C U R R I C U L U M

A N D

S Y L L A B U S

FOR

MASTER OF TECHNOLOGY (M. Tech.)

IN

MANUFACTURING ENGINEERING

(**Operative from 2020 - 21 Session**)

DEPARTMENT OF MANUFACTURING ENGINEERING

NATIONAL INSTITUTE OF FOUNDRY & FORGE TECHNOLOGY

HATIA, RANCHI - 834 003

Credits Requirement for the Award of Degree

Minimum credits needed for the award of M. Tech. degree in Manufacturing Engineering will be 68. The structure of M. Tech. in Manufacturing Engineering shall have the following categories of courses. Audit courses will require a pass and carry no credits.

S#	Category	Letter@3	No. of Subjects	No. of Credits
1	Programme Core (PC)	C/P	10	24
2	Programme Electives (PE)	E	5	15
3	Open Electives (OE)	O	1	3
4	Audit Courses (AU)*	A	3	0
5	Dissertation	D	2	26
		Total	**21**	**68**

* Summer internship of minimum 4 weeks (to be carried out at industries / institutions - IITs, IISc and NITs only / R&D laboratories) is also considered as an audit course.

Course Structure

Semester 1

S#	Code	Name of Subject	L	T	P	Credits
1	MFC511	Manufacturing Science and Engineering I	3	0	0	3
2	MFC512	Advanced Machining and Automation	3	0	0	3
3	---	Programme Elective I	3	0	0	3
4	---	Programme Elective II	3	0	0	3
5	---	Open Elective	3	0	0	3
6	MFP511	Advanced Machining Laboratory	0	0	4	2
7	MFP512	Computer Graphics and CAD Laboratory	0	0	4	2
8	MFC513	Research Methodology and IPR	2	0	0	2
9	---	Audit Course I	2	0	0	0
					Total	21

Semester 2

S#	Code	Name of Subject	L	T	P	Credits
1	MFC521	Manufacturing Science and Engineering II	3	0	0	3
2	MFC522	Advanced Metrology	3	0	0	3
3	---	Programme Elective III	3	0	0	3
4	---	Programme Elective IV	3	0	0	3
5	---	Programme Elective V	3	0	0	3
6	MFP521	Metrology Laboratory	0	0	4	2
7	MFP522	Welding Laboratory	0	0	4	2
8	---	Audit Course II	2	0	0	0
9	MFC523	Mini Project	0	0	4	2
					Total	21

Semester 3

S#	Code	Name of Subject	L	T	P	Credits
3	MFC531	Summer Internship Evaluation	4 Weeks			0
4	MFD531	Dissertation - Phase I	0	0	20	10
					Total	10

Semester 4

S#	Code	Name of Subject	L	T	P	Credits
1	MFD541	Dissertation - Phase II	0	0	32	16
					Total	16

Programme Electives (3 - 0 - 0 = 3 Credits)

Note: Two courses will be simultaneously offered against every programme elective (e.g. Programme Elective I, II, etc.). Half of the total strength will have to opt for each course. If more students opt for a particular course, suitable criteria will be used to achieve balance between the courses.

Semester I

MFE101 Artificial Intelligence in Manufacturing
MFE102 Computational Methods for Engineers
MFE103 Computer Aided Design
MFE104 Computer Aided Manufacturing
MFE105 Design of Machine Tools
MFE106 Finite Element Methods and Applications
MFE107 Laser Assisted Manufacturing
MFE108 Manufacturing Systems Engineering
MFE109 Quality Control and TQM

Semester II

MFE201 Additive Manufacturing
MFE202 Advanced CAD/CAM
MFE203 Advanced Metal Forming
MFE204 Advanced Welding Technology
MFE205 Forging Die Design and Manufacture
MFE206 Foundry Tooling and Methoding
MFE207 Non-destructive Evaluation
MFE208 Optimization Methods for Engineers
MFE209 Reliability Engineering
MFE210 Geometrical Product Specifications
MFE211 Modern Casting Processes
MFE212 Near Net Shape Processes
MFE213 Precision Manufacturing
MFE214 Robotics and Applications

Open Electives (3 - 0 - 0 = 3 Credits)

Note: Only one course will be offered depending the availability of faculty.

MFO531 Advanced Operations Research
MFO532 Data Analytics
MFO533 Design and Analysis of Experiments
MFO534 Facility Layout and Design
MFO535 Knowledge Management for Competitiveness
MFO536 Management Concepts and Techniques

MFO537 Probability and Statistics for Engineers

MFO538 Project Management

MFO539 Supply Chain Management

Audit Courses (2 - 0 - 0 = 0 Credits)

Note: Only one course will be offered in each semester depending the availability of faculty.

Semester I

MFA511 Constitution of India

MFA512 Disaster Management

MFA513 English for Research Paper Writing

MFA514 Environmental Pollution and Control

MFA515 Industrial Psychology

MFA516 Personality Development through Life Enlightenment Skills

Semester II

MFA521 Pedagogy Studies

MFA522 Sanskrit for Technical Knowledge

MFA523 Stress Management by Yoga

MFA524 Engineering Economics

MFA525 Trends in Manufacturing Engineering

MFA526 Value Education

DETAILED SYLLABUS

SECTION 1: PROGRAMME CORE

MFC511 MANUFACTURING SCIENCE AND ENGINEERING I (3 - 0 - 0)

Unit I: Foundry **18 Lectures**

Fluidity and factors effecting fluidity - design of gating systems - gases in metals and alloys - gas porosity and shrinkage phenomena - direction solidification - risering of castings - riser design - mechanism of feeding - method of risering - feeding distance and feeder heads - use of padding, chills and fine inoculation of CI - grain refinement principle - casting defects and remedies.

