cycles. Computer Aided CNC Part Programming-Using APT language CAD/CAM aided CNC part programming. Group Technology and Cellular Manufacturing: Part family's formation, Selection of classifications and Coding Systems, Production flow analysis, Cellular Manufacturing, Application Considerations in Group Technology, and Quantitative analysis in Cellular Manufacturing. Flexible Manufacturing Systems: Introduction to Manufacturing Systems, Flexibility and automation, different types of flexibilities in manufacturing, volume variety relationships, Flexible Manufacturing System (FMS), FMS Components, FMS Applications and Benefits, FMS Planning and Implementation Issues, Quantitative Analysis of Flexible Manufacturing Systems, FMS Control Systems. Transfer Lines and Similar Automated Manufacturing Systems, Analysis of Transfer Lines with Storage Buffers, Automated Assembly Systems, Quantitative Analysis Assembly Systems. Material Handling Systems: Overview of Material Handling systems, Material transport systems, Automated Guided Vehicles (AGVs), Automated Storage and Retrieval Systems (ASRS); Engineering Analysis of storage Systems. Manufacturing Support Systems and FMS Layout: Computer-aided process planning, Advanced Manufacturing Planning. CAD/CAM in the Production system, Production Planning and Control systems, Justin in time and lean production, Layout considerations for flexible manufacturing systems, and scheduling of flexible manufacturing systems. FMS SIMULATION: Future developments in FMS, case studies on FMS.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To understand and do programming of CNC machines

CO2: Implementing of GT philosophy in Industries

CO3: Design and analyze different manufacturing systems for industries

CO4: Understand the design and implementation of material handling systems

CO5: Understand various systems used in automated manufacturing

Books and References

1. Systems Approach to Computer Integrated Design and Manufacturing Automation, Production Systems – Nanua Singh, Wiley Publication
2. Automation, Production Systems and Computer Integrated Manufacturing – M.P. Groover Pearson Publication.
3. Flexible Manufacturing Systems – R.A. Maleki Prentice Hall publication
4. Handbook of Flexible Manufacturing Systems – Nand K. Jhaby Academic Press CNC Programming by S.K. Sinha, McGraw Hill Professional.

Advanced Machining Processes

Course Code: **ME-653**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart the knowledge of different material removal mechanisms of advanced machining processes.
- To impart knowledge about the significance of controlling process parameters for optimal performance.
- To introduce the process capabilities and limitations of the advanced machining processes.
- To impart the knowledge of suitable areas of the applications of advanced machining processes.

Course Content

Introduction: Introduction to nontraditional/advanced machining processes, need for non-traditional machining, classification on the basis of energy sources -parameters influencing the selection of process. Mechanical Energy Based Processes: Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive water jet machining (AWJM), Ultrasonic Machining (USM), Advanced finishing processes: Abrasive flow finishing, Chemical mechanical polishing, Magnetic abrasive finishing, Magnetorheological Finishing, Magnetorheological abrasive flow finishing, Magnetic float polishing, Elastic Emission machining- Operating principles, equipment, process variables, mechanism of material removal, advantages, limitations, effect of process parameters on MRR, Accuracy, Surface finish. Electrical Energy Based Processes: Electrochemical process: Fundamentals of electrochemical machining, electrochemical grinding, electrochemical honing and deburring process, metal removal rate in ECM, Tool design, surface finish and accuracy, economic aspects of ECM simple problems for estimation of metal removal rate, applications and limitations, recent developments. Thermo-Electrical Energy Based Processes: General principles of Electrical discharge machining, process-power circuits for EDM, metal removal rate in EDM, process parameters, selection of tool electrode and dielectric fluids, surface finish and machining accuracy, characteristics of spark eroded surface and machine tool selection, recent developments, Electrical discharge grinding and wire-EDM. Thermal Energy Based Processes: Electron beam machining, Plasma arc machining and laser beam machining- Operating principles, Equipment and sub-systems, Parameters influencing metal removal, Applications- Advantages and limitations, recent developments.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the mechanism of material removal in various advanced machining processes.
CO2: Analyze the processes and evaluate the role of each process parameter during the machining of various advanced materials.
CO3: Design of tools for the given profiles to be imparted on the work specimens.
CO4: Optimize the process parameters involved based on the requirements.
CO5: Identify the suitable area of application based on the correct applicability of the process.

Books and References

1. Modern Machining Processes by P.C. Pandey and H.S. Shan, Tata McGraw-Hill.
2. Advanced Machining Processes by V.K. Jain, Allied Publishers.
3. Non Conventional Machining by P.K Mishra, Narosa Publication.
4. Advanced Manufacturing Process by H.E. Hofy, McGraw-Hill.

Additive Manufacturing Technologies

Course Code: **ME-661**

Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To acquaint students with the concept of Additive Manufacturing (AM) and its various technologies.
- To make students acquainted with pre-and post-processing methods in AM.
- To familiarize students with the selection of materials for AM, modelling of AM processes, and their applications in various fields.

Course Content

Introduction: Traditional Manufacturing v/s Additive Manufacturing (AM); Computer-Aided Design (CAD) and AM; AM Process Chain; Application Level: Direct Processes, Rapid Prototyping, Rapid Tooling, Rapid Manufacturing; Indirect Prototyping and Tooling, Simultaneous Engineering and Additive Manufacturing Technologies (AMT), Accuracy and Surface Quality in AM, Surface Finish, Build Time and Cost; Various Rapid Tooling Techniques. Materials for AM: Different Materials used for AM. Use of Multiple Materials, Multi-Functional and Graded Materials in AM, Role of Solidification Rate, Evolution of Non-Equilibrium Structure, Structure Property Relationship, Grain Structure and Micro-Structure. Technologies of AM: Liquid Based-Stereo Lithography and Solid Ground Curing; Solid Based-Fused Deposition Modelling (FDM) and Laminated Object Manufacturing (LOM), Micro and Nano AM Processes, Powder-Based AM-Selective Laser Sintering, Selective Laser Melting and Three-Dimensional Printing, Directed Energy Deposition and Binder Jet Processes. 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. Post-Processing in Additive Manufacturing: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Property Enhancements Using Non-thermal and Thermal Techniques, Brief Information on Characterization Techniques used in Additive Manufacturing, Repairing and coating.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify areas where the knowledge of additive manufacturing can be applied.

