I SEMESTER

15PP01 STATISTICS, QUALITY CONTROL AND RELIABILITY ENGINEERING

2 2 0 3

SAMPLING CONCEPTS: Lot-by-Lot acceptance sampling for attributes – acceptance sampling problem, single sampling plans for attributes, double, multiple and sequential sampling plan, chain sampling, continuous sampling, skip-lot sampling plans. (5+5)

ONE FACTOR EXPERIMENTS: Analysis of variance technique – strategy of experimental design, one-way analysis of variance, completely randomized design, randomized complete block design. (3+3)

STATISTICAL QUALITY CONTROL: Methods and philosophy of statistical process control – Introduction – chance and assignable causes of quality variation, statistical basis of control charts, control charts for variables, control charts for attributes. (4+4)

RELIABILITY: Definition of reliability – reliability vs quality, the failure distribution, the reliability function, mean time to failure, Hazard rate function, bathtub curve, conditional reliability - constant failure rate model - time-dependent failure models - exponential, Weibull and normal distribution. (3+3)

RELIABILITY OF SYSTEMS AND PHYSICAL RELIABILITY MODELS: Serial configuration, parallel configuration, combined series parallel systems, system structure function, minimal cuts and minimal paths – load sharing systems – standby systems – degraded systems, three state devices – physical reliability models - covariate models, static models , dynamic models, physics of failure models. (5+5)

DESIGN FOR RELIABILITY, MAINTAINABILITY AND AVAILABILITY: Reliability specification and system measurements - reliability allocation - design methods – failure analysis – system safety and fault tree analysis – analysis of down time – the repair time distribution, reliability under preventive maintenance, maintenance requirements, availability concepts and definitions, system availability. (6+6)

THE ANALYSIS OF FAILURE DATA AND RELIABILITY TESTING: Data collection – empirical methods, ungrouped and grouped complete data, ungrouped and grouped censored data – static life estimation – test time calculation, burn in testing, acceptance testing. (4+4)

Total L: 30 + T: 30 = 60

REFERENCES:

1. Ronald E Walpole, Raymond H Myers, Sharon L Myers and Keying Ye, “Probability and Statistics for Engineers and Scientists”, Pearson Education, New Delhi, 2007.
2. Douglas C Montgomery, “Introduction to Statistical Quality Control”, John Wiley & Sons, New York, 2009.
3. Dale H Besterfield, “Quality Control”, Pearson Education, New Delhi, 2008.
4. Charles E Ebeling, “An Introduction to Reliability and Maintainability Engineering”, Tata McGraw Hill, New Delhi, 2009.
5. Trivedi K S, “Probability and Statistics with Reliability, Queueing and Computer Science Applications”, Prentice Hall, New Delhi, 2008.
6. Amitava Mitra, “Fundamentals of Quality Control and Improvement”, John Wiley and Sons, New Jersey, 2008.

15PP02 ADVANCED MANUFACTURING PROCESSES

3 0 0 3

ADVANCED CASTING PROCESSESES: Expendable-Mold - shell mould casting, Vacuum Mould casing, investment casting, plaster-mold and ceramic-mold casting, Permanent-Mold casting processes - squeeze casting and semisolid metal casting, centrifugal casting, uses of Rapid Prototyping to produce pattern, process selection - dimensional tolerances for various casting processes and metals. (6)

ADVANCED WELDING PROCESSES: Electron beam welding, laser beam welding, Solid-State welding - diffusion welding, friction welding, ultrasonic welding, physics of welding, design considerations in welding, NDT methods for testing. (6)

ADVANCED FORMING PROCESSES: Material behavior in metal forming, temperature in metal forming, strain rate sensitivity, friction and lubrication in metal forming, bulk deformation processes, sheet metalworking, HERF, hydro forming, explosive forming, magnetic forming process. (6)

HIGH-SPEED MACHINING: High-Speed machining centers, high-speed spindles, spindle sped, feed rate, cutting velocity, surface finish, selection of process parameters, ultra-high-speed machining centers, hard machining. (6)

APPLICATION OF CAE IN MANUFACTURING: Need for CAE in manufacturing, simulation of molten metal flow using CAE Techniques, solidification process in casting, inspections of casting. Thermal analysis of Heat-Affected Zone (HAZ), analysis of forging process using CAE, CL data generation for machining process. (8)

POWDER METALLURGY: Introduction, sintering, hot isostatic pressing, materials and products for powder metallurgy, design considerations in powder metallurgy, Rapid prototyping – metals – Selective Laser Sintering techniques. (4)

PROCESSING OF PLASTICS AND COMPOSITES: Classification, binders, applications, manufacturing of plastic products by different processes like injection moulding, transfer moulding, blow moulding, expansion moulding, Fabrication of Particulate Composites Fabrication of Laminar Composites Fabrication of Fiber-Reinforced Composites.. (5)

MANUFACTURING SYSTEMS: Automation technologies for manufacturing systems, integrated manufacturing systems - cellular manufacturing, flexible manufacturing systems, group technology, robotics. (4)

Total L: 45

REFERENCES:

1. Mikell P Grover "Principles of Modern Manufacturing (SI Version)" John Wiley & Sons, 2014.
2. Paul DeGarmo E, Black J T and Ronald A Kohjer, "Materials and Processes in Manufacturing, John Wiley India, 2011.
3. Philip F Ostwald and Jairo Munoz, "Manufacturing Processes and Systems" John Wiley India, New Delhi, 2013.
4. Kaushish J P, "Manufacturing Processes", Prentice Hall India, 2013.
5. Sanjay K Mazumdar, "Composite Manufacturing: Materials, Product and Process Engineering", CRC Press, 2010.
6. Claudio R Boer, Hans A B Rydstad and Ginther Schroder, "Process Modelling of Metal Forming and Thermo Mechanical Treatment", BBC Brown, Borern & Company Limited, Research Centre, Springer Verlag, New York, 2011.

15PP03 / 15PD03 MATERIALS SELECTION AND METALLURGY

3 0 0 3

CLASSIFICATION OF MATERIALS: Metals, ceramics, glasses, elastomers, polymers, composites, smart materials, material science tetrahedron. (3)

MATERIAL AND ALLOY SELECTION: Selection strategy, property limits and material indices, function objectives and constants, performance maximizing criteria, strengthening mechanisms. Material property charts: Modulus - density, strength - density, modulus - strength, specific stiffness - specific strength, fracture toughness etc. Materials selection- case studies. (3)

SELECTION OF MATERIALS AND SHAPE: Shape factors, elastic bending and twisting, failure in bending and twisting, axial loading and column buckling, efficiency of standard sections, limits for shape factors, microscopic shape and shape factors. Case studies on co-selection of materials and shape. (4)

PLASTIC DEFORMATION & STRENGTHENING MECHANISMS: Dislocations, theoretical cohesive strength, deformation by slip, critical resolved shear stress, Strain hardening of single crystals. Cold working, Grain size control, precipitation hardening, martensitic strengthening, dispersion hardening. (7)

MECHANICAL BEHAVIOR: Engineering stress - strain curve and true stress - strain curve, tensile properties, S - N curve, fatigue testing, factors affecting fatigue properties, structural features of fatigue failures, statistical nature of fatigue, low and high cycle fatigue. Impact test - Izod and Charpy tests, significance of transition - temperature curve, DBTT, factors affecting transition temperature, types of fracture, Griffith's theory of brittle fracture, size effect, effect of temperature, stress raisers and strain rate on fracture behavior. (10)

FERROUS AND NON FERROUS ALLOYS: Types of cast irons, properties, structures, compositions and applications, plain carbon steels, low alloy steels and effects of alloying elements in steel and cast iron, high alloy steels, stainless steels, tool steels, manganese steels, heat resistant steels, HSLA, UHSLA, Dual phase steels, TRIP and IF steels, maraging steels. Alloys of aluminium, copper, nickel, magnesium, titanium, lead, tin and zinc - compositions, heat treatments, structures, properties and applications. (9)

SUPER ALLOYS: Fe base, Ni base, Co base, ODS super alloys. (5)

CHARACTERIZATION OF MATERIALS: X-ray diffraction, SEM, TEM - crystal structure and phase identification, residual stress measurement, thermal analysis, fractography. (4)

Total L: 45

REFERENCES:

1. Courtney T H, "Mechanical Behavior of Materials", Overseas Press (India) Private Limited, 2006.
2. Vijendra Singh, "Physical Metallurgy", Standard Publishers Distributors, 2005.
3. Michael F Ashby, "Materials Selection in Mechanical Design", Butterworth Heinemann, 2005.
4. Meyers M A and Chawla K K, "Mechanical Behavior of Materials", Prentice-Hall International Inc, Upper Saddle River, New Jersey, 1999.
5. William D Callister, "Material Science and Engineering", John Wiley & Sons Inc, 1997.
6. Polmear I J, "Light Alloys", Arnold Publishers, 1995.
7. Hertzberg R W, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley & Sons, 1994.
8. Guy A G," Elements of Physical Metallurgy", Oxford & IBH Pub. Co., New Delhi, 1990.
9. Hayden W, Moffatt W G and Wulff J, "Structure and Properties of Materials, Volume: III: Mechanical Behavior", Fifth Reprint, Wiley Eastern Limited, New Delhi 1986.
10. Brick, Pense and Gordon, "Structure and Properties of Engineering Alloys", McGraw Hill, 1978.