Unit II: Welding **18 Lectures**

Heat flow of metals - isothermal contours - cooling rate of welds - heat effects in base metal - residual stress and weldability test - TIG, MIG, ultrasonic and laser welding - plasma arc welding - underwater welding - friction welding - electron beam, electro-slag and electro-gas welding - explosive welding.

Unit III: Forging **3 Lectures**

Classification - equipment - forging defects.

Unit IV: Rolling and Extrusion **6 Lectures**

Rolling: classification - equipment - defects - Extrusion: classification - extrusion equipment - extrusion defects.

Unit VI: Sheet Metal Forming **3 Lectures**

Formability of sheets - forming tests - principles of deep drawing - redrawing - ironing and sinking - stretch forming - hydroforming - spinning - bending - forming defects.

Textbooks / References

1) Ghosh, A. and A. K. Mallik, Manufacturing Science, East West Press.
2) Mukherjee, P. C., Fundamentals of Metal Casting Technology, Oxford and IBH Publishers.
3) Rao, P. N., Manufacturing Technology - Vol. I and II, Tata McGraw-Hill Pub.

Course Outcomes

This course provides for an easy understanding various manufacturing processes and their analysis.

MFC512 ADVANCED MACHINING AND AUTOMATION (3 - 0 - 0)

Unit I: **6 Lectures**

Introduction to NC/CNC/DNC - basics elements of CNC - 2-axis, 2½-axis and 3 axis machines - multiple axis machines - conditions where CNC machines are most suitable - economics of CNC machines - part programming for milling (basic): G codes and M codes - 2-axis programming (milling): absolute and incremental programming - G54 and G92 - 2½-axis programming: G02 and G03 programming - cutter radius compensation programming.

Unit II: **6 Lectures**

Part programming for milling (canned cycles): drilling and boring - cutter length compensation - multiple tools - advanced techniques: do and nested do loops - subroutine - mirror image - polar rotation - pocket milling.

Unit III: **14 Lectures**

Part programming for turning - G and M codes: 2-axis programming (turning) - absolute and incremental programming - program for machining of castings - G90 box turning cycle and taper turning cycle - G94 facing cycle and taper turning cycle - G71 multiple turning cycle - G72 multiple facing cycle - G73 pattern repeating cycle - threading cycles and double start thread - peck drilling cycle - grooving cycle - boring, blend radius and chamfer.

Unit IV: **8 Lectures**

APT, freeform curves and surfaces: APT structure - geometric statements - motion commands - processor and post processor - tolerances - freeform curves: cubic splines and Bezier curves - parameterization - introduction to Bezier surfaces - surface interpolation.

Unit V: **6 Lectures**

Adaptive control and flexible fixtures: in-process gauging - in-cycle gauging - near machine offline gauging - tool monitoring - importance of adaptive control - advantages and limitations - ACO, ACC and GAC - flexible fixturing: types, properties, advantages and limitations - examples.

Textbooks / References

1) Fanuc CNC Program Manual.
2) Seames, W., Computer Numerical Control: Concepts and Programming, Delmar Thomson Learning / Cengage Learning.
3) Smid, P., CNC Programming Handbook, 2nd Edition, Industrial Press Inc.

Course Outcomes

After taking this course the students should be able to

1) Understand how CNC Machine may be used to machine parts and when to select CNC machine.
2) Develop CNC program for machining components using CNC turning and milling machines.
3) Develop programs in APT language for machining components using 2½-axis milling machine.
4) Grasp the essence of adaptive control, their types and the way the system works.
5) Understand the needs, uses and different types of flexible fixtures.

MFP511 ADVANCED MACHINING LABORATORY (0 - 0 - 4)

1) To write and verify CNC programs using G & M codes for five components to be produces by milling (use of special features like Do Loop, subroutine, mirror image & polar rotation, pocket milling).
2) To write and verify CNC programs using G & M codes for five components to be produces by turning (use of features like taper turning, multi-start threading, grooving, boring, do loop & subroutine).
3) To write CNC programs using APT for three components to be produces by milling.

MFP512 COMPUTER GRAPHICS AND CAD LABORATORY (0 - 0 - 4)

1) Writing and validation of computer programs for
   a) Line drawing and circle drawing
   b) Geometric transformations for translation, rotation and scaling
   c) Design problems from engineering applications: kinematics analysis, solid mechanics, etc.
   d) FEM (linear bar, quadratic bar and plane truss).
2) Understanding and use of 3D modelling software: part drawing, assembly and drafting.
3) Introduction to MATLAB for basic programming: variables, array, loops and conditional statements.

MFC513 RESEARCH METHODOLOGY AND IPR (2 - 0 - 0)

Unit I: Introduction to Research **5 Lectures**

Meaning of research - scope and objectives of research - motivation in research - types of research - sources of research problem - criteria characteristics of a good research problem - technique involved in defining a problem - errors in selecting a research problem - approaches of investigation of solutions for research problem.

Unit II: Literature Review and Research Design **5 Lectures**

Effective approaches to literature review and analysis - plagiarism - research ethics - research design: meaning of research design - need for research design - features of good design - important concepts relating to research design - different research designs - principles of experimental design - developing a research plan.

Unit III: Processing and Analysis of Data **5 Lectures**

Processing of data: some problems in data processing - analysis of data: elements / types of analysis - statistics in research - measures of central tendency - measures of dispersion - measures of asymmetry (skewness) - measures of relationship - simple regression analysis - multiple correlation and regression partial correlation – association in case of attributes - other measures - summary chart concerning analysis of data.