CO2: Describe the portrayal of additive manufacturing and prototyping, their concepts, techniques, recent trends and challenges for the future.

CO3: Utilize different materials in additive manufacturing based on the specific application.

CO4: To select the proper technology of additive manufacturing based on economics, complexity, and other needs of the product.

CO5: Analyze the effect of process parameters on the process output.

Books and References

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by I. Gibson,
   D. Rosen and B. Stucker, Springer.
2. Rapid Prototyping: Principles and Applications in Manufacturing by Chua C. K. and L. K. Fai, World Scientific Publishing Co., Inc.
3. Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing by Andreas Gebhardt, Hanser Publishers.
4. Laser Induced Materials and Processes for Rapid Prototyping by Lu, Fuh and Wong, Springer.

Industrial Robotics	
Course Code: **ME-662**	
Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart the knowledge of robot kinematics and robot programming
- To acquaint students with different application areas of robotics.
- To impart the knowledge of components of robotics systems such as drive systems, sensors etc.

Course Content

Introduction to Robotics: Historical background, Definitions, Laws of Robotics, Configurations of Manipulators: Components of robots, Arm configuration, Wrist configurations; Classification of Robots, Specification of robots, Analysis of Precision of movement in robotics: Resolution, Accuracy and repeatability, Economic Analysis of robotization in industries, Applications of robots in manufacturing, automation and Services, Introduction to mobile robots. Components of Robotic Systems: Introduction, Drive system-Hydraulic system. Pneumatic system, Electrical actuators, other actuating systems, Sensors: Need for sensing systems, classification of sensors, characteristics of sensors, various types of sensors, Smart Sensors, Robot vision systems and analysis, Robot cell design and Control, Robot Control system, Manipulator Control, Robot end effectors. Manipulator Kinematics and Dynamics: Introduction, Coordinate frames and Transformations, Homogenous Transformations Matrix, Composite Transformations, Inverse Homogenous Transformations, Forward and Inverse Kinematic equations, Denavit Hardenberg(D-H) representation, Forward Kinematic solution of various Manipulators, Inverse Kinematic Analysis-Solvabilty of inverse kinematics problems, Multiple solutions, the solution to inverse Kinematics. Dynamic analysis of manipulator, Trajectory Planning. Robot Programming: Introduction, Methods of Programming, Motions Programming, Robot Languages - Textual robot languages, Generation of robot programming Languages, Robot programming Language structure. Robots Applications, Implementation Principles and Issues: Introduction, Work cell layout, Work cell design, Industrial Applications Material handling, Processing operations, Assembly and inspection, Approach for implementing robotics, safety, training, maintenance and quality, Social issues and future of robotics. Advances in robotics, software systems and hardware integration.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain various industrial robot configurations and economics for the implementation of robotics in industries.

CO2: Design / simulate a robot that meets kinematic requirements.

CO3: Apply localization and mapping aspects of mobile robotics.

CO4: To understand robot programming.

Books and References

1. Robotics-control and programming by J. Srinivas, Narosa Publication
2. Industrial Robotics by M.P. Groover, McGraw Hill Publication
3. Fundamental of Robotics: Analysis and Control by Robert J Schilling, Person Publication Education
4. Industrial Robotics by Ganesh S. Hegde, Laxmi Publication

Manufacturing Automation

Course Code: **ME-663**

Course Type: **Core**

Contact Hours/Week: **4L** — Course Credits: **04**

Course Objectives

- To understand the need and differentiate between different types of automation systems.
- To understand various components of state-of-the-art automation technologies encountered in modern manufacturing industries.
- To introduce the design and practical aspects of automatic control of machines, processes and systems.

Course Content

Introduction: Introduction of automation technologies, applications in manufacturing, types of automation systems – hydraulic, pneumatic, electrical, and electronic with comparison. Role of energies in automation: fluid power and electrical. Different types of sensors, actuators, and controllers. Pneumatic systems and circuits: Introduction to pneumatic systems and their components, various types of valves and their applications. Pneumatic circuit design approach and examples. Pneumatic circuit sequencing. Limit switches. Limitations of pneumatic systems. Electro-pneumatic systems and circuits: Basics of electro-pneumatic systems. Electro-pneumatic and electro-hydraulic systems and their components, circuit design, relay control, sequence control application with example, terminal allocation. Programmable logic controllers (PLCs): Introduction to PLCs, inputs and outputs and their types. Interfacing of I/O devices with a PLC. Programming languages and instruction sets, ladder logics, structured text, functional blocks and applications. Example of sensor, actuator and controller integration for common microcontrollers.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend and differentiate between various types of automation systems.
CO2: Analyse and solve an engineering problem using the proper automation technology.
CO3: Apply gathered knowledge to synthesize i.e. design and formulate an industrial automation system.
CO4: Evaluate i.e. test, detect and monitor the working of different automation systems used in the industry.
CO5: To analyze the need for PLC, to install and programme the PLC for performing multiple tasks

Books and References

1. Introduction to Industrial Automation, Stamatios Manesis and George Nikolakopoulos, CRC press.
2. Fluid power with applications. Anthony Esposito, Pearson Education, 4th Edition.
3. Industrial Automation: Hands-On, Frank Lamb, McGraw Hill publisher.
4. Mechatronics. W. Bolton, Pearson publishers, 4th Edition

Theory of Plasticity and Advanced Metal Forming

Course Code: **ME-771**

Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To comprehend the concepts of stress-strain relations, theory of plasticity and mechanism of plastic deformation of materials.
- To analyze metal forming processes using various methods.
- To understand advanced metal forming technologies, their tooling, and equipment requirements.