15PP04 GEOMETRIC MODELING FOR MANUFACTURING

3 2 0 4

INTRODUCTION: Definition, Introduction to C graphics, Mathematical foundations (linear algebra, geometry, transformations, set theory) (6)

COMPUTER GRAPHICS: Graphical models, surface models, Solid models, Representations of rigid solids. (8)

FEATURE BASED MODELING: Role of features in design and manufacturing, Feature - properties, modeling, validation and mapping. Feature creation techniques. (7)

FEATURES IN MANUFACTURING: Introduction to manufacturing features, generation of manufacturing features, Issues and alternate approaches, case studies. (8)

DESIGN BY FEATURES: Architectural framework, Procedural and Declarative techniques, part and part family modeling. (8)

FEATURE-BASED PROCESS PLANNING: Feature extraction, Recognizing manufacturing features and feature topologies, automated process planning. Case studies (8)

TUTORIAL COMPONENT: (30)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Ibrahim Zeid and Sivasubramanian R, “CAD/CAM: Theory & Practice”, Tata McGraw Hill, 2009.
2. Agoston and Max K, “Computer Graphics & Geometric Modeling”, Springer-Verlag London Limited, 2005.
3. Gerald Farin, “Curves and Surfaces for CAGD - A Practical Guide”, Morgan-Kaufmann, 2002.
4. Shah J J and Mantyla M, “Parametric and Feature-based CAD/CAM”, John Wiley & Sons, New York, 1995.

15PP05 / 15PD05 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 2 0 4

DFM APPROACH: DFM approach, guidelines, standardization - comparison of materials on cost basis, design for assembly, DFA index, poka-yoke, lean principles, six sigma concepts. (2)

TOLERANCE ANALYSIS: Cumulative effect of tolerances - Worst case method, root sum square method, dimensions following truncated normal distributions, Monte Carlo simulation. Tolerance synthesis, non linear tolerance tolerance analysis, tolerance cost relationships. Process capability, mean, variance, C_p, C_{pk}, cost aspects, feature tolerances, geometric tolerances - ISO standards - surface finish, review of relationship between attainable tolerance grades and different machining and sheet metal processes. (9)

GEOMETRIC DIMENSIONING AND TOLERANCING: Introduction to GD&T, ASME Y 14.5 standard - Examples for application of geometric tolerances - True Position Theory - Comparison between co-ordinate and convention method of feature location, tolerancing and true position tolerancing, virtual size concept, floating and fixed fasteners, projected tolerance zone, zero true position tolerance, functional gauges, paper layout gauging, compound assembly, examples. Datums, datum feature, simulate datum feature, datum targets - Grouped datum system with spigot and recess, pin and hole - computation of translational and rotational accuracy, geometric analysis and applications. (13)

SELECTIVE ASSEMBLY: Interchangeable part manufacture and selective assembly, deciding the number of groups - Model-I: Group tolerances of mating parts equal; Model-II: total and group tolerances of shaft equal. Control of axial play - introducing secondary machining operations, laminated shims, examples. (6)

FORM DESIGN OF CASTINGS AND WELDMENTS: Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, form design aspects of sheet metal components. (6)

TOLERANCE CHARTING: Operation sequence for typical shaft type of components. Preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples. (8)

DESIGN FOR THE ENVIRONMENT: Introduction - Environmental objectives - Global issues - Regional and local issues - Basic DFE methods - Design guide lines - Example application. (1)

TUTORIAL COMPONENT: (30)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Basem said El-Haik, “Axiomatic Quality”, John Wiley and Sons, 2005.
2. Micheal Wader, “Lean Tools: A Pocket Guide to Implementing Lean Practices”, Productivity and Quality Publishing Private Limited, 2002.

3. Fixel J, “Design for the Environment” McGraw Hill, 1996.
4. Graedel T Allen By B, “Design for the Environment Angle Wood Cliff”, Prentice Hall. Reason Pub., 1996.
5. Poka - Yoke, “Improving Product Quality by Preventing Defects”, Productivity Press, 1992.
6. Trucks H E, “Design for Economic Production”, Society of Manufacturing Engineers, Michigan, 1987.
7. Spotts M F, “Dimensioning and Tolerance for Quantity Production”, Prentice Hall Inc., 1983.
8. James G Bralla, “Hand Book of Product Design for Manufacturing”, McGraw Hill Publications, 1983.
9. Harry Peck, “Designing for Manufacture”, Pitman Publications, 1983.
10. Oliver R Wade, “Tolerance Control in Design and Manufacturing”, Industrial Press Inc., 1967.

15PP55 / 15PD55 / 15PM55 OBJECT COMPUTING AND DATA STRUCTURES LABORATORY

0 0 4 2

Object Computing (Using C++):

Implementation of the following problems:

1. Creation of class and objects.
2. Implementation of array of objects and dynamic objects.
3. Simple Arithmetic operations.
4. Implementation of Static members.
5. Implementation of different types of functions.
6. Creation of derived class and implementation of different visibilities and access specifiers.
7. Implementation of virtual classes and virtual functions
8. Overloading operators.
9. Overloading stream operators and creation of user manipulators.
10. Usage of file stream.

Data Structures (Using C or C++):

1. Program using arrays.
2. Representation of Sparse & dense Matrix using arrays.
3. Implementation of Stacks using array.
4. Application of Stack: Conversion of infix to postfix expression
5. Implementation of queue using array.
6. Implementation of Linked Lists: Singly linked, doubly linked and Circular lists and applications.
7. Implementation of various sorting algorithms.

Total P: 60

REFERENCES:

1. Harvey M Deitel,and Paul J Deitel, “C++ How to Program”, Prentice Hall, New Delhi, 2010.
2. Herbert Schildt, “C++ - The Complete Reference", Tata McGraw Hill, New Delhi, 2012.
3. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2005.
4. Aaron M Tanenbaum, Moshe J Augenstein and Yedidyah Langsam, "Data structures using C and C++", Pearson Education, New Delhi, 2009.
5. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C”, Pearson Education, New Delhi, 2007.
6. Robert L Kruse, Bruce P Leung and Clovin L Tondo, “Data Structures and Program Design in C”, Pearson Education, New Delhi, 2009.

15PP61 INDUSTRY VISIT & TECHNICAL SEMINAR

0 0 2 1

Every candidate shall make a technical presentation on an appropriate topic allotted by the department and submit a report on dates announced by the department. The seminar and the report will be evaluated by a review committee constituted by the HoD.

A minimum of two industrial visits are to be arranged as part of the course and the candidates are expected to make a presentation of their learnings in the industrial visit. There will be a viva-voce examination on the dates announced by the department to verify the depth of understanding of the candidate in both the industrial visits and the technical topic.

Total P: 30

II SEMESTER

15PP06 / 15PD08 ENGINEERING ECONOMICS

3 0 0 3

INTRODUCTION: Present economic policy, liberalization, privatization, globalization, scope for industrial growth, Interest and time value of money, cash-flow diagram, simple interest, compound interest, single payments, uniform series payments, interest factors and interest tables, nominal and effective interest rates, continuous compounding, uniform continuous payments. (5)

METHODS FOR EVALUATION OF TANGIBLE ALTERNATIVES: Present worth comparison - equal, unequal lived assets, study period, assets with infinite life, capitalized cost, bond valuation. Equivalent uniform annual cost comparison, situations for EUAC, rate of return comparisons - IRR - MARR - IRR misconceptions. (6)

REPLACEMENT ANALYSIS: Review of conventional approach, group replacement, analysis with time value accounting, replacement due to deterioration, obsolescence, inadequacy, economic life for cyclic replacements, current salvage value of the defender, defender and challenger with different lives, additional one year assessment. (5)

PROJECT FEASIBILITY ANALYSIS: Case study, report preparation. Depreciation, reasons, depreciation accounts, causes of declining value, depreciation methods. Cost, volume, profit analysis: review of conventional approach, analysis with time value, linear, non-linear, multi product break even analysis. Review of project management, PERT - CPM, crashing, cost system. (6)

PRODUCT COSTING: Cost structure of a product - direct, indirect cost - overheads - factory, administrative, selling and distribution overheads - absorption - target costing. (3)

MARKETING FEASIBILITY: Types of market, identification of investment opportunities, market and demand analysis, forecasting demand (review), forecast control, secondary sources of information. (5)

TECHNICAL FEASIBILITY: QFD, Product design, concept of concurrent engineering; plant design, make vs buy decisions; value analysis, FAST approach. (6)

FINANCIAL FEASIBILITY: Means of financing, financial institutions, all India, state level; profitability, cash flows of a project, financial leverage of a business. Tax factors in investment analysis, effects of inflation in economic analysis. (5)

RISK AND MULTI STAGE SEQUENTIAL DECISION ANALYSIS: Recognising risk, including risk in economic analysis, expected value, payoff table, decision tree, discounted decision tree. (4)

Total L: 45

REFERENCES:

1. James L Riggs, David D Bedworth and Sabah U Randhawa, “Engineering Economics”, McGraw Hill Book Company, 2010.
2. Prasanna Chandra, “Projects - Preparation, Appraisal and Implementation”, Tata McGraw Hill, 2010.
3. John A White et al, “Principles of Engineering Economic Analysis”, John Wiley and Sons, 2008.
4. Leland T Blank and Anthony J Tarquin, “Engineering Economy”, McGraw Hill Book Company, 2008.
5. William G Sullivan et al. “Engineering Economy”, Pearson Education Inc., 2006.

