

**ANNEXURE - A: M. TECH. (MANUFACTURING ENGINEERING)****COURSE STRUCTURE**

Course No.	Year and Semester	Course Title	L-T-P	Credits
ME501	I Year I Semester	Computational Methods for Engineers	3-0-2	4
ME502		Advanced Casting Technology	3-0-2	4
ME503		Advanced Welding Technology	3-0-2	4
ME504		Computer Graphics and CAD	3-0-2	4
ME505		Manufacturing Systems Engineering	3-0-2	4
ME506		Non Traditional Machining	3-1-0	4
Total Credits (First Semester)				24
ME507	I Year II Semester	Quality Control and TQM	3-0-2	4
ME508		Forging Die Design and Manufacture	3-0-2	4
ME509		CNC and Programming	3-0-2	4
ME510		Design of Machine Tools	3-1-0	4
-----		Elective I	3-0-2/3-1-0	4
-----		Elective II	3-0-2/3-1-0	4
Total Credits (Second Semester)				24
-----	II Year I Semester	Elective III	3-0-2/3-1-0	4
-----		Elective IV	3-0-2/3-1-0	4
ME511		Seminar	-----	1
ME512		Industrial Training	-----	1
ME513		Project Work (Part I)	-----	5
Total Credits (Third Semester)				15
ME514	II Year II Semester	Comprehensive Viva-voce	-----	2
ME515		Project Work (Part II)	-----	15
Total Credits (Fourth Semester)				17
<b>Total Credits (All Semesters)</b>				<b>80</b>

**LIST OF ELECTIVES**

(All these courses will have 4 credits and will be offered in 3-0-2 or 3-1-0 pattern)

S. No.	Course No.	Course Title
1	ME521	Finite Element Methods and Applications
2	ME522	Geometric Modeling for Manufacturing
3	ME523	Non Destructive Evaluation
4	ME524	Optimization Methods for Engineers
5	ME525	Metrology and Computer Aided Inspection

6	ME526	Advanced Metal Forming Technology
7	ME527	Advanced CAD and Computational Geometry
8	ME528	Soft Computing Techniques
9	ME529	Artificial Intelligence in Manufacturing
10	ME530	Design of Jigs and Fixtures
11	ME531	Micro and Nano Manufacturing
12	ME532	Laser Assisted Manufacturing
13	ME533	Flexible Manufacturing Systems
14	ME534	Mechatronics
15	ME535	Precision Engineering
16	ME536	Rapid Prototyping and Reverse Engineering
17	ME537	Design for Manufacture and Assembly
18	ME538	Design and Analysis of Experiments
19	ME539	Modern Casting Processes
20	ME540	Foundry Tooling and Methoding
21	ME521	Reliability Engineering
22	ME542	Rolling Technology
23	ME543	Near Net Shape Processes
24	ME544	Concurrent Engineering
25	ME545	Tool Design

## LIST OF ELECTIVES

(These courses will be offered in 3-0-2 or 3-1-0 pattern)

S. No.	Course No.	Course Title	L-T-P	Credits
1	ME521	Finite Element Methods and Applications	3-0-2	4
2	ME522	Geometric Modeling for Manufacturing	3-0-2	4
3	ME523	Non Destructive Evaluation	3-0-2	4
4	ME524	Optimization Methods for Engineers	3-0-2	4
5	ME525	Metrology and Computer Aided Inspection	3-0-2	4
6	ME526	Advanced Metal Forming Technology	3-0-2	4
7	ME527	Advanced CAD and Computational Geometry	3-0-2	4
8	ME528	Soft Computing Techniques	3-0-2	4
9	ME529	Artificial Intelligence in Manufacturing	3-0-2	4
10	ME530	Design of Jigs and Fixtures	3-0-2	4
11	ME531	Micro and Nano Manufacturing	3-1-0	4
12	ME532	Laser Assisted Manufacturing	3-1-0	4
13	ME533	Flexible Manufacturing Systems	3-1-0	4
14	ME534	Mechatronics	3-1-0	4
15	ME535	Precision Engineering	3-1-0	4
16	ME536	Rapid Prototyping and Reverse Engineering	3-1-0	4
17	ME537	Design for Manufacture and Assembly	3-1-0	4
18	ME538	Design and Analysis of Experiments	3-1-0	4
19	ME539	Modern Casting Processes	3-1-0	4
20	ME540	Foundry Tooling and Methoding	3-1-0	4
21	ME521	Reliability Engineering	3-1-0	4
22	ME542	Rolling Technology	3-1-0	4
23	ME543	Near Net Shape Processes	3-1-0	4
24	ME544	Concurrent Engineering	3-1-0	4
25	ME545	Tool Design	3-1-0	4