Course Content

Theory of Plasticity: Theory of plastic deformation, Engineering stress and strain relationship, Stress Tensor, Strain Tensor, Yield criteria, Plastic stress-strain relationship, Incremental plastic strain. Empirical equations to stress-strain curves, Work Hardening. Residual stresses, Bauschinger effect. Constitutive Relationships and Instability: Anisotropy, Work hardening, Compression test, bulge test, Plane strain compression stress, Plastic instability in uniaxial tension stress, Plastic instability in biaxial tension stress, Yield criteria and yield locus of materials, Tresca and Von-Mises theory, Prandtl Reuss and Levy Mises stress-strain relations. Mechanism of Metal Forming: Slab analysis, Slip line method, Upper bound solutions, Statistically admissible stress field, Thermo elastic Elasto-plasticity, Elasto-visco plasticity, Thermo mechanical coupling, Bending theory, Cold rolling theory, Hill's anisotropic theory, Hill's general yield Theory, Forming limit diagrams. Plastic Forming Processes: Rolling classification, rolling mills, rolling of bars & shapes, rolling forces, analysis of rolling, defects in rolling, theories of hot & cold rolling, torque power estimation, Process analysis. Extrusion classification, equipment, lubrication and defects, mathematical analysis, hydrostatic extrusion, tube extrusion. Drawing & Sheet Metal Forming, rod & wire drawing equipment, mathematical analysis, Deep drawing, Tube drawing, Residual stresses, Sheet metal forming methods, Shearing and Blanking, Bending, Stretch forming, Deep drawing, Forming Limit Criteria, defects, Press brake forming, Explosive forming. Advances In Metal Forming: Overview of high-speed extrusion, Rubber pad forming, Micro blanking, Superplastic forming, Powder metal techniques, Powder rolling, Tooling and process, Parameters Classification; Process Principle, Applications, Equipment, Process Analysis and Die Design of Explosive Forming; Electro-Magnetic Forming, Electro-Hydraulic Forming; Laser Beam Bending and Laser-Assisted Deep Drawing, Dieless Forming Operations, Micro Forming Processes: Classification; Process Principle and Applications of Conventional Micro Forming Processes and Unconventional Micro-Forming Processes

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend the theory of plasticity and the mechanism of plastic deformation of materials.

CO2: Understand plastic stress-strain relations and associated flow rules.

CO3: Perform the analysis of various plastic forming processes and outline tooling and equipment requirements

CO4: Understand the mechanism of advance metal forming processes.

CO5: Analyse the differences in mechanism between conventional, un-conventional and micro-forming processes

Books and References

1. Metal Forming analysis by R. H Wagoner. and J.J Chenot, Cambridge University Press.
2. Engineering Plasticity - Theory & Applications to Metal Forming by R.A.C Slater, John Wiely and Sons.
3. Theory of Metal Forming Plasticity by R. Narayanaswamy, Narosa Publishers.
4. Technology of Metal Forming Processes by Surender Kumar, Prentice Hall of India.
5. Metal Forming Mechanics and Metallurgy by W. F Hosford and RM Caddell, Prentice. Hall.Eaglewood Cliffs.

Theory of Casting and Welding

Course Code: **ME-772**

Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge of the design of different components related to casting, such as pattern, core, gate, riser, etc.
- To understand the concepts of cooling and solidification of metal and alloys in casting processes.
- To impart the knowledge of the physics involved in different welding techniques.
- To impart knowledge of advanced welding processes such as underwater welding and welding in space.

Course Content

Theory of Metal Casting: Overview and Classification, Mould Parting Analysis, Pattern Design; Core Design; Gating Design and Analysis: Mould Filling Characteristics, Fluidity and Turbulence, Types of Gating Element Design, Mould Filling Analysis Including Effect of Different Head Losses, Cooling and Solidification, Solidification of Pure Metals and Alloys, 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, Feeder Design and Analysis: Feeder Shapes and Location, Risering Curves, NRL Method of Riser Design, Risering of Complex Casting, Feeding Distance and Riser Placement, Feed Aid Design.

Theory of Metal Welding: Overview and Classification of Welding Processes, Theory of Arc Welding: Physics of Welding Arc, Welding Power Sources, Constructional Features, Static and Dynamic Characteristics, Duty Cycle, Welding arc Characteristics and its Relationship with Power Source, Arc Efficiency, Arc Below; Metal Transfer: Classification, Forces Acting on The Drop, Metal Transfer Mechanism, Transition Current, Melting Rate, Effect of Polarity, Deposition Efficiency; 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, 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.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the process requirements to manufacture a specific product by casting and welding processes.
CO2: Describe the effects of various parameters on the quality of the product produced.
CO3: Do the correct designing of gating system elements.
CO4: Describe the mechanism of metal transfer in electric arc welding.
CO5: Assess the various potential areas in manufacturing industries where the knowledge of advanced welding processes can be of great use.

Books and References

1. Fundamentals of Metal Casting by R. A. Flinn, Addison Wesley.
2. Manufacturing Science by Ghosh and Malik, East West Press New Delhi.
3. The Physics of Welding byJ. F. Lancaster, Pergamon Press.
4. Principles of Welding by R.W. Messler, John Wiely & Sons.

Optimization Methods in Engineering

Course Code: **ME-773**

Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To formulate design problems as mathematical programming problems.
- To determine the degree of attainment of the goals with the available resources.
- To impart the knowledge of solving various types of optimization problems.

Course Content

Introduction: Introduction, Terminologies, Design Variables and Constraints, Objective Function, Variable Bounds, and Problem Formulation. Linear Programming Based Methods: Simplex Method, Duality in Linear Programming. Single Variable Optimization Problems: Optimality Criterion; Bracketing Methods: Exhaust 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. Multi-variable 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, Marquan Method, Conjugate Gradient Method, Variable- Metric (DFP) Method. Constrained Optimization Methods: Kuhn Tucker Conditions, Transformation Methods: Penn Function Method, Method of Multipliers (MOM), and Sensitivity Analysis. Specialized Optimization Methods: Integer Programming: Penalty Function Method, Branch and Bo' Method, Geometric Programming. Non-Traditional Optimization Methods: Genetic Algorithms, Simulated Annealing, Tabu Search and Ant Colony Optimization, Particle Swarm Optimization; Applications to Engineering Optimization Problems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the required techniques to achieve a desired set of objectives.