15PP07 FINITE ELEMENT APPLICATIONS IN MANUFACTURING

3 2 0 4

INTRODUCTION: Review of near net shape manufacturing processes, material removal processes, bulk manufacturing processes, joining processes, tooling, significant process variables, influence on cost and quality, Need for FEA in manufacturing. (6)

MATHEMATICAL MODELING OF BASIC MANUFACTURING PROBLEMS: General governing equations for Metal forming, metal casting and welding problems, boundary and initial conditions and their physical meaning. (6)

INTRODUCTION TO FINITE ELEMENT ANALYSIS: Review of numerical methods to solve PDEs, introduction to variational calculus, plane stress and plane strain models in manufacturing problems, concept of elements, 1D, 2D and 3D models element connectivity, shape functions, stiffness matrix - for metal forming problems and heat transfer problems. (10)

FEA OF METAL FORMING PROBLEMS: Modeling of forging process, derivation of governing equation and boundary conditions, Computer implementation, Interpretation of results, extending this model to other metal forming problems. (8)

FEA OF METAL CASTING PROCESSES: Mathematical modelling of solidification processing, boundary conditions and initial conditions - solutions by FEA - simple case studies on sand casting and die casting, Problem solving using CAE packages and softwares used in foundries - interpretation of results. (9)

FEA OF WELDING PROCESSES: Mathematical model for manual metal arc welding, moving heat source, boundary conditions,

solutions by FEA using CAE software, interpretation of results. (6)

TUTORIAL COMPONENT: (30)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Reddy J N, “Introduction to Finite Element Method”, Tata McGraw Hill, New Delhi, 2012.
2. Sindo Kou, “Transport Phenomena and Materials Processing”, John Wiley & Sons Inc., New York, 1996.
3. Edward R Champion, “Finite Element Analysis in Manufacturing Engineering”, McGraw Hill, New York, 1992.
4. Shiro Kobayashi, Soo Ikoh and Taylan Altan, “Metal Forming and the Finite Element Method”, Oxford and IBH Publishing, New Delhi, 1989.
5. Claudio R Boer, Hans A B Rydstad and Ginther Schroder, “Process Modelling of Metal Forming and Thermo Mechanical Treatment”, BBC Brown, Borern & Company Limited, Research Centre, Springer Verlag, New York, 1986.
6. Owen D R J and Himton E, “Finite Elements in Plasticity, Theory and Practice”, Pinevidge Press Limited, UK, 1980.
7. Moldflow, C-Mold and Procast Manuals.

15PP08 ADVANCED METROLOGY

3 0 0 3

CALIBRATION: Introduction to measurement, measurement principle, measurement method, measuring system, reference material, certified reference material (CRM), categories of metrology. Calibration, purpose, importance of calibration, environmental conditions required for calibration, care in calibration, calibration methodologies, calibration procedure, traceabilty aspects in calibration, calibration procedure for vernier caliper and micrometer. (7)

UNCERTAINTY MEASUREMENT: Definition, importance, evaluation of uncertainty of measurement type-A and type-B, one-tenth uncertainty rules, examples, evaluation of uncertainties (Type-A and Type-B) in micrometer, evaluation of uncertainty in slip gauge calibration . (7)

CO-ORDINATE MEASURING MACHINE AND NON-CONTACT MEASUREMENT SYSTEM: Need, merits and demerits of CMM, types - manual CMMs, CNC CMMs, multi-sensor CMMs, CMM software, modes of operation, types of probes, portable CMMs. Machine Vision system - need, system functions, image processing, need of algorithms in image processing, applications of machine vision system. (7)

LASER METROLOGY: Interferometry, applications of interferometry, methods of interferometry, Michelson’s Interferometer, N.P.L flatness Interferometer, Zeiss interferometer, Twyman-Green interferometer, sources of errors, corrections to be made, laser spectroscopy, laser holography, alignment telescope, machine tool alignment. (7)

COMPUTATIONAL METROLOGY: Introduction to computational metrology, mathematical representation of geometric elements such as line, plane, circle, cylinder and cone etc., geometric data fitting criteria-least sum of distances fitting, total least squares fitting, two sided minimax fitting, one sided minimax fitting, smallest circumscribed fitting and largest inscribed fitting, minimum tolerance calculation and the need for algorithms, straightness and flatness tolerance zone, circularity tolerance zone, cylindricity tolerance zone. (10)

MICRO AND NANO METROLOGY: Introduction, scanning electron microscopy, optical microscopy, scanning white light interferometry, confocal laser scanning microscopy, fringe projection microscopy, scanning probe microscopy, computed tomography, digital volumetric imaging, molecular measuring machine, microfabricated scanning grating interferometry (µSGI), autofocussing probing, scanning laser Doppler vibrometry (LDV), digital holographic microscope systems, micro coordinate measuring machines (µCMM). (7)

Total L: 45

REFERENCES:

1. Paolo Fornasini, “The Uncertainty in Physical Measurements”, Springer, 2008.
2. Les Kirkup and Bob Frenkel, “An introduction to Uncertainty in Measurement”, Cambridge University Press, 2006.
3. Connie Dotson and Roger Harlow, “Fundamentals of Dimensional Metrology”, Thomson Learning Publishers, New York, 2003.
4. Galyer J F W and Shotbolt C R, “Metrology for Engineers”, Cassel and Company Publishers, London, 1990.
5. Hume K J and Sharp G H, “Practical Metrology”, MacDonald & Co. (Publishers) Ltd., London, 1965.
6. Hume K J, “Engineering Metrology”, MacDonald & Co. (Publishers) Ltd., London, 1963.
7. Parsons S H J, “Metrology and Gauging”, Macmillan Company Publishers, London, 1960.

15PP09 AUTOMATION IN MANUFACTURING

2 2 0 3

INTRODUCTION: Historical perspective of industrial automation - Origin - Evolution, current and future trends - Components of industrial automation systems and their functionalities, soft and hard automation. (2)

SENSORS: Sensors and transducers, contact and non contact sensing proximity sensors, vision sensors, application case studies. Photo electric - Inductive, capacitive - Application profile of digital sensor and analysis of different applications - Fiber optic sensors - Laser sensors - Intelligent sensors - Networking of sensors for manufacturing automation - sensors for diagnostics and analysis. (8)

MANUFACTURING AUTOMATION: Automated flow lines, buffers, part feeding systems, quantitative analysis of transfer lines and assembly systems. Material handling - AGV, AS/RS. Automated inspection. (6)

CONTROLLERS FOR INDUSTRIAL AUTOMATION: Programmable Logic Controllers - Evolution - Architecture - Scanning principle - different types of I/O modules - Interfacing real world devices with PLC - Communication possibilities - Software development: Features, different methodologies and strategies adopted for logic development.Basics of HMI and SCADA systems. (8)

NETWORK INTEGRATION: Network communication, network architecture and protocols, interconnection devices, routers, bridges, gateways, network performance analysis, database management system, database linkages, framework for enterprise-wide integration, illustration of integration concepts. (4)

MODULAR PRODUCTION SYSTEMS: Introduction - elements of MPS - need for MPS - benefits and case studies. (2)

TUTORIAL COMPONENT: (30)

Total: L: 30 + T: 30 = 60

REFERENCES:

1. Bolton W, “Mechatronics”, Pearson Education Asia, New Delhi, 2010.
2. Mikell P Groover, “Automation, Production Systems and Computer-Integrated Manufacturing”, Prentice Hall, 2007.
3. Charles H Roth Jr, “Fundamentals of Logic Design”, Jaico Publishing House, 2007.
4. Frank D Petruzella, “Programmable Logic Controllers”, McGraw Hill Book Company, 1997.
5. Nanua Singh, “Systems Approach to Computer-Integrated Design and Manufacturing”, John Wiley & Sons, 1996.
6. Boucher T O, “Computer Automation in Manufacturing: An Introduction”, Chapman and Hall, 1996.
7. Sabrie Soloman, “Sensors and Control Systems in Manufacturing”, McGraw Hill, 1994.

15PP10 COMPUTER NUMERICAL CONTROL

3 2 0 4

OVERVIEW OF MACHINE TOOLS: Types of CNC machines - general purpose - special purpose, multitask machines, construction / operation, tools, insert, holder, ISO designation. (4)

CNC TURNING CENTRE: Constructional features - structures, guide/slide ways, ball screws - backlash, double nut, variable pitch, gothic arc, guideways, dovetail, LM guideway, turret, curvic coupling, spindle, bearings, work holding, hydraulic chuck, power pack, pumps, valves, types, tailstock working, circuit. (8)

CONTROL SYSTEM: Electrical switchgear items - MCB, limit switch, encoder, feedback devices, servo motor, feed drives, spindle drives, control system, block processing. (3)

PART PROGRAMMING: Interpolators, ISO and EIA standards, G and M codes, absolute, incremental positioning, canned cycles, turning, facing, grooving, threading, work datum, home position, tool offset, programming simple components, shaft, pin, industrial components housing, brake drum. (8)

CNC MACHINING CENTRE: Constructional features, automatic tool changer, tool magazine, types, drum, chain, automatic pallet changer, spindle, nose types, capacity, tool holder, hydraulic power pack, actuators, pumps, valves, machine specification. (5)

MACHINING CENTRE PROGRAMMING: Types of compensation, cutter radius compensation, tool length offset, canned cycle, programming simple profile, pocket milling, automobile components, engine block, dry run. (5)

PROGRAMMING USING CAM: Component modeling, machine selection, tool selection, coordinate reference, step by step procedure, cutter location data, simulation, post processer. (5)

TESTING OF MACHINE TOOLS: Geometrical alignment test, cutting tests, national and international test charts, testing of CNC machine tools, standard test specimen, dynamics - self excited and forced vibration, test for thermal stability, accuracy, repeatability, isolation of machine tools. (4)

OTHER CNC DRIVEN MACHINES: Laser - engraver, cutting, plasma cutting, EDM - wire, spark, ECM. (3)

TUTORIAL COMPONENT: (30)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Hans B Kief Helmut A Roschiwal “CNC Handbook” Mcgraw Hill Company, New York, 2013.
2. Michael Mattson “CNC Programming: Principles and Applications” Cengage Learning India P Ltd., New Delhi, 2014.
3. Joshi P H, “Machine Tool Hand Book, Design and Operation”, McGraw Hill, 2013.
4. Peter Smid, “CNC Programming Hand Book”, Industrial Press Inc., New York, 2007.

5. Steve Krar, “Computer Numerical Control Simplified”, Industrial Press, 2001.
6. HMT, “Mechatronics”, Tata McGraw Hill, 2012.
7. Radhakrishnan P, “Computer Numerical Control, (CNC) Machines”, Newness - Butterworth and Co. Publisher Limited, 1992.
8. Mehta N K, “Machine Tool Design and Numerical Control - ED 3”, McGraw Hill Co., New Delhi, 2013.