## **CORE SUBJECTS**

### **ME501 COMPUTATIONAL METHODS FOR ENGINEERS (3-0-2)**

Approximations - Accuracy and precision - Definitions of round-off and truncation errors - Error propagation - Algebraic equations - Formulation and solution of linear algebraic equations - Gauss elimination - LU decomposition - Iteration methods (Gauss-Siedel) - Convergence of iteration methods - Eigen values and Eigen vectors - Interpolation methods - Newton's divided difference - Interpolation polynomials - Lagrange interpolation polynomials - Differentiation and integration - High accuracy differentiation formulae - Extrapolation - Derivatives of unequally spaced data - Gauss quadrature and integration - Transform techniques - Continuous Fourier series - Frequency and time domains - Laplace transform - Fourier integral and transform - Discrete Fourier transform (DFT) - Fast Fourier transform (FFT) - Differential equations - Initial and boundary value problems - Eigen value problems - Solutions to elliptical and parabolic equations - Partial differential equations - Regression methods - Linear and nonlinear regression - Multiple linear regression - General linear least squares - Statistical methods - Statistical representation of data - Modeling and analysis of data - Tests of hypothesis - Introduction to optimization methods - Local and global minima - Line searches - Steepest descent method - Conjugate gradient method - Quasi Newton method - Penalty functions - Solution to practical engineering problems using software tools.

### **ME502 METAL CASTING TECHNOLOGY (3-0-2)**

Introduction - Pattern materials and pattern allowances - Types of patterns and core boxes - Base sands and their characteristics - Clay bonded sand systems and practices - Additives and washes - Inorganic and organic binder based processes - Melting furnaces for different types of metals and alloys - Cupola melting and melt control - Introduction to gating and feeding - Fettling and salvaging of castings - Casting defects and remedies.

### **ME503 ADVANCED WELDING TECHNOLOGY (3-0-2)**

Review of major welding processes - Heat flow in welding - Welding stresses and distortion - Weldability of specific materials - Cracks in welds - Weldability tests - Weld Defects - Weld inspection, repair and maintenance welding - Weld design based on static, fatigue loading and fracture toughness.

### **ME504 COMPUTER GRAPHICS AND CAD (3-0-2)**

Computer graphics fundamentals - Points and lines - Algorithms for generating lines, circles, ellipses and other conic sections - Primitives and functions - 3D concepts and object representation - 3D display methods - 2D and 3D transformations and their matrix representations - Principles of computer aided design - Plane and space curves (Splines, Bezier and B-spline curves) - Surface description and generation - Parametric surfaces (Splines, Bezier and B-spline surfaces) - Implementation of parametric curves and surfaces using C++ language and OpenGL - Solid modeling - Representation of 3D objects - Use of standard CAD software.

### **ME505 MANUFACTURING SYSTEMS ENGINEERING (3-1-0)**

Introduction to process planning - Process planning in integrating CAD/CAM - Approaches to process planning: mutual, variant, generative and feature based systems - Some examples of process planning systems - Introduction to just-in-time manufacturing systems - Describing three M's - Pull Vs. Push - Types of Kanbans and Kanban planning and control models - Basics of concurrent engineering - Understanding interactions between design and manufacturing - Serial engineering Vs. concurrent engineering - Benefits of concurrent engineering - Introduction of group technology - Coding and classifications - Selection of coding systems - Examples of coding systems - Benefits of group technology - Cell formation approaches - Rank order clustering algorithm - Cluster identification algorithm - Similarity coefficient-based methods - Mathematical programming based methods and graph theoretic methods - Layout planning in cellular manufacturing - Scheduling problems in flexible manufacturing systems.