Unit IV: Interpretation and Documentation **5 Lectures**

Meaning of interpretation - why interpretation? - interpretation techniques - precautions in interpretation - significance of report writing - different steps in report writing - layout of the research report - types of reports - oral presentation - mechanics of writing research reports - effective technical writing: how to and how not to write a research paper - developing a research proposal: format of research proposal - presentation and assessment by a review committee.

Unit V: Intellectual Property Rights **5 Lectures**

Patent rights: the scope of patent rights - licensing and transfer of technology - patent information and databases - geographical indications - nature of intellectual property: patents, designs, trademarks and copyright - process of patenting and development: technological research, innovation, patenting development, grants of patents - patenting under PCT - new developments in IPR.

Textbooks / References

1) Asimov, M., Introduction to design, Prentice Hall, 1962.
2) Goddard, W. and S. Melville, Research methodology: An introduction, JUTA & Co. Ltd., Lansdowne.
3) Halbert, D. J., Resisting intellectual property, Taylor & Francis Ltd., Oxon.
4) Kumar, R., Research methodology: A step-by-step guide for beginners, SAGE Publications Ltd.
5) Merges, R. P., Menell, P. S. and Mark A. Lemley, Intellectual property in new technological age, Clause 8 Publishing, 2018.
6) Panner Selvam, R., Research methodology, Prentice Hall of India, New Delhi, 2004.
7) Ramappa, T., Intellectual property rights under WTO, S. Chand & Co., 2008.
8) Spiegel, M. R., Theory and problem of Statistics, Schaum Publishing Co., New York, 2000.

Course Outcomes

Upon completion of the course, the students will be

1) Understanding of the research problem formulation, literature review, research designs, and analysis and interpretation of data.
2) Acquiring the documentation, presentation, and report writing skills.
3) Aware of research ethics, patenting and IPR.

MFC521 MANUFACTURING SCIENCE AND ENGINEERING II (3 - 0 - 0)

Unit I: Mechanical Processes **8 Lectures**

Abrasive jet machining, water jet machining, abrasive water jet machining, abrasive flow machining, ultrasonic machining and ultrasonic welding: working principles, equipment, process capabilities, applications, advantages and limitations.

Unit II: Chemical and Electrochemical Processes **8 Lectures**

Chemical machining, photo chemical machining, electrochemical machining, drilling, grinding and deburring: working principles, equipment, process capabilities, applications, advantages and limitations.

Unit III: Electro-thermal Processes **8 Lectures**

Electro-discharge machining, Electro-discharge wire cutting or Wire-EDM, Electro-discharge grinding, and Electrochemical discharge grinding: working principles, equipment, process capabilities, applications, advantages and limitations - Electron Beam Machining, Electron Beam welding, Plasma Arc Cutting and Ion Beam Machining.

Unit IV: Laser Processing **8 Lectures**

Process principles - types of laser - equipment - laser processes: drilling, cutting, machining, welding, heat treating and cladding; applications, advantages and limitations.

Unit V: High Energy Rate Forming **8 Lectures**

Electromagnetic forming, explosive forming and electrohydraulic forming: process principles and applications.

Unit VI: Emerging Trends **8 Lectures**

Micro-manufacturing, Micro electromechanical systems (MEMS) and Additive manufacturing.

Textbooks / References

1) Benedict, G. F., Non-traditional Manufacturing Processes, Marcel Dekker Inc.
2) Gibson, L., D. W. Rosen and B. Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.
3) Jain, V. K., Advanced Machining Processes, Allied Publishing Private Ltd.
4) Mahalik, N. P., Micromanufacturing and Nanotechnology, Springer.
5) McGeough, J. A., Advanced Methods of Machining, Chapman & Hall.
6) Mishra, P. K. Nonconventional Machining, Narosa Publishing House.

Course Outcomes

1) Learning about different types of non-conventional machining process and advanced machines.
2) Learning about different types of micro-fabrication methods and other emerging technologies.

MFC522 ADVANCED METROLOGY (3 - 0 - 0)

Unit I: Dimensional and Form Measurements **9 Lectures**

Principles of dimensional and form measurements - standards - measurement errors - uncertainty in measurements - some typical examples of linear and angular measurements - introduction to geometric dimensioning and tolerancing (GD&T) - measurement and evaluation of form tolerances.

Unit II: Metrology of Gears and Screw Threads, and Surface Finish **9 Lectures**

Metrology of gears: measurement of gears using constant chord and base tangent methods - testing of involute form - gear pitch measurements - Metrology of screw threads: measurement of major and minor diameters and thread form - pitch errors - measurement of simple effective diameter using wire methods - Measurement of surface finish: various parameters - measuring instruments - filtering techniques.

Unit III: Interferometry and Laser Metrology **9 Lectures**

Interferometers: types of light sources - scales and gratings - optical flats - use of interferometers for calibration of height standards, etc. - Laser metrology: principles of measurement - laser interferometer - laser alignment telescope - laser micrometer - Online and in-process measurements of diameter and surface roughness - Micro-holes and topography measurements.

Unit IV: Coordinate Measuring Machines (CMMs) **9 Lectures**

Types - major hardware elements - hard probing and soft probing - software - performance evaluation - environmental control - accuracy enhancement - applications.

Unit V: Vision-based Measurements **9 Lectures**

Introduction to image acquisition and processing - shape identification - edge detection - normalization - greyscale correlation - template techniques - applications of vision systems for the measurement of surface roughness, tool wear, lengths and diameters.