CO2: Describe the best satisfying solution under a varying number of resources and priorities of the goals.

CO3: Apply principles of resource optimization.

CO4: Assess the suitability of the technique for optimizing the real-world problem.

CO5: Learn efficient computational procedures to solve optimization problems.

Books and 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, New International (P) Limited Publishers, New Delhi.
4. Engineering Optimization - Methods and Applications by Ravindran, Ragsdell and Rekla, John Wiley & Sons, Delhi.

Computer-Aided Geometric Design

Course Code: **ME-781**

Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To understand the basic fundamentals of computer-aided geometric design.
- To learn the fundamentals of the design of Curves.
- To understand different geometric modeling techniques like solid modeling, surface modeling, feature-based modeling, etc., and to visualize how the components look like before their manufacturing or fabrication.

Course Content

Introduction: Historical development, explicit and implicit equations, intrinsic equations, parametric equations, coordinate systems. Curve Design: Fundamentals of curve design, parametric space of a curve, blending functions, reparameterization, space curves, straight lines, spline curves, Bezier curves, b-spline curve, rational polynomials, rational curves, and NURBS. Geometric Transformations: Transformations: translation, rotation, scaling symmetry and reflection, homogeneous transformations. Orthographic projections, axonometric projections, oblique projections, perspective transformation. Design of Surfaces: Fundamentals of surface design, parametric space of a surface, re-parameterization of a surface patch, sixteen-point form, four curve form, plane, cylindrical, and ruled surfaces, surface of revolution, Bezier surface, b-spline and NURBS surface. Design of Solids: Solid models and entities and representation, fundamentals, half spaces, B-rep, CSG, Sweep, ASM, organization of modelers, manipulations. Geometric Properties: Local and global properties of a curve, local and global properties of a surface, global properties of a complex solids, relational properties, intersections, application in product development and other areas.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Design various Curves, Surfaces and understand inherent mathematics.

CO2: Perform various types of geometric transformations.

CO3: Design various solids and understand inherent mathematics.

CO4: Design and validate technological solutions to defined problems.

CO5: Interrelate the course with other technologies such as 3D printing, product development, etc.

Books and References

1. Geometric Modeling by Michael E. Mortenson, Third addition, Industrial Press Inc.
2. Mathematical Elements of Computer Graphics by Hearn & Becker, Pearson.
3. CAD CAM Theory and Practice by I. Zeid, McGraw Hill.
4. Computer Aided Engineering Design by Saxena and Sahay, Anamaya N. Delhi

Inspection and Quality Control in Manufacturing

Course Code: **ME-782**

Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart the knowledge of the importance of quality and the techniques to maintain quality in manufacturing.
- To introduce the students with inspection fundamentals, destructive and non-destructive testing methods, inspection metrology and tools, etc.
- To introduce the concept of quality control, quality assurance and causes of quality failure.

Course Content

Quality Program for Manufacturing: Quality in Design and Manufacturing, Traditional and Modern quality Control, Process variability and Process capability, Statistical Process control, Six Sigma, Taguchi Method of quality control, ISO 9000. Statistical Quality Control (SQC): Definition, Benefits and Limitations of SQC, Quality Assurance, Quality Cost, Variation in Process & Process Capability, Process Capability Studies and Simple Problems, Theory of Control Chart, Uses of Control Chart, Control Chart for Variables-X Chart, R Chart and S Chart. Inspection Principles and practices: Inspection fundamentals, Role of Inspection and Measurement for Quality Control in Manufacturing, Need of Inspection, Inspection types and Principles, Design for Inspection, Destructive Inspection, Testing of Composites, Materials Sampling Vs 100% inspection, Automated inspection, When and where to inspect, Analysis of inspection systems. Inspection and Testing Technologies: Inspection Metrology, Conventional Measuring and Gauging Techniques, Co-ordinate Measuring Machines, Surface measurements, Machine Vision, Optical inspection Methods, Non-contact non-optical inspection techniques, Non-destructive testing, Online inspection Techniques, Engineering Metrology: Linear Measurement, Angular Measurement, Measurement of Surface Finish, Screw Thread Metrology, Gear Measurement, Miscellaneous Measurements. Integrated Quality Control and Quality Assurance: Contemporary Developments in the Field of Quality Management, The Role of Quality Control in the Modern Enterprise, Responsibility as a Result of Poor Quality, Quality and Standardization, Causes of Quality Failure, Quality Assurance: Need and Various Elements in Quality Assurance Programme, Quality Control- on Line and offline, Statistical Concepts in Quality, Chance and Assignable Causes, Bench Marking in Quality Management.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the ways to induce quality in every segment of manufacturing organization.

CO2: Identify three components of a quality system: high accuracy, compliance with applicable standards, and high customer satisfaction.

CO3: Understand the concept of inspection and Testing in Manufacturing

CO4: Apply principles of Total Quality Management

CO5: Assess each measure of Quality Control and Assurance to ensure the product's competency in the world market.