### **ME506 NON TRADITIONAL MACHINING (3-1-0)**

Newer processes in manufacturing - Process principles, process parameters, advantages and limitations and industrial applications of processes such as Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water Jet Machining (AWJM), Abrasive Flow Machining (AFM), Ultrasonic Machining (UM), Electro Chemical Machining (ECM), Electro Chemical Grinding (ECG) and Electro Chemical Discharge Grinding (ECDG), Shaped-Tube Electrolytic Machining (STEM), Electro Stream Drilling (ESD), Chemical Machining (CM), Electrical Discharge Machining (EDM), Electrical Discharge Wire Cutting (EDWC), Electron Beam Machining (EBM), Laser Machining (LM), Plasma Arc Cutting (PAC), Thermal Energy Method Deburring (TEM) and Ion Beam Machining (IBM) - Introduction to micromachining.

### **ME507 QUALITY CONTROL AND TQM (3-0-2)**

Probability and statistics - Statistical parameters for quality assurance - Prediction of process or product quality using normal distribution - Sampling inspection - Selection of sampling schemes for attributes and variables - Use of control charts for attributes and variables - Interpretation of control charts - Seven QC tools and their applications - Quality function deployment - Quality circles - Quality audits - TQM in manufacturing and services - Tools and improvement cycle (PDCA) - Life cycle approach to quality costs - Prevention, appraisal and failure costs - Basics of ISO 9000 and ISO 14000 - Relevance and misconceptions - Six-sigma philosophy - Implementation barriers to TQM practices.

### **ME508 FORGING DIE DESIGN AND MANUFACTURE (3-0-2)**

Study of forging drawing and its simplification from die design point of view - Determination of stock size, tensile strength of material at the finishing temperature while forging - Calculation of weight of falling parts or die of a drop hammer - Mechanical press - Selection of the size of massive die blocks or insert dies - Production of die blocks and factors controlling their quality - Location of parting line -

Selection of flash gutter - Determination of flash thickness and volume of fin - Calculation of wall thickness and distance between two impressions - Design of edger, fuller, bender, blocker, finishing impression, dovetail, cross, key and tapered key - Laws governing the design of dies of horizontal forging machine - Design of punches and heading tools for upsetter (horizontal forging machine) - Upsetting rules - Coining tool design method - Determination of capacity of trimming press - Design of trimming and piercing tool, die clearance between punch and die - Design of stripping and clipping tools - Assembly detail for trimming - Technical requirements for sinking, re-sinking and rectification of dies - Die-sinking methods like copy-milling, EDM, ECM, etc. - Instruction for mounting, setting and working of dies - Reduced roll design - Saved preform design - Die life improvement - Computer aided design of forging dies - Optimization of die design parameters - Optimum material utilization - Modeling and analysis of forging process using software.

### **ME509 CNC AND PROGRAMMING (3-1-0)**

Introduction to NC/CNC/DNC - Basics elements of CNC - Introduction to part programming - Radius and length compensation schemes - Tooling and Work-holding for CNC machine tools - Advanced programming features and canned cycles - Geometric modeling for NC machining and machining of freeform surfaces - NC program generation from CAD models - Introduction to APT programming - Post processors - NC program verification and virtual NC - Recent developments in CNC machine tools.