15PP51 ADVANCED MANUFACTURING LABORATORY

0 0 2 1

In this course, students will be provided with an orientation programme on the following equipment/software for a duration of 10 hours. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, state of technology/knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments and their interpretation with respect to the assumptions/background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 20 hours.

Topics for orientation programme

1. Modeling and assembly of components using software
2. Generation of CNC code using CAM software
3. Exercise on casting simulation
4. Exercise on Injection molding simulation
5. Manufacturing components by subtractive rapid prototyping
6. Exercise on ultrasonic welding (Thermoplastics)
7. Exercise on ultrasonic welding (Metals)
8. Exercise on electro chemical machining
9. Exercise on electro discharge machining
10. Measurement of cutting forces using dynamometer
11. Measurement of machine vibration using accelerometer

Total P: 30

III SEMESTER

15PP52 AUTOMATION, METROLOGY AND SIMULATION LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software for a duration of 20 hours. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, state of technology/knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments and their interpretation with respect to the assumptions/background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 40 hours.

Topics for orientation programme

1. Simulation of pneumatic sequential circuit
2. Simulation of pneumatic sequential circuit with fringe condition modules
3. Simulation of electro pneumatic sequential circuit
4. Simulation of PLC based sequential circuit
5. Simulation of hydraulic circuit - meter in and meter out circuit
6. Experiment using computer aided inspection
7. Measurement of surface finish parameters
8. Experiment using pneumatic gauges
9. Factory Simulation using Software
10. Exercise on Enterprise resource planning using Software
11. Demonstration of virtual reality and Rapid prototyping

Total P: 60

15PP71 PROJECT WORK – I

0 0 6 3

1. Identification of a real life problem in thrust areas
2. Developing a mathematical model for solving the above problem
3. Finalisation of system requirements and specification
4. Proposing different solutions for the problem based on literature survey
5. Future trends in providing alternate solutions
6. Consolidated report preparation

IV SEMESTER

15PP72 PROJECT WORK - II

0 0 28 14

The project work involves the following:

Preparing a project - brief proposal including

I. Problem Identification

1. A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
2. List of possible solutions including alternatives and constraints
3. Cost benefit analysis
4. Time Line of activities

II. A report highlighting the design finalization [based on functional requirements and standards (if any)]

III. A presentation including the following:

1. Implementation Phase (Hardware / Software / both)
2. Testing and Validation of the developed system
3. Learning in the Project

IV. Consolidated report preparation

ELECTIVE THEORY COURSES

15PP21 / 15PD30 PRODUCTION AND OPERATIONS MANAGEMENT

3 0 0 3

FACILITY CAPACITY, LOCATION AND LAYOUT: Long-range capacity planning - definition, measurement, Economies of scale; Facility location - analysing industrial facility locations; Facility layout - types, new trends, analyzing manufacturing facility layouts, systematic layout design procedure, CRAFT. (6)

AGGREGATE PLANNING AND MASTER PRODUCTION SCHEDULING: Approaches to aggregate planning - graphical, empirical, optimization and parametric. Development of a master production schedule, Make-to-stock, assemble-to-order, make-to-order/engineer-to-order, materials requirement planning (MRP-I) manufacturing resource planning (MRP-II) and ERP. (5)

INVENTORY ANALYSIS AND CONTROL: Need for inventory, continuous and periodic review policies, lot sizing techniques, EOQ, EMQ models, Inventory model with purchase discounts, inventory models with uncertain demand and lead times; Selective inventory control techniques - ABC and other classification of materials; vendor managed inventory. (6)

SEQUENCING AND SCHEDULING: Objectives in scheduling, single machine models - SPT and EDD sequences, mean flow time, weighted mean flow time, number of tardy jobs and mean tardiness, Parallel machine models - minimizing make span and weighted mean flow time, Flow shop models - Johnson's algorithm, Job shop models - branch and bound approach. (6)

SCHEDULING WITH RESOURCE CONSTRAINTS: Allocation of units for a single resource - Lang's algorithm, Brook's algorithm, TIMRES approach, allocation of multiple resources. Line balancing - Helgeson-Birnie approach, region approach, Ranked positional weights approach, Stochastic mixed - product line balancing. (6)

LEAN PRODUCTION AND JIT: Elements of lean production, MRP Vs JIT, cycle time, takt time, KANBAN, SMED, 5S, theory of

constraints - drum, buffer and rope, Agile manufacturing. (6)

MAINTENANCE MANAGEMENT: Objective, statistics of failure, Time to failure and probability distributions, bath tub curve, Weibull's probability distribution, reliability engineering; Preventive maintenance, Total productive maintenance, OEE. (5)

SUPPLY CHAIN MANAGEMENT: Definition, global optimization, bull-whip effect, push-pull supply chain, delayed differentiation, downward substitution, product and process modularity, mass customization. (5)

Total L: 45

REFERENCES:

1. Chary S N, "Production and Operations Management", Tata McGraw Hill Publishing Company Limited, 2004.
2. Mukhopadhyay S K, "Production Planning and Control - Text and Cases", Prentice Hall of India Private Limited, 2004.
3. Jay Heizer, Barry Render and Jagadeesh Rajashekhar, "Operations Management", Ninth Edition, Pearson Education Inc., 2009.
4. Baker K, "Introduction to Sequencing and Scheduling", John Wiley & Sons, 2004.
5. David Simchi-Levi, Philip Kaminsky and Edith Simchi-Levi, "Designing and Managing the Supply Chain - Concepts, Strategies and Case Studies", Tata McGraw Hill Publishing Company Limited, 2004.
6. Norman Gaither and Greg Frazier, "Operations Management", Thomson Asia Private Limited, 2002.
7. Elwood S Buffa and Rakesh K Sarin, "Modern Production and Operations Management", John Wiley & Sons Inc, 2002.
8. Richard B Chase, Nicholas J Aquilano and F Robert Jacobs, "Production and Operations Management - Manufacturing and Services", Tata McGraw Hill Inc, 2000.
9. Bedworth D D, "Integrated Production Control Systems Management, Analysis, Design", John Wiley & Sons, 1987.

15PP22 INDUSTRIAL ROBOTICS

3 0 0 3

FUNDAMENTALS OF ROBOT: Robot - Definition - Robot Anatomy - Co-ordinate Systems, Work Envelope, types and classification - Specifications - Joint Notations, Speed of Motion, Pay Load - Robot Parts and Their Functions. (4)

ROBOT DRIVE SYSTEMS AND END EFFECTORS: Pneumatic Drives - Hydraulic Drives - Mechanical Drives - Electrical Drives - D.C.Servo Motors, Stepper Motor, A.C. Servo Motors - Salient Features, Applications and Comparison of All these Drives; End Effectors - Types of Grippers - Gripper mechanisms - Selection and Design Considerations. (10)

SENSORS: Non-optical position sensors, optical. Position sensors, velocity sensors, proximity sensors, contact and non-contact type, touch and slip sensors, force and torque sensors. (8)

MANIPULATOR KINEMATICS: Spatial transformations, Homogeneous coordinates, homogeneous transformation and manipulator, forward solution, inverse solution, motion generation, Jacobian control. (8)

MANIPULATOR DYNAMICS: Newton's equation, Euler's equation, closed form dynamic equations, Lagrangian formulation, trajectory generation (9)

PROGRAMMING AND APPLICATIONS: Computational elements in robotic applications, robot programming - sample programs, path planning, obstacle avoidance, AI and robotics, the future of robotics. (6)

Total L: 45

REFERENCES:

1. John Craig, "Introduction to Robotics, Mechanics and Control", Pearson Education, 2008.
2. James A Rehg, "Introduction to Robotics in CIM Systems", Prentice Hall of India, 2002.
3. Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, "Robotic Engineering - An Integrated Approach", Prentice Hall India, New Delhi, 2001.
4. Shiman Y Nof, "Handbook of Industrial Robotics", John Wiley & Sons, New York, 1999.
5. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.
6. Mikell P Groover, "Industrial Robotics - Technology, Programming and Applications", McGraw Hill, 1986.
7. Richard Paul, "Robot Manipulators: Mathematics, Programming and Control", MIT Press, 1981.

15PP23 TOOL DESIGN

3 0 0 3

INTRODUCTION TO TOOL DESIGN: Introduction, Tool engineering, Tool classifications, Tool design objectives, Tool design in manufacturing, Challenges and requirements, Standards in tool design, Tool drawings, Surface finish, Fits and tolerances, Tooling materials - Ferrous and non ferrous tooling materials - Carbides, Ceramics and Diamond - Non metallic tool materials, Importance of tool design in PLM, Importance of tool design in process planning and selection of machine tool. (6)

DESIGN OF CUTTING TOOLS: Single point cutting tools, Design of form tools**,** Design of drills, Reamers, Milling cutters, Broaching tools, Gear cutting tools, Thread cutting tools, Cutting tools and tool holding methods for CNC machines, ISO standard for Inserts,

Tool holders, Selection of inserts and tool holders for specific applications, Automatic tool changers, Tool positioners and Tool presetting in CNC machines. (10)

DESIGN OF JIGS AND FIXTURES: Locating and supporting principles, Clamping and work holding principles, Drill bushes, Design of drill jigs and Milling fixtures, Turning fixtures, Welding fixtures, Modular fixtures. (8)

DESIGN OF TOOLS FOR PRESS WORK: Study of power presses and accessories, Types of dies, Method of die operation, Clearance and cutting force calculations, Pilots, Strippers and pressure pads, Presswork materials, Strip layout, Design of blanking and piercing dies, Drawing dies, Bending dies, EDM for press tool making. (8)

DESIGN OF PLASTIC MOLDS: Mold Elements. Two plate and Three plate mold design, design of gates - runners - ejectors, under cut molds, hot runner mold, mold materials, mold manufacturing. (8)

GAUGES ANG GAUGE DESIGN: Fixed gauges, Gauge tolerances, Selection of material for gauges, Indicating gauges, Automatic gauges, Design of gauges. (5)

Total L: 45

REFERENCES:

1. Cyril Donaldson, George H Lecain and Goold V, “Tool Design”, Tata McGraw Hill, 2012.
2. Edwrd G Hoffman, “Jigs and Fixtures Design”, Thomson Learning, 2010.
3. Joshi P H, “Jigs and Fixtures”, McGraw Hill, 2010.
4. Joshi P H, “Press Tools - Design and Construction”, S.Chand, 2010.
5. Ivana Suchy, “Hand Book of Die Design”, McGraw Hill, 2006.
6. Joshi P H, “Tooling Data”, Wheeler Publication, 2005.
7. Pye R G W, “Injection Mold Design”, East West Press, 2001.
8. Ranganath B J, “Metal Cutting and Tool Design”, Vikas Publishing House, 2001.
9. ASTME, “Fundamentals of Tools Design”, Prentice Hall India Publications, 1983.
10. Arshinov V and Alekseev G, “Metal Cutting Theory and Cutting Tool Design”, MIR Publication, 1979.