Books and References

1. Automation, Production Systems, Computer Integrated Manufacturing by Mikell P. Groover, Pearson India.
2. Statistical Quality Control by V. Grant, Eugene, McGraw-Hill, New Delhi.
3. Quality Control by D.H. Biesterfield, Prentice Hall, Delhi.
4. Total Quality Management by Dale H Besterfield, Pearson India

Production and Operation Management

Course Code: **ME-783**

Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To develop an understanding of the role of production and operations management.
- To familiarize with the key factors in the design of effective operating systems.
- To familiarize with the application of production and operations management policies and techniques

Course Content

Introduction: An overview of Production and Operations Management (POM), Managing a Production System, Types of Production Systems, Significance of Productivity, Decision making in POM, Problems in POM, Sub functional areas of POM, Recent trends in POM. Product Planning and Development (PPD): Product definition, Need, Objectives and Challenges of PPD, characteristics of Successful Product Development, New Product development Strategy and Process, Factors to be considered in Product Development, The Product Life Cycle Concept, Factors affecting Product Design and Product Development, Stages in Product Design and Product Development. Facility Location and Plant Layout: The need for location decisions, Procedure for making location decisions, Factors affecting location decisions, Methods of evaluating location decisions, Types of Layout, Significance and Factors influencing layout choices, Principles of Plant Layout, Computerised Layout Techniques. Materials Handling: Function, Importance and Objectives of Material Handling, Material handling Principles, Types of Material Handling Systems, Selection of Material Handling Equipments, Evaluation of Material handling Performance Relationship with Plant layout. Production Planning and Control: Classification of PPC functions, Factors determining PPC, procedure Role of PPC in POM, Principles of PPC, PPC in different Production System, Organisation of PPC department. Inventory Management: Nature, Importance, Classification and Functions of Inventory, Inventory Costs, Importance of Inventory Management, Inventory Control System for Dependent Demand and Independent Demand, Inventory Ordering Systems. Inventory Control subject to Known Demand. The EOQ Model, Extension to Finite Production Rate, Quantity Discount Model. Inventory Control subject to Uncertain Demand, The Newsboy Model, Service Levels in Q and R Systems. Advances in POM: Material Requirement Planning (MRP), Manufacturing Resource Planning (MRP II), Enterprise Resource Planning (ERP), Just in Time Manufacturing, Lean Production, Agile Manufacturing, Line Balancing, Line of Balance, Sustainable Production and Green Manufacturing.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Analyze implications of Production and Operations Management in industries.

CO2: Analyze various constituents of production operations in manufacturing and service.

CO3: Plan and control various production related activities.

CO4: Apply various inventory management procedures with the tools employed therein.

CO5: Apply the concept of JIT, MRP, and ERP towards production and operations management.

Books and References

1. Production and Operations analysis by Steven Nahmias, McGraw-Hill/Irwin publication
2. Facilities Planning 4th Edition by James A. Tompkins, John Wiley and Sons Inc.
3. Elements Of Production Planning and Control by Eilon, Samuel, New York: Macmillan
4. Production and Operations Management by R. Panneerselvam, Prentice-Hall of India

Smart Manufacturing

Course Code: **ME-784**

Course Type: **Programme Elective-II**

Contact Hours/Week: 4**L** Course Credits: **04**

Course Objectives:

- To impart knowledge about manufacturing automation.
- To introduce the fundamental concepts of additive manufacturing technologies, industry 4.0 and industrial IoT.
- To introduce the concepts of smart sensing, machine learning, data preparation and augmented reality in manufacturing.

Course Content

Introduction to Smart Manufacturing and its key elements**,** Fluid power- Pneumatic and Hydraulic, various types of valves and their applications, PLCs and PLC-based control, Programming languages and instruction sets, ladder logics, structured text, functional blocks and applications, Additive Manufacturing (AM) Technologies: basics and need of additive manufacturing, preprocessing stage in AM, various AM technologies, Industry 4.0 and Industrial IoT system, IIoT Reference architecture, Smart Sensing for Industry 4.0, review of smart industrial sensors, identification system, basics of industrial network and communication, IO Links Technology, Machine learning in manufacturing, supervised and unsupervised learning, data preparation for machine learning, Traditional Predictive Maintenance and Machine Learning approach. Introduction to augmented reality and its role in empowering design, marketing, and service industries.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Identify the requirements and needs of smart manufacturing.

CO2: Select suitable automation strategy as per the requirement.

CO3: Identify areas of knowledge of additive manufacturing that can be applied through theoretical studies.

CO4: Apply the concept of machine learning and augmented reality in manufacturing.

Books and References

1. Fluid power with applications by Anthony Esposito, Pearson Education, 4th Edition.
2. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by I. Gibson, D. Rosen and B. Stucker, Springer.
3. Industry 4.0- The Industrial Internet of Things by Gilchrist, Apress.
4. Machine Learning in Production: Developing and Optimizing Data Science Workflows and Applications by Andrew Kelleher and Adam Kelleher, Addison-Wesley

Laser Material Processing

Course Code: **ME-791**

Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart in-depth knowledge of laser-assisted processes such as laser machining, laser welding, laser heat treatment, laser glazing, laser alloying, etc.
- To brief the students about the interaction of laser with different metals, alloys, ceramics, polymers and composites.

Course Content

Introduction: Concept of Laser, Basic Mechanisms in Lasers, Properties of Laser, Types of Lasers, 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, Aluminum 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 Surface Engineering: Laser Glazing, Laser Alloying, Microstructural Considerations in Laser Rapid Heating Process.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To select the most suitable laser for processing different workpiece materials.

CO2: To study the parametric influences during laser material processing.

CO3: To understand the theoretical model of laser material processing.

CO4: To understand how to perform welding of different materials using laser systems.

CO5: To understand how laser processing can be used in a variety of surface engineering processes.

Books and References

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

Mechatronics

Course Code: **ME-792**

Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- Understand key elements of the Mechatronics system and representation in the block diagram.
- Understand principles of sensors and signal conditioning, its characteristics, interfacing with DAQ microcontroller
- To impart the knowledge of mechanical, pneumatic and hydraulic actuators.