### **ME510 DESIGN OF MACHINE TOOLS (3-1-0)**

Introduction to machine tool drives and mechanisms - General principles of machine tool design - Selection of electric motor - Mechanical transmission and its elements - Devices for intermittent motion - Regulation of speed and feed rates - Stepped regulation of speed - Design of speed and feed boxes - Classification of speed and feed boxes - Design of machine tool structures - Basic design principles - Process capability of machine tools - Static compliance and overall compliance of machine tools - Design of beds, columns, housings, bases and tables - Design of cross rails, arms, saddles and carriages - Design of rams - Design of guide ways: Slide ways and their design - Stick slip phenomenon in slide ways - Design of hydrodynamic slide ways - Design of hydrostatic slide ways - Design of antifriction guide ways - Design of spindles and spindle supports - Antifriction bearings - Preloading of antifriction bearings - Sliding bearings - Sleeve bearings - Hydrodynamic journal bearings - Vibrations in machine tools - Effects of vibrations - Sources of vibrations - Analysis of single degree of freedom system - Chatter theory - Regenerative principle - Elimination of vibrations - Damping - Testing of machine tools for alignment and accuracy - Standard test charts.

## **ELECTIVE SUBJECTS**

### **ME521 FINITE ELEMENT METHODS AND APPLICATIONS**

Introduction to FEM - Heat transfer - Coordinates and shape functions - Linear, quadratic, triangular and axisymmetric - Euler-Lagrange equation - Galerkin approach - Assembly of the global stiffness

matrix - Boundary conditions such as convection, radiation, etc. - Unsteady state heat transfer problems using finite difference time stepping techniques, like Euler, Crank-Nicolson's and Implicit methods - Point sources - Torsion of shafts - Solid mechanics - Potential energy approach, Galerkin approach - Finite element equations for one dimensional problems and treatment of boundary conditions - Temperature effects - Plane trusses - Two dimensional problems using constant strain triangles - Beams - Introduction to mass transfer, fluid flow and plate bending - Local coordinate system - Shape functions in local coordinate system and evaluation of element characteristic matrices and element characteristic vectors.

### **ME522 GEOMETRIC MODELING FOR MANUFACTURING**

Geometric representation of curves, surfaces and solids - Machining of freeform surfaces from geometric models - Geometric modeling for die and mold design - Geometric model driven process simulation and process planning - Use of geometric models in inspection of curved geometries and reverse engineering - Realization of freeform solids by layered manufacturing - Computational geometry for manufacturing and inspection.

### **ME523 NON DESTRUCTIVE EVALUATION**

Scope of non-destructive evaluation - Liquid-penetrant and magnetic particle inspection techniques - X-ray and gamma-ray radiography - Ultrasonic inspection: Principle of wave propagation through solids, surface waves, pulse echo technique, A,B and C scans - Eddy current testing - Image sensing through welding arc - Thermal imaging - Image reconstruction - Non-destructive inspection of typical components: Castings, forgings, welded components, brazed and adhesive bonded assemblies.

### **ME524 OPTIMIZATION METHODS FOR ENGINEERS**

Optimization problem formulation - Design variables, constraints, objective functions and variable bounds - Single variable optimization algorithms: Bracketing methods, Exhaustive search method and bounding phase method - Region elimination methods: Fibonacci search and golden search methods, gradient based methods, Newton-Raphson method, bisection method, secant method and cubic search methods - Computer programs for bounding phase method and golden selection search method - Multi-variable optimization algorithms: Direct search method, simplex search method and Hooke-Jeeves pattern search method - Gradient based methods - Cauchy's (steepest descent) method and Newton's method - Constrained optimization algorithms: Kuhn-Tucker conditions - Penalty function method - Method of multipliers - Cutting plane method - Generalized reduced gradient method - Computer program for penalty function method - Integer programming - Penalty function method - Global optimization using steepest descent method, genetic algorithms and simulated annealing.