Textbooks / References

1) ASTME, Handbook of Industrial Metrology, Prentice-Hall Inc., Englewood Cliffs.
2) Bosch, J. A., Coordinate Measuring Machines and Systems, Marcel Dekker, Inc.
3) Davies, E. R., Machine Vision: Theory, Algorithms, Practicalities, Morgan Kaufmann Publishers, San Francisco.
4) Galyer, J. F. W. and C. R. Shotbolt, Metrology for Engineers, Cassell Publishers, London.
5) Gupta, I. C., A Textbook of Engineering Metrology, Dhanpat Rai Publications, New Delhi.
6) Hume, K. J., Engineering Metrology, Kalyani Publishers, Ludhiana.
7) Meadows, J. D., Geometric Dimensioning and Tolerancing: Applications and Techniques for use in Design, Manufacturing and Inspection, Marcel Dekker, Inc., New York.
8) Relevant Indian and International Standards.
9) Whitehouse, D. J., Surfaces and their Measurement, Hermes Penton Science, London.

Course Outcomes

1) Introduces the basics of dimensional and form measurements, the standards of lengths and angles, and the errors in measurement.
2) Students will become familiar with various form tolerances and their assessment, measurement of gears and screw threads, and measurement of surface finish.
3) Students will become familiar with sophisticated measurement techniques, such as interferometry, coordinate measuring machines, and vision-based measurements.
4) All the above will help the students to perform well in their profession as metrologists.

MFP521 METROLOGY LABORATORY (0 - 0 - 4)

1) Calibration of basic measuring instruments, such as micrometer and vernier calliper
2) Calibration of dial gauges
3) Computational metrology - practice on the evaluation of straightness, roundness and flatness using different algorithms
4) Inspection using vision-based measurements
5) Measurement of angles using sine bar / bevel protractor
6) Measurement of dimensions using LASER
7) Measurement of height using vernier height gauges
8) Measurement of taper angles
9) Measurement of roundness
10) Measurement of screw thread / tool angle by profile projector
11) Measurement of surface texture
12) Measurements by comparison approach
13) Measurements using CMM
14) Measurements using profile projector
15) Straightness measurement using autocollimator

Course Outcomes

The experiments are designed to train the students in traditional as well as advanced measurements of dimensions and surface finish, which will help them to play key roles in inspection rooms.

MFP522 WELDING LABORATORY (0 - 0 - 4)

1) Initiation of welding arc and bead formation, preparation of butt and fillet joint by SMAW, SAW, MIG welding and TIG welding.
2) Preparation of welded joint by gas welding, gas cutting.
3) Preparation of welded joint by spot welding.
4) Mechanical testing of welded joint.
5) Study of microstructure of weldment.

SECTION 2: PROGRAMME ELECTIVES

MFE101 ARTIFICIAL INTELLIGENCE IN MANUFACTURING (3 - 0 - 0)

Unit I: Introduction to Artificial Intelligence (AI) **8 Lectures**

Definitions of intelligence and artificial intelligence - Human mental capabilities: association, stereotyping, reasoning and vision - Artificial intelligence: components, scope and application areas.

Unit II: AI Languages **12 Lectures**

Programming in Prolog.

Unit III: Expert Systems **8 Lectures**

Knowledge-based or expert systems: definition, structure, characterization and justification - Knowledge sources - Expert - Knowledge acquisition and representation - Knowledge base - Interference strategies: forward and backward chaining.

Unit IV: Expert Systems Tools and Applications **8 Lectures**

Expert system languages - Expert system shells: typical examples of shells - CLIPS programming - Expert system software for manufacturing applications in CAD, CAPP, MRP, adaptive control, robotics, process control, fault diagnosis, failure analysis, process selection, group technology, etc.

Unit V: Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms **9 Lectures**

Concepts of artificial neural networks, fuzzy logic and genetic algorithms - Manufacturing applications of neural networks, fuzzy logic and genetic algorithms - Case studies of typical applications in tool selection, process selection, part classification, inventory control, process planning, etc.

Textbooks / References

1) Clocksin, W. F. and C. S. Mellish, Programming in PROLOG, Narosa Publishing House, New Delhi.
2) Giarratano, J. C. and G. D. Riley, Expert Systems - Principles and Programming, Cengage Learning, New Delhi.

3) Padhy, N. P., Artificial Intelligence and Intelligent Systems, Oxford University Press, New Delhi.
4) Rajasekaran, S. and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning Private Limited, New Delhi.

Course Outcomes

1) This course systematically introduces the aspects of artificial intelligence, in the context of manufacturing engineering, which has very good potential in modern industries.
2) The students will become familiar with the tools required for creating artificial intelligence applications in the manufacturing domain.

MFE102 COMPUTATIONAL METHODS FOR ENGINEERS (3 - 0 - 0)

Unit I: **9 Lectures**

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.

Unit II: **9 Lectures**

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

Unit III: **9 Lectures**

Transform techniques: continuous Fourier series - frequency and time domains - Laplace transform - Fourier integral and transform - Discrete Fourier transform (DFT) - Fast Fourier transform (FFT)

Unit IV: **9 Lectures**

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.

Unit V: **9 Lectures**

Statistical methods: statistical representation of data - modelling 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.

Course Outcomes

1) This course systematically introduces the various aspects of computational methods, which are essential for manufacturing engineers.
2) Students will become familiar with tools and techniques needed for solving complex computational problems encountered in the manufacturing domain.

MFE103COMPUTER AIDED DESIGN (3 - 0 - 0)

Unit I: **3 Lectures**

Introduction: introduction to design process and role of computers in the product cycle - definition and scope of CAD.

Unit II: **6 Lectures**

Graphics input devices - cursor control devices - digitizers - image scanner - graphics display devices - cathode ray tube - random and raster scan display - color CRT monitors - direct view storage tubes - flat panel display - hard copy printers and plotters - data base coordinate system.