15PP24 / 15PD24 RAPID PROTOTYPING

3 0 0 3

INTRODUCTION: Need for the compression in product development, history of RP systems, survey of applications, growth of RP industry, classification of RP systems. (4)

FUSED DEPOSITION MODELING: Principle, process parameters, path generation, applications. (4)

SELECTIVE LASER SINTERING: Types of machines, principles of operation, process parameters, data preparation for SLS, applications. (4)

STEREOLITHOGRAPHY SYSTEMS: Principle, process parameters, process details, data preparation, data files and machine details, applications. (5)

LAMINATED OBJECT MANUFACTURING: Principle of operation, LOM materials, process details, applications. (2)

SOLID GROUND CURING: Principle of operation, machine details, applications. (2)

LASER ENGINEERED NET SHAPING (LENS): Net shaping development at Sandia National Lab. (2)

CONCEPT MODELERS: Principle, Thermo jet printer, Sander's model market, 3-D printer, Genisys Xs printer, JP system 5, object quadra system. (4)

RAPID TOOLING: Indirect rapid tooling - silicone rubber tooling, aluminum filled epoxy tooling, spray metal tooling, cast Kirksite, 3D Keltool, etc., direct rapid tooling - direct AIM, quick cast process, copper polyamide, rapid tool, DMILS, prometal, sand casting tooling, laminate tooling, soft tooling Vs hard tooling. (7)

SOFTWARE FOR RP: STL files, overview of solid view, magics, mimics, magics communicator, etc., internet based software’s, collaboration tools. (4)

RAPID MANUFACTURING PROCESS OPTIMIZATION: Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation. (3)

ALLIED PROCESSES: Vacuum casting, surface digitizing, surface generation from point cloud, surface modification, data transfer to solid models. (4)

Total L: 45

REFERENCES:

1. Terry Wohlers, “Wohlers Report 2001”, Wohlers Associates, 2008.

2. Pham D T and Dimov S S, “Rapid Manufacturing”, Verlag, 2001.
3. Paul F Jacobs, “Stereo lithography and other RP&M Technologies”, SME, 1996.
4. FDM Maxum User Guide.
5. FDM 1650 User Guide.
6. Sinterstation 2500 plus System User Guide.
7. MK-Technology Gmbh. System User Guide.

15PP25 APPLIED PNEUMATICS AND HYDRAULICS

3 0 0 3

ELEMENTS OF PNEUMATIC SYSTEMS: Pneumatic Vs hydraulics, compressors - types, selection. Symbols of pneumatic elements. Cylinders - types, typical construction details. Valves - direction control, flow, pressure, types, typical construction details. (8)

PNEUMATIC SYSTEMS DESIGN: General approach, travel step diagram. Sequential circuit design, step counter method. K.V. Mapping for minimization of logic equation, fringe condition modules, sizing of components in pneumatic systems. (12)

TYPICAL INDUSTRIAL APPLICATIONS OF PNEUMATIC SYSTEMS: Metal working, handling, clamping, application with counters. (8)

ADVANCED TOPICS IN PNEUMATICS: Electro pneumatics, ladder diagram. Servo and proportional valves - types, operation, application, hydro-mechanical servo systems. PLC - construction, types, operation, programming. (8)

DESIGN OF TYPICAL HYDRAULIC SYSTEMS: Total design of a fluid power system for an industrial application. Specifications of the circuit, circuit design, selection of elements based on force, speed, travel and time, sizing of pipes, design of power packs/selection of compressor, piping layout and accessories. (9)

Total L: 45

REFERENCES:

1. Anthony Espisito, “Fluid Power with Application”, Pearson Education Private Limited, 2003.
2. Majumdar S R, “Oil Hydraulic Systems: Principles and Maintenance”, Tata McGraw Hill Publishing Company Limited, 2003.
3. Majumdar S R, “Pneumatic Systems : Principles and Maintenance”, Tata McGraw Hill Publishing Company Limited, 2003.
4. Peter Rohner, “Fluid Power Logic Circuit Design - Analysis, Design Method and Worked Examples”, The Macmillan Press Limited, 1979.
5. Werner Deppert and Kurt Stoll, “Pneumatic Controls : An Introduction to Principles”, Vogel-Druck Wurzburg, 1975.

15PP26 / 15PD28 OPTIMIZATION TECHNIQUES

3 0 0 3

NONLINEAR OPTIMIZATION: Introduction, unconstrained optimization, one-dimensional optimization, elimination methods, Fibonacci method, golden section methods, interpolation methods, quadratic, cubic interpolations, direct root methods, multivariable optimization, direct search methods, pattern search methods, univariate method, Hooks and Jeeves method, Powel’s method, simplex method, descent methods, steepest descent, conjugate gradient, Newton methods. (10)

CONSTRAINED NONLINEAR OPTIMIZATION: Direct methods, the complex method, cutting plane method, indirect methods, transformation techniques, interior and exterior penalty function methods, Kuhn-Tucker conditions, Lagrangian method. (7)

INTEGER PROGRAMMING: Introduction to integer programming, solution techniques - graphical method & branch and bound technique, Gomory’s cutting plane method, examples on the application in manufacturing systems and design. (4)

DYNAMIC PROGRAMMING: Bellman’s principle of optimality, examples on the application on routing problem, inventory problem, marketing problem. (3)

NETWORK OPTIMIZATION MODELS: Terminology of networks, the shortest route problem, the minimum spanning tree problem, the maximum flow problem, the minimum cost flow problem, the network simplex method. (7)

INTRODUCTION TO NON-TRADITIONAL OPTIMIZATION: Computational complexity, NP-hard, NP-complete, no free lunch theorem. (2)

RANDOM SEARCH METHODS: Genetic algorithms, Simulated annealing, ant colony algorithm, particle swap algorithm, Tabu search, neural networks, hybrid algorithms - simple applications. (12)

Total L: 45

REFERENCES:

1. Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall India Private Limited, 2000.
2. Fred Glover, Manuel Laguna and Fred Laguna, “Tabu Search”, Kluwer Academic Publishers, 1997.

3. Rao S S, “Engineering Optimization: Theory and Practice”, Wiley-Interscience, 1996.
4. Stephen G Nash and Ariela Sofer, “Linear and Nonlinear Programming”, McGraw Hill College Div., 1995.
5. Cihan H Dagli, “Artificial Neural Networks for Intelligent Manufacturing”, Chapman and Hall, 1994.
6. David E Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Addison-Wesley Pub Co., 1989.
7. Dimitri P Bertsekas, “Dynamic Programming: Deterministic and Stochastic Models”, Prentice Hall, 1987.
8. Harvey M Salkin, “Integer Programming”, Addison-Wesley Pub. Co., 1975.

15PP27 NON-TRADITIONAL MACHINING PROCESSES

3 0 0 3

INTRODUCTION: Technological and commercial need, classification, performance constraints, selection of NTM, advanced processes. (2)

MECHANICAL MACHINING PROCESS: Abrasive jet machining, water jet cutting, abrasive water jet machining, abrasive flow machining, magnetic abrasive finishing - process variables, material removal rate, mechanism of material removal, process capabilities, abrasive particle size, limitations and applications. (9)

ULTRASONIC MACHINING: Ultrasonic machining system, mechanics of cutting, process parameters, analysis, capability, grain growing model, grain hammering model, applications and limitations. (5)

ELECTRO DISCHARGE MACHINING (EDM): Working principle, process parameters, process capabilities, components of system and its functions, analysis of RC circuit, power delivered to discharging circuit, current in discharge circuit, parametric relation for material removal rate and surface finish, gap cleaning, process characteristics, effect of various parameters on material removal rate, application and limitations,, wire EDM machine, stratified wire, process characteristics, applications and limitations. (8)

LASER BEAM MACHINING (LBM): Production of lasers, types of lasers, process characteristics, working principle, process parameters, process capabilities, components of system and its functions, limitations, application in drilling, cutting, marking and miscellaneous applications. (3)

PLASMA ARC MACHINING (PAM): Working principle, process parameters, process capabilities, elements of PAM system and their functions, various plasma arc torches, process capabilities, comparison with oxy fuel cutting, applications and limitations. (3)

ELECTRON BEAM MACHINING (EBM): Working principle, process parameters, process capabilities, elements of EBM system and their functions, applications and limitations. (2)

ELECTRO CHEMICAL AND CHEMICAL MACHINING PROCESSES: Working principle, components and functions, process parameters, limitations and applications - electro chemical machining, material removal rate and mechanism, inter electrode gap, zero feed rate, finite feed rate, maximum permissible feed rate, self regulation feature, effect of Joule’s heating, effect of hydrogen bubbles generation , anode shape prediction, cos θ method, tool design - Chemical machining, masks, etchants, advantages and limitations. (8)