## **ME525 METROLOGY AND COMPUTER AIDED INSPECTION**

Principles of dimensional and form measurements - Errors in measurement - Linear and angular measurements - Description, merits and demerits of some common types of comparators - Limits, fits and tolerances - Disposition of tolerances and deviations - Gauges and design of gauges - Measurement and evaluation of straightness, flatness and roundness - Introduction to metrology of gears and screw thread: Measurement of gears using constant chord and base tangent methods - Measurement of screw thread using wire methods - Best size wire - Measurement of surface finish: Various parameters - Measuring instruments - Interferometers: Types of light sources - Types of scales and gratings - Optical flats - Use of interferometers for calibration of height standards, etc. - Laser metrology: Laser light source - Laser interferometer - Laser alignment telescope - Laser micrometer - Online and in-process measurements of diameter and surface roughness - Micro-holes and topography measurements - Coordinate measuring machines (CMMs): Types and major elements of CMMs - Hard probing and soft probing - Construction and working of touch trigger probe - CMM software - Performance evaluation - Environmental control - Accuracy enhancement - Applications of CMMs - Image processing: Shape identification - Edge detection techniques - Normalization - Grey scale correlation - Template techniques - Applications of vision systems for the measurement of surface roughness, tool wear, lengths and diameters - Sorting and counting of objects - Interfacing robot and image processing systems - Computer integrated inspection - Statistical evaluation of data using computers - Integration of CMM and data logging in computers.

## **ME526 ADVANCED METAL FORMING TECHNOLOGY**

Elements of theory of plasticity - Formulation of plastic deformation problems and different methods of solution - Applications of upper bound method for solving metal forming problems, such as forging, rolling, extrusion and wire drawing - Slip line theory and its applications - Friction and lubrication in cold and hot working - Advances in sheet metal forming - Concept of formability and its evaluation - Hydro-forming of sheets and tubes - Superplastic forming.

## **ME 527 ADVANCED CAD AND COMPUTATIONAL GEOMETRY**

NURBS (Non-Uniform Rational B-Splines): Definition and properties of NURBS curves and surfaces - Implementations using C++ and OpenGL - Geometric algorithms for knot and degree manipulation, point inversion and projection, transformations and projections, etc. - Applications of NURBS for representation of conic sections - NURBS curve and surface fitting - Shape modification.

Computational geometry: Introduction and applications - Polygon triangulation and partitioning - Convex hulls - Algorithms for generating convex hulls in 2D and 3D - Voronoi diagrams - Delaunay triangulations - Search and intersection algorithms - Motion planning - Some applications of computational geometry in manufacturing and metrology.

## **ME 528 SOFT COMPUTING TECHNIQUES**

Introduction to soft computing - Need for soft computing - Genetic algorithms: Introduction, mathematical foundation, computer implementation, applications - Neural networks: Introduction - Neurons and neural networks - Basic models of neural networks, such as single-layer and multi-layer networks, recurrent networks, radial basis function networks - Training of neural networks and learning paradigms - Fuzzy analysis: Introduction to fuzzy set theory, mathematical foundation, applications - Combined techniques: Genetic algorithms and fuzzy logic, Genetic Algorithms and neural networks, Neural networks and fuzzy logic - Chaos: complexity and simplicity, evolution of possibilities, simple models of chaos, deterministic chaos and self-organization - Applications of soft computing techniques in manufacturing engineering.

## **ME 529 ARTIFICIAL INTELLIGENCE IN MANUFACTURING**

Definitions of intelligence and artificial intelligence - Human mental capabilities: Association, stereotyping, reasoning and vision - Artificial intelligence: Components, scope and application areas - AI languages: Introduction to PROLOG and LISP - Knowledge-based or expert systems: Definition, structure, characterization and justification - Knowledge sources - Expert - Knowledge acquisition and representation - Knowledge base - Inference strategies: Forward and backward chaining - Expert system languages - Expert system building tools or shells - Typical examples of shells - Expert system software for manufacturing applications in CAD, CAPP, MRP, adaptive control, robotics, process control, fault diagnosis, failure analysis, process selection, group technology, etc. - Introduction to artificial neural networks and genetic algorithms - Manufacturing applications of neural networks and genetic algorithms - Case studies of typical applications in tool selection, process selection, part classification, inventory control, process planning, etc.