Unit III: **9 Lectures**

Computer graphics: introduction - transformation of geometric models: translation, scaling, reflection and rotation - homogeneous representation - concatenated transformations - mappings of geometric models - translational mapping - rotational mapping - general mapping - mappings as changes of coordinate system - inverse transformations and mapping.

Unit IV: **9 Lectures**

Output primitives: DDA, Bresenham's mid-point line, circle, ellipse algorithms - wireframe models - analytical and synthetic curves with advantages and disadvantages - comparison with parametric curves - geometric modelling of Hermite cubic spline, Bezier and B-spline curves.

Unit V: **8 Lectures**

Parametric representation of surfaces: plane, ruled, tabulated cylinder, coon patches and surfaces of revolution - solid models: fundamentals of solid modeling - different solid representation schemes: half -spaces - Boundary representation (B-rep) - Constructive Solid Geometry (CSG).

Unit VI: **7 Lectures**

Finite element modeling and analysis: basic concept of the finite element method - comparison of FEM with direct analytical solutions - steps in finite element analysis of physical systems - finite element analysis of 1-D problems like spring, bar, truss and beam elements formulation by direct approach - development of elemental stiffness equations and their assembly, solution and its post processing.

Textbooks / References

1) Banks, J., J. Carson, B. Nelson and D. Nicol, Discrete Event System Simulation.
2) Browne, J. Computer Aided Engineering and Design.
3) Radhakrishnan, P., V. Raju and S. Subramanyam, CAD / CAM / CIM.
4) Rao, P. N., CAD / CAM Principles and Applications, Tata McGraw-Hill.
5) Rogers and Adams, Mathematical Elements for Computer Graphics.
6) Rooney and Steadman, Principles of Computer Aided Design.
7) Zeid, I., CAD / CAM Theory and Practice.

Course Outcomes

At the end of the course, the student will

1) Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
2) Understand 2D, 3D transformations and projection transformations.
3) Get knowledge of various approaches of geometric modeling.
4) Understand mathematical representation of 2D and 3D entities.
5) Understand basic fundamentals of FEM.

MFE104 COMPUTER AIDED MANUFACTURING (3 - 0 - 0)

Unit I: **13 Lectures**

Introduction to production layout, group technology and process planning - variant process planning and generative process planning - flexible manufacturing systems - just-in-time - material requirement planning - MRP II - computer integrated manufacturing.

Unit II: **6 Lectures**

Introduction to NC/CNC/DNC - basics elements of CNC - 2, 2½ and 3-axis machines - multiple axis machines - conditions where CNC machines are most suitable - economics of CNC machines - part programming for milling (basic): G and M codes - 2-axis programming (milling) - absolute and incremental programming - G54 and G92 - 2½-axis programming - G02 and G03 programming - cutter radius compensation programming.

Unit III: **6 Lectures**

Part programming for milling (canned cycles and advanced techniques) - canned cycles: drilling and boring - cutter length compensation - multiple tools - do and nested do loops - subroutines - mirror image - polar rotation - pocket milling.

Unit IV: **10 Lectures**

Part programming for turning: G and M codes - 2-axis programming (turning) - absolute and incremental programming - program for machining of castings - G90 box turning cycle and taper turning cycle - G94 facing cycle and taper turning cycle - G71 multiple turning cycle - G72 multiple facing cycle - G73 pattern repeating cycle - threading cycles and double start thread - peck drilling cycle - grooving cycle - boring.

Unit V: **5 Lectures**

APT, freeform curves and surfaces: APT structure - geometric statements - motion commands - processor and post processor - tolerance - freeform curves: cubic splines and Bezier curves - parameterization - introduction to Bezier surface - surface interpolation.

Textbooks / References

1) Chang, T. C., R. A. Wysk and H. P. Wang, Computer Aided Manufacturing, Prentice Hall.
2) Groover, M. P., Automation, Production Systems, and Computer Integrated Manufacturing, Prentice Hall India.
3) Fanuc CNC Program Manual gcodetraining.

4) Seames, W., Computer Numerical Control: Concepts and Programming, Delmar Thomson Learning / Cengage Learning.
5) Smid, P., CNC Programming Handbook, 2nd Edition, Industrial Press Inc.

Course Outcomes

After taking this course the students should be able to

1) Decide on type of layout to be used.
2) Understand the basic of process planning.
3) Understand the basics of MRP, MRP-II, and the issues involved in FMS and CIM.
4) Develop CNC program for machining components using CNC turning and 2½-axis milling machines.
5) Develop programs in APT language for machining components using 2½-axis milling machine.

MFE105 DESIGN OF MACHINE TOOLS (3 - 0 - 0)

Unit I: **5 Lectures**

Introduction to machine tool drives and mechanisms - general principles of machine tool design - selection of electric motors.

Unit II: **8 Lectures**

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.

Unit III: **8 Lectures**

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 -

Unit IV: **12 Lectures**

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 -

Unit V: **9 Lectures**

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.

Course Outcomes

After taking this course the students will have a clear understanding of

1) Various aspects of design of machine tools, viz. motor selection, transmission systems design, structural design, bearings and their selection, etc.

2) Role of vibrations in the design of machine tools and to contain the vibrations.

MFE106 FINITE ELEMENT METHODS AND APPLICATIONS (3 - 0 - 0)

Unit I: **6 Lectures**

Introduction to finite element method - advantages and limitations - concept of nodes and elements - meshing - generation of equations - assembly - boundary condition and solution through examples - variational method - Euler-Lagrange equation - weighted residual method - weak formulation - Galerkin method.

Unit II: **12 Lectures**

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 - one dimensional mass transfer - torsion of shafts.