Course Content

Fundamentals of Mechatronics: Definition, Systems, Measurement systems, Control systems, Programmable logic controller, Block Diagram of Mechatronic System, Functions of Mechatronic Systems, Comparison between Traditional and Mechatronics approach, Examples of Mechatronic Systems. Sensors and Signal Conditioning: Sensors and Transducers, micro and Nanosensors, Signal conditioning, Digital signal and digital logic, Data conversion devices, signal processing devices, Data acquisition and data presentation, PID Controller, Microprocessors and Microcontrollers and PLCs. Actuation Systems: Mechanical actuation systems: Cams, Gears, Bearings, Belt and chain drives, Ratchet and pawl, Mechanical aspect of Motor selection; Pneumatic and hydraulic actuation system: Directional control Valves, Pressure control Valves, Servo and proportional control Valves, Rotary actuators; Electrical actuation systems: Mechanical and solid switches, Solenoids, D.C. Motors, Stepper motors, Servomotors, Motor selection. System Models: Mathematical Models, Modeling of Mechanical systems, Fluid systems, Thermal systems and Electrical systems, dynamic response of systems, System Transfer function. Mechatronics-Products and systems in manufacturing: Application of Mechatronic systems Computer numerical control (CNC) machines, Tool monitoring systems, Advanced manufacturing systems: Flexible manufacturing system (FMS), Computer integrated manufacturing (CIM); Automatic inspection systems: machine vision systems, Automatic packaging systems, Industrial Robotics, Automobile control systems, Introduction to Artificial intelligence.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Understand the concept of Mechatronics systems in the automation of various products.
CO2: Select appropriate sensors and actuators and devise a system for collecting information about processes.
CO3: Demonstrate the concepts of actuating systems to be used in Mechatronic systems products.
CO4: Develop a mathematical model of the real-world problem in different industrial environments.
CO5: Generate conceptual design for Mechatronic products based on potential customer requirements

Books and References

1. Mechatronics: Electronic control systems in Mechanical and Electrical Engineering by W. Bolton, Pearson.
2. Introduction to Mechatronics & Measurement Systems by D. G Alciatore and M. B Histand, McGraw-Hill.
3. Robotics:Control and Programming by J. Srinivas, R.V. Dukkipati and K. Ramji, Alpha Science International
4. Mechatronic Systems: Fundamentals, R. Iserman, Springer.
5. Fundamentals of Mechatronics, Musa Jouaneh, Cengage Learning.

Machining Science and Technology

Course Code: **ME-793**

Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To study the basics and mechanics of metal machining.
- To study the different types of cutting tools, tool materials and geometry of cutting tools.
- To understand the details of the grinding process.
- To learn introductory concepts of various advanced machining processes.

Course Content

Introduction: Need and Classification of Machining Processes, concept of cutting speed, feed, and depth of cut. Determination of machining time in turning, milling, and drilling operations. Geometry of Cutting Tools: Geometry of single point cutting tool, Tool nomenclature in tool in hand system, ASA system, ORS system, MRS and NRS system and their conversion from one system to another. Mechanics of Metal Cutting: Orthogonal and Oblique cutting, Mechanics of chip formation, Merchant's analysis: forces, power, shear strain, strain rate and specific energy in cutting. Theories of metal cutting: Ernst & Merchant's theory, Modified Merchant's theory, Lee & Shaffer's theory. Heat generation in metal cutting: sources of heat generation, temperature in primary and secondary deformation zone, measurement of cutting temperature. Cutting fluids and their types, the action of coolants and their characteristics. Tool wear and tool life, different tool wear mechanisms: abrasion, adhesion, diffusion. Tool life criteria and machinability index. Mechanics of Multipoint Cutting Tool Machining: Multi-point cutting tools: geometry of peripheral milling cutters and twist drill. Abrasive machining and finishing, Grinding process: specifications of grinding wheel, classification of grinding processes, Mechanics of grinding: thickness of uncut layer, length of chips for surface, external and internal cylindrical grinding, Specific energy in grinding, Wheel wear and thermal analysis of grinding. Other finishing processes: Lapping, Honing, Polishing, Buffing, and Superfinishing. Machining of Composites and Difficult to Machine Materials: Challenges in machining of composites, Ti-alloys, carbides, etc. Methods to enhance the machinability of these materials.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the mechanism of metal removal in different machining processes.

CO2: Describe the effect of different grinding and dressing parameters on forces and surface integrity.

CO3: Implement the knowledge of advanced machining processes to machine the components made of difficult-to-machine materials.

CO4: Describe the various aspects of tool design in advanced machining processes.

CO5: Analyze the output of the process based on process parameters.

Books and References

1. Introduction to Machining Science by G. K. Lal, New Age International Publisher Limited, New Delhi.
2. Principles of Abrasive Processing by M. C. Shaw, Clarendon Press.
3. Manufacturing Science by A Ghosh and A K Mallik, East West Press
4. Machining and Machine Tools by A B Chattopadhyay, Wiley.

Optimization Methods in Engineering

Course Code: **ME-703**

Course Type: **Institute Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To formulate design problems as mathematical programming problems.
- To determine the degree of attainment of the goals with the available resources.
- To impart the knowledge of solving various types of optimization problems.

Course Content

Introduction: Introduction, Terminologies, Design Variables and Constraints, Objective Function, Variable Bounds, and Problem Formulation. Linear Programming Based Methods: Simplex Method, Duality in Linear Programming. Single Variable Optimization Problems: Optimality Criterion; Bracketing Methods: Exhaust 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. Multi-variable 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, Marquan Method, Conjugate Gradient Method, Variable- Metric (DFP) Method. Constrained Optimization Methods: Kuhn Tucker Conditions, Transformation Methods: Penn Function Method, Method of Multipliers (MOM), and Sensitivity Analysis. Specialized Optimization Methods: Integer Programming: Penalty Function Method, Branch and Bo' Method, Geometric Programming. Non-Traditional Optimization Methods: Genetic Algorithms, Simulated Annealing, Tabu Search and Ant Colony Optimization, Particle Swarm Optimization; Applications to Engineering Optimization Problems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the required techniques to achieve a desired set of objectives.

CO2: Describe the best satisfying solution under a varying number of resources and priorities of the goals.

CO3: Apply principles of resource optimization.

CO4: Assess the suitability of the technique for optimizing the real-world problem.

CO5: Learn efficient computational procedures to solve optimization problems.

Books and 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, New International (P) Limited Publishers, New Delhi.
4. Engineering Optimization - Methods and Applications by Ravindran, Ragsdell and Rekla, John Wiley & Sons, Delhi.