## **ME 530 DESIGN OF JIGS AND FIXTURES**

Introduction to jigs and fixtures - Need for development of jigs and fixtures - Potential benefits, advantage and limitations of jigs and fixtures - Principles of location - Examples of locations using different types of surfaces - Locating devices - Principles and purposes of clamping - Different types of clamping devices and their merits and demerits - Automatic clamping devices - Design principles common to jigs and fixtures - Design principles specific to jigs and fixtures - Indexing in jigs and fixtures - Drilling jigs: Drill bushes and their design principles - Types of drilling jigs: Template jig, plate type jig, open type jig, swinging leaf jig, box type jig, channel type jig, etc. - Jig feet - Milling fixtures - Essential features of milling fixtures - Milling machine vice - Design principles for milling fixtures - Design of fixtures for grinding, boring, welding, assembly, measurements and inspection, etc. - Development of jigs and fixtures for typical engineering components.

## **ME 531 MICRO AND NANO MANUFACTURING**

An overview of micro and nano mechanical systems and their applications in mechanical engineering - MEMS micro fabrication methods - Silicon micromachining methods - Laser micromachining

methods - Mechanical micromachining techniques - Nano manufacturing methods - CAD/CAM tools for micro and nano manufacturing processes.

### **ME 532 LASER ASSISTED MANUFACTURING**

Laser fundamentals: Spontaneous and stimulated emission or absorption, population inversion and pumping, cavity design, coherence and interference - Common industrial lasers and their output characteristics: CO<sub>2</sub>, Ruby, Nd-YAG, Nd-glass, Excimer and He-Ne - Overview of laser applications in manufacturing: application areas, economics, advantages and disadvantages - Laser processing fundamentals: Beam characteristics, absorption characteristics of materials, heat flow theory and metallurgical considerations - Cutting and drilling: process characteristics, material removal modes, development of theoretical models and practical performance - Welding: Process mechanisms, like keyhole and plasma, development of theoretical models, operating characteristics and process variation - Surface modification: Heat treatment, rapid solidification, alloying and cladding, surface texturing and development of theoretical models - Introduction to interferometry - Working principles of some popular interferometers - Elementary holography - Detection and measurement of radiation - Laser safety.

### **ME 533 FLEXIBLE MANUFACTURING SYSTEMS**

Technology and management - Mid-volume and mid-variety production - CIM - Manufacturing cell - Special manufacturing systems and FMS - FMS benefits - FMS technology - NC, CNC and DNC - Material handling systems - Hierarchical FMS computer networking and control - Automated inspection and storage - Management - Setting goals and objectives - Analysis of products for selecting production techniques - Selection of machine tools - CAPP - Automated material handling and storage - ASRS - Just-in-time - Control system for FMS - MRP II - Production planning, forecasting, scheduling and MPC - FMS cost justification.

### **ME 534 MECHATRONICS**

Introduction to mechatronics - Definition - Mechatronics in manufacturing, products and design - Key elements - Advanced approaches in mechatronics - Basics of fuzzy logic, neural networks and artificial intelligence - Review of electronics fundamentals - Introduction to mechatronics devices - Data conversion devices - Motion and position sensors - Force and tactile sensors - Flow and temperature sensors - Ultrasonic sensors - Range sensors - Vibration control using magneto structure transducers - Fiber optic devices in mechatronics - Signal processing devices - Output devices - Microprocessors and controllers - Actuating devices - DC and AC drives - Stepper motors - Servo motors - Piezoelectric actuators - Mechanical devices, such as ball screws, linear motion bearings, cams, systems controlled by camshafts, indexing mechanisms, hoppers, magazines, chutes and transfer systems - Hydraulic actuators - Design of hydraulic circuits - Pneumatic actuators - Design and selection of actuating devices - Signals, systems and controls - Introduction - System representation - Linearization of non-linear systems - Time delays - Measures of system performance - Root locus and Bode plots - Applications in Mechatronics - Sensors for condition monitoring -

Mechatronic control in automated manufacturing - Artificial intelligence and fuzzy logic applications in mechatronics - Micro sensors and case studies.