Unit III: **10 Lectures**

The potential energy approach - Galerkin approach - finite element equations for one dimensional problems and treatment of boundary conditions in fields, such as solid mechanics, springs, fluids and electrical - temperature effects and multipoint constraints in solid mechanics - two dimensional problems in solid mechanics using constant strain triangles.

Unit IV: **6 Lectures**

Analysis of trusses: skewed support and temperature effects in truss elements - analysis of beams: shear force and bending moment diagrams.

Unit V: **6 Lectures**

Analysis of frames - shape functions in local coordinate system and evaluation of element characteristic matrices and element characteristic vectors - Gaussian quadrature - mapping of master to actual element.

Textbooks / References

1) Logan, D. L., A First Course in the Finite Element Method, 4th Edition, Cengage Learning.
2) Rao, S. S., The Finite Element Method in Engineering, 5th Edition, B&H.
3) Segerlind, L. J., Applied Finite Element Analysis, 2nd Edition, John Wiley and Sons.

Course Outcomes

After taking this course the students should be able to

1) Generate the governing FE equations for systems governed by partial differential equations.
2) Generate models for FE analysis.
3) Use FE method for solving both steady state and transient heat transfer problems, 1D and 2D solid mechanics problems, and truss, beams and frames subjected to different types of loading.

4) Understand the limitations of FE method and possible sources of error.
5) Evaluate and interpret FEA analysis results for design and evaluation purpose.

MFE107 LASER ASSISTED MANUFACTURING (3 - 0 - 0)

Unit I: **9 Lectures**

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_2, Ruby, Nd-YAG, Nd-glass, Excimer and He-Ne.

Unit II: **9 Lectures**

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.

Unit III: **9 Lectures**

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 variations.

Unit IV: **9 Lectures**

Surface modification: heat treatment, rapid solidification, alloying and cladding, surface texturing and development of theoretical models.

Unit V: **9 Lectures**

Introduction to interferometry - working principles of some popular interferometers - elementary holography - detection and measurement of radiation - laser safety.

Course Outcomes

1) Students will have sound knowledge of generation of lasers and their manufacturing applications.
2) Students will acquire the knowledge of surface treatment using lasers.
3) Students will also understand the basics of laser interferometry and its applications.

MFE108 MANUFACTURING SYSTEMS ENGINEERING (3 - 0 - 0)

Unit I: **10 Lectures**

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.

UNIT II: **6 Lectures**

Introduction to just-in-time manufacturing systems - describing three M’s - pull vs. push - types of Kanbans and Kanban planning and control models.

Unit III: **6 Lectures**

Basics of concurrent engineering - understanding the interaction between design and manufacturing - serial engineering vs. concurrent engineering - benefits of concurrent engineering.

Unit IV: **8 Lectures**

Introduction of group technology - coding and classifications - selection of coding systems - examples of coding systems - benefits of group technology.

Unit V: **12 Lectures**

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.

Course Outcomes

1) Students will have sound knowledge of various aspects of manufacturing systems, viz. process planning, group technology, concurrent engineering, just-in-manufacturing, machine cell formation, etc., all of which have relevance in modern manufacturing.
2) Students will also understand the practical aspects of the techniques taught during the course.

MFE109 QUALITY CONTROL AND TQM (3 - 0 - 0)

Unit I: **9 Lectures**

Concepts of quality: Inspection, definition of quality, quality control, cost of quality, value of quality - Statistical quality control (SQC): SQC needs, benefits and limitations - Theory of control charts - control chart for variable - X & R chart - Frequency distribution - Variables and attributes - quality characteristics - control chart for attribution p, np, and c charts - process capability.

Unit II: **8 Lectures**

Quality circle: characteristics of quality circle and the process of operation of quality circle - Quality assurance: quality assurance manual - quality policy, procedure and objectives - Sampling inspection: acceptance sampling - fundamental concepts, O-C curve and its construction - AQL, LTPD, AOQL - sampling plans for single, doubles and multiple sampling plans.

Unit III: **7 Lectures**

Quality philosophies by quality gurus: Juran Trilogy, Deming's 14 Points, P-D-C-A Wheel, Taguchi's philosophy - Design of experiment - Seven QC tool of quality and their applications - Philip Crosby's zero defect - Quality function deployment.

Unit IV **9 Lectures**

TQM definition - implementation of TQM - tools for TQC & 5's TQM - Kaizen: seven types of waste - six sigma concept - six sigma tools - TQM and six sigma - Life cycle approach to quality costs - Prevention, appraisal and failure costs - Introduction to ISO 9000 and ISO 14000 - various models of ISO 9000 and ISO 14000 - benefits of ISO standards.

Unit V: **9 Lectures**

Leadership definitions and concepts - styles of leadership - principle of leadership - role of the leader - quality council - quality statement - customer focus and orientation - customer satisfaction and benefits - customer`s perception of quality - service quality and its dimensions - Reliability: definitions - bathtub curve - FMEA: failures and causes of failures - maintainability and availability - MTBF - benchmarking.

Textbooks / References

1) Besterfield, D. H., C. Besterfield-Michna, G. H. Besterfield and M. Besterfield-Sacre, Total quality management, Pearson Education India.
2) Charantimath, P. M., Total quality management, Pearson Education India.
3) Feigenbaum, A. V., Total quality control, McGraw-Hill Co.
4) Grant, E. L. and R. S. Leavenworth, Statistical quality control, McGraw-Hill Co.
5) Gryna, F. M. and J. M. Juran, Quality planning and analysis, McGraw-Hill Co.
6) Mahajan, M., Statistical quality control, Dhanpat Rai Publication, New Delhi.
7) Montgomery, D. C., Introduction to statistical quality control, John Wiley & Sons.