Soft Computing Methods in Engineering

Course Code: **ME-704**

Course Type: **Institute Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To cover fundamental concepts used in soft computing.
- To understand concepts of Fuzzy Logic (FL) and Artificial Neural Networks (ANNs) and optimization techniques using Genetic Algorithm (GA).
- The course will provide exposure to theory as well as practical systems and software.

Course Content

Introduction to Soft Computing: Need and Classification of Soft Computing Methods. Artificial Neural Networks: Characteristics, Learning Methods, Taxonomy, Evolution of Neural Networks, Basic Models, Important Technologies, Applications, Single Layer Perceptron's, Multi-1 Feed-Forward Neural Networks, Learning Processes, Radial Basis Function Networks, Recurrent Networks, Principal Component Analysis; Applications of ANN in Engineering. Fuzzy Sets and Fuzzy Logic: Operations on Fuzzy Sets Crisp Relations and Fuzzy Relations, Cartesian Product of Relation, Classical Relation, Fuzzy Relations, Tolerance and Equivalence Relations, Non- Iterative Fuzzy Sets, Genetic Algorithm, Introduction, Biological Background, Traditional Optimization and Search Techniques, Genetic Basic Concepts, Membership Functions, Features, Fuzzification, Methods of Membership Value Assignments, Defuzzification, Lambda Cuts, Methods, Fuzzy Arithmetic and Fuzzy Measures, Fuzzy Arithmetic Extension Principle, Fuzzy Measures, Measures of Fuzziness, Fuzzy Integrals, Fuzzy Rule Base and Approximate Reasoning, Truth Values and Tables, Fuzzy Propositions, Formation of Rules, Decomposition of Rules, Aggregation of Fuzzy Rules, Fuzzy Reasoning, Fuzzy Inference Systems, Overview of Fuzzy Expert System, Fuzzy Decision Making, Applications of Fuzzy systems in Engineering. Genetic Algorithm: Genetic Algorithm and Search Space, General Genetic Algorithm, Operators, Generational Cycle, Stopping Condition, Constraints, Classification, Genetic Programming, Multilevel Optimization, Real Life Problem, Applications of GA in Engineering.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the idea of conceptual intelligence in machines.

CO2: Describe the reasoning, thinking, analyzing and detecting that correlates the real-world problems to the technically inspired methods.

CO3: Apply principles of extension of heuristics: neural networking, fuzzy logic, and genetic algorithm.

CO4: Assess more complex systems, which often remain intractable to conventional mathematical and analytical methods.

CO5: Develop applications on different soft computing techniques like Fuzzy, GA and Neural networks.

Books and References

1. Tool Design by Herman W. Pollack, Prentice Hall.
2. Tool Design by Donaldson, Tata McGraw Hill.
3. Machine Tool Design & Numerical Control by N. K. Mehta, Tata McGraw Hill.
4. CMTI: Machine Tool Design Handbook, Tata McGraw Hill.

Introduction to Design of Experiments

Course Code: **ME-706**

Course Type: **Institute Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To design the experiment that aims to describe the variation of information under conditions that are hypothesized to reflect the variation.
- To predict the outcome by introducing a change of the pre-conditions; this is represented by one or more independent variables by identifying control variables.
- To explore the main concerns in experimental design that include the establishment of validity, reliability, and replicability.

Course Content

Introduction, Basic Principles and Applications of Experimental Design, Statistical Methods, Sampling and Sampling Distributions, Randomized Designs, Paired Comparison Designs, Mean and Variances of Normal Distribution, 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 ANOVA, Non Parametric Methods, 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; 2^2 and 2^3 Design, General 2^k Design: Single Replicate and un-replicated, Addition of Center Points, Blocking and Confounding; Factorial Design in Two Blocks; Two-Level Fractional Factorial Designs; General 2^{k-P} Fractional Factorial Design; Regression Modeling and Linear Regression Models; Hypothesis Testing in Multiple Regression, Prediction of New Regression Observations, Regression Model Diagnostics, Testing for Lack of Fit; Response Surface Methodology: Introduction, Method of Steepest Ascent, Analysis of a Second Order Response Surface; Experimental Design for Fitting Response Surface; Experiments with Computer Models, Random Effects Models; Two-Factor Factorial with Random Factor and Two-Factor Mixed Model, Rules for Expected Mean Square; Approximate *F* Tests; Non-Normal Response and Transformations, Unbalanced Data in a Factorial Design, Analysis of Covariance, Repeated Measures.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and select suitable experimental design for the study.

CO2: Describe the variation of information under conditions that are hypothesized to reflect the variation.

CO3: Apply the principles of statistics.

CO4: Assess the risk of measurement error and select the suitable variables for the study.

CO5: Understand the concept of response surface methodology and its use in experimentation.

Books and References

1. Design and analysis of experiments by D.C. Montgomery, Wiley.
2. Design and analysis of experiments by Angela M. Dean and Daniel Voss, Springer.
3. Experiments: Planning, analysis and optimization by C.F. Jeff Wu and S. Michael, Hamada Publishers.

Logistics and Supply Chain Management

Course Code: **ME-707**

Course Type: **Institute Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objective:

- To impart knowledge about maximization of overall value generated through the connected network of individuals, organizations, resources, activities and technologies involved in manufacturing.
- To introduce cost reduction mechanism while maintaining quality and timely management of different operational activities.

Course Content

Introduction: Concepts, Drivers and Obstacles, Planning Demand and Supply in a Supply Chain, Demand Forecasting. Physical Distribution: Participation in the Physical Distribution Functions, The Environment of Physical Distribution, Channel Design Strategies and Structure, Electing Channel Members, Setting Distribution Objectives and Tasks, Target Markets and Channel Design Strategies. Logistics Management: Logistics as Part of SCM, Logistics Costs, Different Models, Logistics Subsystem, Inbound and Outbound Logistics, Bullwhip Effect in Logistics, Distribution and Warehousing Management. Purchasing & Vendor Management: Centralized and Decentralized Purchasing, Functions of Purchase Department and Purchase Policies, Use of Mathematical Model for Vendor Rating / Evaluation, Single Vendor Concept, Management of Stores, Accounting for Materials, Aggregate Planning, Management of Inventory in Global Supply Chain. Supply Chain: Building Blocks of Supply Chain Network, Performance Measures in Decisions in the Supply Chain World, Models for Supply Chain Decision Making, Supply Chain Inventory Management, Economic Order Quantity Models, Recorder Point Models, Multichannel Inventory Systems, Supply Chain Facilities Layout, Capacity Planning, Inventory Optimization, Dynamic Routing and Scheduling. Role of Information Technology in Supply Chain, E-Business and the Supply Chain, Factors Influencing Logistics and Decision, Bench Marking and Performance Measurement, Supply Chain Risk, Reverse Logistics, Green Supply Chain.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Identify ways to fulfill customer demand through efficient resources.