### **ME535 PRECISION ENGINEERING**

Concepts of accuracy - Accuracy of machine tools - Spindle and displacement accuracies - Accuracies of NC systems - Numerical interpolation errors - Displacement measurement system and velocity lags - Geometric dimensioning and tolerancing (GD&T) - Tolerance zone conversions - Surface, features and features of size, datum features - Datums - Oddly configured and curved surfaces as datum features - Equalizing datums - Datum feature of size representation - Form and orientation controls - Logical approach to tolerancing - Foundations of nanotechnology and measuring systems - Processing systems for nanometer accuracies - Mechanism of metal processing - Nano physical processing of atomic bit units - Nano chemical and electrochemical atomic bit processing - In-process measurement of position of processing unit - Post process and on-machine measurement of dimensional features and surface mechanical and optical measuring systems - Nano positioning systems - Guide systems for moving elements - Servo control systems for tool positioning - Computer aided digital and ultra-precision position control - Applications and future trends in nano technology - Nano grating systems - Nano lithography, photo lithography and electron beam lithography - Machining of soft metals - Diamond turning - Mirror grinding of ceramics - Development of intelligent products - Nano processing of materials for super high density ICs - Nano mechanical parts and micro-machines.

### **ME536 RAPID PROTOTYPING AND REVERSE ENGINEERING**

Basic principles of RP processes - Classification of RP processes - Various industrial RP systems like stereolithography, fused deposition modeling, selective laser sintering, laminated object manufacturing, 3D printing, ballistic particle modeling, etc. - Role of rapid prototyping and rapid tooling in product development - Process planning for rapid prototyping - STL file generation - Defects in STL files and repairing algorithms - Slicing and various slicing procedures - Accuracy issues in rapid prototyping - Strength of RP parts - Surface roughness problem in rapid prototyping - Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost, etc. - Rapid tooling techniques, such as laminated metallic tooling and direct metal laser sintering - Introduction to reverse engineering - Point cloud data generation methods and processing techniques - Integration of reverse engineering and rapid prototyping.

### **ME537 DESIGN FOR MANUFACTURE AND ASSEMBLY**

An overview of three stages of product design, generating and evaluating conceptual alternatives from manufacturability point of view, selection of materials and processes - Evaluating part configurations for manufacturability - Evaluating parametric mechanical engineering designs for manufacturability - DFM analysis for various manufacturing processes - Product design for manual assembly - Product design for high-speed automatic assembly - Product design for robot assembly.

## **ME538 DESIGN AND ANALYSIS OF EXPERIMENTS**

Overview and basic principles - Simple designs and analysis of variance (ANOVA) - Block designs, Latin squares and related designs - Full factorial designs - 2-level full factorial and fractional factorial designs - Overview of response surface methods and designs - Designs with random factors, nested designs and split plot designs - Examples of scientific and engineering applications - DOE software.

## **ME539 MODERN CASTING PROCESSES**

Process details, ingredients used, process variables and economy of processes using sodium silicate as binder and organic binder processes, e.g. hot box, cold box, ABC, silicate-ester, catalyzed no-bake and warm box - Fluid sand, full mold, magnetic molding, investment casting, frozen mold, vacuum sealed molding, high pressure molding, impact molding, explosion molding and squeeze casting processes - Centrifugal casting and continuous casting processes.

## **ME540 FOUNDRY TOOLING AND METHODING**

Gating - Elements of the gating system - Design of gating system for cast iron and steel - Fluidity and its significance in castings - Riser - Solidification of iron and steel with reference to Fe-C diagram - Riser classification - Design of riser - Methods to achieve directional solidification - Pattern equipment for quality production of castings - Pattern plates - Types and materials used - Design and constructional features suiting to various molding machines - Special design features for high pressure molding machines - Core boxes - Type, materials used, design and constructional features for core blowing and shooting machines - Special features for shell core shooters - Core prints - Gravity die-casting - Die-types and design features - Pressure die-casting - Die-design features.