Course Outcomes

1) Provides an understanding about the principle of quality control and TQM. Besides, it deals with the tools and techniques of quality control and TQM.
2) Also covers the discussion on quality systems, i.e. ISO certifications and standards, documentation etc. Analytical frameworks will be considered in order to develop students' analytical thinking and decision-making skills.

MFE201 ADDITIVE MANUFACTURING (3 - 0 - 0)

Unit I: Introduction **3 Lectures**

Process classification - advantages - additive vs. conventional manufacturing processes - applications.

Unit II: CAD for Additive Manufacturing **4 Lectures**

CAD data formats - data translation - data loss - STL format.

Unit III: Additive Manufacturing Techniques **12 Lectures**

Stereo-lithography, LOM, FDM, SLS, SLM and Binder-jet technology: process, process parameter and process selection for various applications - application domains: aerospace, electronics, healthcare, defence, automotive, construction, food processing and machine tools.

Unit IV: Materials **8 Lectures**

Polymers, metals, non-metals and ceramics - forms of raw materials: liquid, solid, wire and powder - powder preparation and their desired properties - polymers and their properties - support materials.

Unit V: Additive Manufacturing Equipment **10 Lectures**

Process equipment - design and process parameters - governing bonding mechanism - common faults and troubleshooting - process design.

Unit VI: Post-processing **4 Lectures**

Requirements and techniques.

Unit VII: Product Quality **4 Lectures**

Inspection and testing - defects and their causes.

Textbooks / References

1) Chua, C. K. and K. F. Leong, 3D Printing and Rapid Prototyping - Principles and Applications, World Scientific.
2) Gebhardt, A., Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, Hanser Publisher.
3) Gibson, L., D. W. Rosen and B. Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.
4) Lu, L., J. Fuh and Y. S. Wong, Laser-induced Materials and Processes for Rapid Prototyping, Kluwer Academic Press.
5) Majumdar, J. D. and I. Manna, Laser-assisted Fabrication of Materials, Springer.

Course Outcomes

The course is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in Industry 4.0 environment.

MFE202 ADVANCED CAD/CAM (3 - 0 - 0)

Unit I: Introduction **6 Lectures**

Introduction to geometric representation of curves, surfaces and solids - NURBS (Non-Uniform Rational B-Splines): definition and properties of NURBS curves and surfaces.

Unit II: Algorithms for NURBS **10 Lectures**

Geometric algorithms for knot and degree manipulation, point inversion and projection, transformations, etc. - applications of NURBS for representation of conic sections.

Unit III: Fitting Techniques **9 Lectures**

NURBS curve and surface fitting - shape modification.

Unit IV: Computational Geometry **10 Lectures**

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.

Unit V: Applications **10 Lectures**

Machining of freeform surfaces from geometric models: geometric modelling for die and mould 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.

Textbooks / References

1) David F. Rogers, An Introduction to NURBS with Historical Perspective, Morgan Kaufmann.
2) David Solomon, Curves and Surfaces for Computer Graphics, Springer.
3) Frank P. Preparata and Michael I. Shamos, Computational Geometry: An Introduction, Springer.
4) Joseph O'Rourke, J., Computational Geometry in C, Cambridge University Press.
5) Les Piegl and Wayne Tiller, The NURBS Book, Springer.
6) Mark de Berg, Otfried Cheong, Marc van Kreveld and Mark Overmars, Computational Geometry: Algorithms and Applications, Springer.

Course Outcomes

On completion of this course, the students will

1) Have an understanding of NURBS from basics to advanced techniques.
2) Have an understanding of various computational geometry techniques and algorithms.
3) Acquire the knowledge of applications of NURBS and computational geometry in manufacturing.

MFE203 ADVANCED METAL FORMING (3 - 0 - 0)

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.

MFE204 ADVANCED WELDING TECHNOLOGY (3 - 0 - 0)

The welding arc - structure and characteristics of arc - arc welding power sources - requirement, characteristics, AC welding power sources, rectified dc welding power sources, inverter type power sources, pulsed arc welding power sources.

Arc welding consumables - coated electrodes, coding of electrodes, welding rods and wire, welding fluxes, shielding gases.

Metal transfer - forces affecting metal transfer, modes of metal transfer, pulsed GMAW, synergic GMAW

Weldability and weldability tests, weldability of carbon steels, HSLA, cast iron, stainless steels

Heat flow in welding - temperature distribution and cooling rate, heat flow equation.

Basic metallurgy of fusion welds - weld metal zone, fusion boundary zone, heat affected zone, microstructure in weldments.

Welding stresses and distortion – residual stresses, development of residual stresses, methods of relieving welding residual stresses, distortion in welds

Weld defects – classification of defects, arc welding defects, resistance welding defects

Weld joints and weld symbols – types of joints, welding symbols

Weld design – for static loading.

Textbooks / References

1. Welding Processes and Technology Dr. R. S. Parmar
2. Welding Engineering and Technology DR. R. S. Parmar
3. A Textbook of Welding Technology O. P. Khanna

MFE205 FORGING DIE DESIGN AND MANUFACTURE (3 - 0 - 0)

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 - Modelling and analysis of forging process using software.

MFE206 FOUNDRY TOOLING AND METHODING (3 - 0 - 0)

Gating - Elements of the gating system - Design of gating system for cast iron and steel - Fluidity and its significance in castings - Risering - 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 moulding machines - Special design features for high pressure moulding 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.

MFE207 NON-DESTRUCTIVE EVALUATION (3 - 0 - 0)

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.

MFE208 OPTIMIZATION METHODS FOR ENGINEERS (3 - 0 - 0)

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.

MFE209 RELIABILITY ENGINEERING (3 - 0 - 0)

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.