ADVANCED PROCESSES: Introduction, working principle, equipment, process parameters, process capabilities and applications of Electro Chemical Grinding (ECG), Electro Chemical Spark Micro Machining(ECSMM), Electrical Discharge Grinding (EDG), Electro Chemical Discharge Grinding (ECDG), Magneto Rheological Finishing (MRF), Magnetorheological Abrasive Flow Finishing (MRAFF), Magnetorheological Jet Finishing(MRJF) process. (5)

Total L: 45

REFERENCES:

1. Vijay K Jain, “Advanced Machining Processes”, Allied Publications Private Limited, 2012.
2. McGeough J A, “Advanced Methods of Machining”, Springer, 2011.
3. Gary F Benedict, “Non Traditional Manufacturing Process”, Taylor and Francis, 2011.
4. Pandey P C and Shan H S, “Modern Machining Process”, Tata McGraw Hill Publications, 2011.
5. Jain V K, “Introduction to Micromachining”, Narosa Publishing House Private Ltd., 2011.
6. Amithaba Gosh and Asok Kumar Mallik, “Manufacturing Science”, East West Press Private Limited, 2006.
7. Hassan Abdel and Gaward El-Hofy, “Advanced Machining Processes”, McGraw Hill Publications, 2005.
8. Carl Sommer, “Non-traditional Machining Handbook”, Advance Publishing Inc., 2000.
9. James Brown, “Advanced Machining Technology Handbook”, McGraw Hill, 1998.

15PP28 /15PD22 PRODUCT DEVELOPMENT STRATEGIES

3 0 0 3

HISTORY IN PRODUCT DEVELOPMENT: Product development versus design, types of design and redesign, modern production development process, examples of product development process, scoping product development - S-curve. (3)

UNDERSTANDING CUSTOMER NEEDS AND PRODUCT TEARDOWN: Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality. Tear down method benchmarking and establishing engineering specifications, product portfolios. (5)

C**ONCEPT GENERATION AND SELECTION:** Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis, concept selection - introduction, technical feasibility, selection process, pugh chart, measurement theory, numerical concept scoring DFMA, design for robustness. (7)

CONCEPT EMBODIMENT AND MODELING OF PRODUCT METRICES: Refining geometry and layout, advanced methods - system modeling, mechanical embodiment principles, FMEA - linking fault states to system modeling, fault tree analysis - modeling of product metrices - introduction, product models. (7)

DESIGN FOR THE ENVIRONMENT: DFE methods, life cycle assessment, weighted sum assessment method, techniques to reduce environmental impact - disassembly, recyclability, remanufacturing regulations and standards. (5)

ANALYTICAL AND NUMERICAL MODEL SOLUTIONS: Overview and strategy, fundamental concepts in optimization. (4)

PHYSICAL PROTOTYPES AND EXPERIMENTATION: Types of prototypes, use of prototypes, rapid prototyping - technique, classification and working principle, scale, dimensional analysis and similitude, physical model and experimentation - design of experiments, statistical analysis of experiments, product applications of physical modeling and DOE. (7)

REVERSE ENGINEERING: Introduction, reverse engineering phases, data collection, mesh reconstruction, surface fitting, computer vision - structured light range imaging systems, reverse engineering hardware and software, applications of reverse engineering in automotive, aerospace and medical industries. (7)

Total L: 45

REFERENCES:

1. George E Dieter, “Engineering Design, A Materials and Processing Approach”, McGraw Hill International Book Co, 2012.
2. Kevin Otto and Kristin Wood, “Product Design - Techniques in Reverse Engineering and New Product Development”, Pearson Education, 2004.
3. Karl T Ulrich and Stephen D Eppinger, “Product Design and Development”, McGraw Hill, 1994.

15PP29 / 15PM27 IMAGE PROCESSING AND MACHINE VISION

3 0 0 3

INTRODUCTION: Digital image fundamentals, binary, gray and color images, steps in digital image processing, imaging requirements, human vision and machine vision. (6)

IMAGE PROCESSING FUNDAMENTALS: Image sampling and quantization, image enhancement - gray level transformations, histogram processing, image sharpening and smoothing, spatial and frequency domain filters, image restoration - noise models, noise reduction by spatial and frequency domain filtering. (10)

IMAGE ANALYSIS: Image segmentation - edge and line detection, thresholding, region-based segmentation, image representation, feature extraction, object recognition. Study of various image operations, 2D and 3D measurements. (9)

MACHINE VISION: Image sensing and acquisition, types of cameras and their principles, machine vision lightings, designing a machine vision system- lens design, choice of camera and illumination, laser vision system, software’s for image processing. (10)

INDUSTRIAL APPLICATIONS: Machine vision in factory automation, dimensional measurement, identification of flaws and defects, pattern recognition applications, sorting and counting, study of surface finish, tool wear measurement, robot guidance, safety monitoring. (10)

Total L: 45

REFERENCES:

1. Davies E R, “Computer and Machine Vision: Theory, Algorithms, Practicalities”, Academic Press, 2012.
2. Bhabatosh Chanda and Dutta Majumder D, “Digital Image Processing and Analysis”, PHI Learning Pvt. Ltd., 2011.
3. Rafael G Gonzalez and Richard E Woods, “Digital Image Processing”, Pearson Education, 2009.
4. Alexander Hornberg, “Handbook of Machine Vision”, WILEY VCH Verlag GmbH & Co, KGaA, 2006.
5. Tinku Acharya and Ajoy K Ray, “Image Processing - Principles and Applications”, John Wiley and Sons Publication, 2005.
6. Linda G Shapriro and George C Stockman, “Computer Vision”, Prentice Hall, 2001.

15PP30 / 15PM24 MECHATRONICS SYSTEM

3 0 0 3

INTRODUCTION: Introduction to Mechatronics, need and applications, elements of mechatronic systems, role of mechatronics in automation, manufacturing and product development. (3)

MEASUREMENT: Importance of sensors in Mechatronics, Static and Dynamic characteristics of sensors, errors and output impedance of sensors, transducers for measurement of displacement, strain, position, velocity, noise, flow, pressure, temperature, humidity, vibration, liquid level, vision sensors. (8)

ACTUATORS: Rotational drives - Pneumatic Motors: continuous and limited rotation - Hydraulic Motors: continuous and limited rotation - Brushless DC Motors - Motion convertors, Fixed ratio, invariant motion profile, variators, remotely controlled couplings Hydraulic Circuits and Pneumatic Circuits. (6)

MECHANICAL SYSTEMS AND DESIGN: Mechatronic approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation - Man machine interface, industrial design and ergonomics, information transfer from machine to man and man to machine, safety. (10)

REAL TIME INTERFACING AND DATA ACQUISITION: Introduction - Elements of data acquisition and control Overview of I/O process - Installation of I/O card and software - Installation of application software - Over framing. General configuration: single channel and multichannel data acquisition system, Digital Filtering, data logging, data conversion, introduction to digital transmission systems PC based data acquisition system. (10)

CASE STUDIES: Transducer calibration system for Automotive applications, Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Pick and place robot - pH control system - Case studies on design of Mechatronic products - Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader. (8)

Total L: 45

REFERENCES:

1. Sabri Cetinkunt, “Mechatronics”, John Wiley, 2007.
2. Bolton, “Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering”, Addison Wesley Longman Ltd., 1999.
3. Devdas Shetty and Richard A Kolk, “Mechatronics System Design”, PWS Publishing Company, 1997.
4. Brian Morriss, “Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics”, McGraw Hill International Edition, 1995.
5. Bradley, Dawson D, Burd N C and Loader A J, “Mechatronics: Electronics in Products and Processes”, Chapman and Hall, London, 1991.

15PP31 SOLIDIFICATION PROCESSING AND FOUNDRY METALLURGY

3 0 0 3

CASTING HYDRODYNAMICS: Basic Hydrodynamics, Gating systems in uphill and downhill casting, fluidity - factors affecting and measurement of fluidity, convection in the bulk liquid, risering of pure metals and alloys, interdendritic fluid flow, macro segregation, Problems. (8)

HEAT FLOW IN SOLIDIFICATION: Basic concepts and laws of heat transport, solidification process in pure metals and alloys, solution of heat equation, temperature distribution in sand mould, chvorinov’s equation, significance of the interface resistance, Problems. (7)

SOLIDIFICATION: Crystallization from the melt, growth, homogenous and heterogeneous nucleation, eutectic freezing, structure of castings, G/R ratio, Niyama criterion, control of cast structure. (6)

NON FERROUS METALLURGY: Specifications, properties, industrial applications, melting and composition control, deoxidation, gating and risering techniques for Zirconium, Cobalt, Nickel, Titanium, Lead, Tin, Silver, Platinum and Gold and their alloys. (6)

CAST IRON METALLURGY: Types of cast iron - Effect of normal elements in cast iron. Influence of composition and cooling rate. Graphitization, Types and sizes of graphite for Grey cast iron and S.G.iron. Effect of normal elements and alloying elements in cast irons. Compositional aspects and properties of Austenitic cast irons, High silicon cast irons, High chrome cast irons and Ni-Hard cast irons. Production of S.G.iron, Austempered S.G.iron, C.G.Iron, Malleable cast iron and alloy cast irons, inoculation - materials, mechanisms and techniques. (13)

METALLURGY OF STEELS: Types of steel, Effect of normal elements and alloying elements in steels. Compositional aspects and properties of alloy steels. (5)

Total L: 45

REFERENCES:

1. Hasse Fredriksson and Ulla Akerlind, “Materials Processing during Casting”, John Wiley and sons, 2006.
2. John Campbell, “Casting”, Butterworth-Heinmann, 2003.
3. Peter Beeley, “Foundry Technology”, Butterworths, Heinmann, Oxord, 2001.
4. John R Brown, “FOSECO Ferrous Foundry Man’s Hand Book”, Butterworth, 2000.
5. ASM Hand Book, “Casting, ASM Hand Book Committee”, Vol. 15, 1998.