## **ME541 RELIABILITY ENGINEERING**

Elements of probability - Density and distribution functions for uniform, exponential, Weibull and normal distributions - Reliability definition - Measures of reliability - Failures - Classification of failures - Failure data Analysis - Availability - Criticality matrix - Event tree analysis - Utilization factor - Factors affecting reliability - Analysis of reliability data - Weibull analysis - Design and manufacture for reliability - Reliability of parts and components - Design for system reliability - Economics of standby or redundancy in a production system - System effectiveness mission reliability design adequacy, operational readiness serviceability performance indices, their evaluation, uses and limitations - Reliability models of maintained systems, fundamental definitions, relationship between reliability and maintainability single equipment systems parallel stand by k-out-of-n configuration - Steady state availability - Non-maintained systems - Reliability definition and its importance - Method of improving reliability redundancy techniques - Reliability models - Reliability testing - Types - Maintenance systems and economics of reliability - Maintenance and spares management - Preventive replacement - Condition monitoring and analysis.

## **ME542 ROLLING TECHNOLOGY**

Hot rolling: Types of hot rolled products - Behavior of steels during deformation at elevated temperature - Friction effects - Basic principles of rolling and pass design - Reheating of ingots and conditioning of semi-finished products - Reheat furnaces - Mills for blooming, slabbing and billeting - Mills for bar, rod, structural, tube, plate and hot strips - Rolling of rails, wheels and rings - Cooling and de-scaling of products - Instrumentation and computer control of hot mills - Further processing.

Cold rolling: Various types of cold mills - Components of cold mills - Mill rolls: Lubrication and thermal aspects - Deformation behavior of materials - Torque and load equations - Instrumentation and automatic control of mills - Strip shapes and their measurement and control - Properties of rolled strips and further processing.

Principles of modeling hot and cold rolling processes - Microstructural evolution and control - Galvanizing process and control of coating.

## **ME543 NEAR NET SHAPE PROCESSES**

Concept of shape, size, accuracy, tolerances and surface roughness - Economical and technological factors - Improved material and energy efficiency - Dimensional accuracy, product integrity and reduced manufacturing cost through near net processing - Foundry processes - Shell process, investment casting, ceramic molding, plaster mould process, V-process, squeeze casting, rheo-casting, permanent mould casting, low pressure die casting and pressure die casting processes - Plastic deformation processes - Warm forging, flashless forging, cold forging - Superplastic forming, powder metal forging, liquid forging, rheo-forging and isothermal forging processes - Electro forming - Principles of electro deposition, production of dies and molds by electro-forming.

## **ME544 CONCURRENT ENGINEERING**

Concurrent engineering - Meaning and need - Review of engineering problem solving methods - Description of methods of analysis, decision making, creativity and information processing and their role in engineering - Discussion of emerging engineering strategies of total design - Design for manufacturing and assembly - Quality function deployment - Product information systems and their architecture - Information environment for suppliers, management, testing and inspection, design engineering, purchasing, process control, manufacturing, support plans, operators, quality control, servicing and maintenance - Product information modeling - Integration of information models and end users applications - Computer aided simultaneous engineering systems - Integrated concurrent design and product development - Constraint networks - Integrating concurrent approaches with those of conventional approach - Implementation of concurrent engineering in industrial environment, especially those of IT and high speed computation.

## **ME545 TOOL DESIGN**

Tooling for traditional material removal process: Design of single point turning, parting and boring tools - Design of form tools - Design of internal and external broaches - Design of milling cutter and drill bit of milling cutters - Design of twist drills, reamers and taps - Design of gear cutting tools.

Tooling for CNC machines: Interchangeable tooling system - Preset and qualified tools - Coolant fed tooling system - Modular fixtures - Quick change tooling system - Automatic head changers - Tooling requirements for turning and machining centres - Tool holders - Tool assemblies - Tool magazines - ATC mechanisms - Tool management.

Tooling for automats - Tooling for nontraditional material removal processes - Design of press tools - Tooling for forming processes - Tooling for metal casting and metal joining processes - Design of welding fixtures - Tooling for inspection and gauging - Design and manufacture of gauges - CAD methods in tool design.