MFE210 GEOMETRICAL PRODUCT SPECIFICATIONS (3 - 0 - 0)

Unit I: Basic Concepts **8 Lectures**

General terms and definitions of geometrical features - General principle of sizes - System of limits and fits - Principles of dimensioning - Introduction to geometric dimensioning and tolerancing (GD&T) - Inspection of dimensional and geometrical deviations - Datums and datum systems.

Unit II: Form and Orientation Tolerances **10 Lectures**

Form tolerances: types, specifications and interpretations - measurement and evaluation of straightness, flatness and roundness - Orientation tolerances: types, specifications and interpretations, and verification of orientation tolerances.

Unit III: Location, Runout and Profile Tolerances **10 Lectures**

Tolerances of location: types, specifications and interpretations - verification techniques - Tolerances of profiles of lines and surfaces with or without datums - Tolerances of runout - Tolerancing of angles and cones.

Unit IV: Surface Roughness **8 Lectures**

Various parameters and their measurements in two dimensions - filtering and filtering techniques - areal parameters.

Unit V: Related Topics **9 Lectures**

Vectorial dimensioning and tolerancing - Statistical tolerancing of mechanical assemblies - Dimensional chains - Measurement uncertainty - Computer-aided tolerancing and verification.

Textbooks / References

1) Drake, P. J., Dimensioning and Tolerance Handbook, McGraw-Hill, Inc., New York.
2) Galyer, J. F. W. and C. R. Shotbolt, Metrology for Engineers, Cassell Publishers, London.
3) Gill, P. S., Geometric Dimensioning and Tolerancing, S. K. Kataria & Sons, New Delhi.
4) Gupta, I. C., A Textbook of Engineering Metrology, Dhanpat Rai Publications, New Delhi.
5) Henzold, G., Handbook of Geometrical Tolerancing: Design, Manufacturing and Inspection, John Wiley & Sons, Chichester.
6) Meadows, J. D., Geometric Dimensioning and Tolerancing: Applications and Techniques for use in Design, Manufacturing and Inspection, Marcel Dekker, Inc., New York.
7) Muralikrishnan, B. and J. Raja, Computational Surface and Roundness Metrology, Springer, USA.
8) Relevant Indian and International Standards.
9) Whitehouse, D. J., Surfaces and their Measurement, Hermes Penton Science, London.

Course Outcomes

1) This course systematically introduces the essentials of the language of geometric dimensioning and tolerancing (GD&T) based on ASME and ISO standards, as well as the essentials of surface roughness measurements in both 2D and 3D including filtering techniques.
2) This course also introduces the related concepts of Vectorial dimensioning and tolerancing, dimensional chains, measurement uncertainty, etc.
3) The knowledge gained by the students by learning the above topics will help them to perform very well in their profession as metrologists as well as product designers.

MFE211 MODERN CASTING PROCESSES (3 - 0 - 0)

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, catalysed no-bake and warm box - Fluid sand, full mould, magnetic moulding, investment casting, frozen mould, vacuum sealed moulding, high pressure moulding, impact moulding, explosion moulding and squeeze casting processes - Centrifugal casting and continuous casting processes.

MFE212 NEAR-NET SHAPE PROCESSES (3 - 0 - 0)

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 moulding, plaster mound process, V-process, squeeze casting, rheo-casting, permanent mound 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 moulds by electro-forming.

MFE213 PRECISION MANUFACTURING (3 - 0 - 0)

Unit I: Concepts of Accuracy **8 Lectures**

Accuracy of machine tools - spindle and displacement accuracies - accuracies of NC systems - numerical interpolation errors - displacement measurement system and velocity lags.

Unit II: Geometric Dimensioning and Tolerancing (GD&T) **12 Lectures**

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.

Unit III: Processing Systems **8 Lectures**

Processing systems for nanometer accuracies - mechanism of metal processing - nano physical processing of atomic bit units - nano chemical and electrochemical atomic bit processing.

Unit IV: Measuring Systems **9 Lectures**

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.

Unit V: Applications and Future Trends **8 Lectures**

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 - nano-mechanical parts and micro-machines.

Textbooks / References

1) Gill, P. S., Geometric Dimensioning and Tolerancing, S. K. Kataria & Sons, New Delhi.
2) Meadows, J. D., Geometric Dimensioning and Tolerancing: Applications and Techniques for use in Design, Manufacturing and Inspection, Marcel Dekker, Inc., New York.
3) Murty, R. L., Precision Engineering in Manufacturing, New Age International (P) Limited, New Delhi.
4) Norio Taniguchi, Nanotechnology, Oxford University Press, New Delhi.
5) Relevant Indian and International Standards.

Course Outcomes

1) This course introduces the elements of precision engineering, the basics of geometric dimensioning and tolerancing (GD&T) based on ASME and ISO standards, and processing and measuring systems at nano levels. All these form the essential knowledge required for advanced manufacturing.
2) The knowledge gained by the students by learning the above topics will help them to pursue career in research and the development of products and processes at nano levels.

MFE214 ROBOTICS AND APPLICATIONS (3 - 0 - 0)

Fundamentals of robotics: wrists design, end effectors, actuators and modular robots - Robotic peripherals: sensors, machine vision, and image processing and analysis - Applications of AI tools - Voice communication - Robotic control units: motion controls - Robot kinematics: homogenous transformations and forward and inverse kinematics - Problems of dynamics - Differential relationships - Motion trajectories - Dynamics of a robot control of single and multiple link robots - Static force analysis - Robot programming: different languages - Expert systems - Applications of robots in manufacturing, material handling and inspection - Robot cell design and control - Cooperative robots - Recent development and special applications.