6. Heine, Loper and Rosenthal, “Principles of Metal Casting”, Tata McGraw Hill Publishing Co., 1995.
7. Merton C Flemings, “Solidification Processing”, McGraw Hill Book Company, 1974.

15PP32 RELIABILITY ENGINEERING

3 0 0 3

CONCEPTS OF RELIABILITY: Definition of reliability, reliability Vs quality, reliability function, MTTF, hazard rate function, bathtub curve, derivation of the reliability function, constant failure rate model, time dependent failure models, Weibull distribution, normal distribution- the lognormal distribution. (5)

SYSTEM RELIABILITY AND MODELS: Serial configuration, parallel configuration, combined series parallel systems, system structure function, minimal cuts and minimal paths, Markov analysis, load sharing systems, standby system, degraded systems, three state devices, covariate models, static models, dynamic models, physics of failure models. (11)

DESIGN FOR RELIABILITY: Reliability design process, system effectiveness, economic analysis and life cycle cost, reliability allocation, optimal, Arinc, Agree, design methods, parts and material selection, derating, stress - strength analysis, failure analysis, identification of failure mode, determination of causes, assessment of effects, classification of severity, computation of criticality index, corrective action, system safety and FTA. (11)

DESIGN FOR MAINTAINABILITY: Analysis of downtime- the repair time distribution, stochastic point processes, system repair time, reliability under preventive maintenance, state dependent systems with repair, MTTR-mean system downtime, MTR - MH/OH, cost model, fault isolation and self diagnostics, repair Vs replacement, replacement model, proactive, preventive, predictive maintenance, maintenance and spares provisioning, maintainability prediction and demonstration, concepts and definition of availability. (11)

THE ANALYSIS OF FAILURE DATA AND RELIABILITY TESTING: Data collection, empirical methods, ungrouped and grouped complete, censored data, static life estimation, test time calculation, burn in testing, acceptance, sequential, binomial testing, accelerated life testing, other acceleration models, experimental design, reliability growth process, idealized growth curve, various growth models, identifying failure and repair distributions. (7)

Total L: 45

REFERENCES:

1. Patrick D T o'connor, “Practical Reliability Engineering”, John-Wiley and Sons Inc, 2002.
2. David J Smith, “Reliability, Maintainability and Risk: Practical Methods for Engineers”, Butterworth, 2002.
3. Way Kuo, Rajendra Prasad V, Frank A, Tillman and Ching-Lai Hwang, “Optimal Reliability Design and Applications”, Cambridge University Press Private Limited, 2001.
4. Charles E Ebling, “An introduction to Reliability and Maintainability Engineering”, Tata McGraw Hill, 2000.
5. Srinath l S, “Engineering Design and Reliability”, ISTE, 1999.
6. Oleg Vinogradov, “Introduction to Mechanical Reliability: A Designers Approach”, Hemisphere Publications, 1991.

15PP33 LOGISTICS AND SUPPLY CHAIN MANAGEMENT

3 0 0 3

INTRODUCTION: Definition of logistics and supply chain management, decision phases in a supply chain, objectives of SCM, examples of supply chains, supply chain drivers, supply chain integration, supply chain performance measures. (7)

LOGISTICS NETWORK DESIGN: Role of distribution in supply chain, distribution network design, factors influencing distribution network design, distribution networks in practice, network design in the supply chain, factors influencing the network design, framework for network design, models for facility location and capacity allocation, Impact of uncertainty on network design. (8)

COORDINATED PRODUCT AND SUPPLY CHAIN DESIGN: General framework - Design for logistics - Standardization - Push-pull boundary - Supplier integration into New Product Development - Keys to effective supplier integration - Mass Customization - Meaning - Mass Customization and Supply Chain Management. (8)

STRATEGIC ALLIANCES: Framework for strategic alliances - Third Party Logistics - 3PL issues and requirements - Retailer - Supplier Partnerships - Issues in Retailer - Supplier Partnerships - Distributor Integration - Types and issues of Distributor Integration. (7)

INVENTORY MANAGEMENT: Cycle inventory, economies of scale to exploit fixed costs, quantity discounts, example problems, multi-echelon inventory, safety inventory in supply chain, safety level estimation, supply uncertainty, data aggregation, replenishment policies, managing safety inventory in practice, product availability, optimal level, affecting factors, supply chain contracts - Bull whip effect. (8)

TECHNOLOGIES FOR SCM: Information Technology (IT) - Infrastructure - Interface devices - System architecture - Electronic commerce - IT for supply chain excellence - Service oriented architecture - Radio Frequency Identification (RFID) - Impact of internet. (7)

Total L: 45

REFERENCES:

1. Simchi - Levi Davi, Kaminsky Philip and Simchi-Levi Edith, "Designing and Managing the Supply Chain", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2012.
2. Sunil Chopra and Peter Meindl, "Supply Chain Management", Prentice Hall, New Jersey, 2010.
3. Sadler I, "Logistics and Supply Chain Integration", Sage Publishers, 2007.

15PP34 / 15PD31 TOTAL QUALITY MANAGEMENT

3 0 0 3

FOUNDATIONS OF TQM: Understanding quality, quality, competitiveness and customers, building quality chains, managing quality, quality in all functions, models and frame works for total quality management, Early TQM frameworks - quality award models - the four Ps and three Cs of TQM - a new model for TQM. (6)

LEADERSHIP AND COMMITMENT: The TQM approach - commitment and policy - creating or changing the culture - effective leadership - excellence in leadership. (4)

DESIGN FOR QUALITY: Design, innovation and improvement - the design process - quality function deployment (QFD) - the house of quality - specifications and standards - design in the service sectors - failure mode effect and criticality analysis (FMECA) - The links between good design and managing the business. (5)

PROCESS REDESIGN / ENGINEERING: Reengineering the organization - process for redesign - the redesign process - the people and the leaders. (5)

HUMAN RESOURCE MANAGEMENT: Introduction - strategic alignment of HRM policies - effective communication - employee empowerment and involvement - training and development - teams and team work - review, continuous improvement and conclusions - organizing people for quality - quality circles or kaizen teams. (6)

COMMUNICATIONS, INNOVATION AND LEARNING: Communicating the quality strategy - communicating the quality message - communication, learning, education and training - a systematic approach to education and training for quality - turning educations and training into learning - the practicalities of sharing knowledge and learning. (7)

IMPLEMENTING TQM: TQM and the management of change - planning the implementation of TQM - sustained improvement. (5)

QUALITY AND ENVIRONMENTAL MANAGEMENT SYSTEMS: Benefits of ISO registration - ISO 9000 series of standards - sector specific standards - ISO 9001 requirements - implementation - documentation - writing the documents - internal audits - registration - ISO 14000 series standards - concepts of ISO 14001 - requirements of ISO 14001 - benefits of EMS - integrating ISO 14000 with ISO 9000 - relationship between health and safety. (7)

Total L: 45

REFERENCES:

1. Besterfield D H et al, "Total Quality Management", Pearson Education Private Limited, 2004.
2. Oakland J S, "Total Quality Management - Text with Cases", Butterworth - Heinemann - An Imprint of Elseiver, First Indian Print, 2003.

15PP35 WORK SYSTEMS ENGINEERING

3 0 0 3

PRODUCTIVITY AND WORK STUDY: Productivity concepts and definitions, productivity Vs standard of living, Techniques for productivity improvement, Measuring productivity of an enterprise, materials, land, building, machines and man power. (4)

METHODS STUDY: Selection of job, record - examine - develop, movement of workers, materials, tools for recording the movement of workers. (5)

PRINCIPLES OF MOTION ECONOMY: Classification of movements, two handed process charts, Micro motion study (therbligs), memo motion study, simo chart, chronocycle graph, recording techniques, define-install-maintain. (8)

WORK MEASUREMENT: Definition, basic procedure, techniques, work sampling, determination of sample size, conducting work sampling study, performance rating systems, various types of allowances. (8)

TIME STUDY: Equipment, forms, selecting the job and worker, basic steps, classification of elements, breaking the job into elements, determination of sample size. (6)

TECHNIQUES FOR WORK MEASUREMENTS: Stop watch time study, work sampling, PMTS, MTM, analytical estimation. (6)

INFLUENCE OF WORKING CONDITIONS IN WORK STUDY: Layout and housekeeping, lighting, noise, vibration, ergonomics, fire prevention and protection, OSHA. (8)

Total L: 45

REFERENCES:

1. ILO, “Introduction to Work Study: Indian Adaptation”, Oxford and IBH Publishing Company Private Limited, 2008.
2. Ralph M Barnes, “Motion and Time: Study Design and Measurement of Works”, John Wiley & Sons Inc., 2002.
3. Benjamin W Niebel, “Motion and Time Study - An Introduction to Methods, Time Study and Wage Payment”, Richard Dirwin, Illinois, 1958.