CO2: Describe the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from point of origin to point of consumption.

CO3: Apply principles of effective distribution and optimization of pre & post inventory levels.

CO4: Assess the product demand by driving customer value, improving responsiveness, facilitating financial success and building a good network.

Books and References:

1. Supply Chain Management by John T. Mentzer, SAGE Publication, New Delhi.
2. Business Logistics/Supply Chain Management by Ballou & Srivastava, Pearson Education, New, Delhi.
3. Supply Chain Logistics Management by Bowersox, Closs and Cooper, Tata McGraw-Hill.
4. Logistics and Supply Chain Management by Martin Christopher, Financial Times Prentice New Delhi.
5. Supply Chain Management: Text and Cases by Janat Shah, Pearson Education, New Delhi.

Manufacturing Engineering Lab-I

Course Code: **ME-654**

Course Type: **Core**

Contact Hours/Week: **04** Course Credits: **02**

Course Objectives:

- To enhance the students' understanding of advanced machining.
- To develop an understanding of concepts behind CNC Machines and part programming.
- To enhance the understanding of different tests and characterization of MMCs.
- To understand the CIM system, SCARA robot and automation.

Course Content

List of Experiments

1 Study of electric discharge machining (EDM) and the effect of different EDM parameters on material removal rate and surface roughness.

2 Study of electrochemical machining (ECM) and the effect of different ECM parameters on material removal rate and surface roughness.

3 Flaw detection in a welded joint using dye penetrant testing /ultrasonic method.

4 Study of MIG and TIG welding processes for microstructure and hardness of given samples.

5 Study the surface topography of a given sample using optical microscope/scanning electron microscopy.

6 Study of CNC lathe machine, developing part programmes for a given product and manufacturing the same on CNC lathe machine.

7 Study of CNC milling machine, developing a part programme for a given product and manufacturing the same on CNC milling machine.

8 Prepare the MMC using stir casting and mechanical characterization of MMC.

9 Perform Tensile and Flexural strength tests on the given sample.

10 Perform fatigue and creep tests on the given sample.

11 Perform a toughness test on the given plastic sample.

12 Measure the surface roughness of a given sample using a surface roughness tester.

13 Study of the CIM system available in the laboratory and develop a program to manufacture a component as per the given drawing with automatic material handling and machining.

14 To develop the part program for a given product using CAM software and manufacture the same on CNC Turing Center.

15 To develop the part program for a given product using CAM software and manufacture the same at the CNC Machining Center.

"The concerned course coordinator will prepare the actual list of experiments/ problems at the start of the semester based on the above generic list"

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Machine the part using the advanced machine.

CO2: Understand the microstructure, hardness and defects in welding.

CO3: Understand the surface characteristics of the given sample.

CO4: Perform the characterization and mechanical testing on the given material.

CO5: Develop and Execute the Part Program on the CNC Machine, understand the CIM system, SCARA robot and automation.

Manufacturing Engineering Lab-II

Course Code: **ME-664**

Course Type: **Core**

Contact Hours/Week: **04** Course Credits: **02**

Course Objectives

- To bridge the gap between theoretical and practical knowledge by providing training in modern manufacturing technology.
- To implement rapid prototyping and reverse engineering to facilitate quick and effective manufacturing of three-dimensional mechanical parts.

Course Content

List of Experiments

1. To study the articulated robot /SCARA robot and perform the operation of sorting the containers on the basis of weight by developing the program.
2. To understand the prerequisites of the CAD model and to prepare the model for the additive manufacturing process.
3. To perform Reverse Engineering by CMM/Laser Scanner.
4. To perform slicing and tool path generation for additive manufacturing.
5. To perform conversion of CAD to STL file and to perform STL data generation and STL data manipulation.
6. Study of different components of a modular automation production system demonstrating the operations of a bottling plant and running the sequential operations by developing and executing the program
7. Demonstration of 3D printing Fused Deposition Modeling (FDM) machine and manufacturing of 3-D parts by FDM Process.
8. Demonstration of 3D printing Stereolithography apparatus (SLA) machine and manufacturing of 3-D parts by SLA.
9. To study the different types of pneumatic components (valves and actuators), identification by symbols and leaning the method of connecting them properly with the pneumatic pressure line.
10. Performing the simulation and developing the pneumatic circuit connections to accomplish different industrial operations in automatic mode using single-acting as well as double-acting cylinders.
11. Developing pneumatic circuit connections using different types of values such as flow control value, pressure sequence value, AND/OR valve.
12. Developing a pneumatic circuit connection for performing tasks in a single cycle as well as in a continuous cycle.
13. To study the different types of electro-pneumatic components, identification by symbols and leaning the method of connecting them properly with the electric power supply and pneumatic pressure line.
14. Developing a pneumatic control system using different types of electro-pneumatic valves, sensors, relays, and logic operators.
15. Developing an automatic system using the PLC and electro-pneumatic valves.

"The concerned course coordinator will prepare the actual list of experiments/ problems at the start of the semester based on the above generic list"

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Use reverse engineering in CAD modelling.

CO2: Perform slicing, path generation and STL data manipulation.

CO3: Make the 3D- product using Fused Deposition Modeling and Stereolithography.

CO4: To develop hydraulic, pneumatic, and electro-pneumatic-based automation systems for a particular need.

CO5: To do ladder programming for any type of PLC.