15PP36 SIX-SIGMA

3 0 0 3

OVERVIEW OF SIX-SIGMA CONCEPT: History of Six- sigma; Benefits; Tools and Themes of Six-Sigma programme. Ingredients of six-sigma; Cost of quality. (4)

KEY CONCEPTS OF THE SIX-SIGMA SYSTEM: A six-sigma vision of business leadership; An introduction to sigma measurement; Six-Sigma improvement and management strategies; The DMAIC Six-Sigma improvement model; Six-Sigma v/s TQM (comparison with TQM). (7)

THE SIX-SIGMA ROAD MAP: Advantages of six-sigma roadmap; Steps in roadmap; over view and rationale behind each step. Application of six-sigma in service: Comparison of service and manufacturing; challenges making six-sigma work in services; using lean sigma in service. (5)

ADOPTING SIX-SIGMA: Relevance of six sigma programme; Strategy phase of six-sigma program; preparing leaders to launch and guide effort. Preparing black belts and other key roles - Master Black belt; Champion and Green belts. (6)

TRAINING THE ORGANIZATION FOR SIX-SIGMA: Essentials of effective training; Planning curriculum; Selecting the right six-sigma projects-Essentials; process and Do’s & Don’ts. (5)

IMPLEMENTING SIX-SIGMA: Identifying core process; Defining customer requirements; measuring current performance. Six sigma process improvement; six sigma process design/ redesign; expanding and integrating the six sigma system. (8)

DESIGN FOR SIX-SIGMA (DFSS): Introduction; Need for DFSS; DFSS Phases; Differences between six sigma and DFSS; Features of a sound DFSS strategy. (4)

SUSTAINABILITY OF DESIGN FOR SIX-SIGMA: Beyond six-sigma, keeping the capability, keep the customers in mind and involved, make the most of what you know, vision and leadership, infrastructure, reinforcement and control organizational culture, expanding DFSS beyond the organization managers checklist. (6)

Total L: 45

REFERENCES:

1. Kai Yang and Basemel-Haik, “Design for Six-Sigma: A Roadmap for Product Development”, McGraw Hill, 2008.
2. Mikel Harry and Richard Schroeder A, “Six-Sigma: The Break through Management Strategy”, Currency Book Published by Doubleday, 2006.
3. Crrevelng C M, Slutsky J L and Antis D, “Design for Six Sigma”, Pearson Education, 2003.
4. Michael L George, “Lean Six Sigma for Service”, Tata McGraw Hill, 2003.
5. Greg Brue, “Design for Six Sigma”, Tata McGraw Hill, 2003.
6. Peter S Pande, Robert P Neuman and Roland Cavanagh R, “The Six-Sigma Way-How GE, Motorola and Other Top Companies are Honing their Performance”, McGraw Hill, 2003.
7. Stamatis D H, “Six-Sigma and Beyond - Foundations of Excellent Performance”, St. Lucie Press, 2001.

15PP37 LEAN MANUFACTURING

3 0 0 3

INTRODUCTION: Holistic view of lean principles, five primary elements, road map. (5)

ORGANIZATION ELEMENT: Communication planning, product - focused responsibility, leadership development, operational roles and responsibilities, workforce preparation. (5)

METRICS ELEMENT: DuPont model, output-based measures, process - driven measures, goal alignment through policy deployment, measurement definition and understanding. (5)

LOGISTICS ELEMENT: Planning/control function, A,B,C material handling, service cells, customer/supplier alignment, JIT Kanban demand signals, cell team work plan, level loading, mix-model manufacturing, workable work. (7)

MANUFACTURING FLOW ELEMENT: Product/quantity analysis, process mapping, routing analysis, takt time, workload balancing and one-piece flow, cell design criteria, cell layout, kanban sizing. (7)

PROCESS CONTROL ELEMENT: Single minute exchange of dies, total productive maintenance, poka-yoke, 5S, visual controls, graphic work instructions. (7)

VALUE STREAM MAPPING: Introduction - Primary icons - Customer and supplier icons - Production control icon - Data box icon - Truck icon - Material direction arrow icon - Process icon - Push icon - Pull icon - Information and communication flow icons - Secondary icons - Developing the VSM - Example illustrating the development of VSM - Current state mapping - Future state mapping. (9)

Total L: 45

REFERENCES:

1. Devadasan S R, Mohan Sivakumar V, Murugesh R and Shalij P R, "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities", Prentice Hall of India (PHI) Private Limited, New Delhi, India, 2012.
2. James P Womack and Daniel T Jones, "Lean Thinking, Banish Waste and Create Wealth in Your Corporation", Simon & Schuster UK Limited, 2010.
3. William M Feld, "Lean Manufacturing, Tools, Techniques and How To Use Them", The St. Lucie Press/APICS Series on Resource Management, 2001.

15PP38 AGILE MANUFACTURING

3 0 0 3

THE AGILE PRODUCTION SYSTEM: The task aligned organisation - agile manufacturing production system - production, production support, production planning and control, quality assurance, purchasing, maintenance, overview of production support, business operations, engineering, marketing, human resource, finance and accounting. (5)

AGILE PRACTICES: Agile practice for product development - Manufacturing agile practices - understanding the value of investing in people, removing inappropriate fear from the shop floor - not sacrificing agility for perfectionism. (6)

IMPLEMENTING TECHNOLOGY TO ENHANCE AGILITY: Implementing new technology - reasons - guidelines preparation for technology implementation - A checklist, technology applications that enhance agility - agile technology make-or-buy decisions. (7)

STRATEGIC DIRECTION: Key concepts, strategic thinking, strategic learning approach to creating strategy - establishing the strategy team, collecting strategic information, creating strategic scenarios, developing strategy options, selecting the best strategy option, testing and refining the strategy, implementing the strategy, strategy partnering, conclusion. (7)

PERFORMANCE MEASURES: Historical view of performance measurement, dysfunctional impacts of cost-accounting performance measures, customer-centered paradigm, developing customer-based performance measures. (7)

CREATING THE LEARNING FACTORY: Imperative for success, factory becoming a learning factory, building a road map for becoming a learning factory - core capabilities, guiding vision, leadership that fits, ownership and commitment, pushing the envelope, prototypes, integration, learning challenges for learning manufacturing business, conclusion. (7)

MANAGEMENT IN THE AGILE ORGANIZATION: Old management styles, role of manger in an agile organization - vision champion, team leader, coach, business analyzer, supporting the new culture - performance appraisal systems, selection systems, reward and recognition systems, organizational measurement, organizational learning processes. (6)

Total L: 45

REFRENCES:

1. Devadasan S R, Mohan Sivakumar V, Murugesh R and Shalij P R, "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities", Prentice Hall of India (PHI) Private Limited, New Delhi, India, 2012.
2. Gunasekaran A, "Agile Manufacturing, 21st Strategy Competitiveness Strategy", Elsevier Publications, 2001.
3. Montgomery J C and Levine L O, "The Transition to Agile Manufacturing - Staying Flexible for Competitive Advantage", ASQC Quality Press, Wisconsin, 1995.
4. Goldman S L, Nagal R N and Preiss K, "Agile Competitors and Virtual Organizations", Van Nostrand Reinhold, 1995.
5. Brian H Maskell, "Software and the Agile Manufacturer, Computer Systems and World Class Manufacturing", Productivity Press, 1993.

15PP39 COMBINATORIAL OPTIMIZATION

3 0 0 3

INTRODUCTION: Introduction to discrete optimization problem. Optimal trees and paths, maximum flow problem, Minimum cost flow problem – Primal, Dual minimum cost flow problems. (9)

MATCHING THEORY: Matching and alternative paths, maximum matching, minimum weight perfect matchings, T-joint and postman problems, general matching problems, geometric duality and Goemans-Williamson algorithm. (9)

POLYHEDRAL COMBINATORICS: Convex hulls, polytopes, facets, integral polytopes, total unimodularity, total dual integrality, cutting planes, separation and optimization. (6)

MATROIDS: Matroids – properties, axioms, constructions, Greedy algorithm, matroid intersection, weighted matroid intersection. (6)

NP AND NP - COMPLETENESS: Introduction, algorithms and running time, the class NP, NP- Completeness, NP –completeness of the satisfiability problems, Turing machines. (6)

APPROXIMATION ALGORITHMS: Set Covering, colouring, approximation schemes, maximum satisfiability, the PCP theorem, L-Reductions. CASE STUDIES - Knapsack problem, Bin Packing, Network design problems – steiner trees, TSP, Facility location. (9)

Total L: 45

REFERENCES:

1. Cook W.J., Cunningham W.H., Pulleyblank W.R. and Schrijver A., “Combinatorial Optimization”, Wiley, 1998.
2. Bernhard Korte and Jens Vygen, “Combinatorial optimization: Theory and Algorithms”, Springer, Berlin, 2005.
3. Jon Lee, “A First Course in Combinatorial Optimization”, Cambridge University Press, New York, 2004.
4. Lovasz L, Pelikan J and Vesztergombi K, “Discete Mathematics: Elementary and Beyond”, Springer, 2011.

15PP40 MECHANICS OF POLYMER MATRIX COMPOSITES

3 0 0 3

INTRODUCTION: Modern materials in design, types, metals, polymers, ceramics, composites, Classification of composites, advantages, applications and limitations, Matrix and reinforcement-their roles, principal types of fibre and matrix materials. (8)

MANUFACTURE OF COMPOSITE COMPONENTS: Lay up and curing, open and closed mould processes, bag moulding, filament winding, pultrusion, pulforming, thermoforming, injection moulding, blow moulding,an overview of metal matrix composite processing and ceramic matrix composite processing. (8)

MICRO MECHANICAL BEHAVIOUR OF A LAMINA: Volume and mass fractions, evaluation of elastic moduli, strength of unidirectional lamina. (9)

MACRO MECHANICAL BEHAVIOUR OF A LAMINA: Hooke's law for different types of materials, engineering constants for orthotropic materials. Stress, strain relations for plane stress in an orthotropic materials and in a lamina of arbitrary orientation, strength of an orthotropic lamina, basic strength theories. (10)

MACRO MECHANICAL BEHAVIOUR OF A LAMINATE: Classical lamination theory - lamina stress - strain behaviour - resultant forces and moments in a laminate - types of laminates - strength and stiffness of laminates – inter laminar stresses in laminates.(10)

Total L: 45

REFERENCES:

1. Autar K Kaw, "Mechanics of Composite Materials", CRC Press, NY, 2006.
2. Matthews F L and Rawlings R D, “Composite Materials: Engineering and Science”, Woodhead Publishing, 1999.
3. Ronald F Gibson, “Principles of Composite Material Mechanics", McGraw Hill Book Co, 2007.
4. Robert M Jones, "Mechanics of Composite Materials", Taylor and Francis, 1999.