SEMESTER 1

15MD01/15MC01 APPLIED NUMERICAL ANALYSIS

2 2 0 3

REVISION: Error analysis

SYSTEM OF EQUATIONS AND EIGENVALUE PROBLEMS: Solving set of equations - Gauss elimination method, LU - Choleski method, successive over relaxation method, system of non-linear equations - Newton Raphson method, power method and inverse power method. (8+8)

CURVE FITTING AND APPROXIMATION OF FUNCTIONS: Concept of least square approximations, linear regression, non-linear regression, error and standard deviation, multiple linear regression, applications of cubic splines - Bezier curves and B-splines.(6+6)

BOUNDARY VALUE PROBLEMS: Shooting method, solution through a set of equations, derivative boundary conditions, Rayleigh-Ritz method. (4+4)

ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS: Laplace's equation, Poisson equation - difference equation, Liebmann method - derivative boundary conditions, alternating direct implicit method, irregular and non-rectangular grids, matrix patterns, sparseness, applications to steady heat flow problems. (4+4)

PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS: Explicit method, Crank-Nicholson method, derivative boundary condition, stability and convergence criteria, parabolic equations in two or more dimensions, applications to heat flow problems. (4+4)

HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS: Solving wave equation by finite differences, stability of the solution, wave equation in two dimensions. (4+4)

Note: Exposure to softwares. Design problems will be given to the students and they have to submit assignments/term papers using programs.

Total L: 30 + T: 30 = 60

REFERENCES:

1. Curtis F Gerald and Patrick O Wheatley, “Applied Numerical Analysis”, Pearson Education, New Delhi, 2011.
2. Steven C Chapra and Raymond P Canale, “Numerical Methods for Engineers”, Tata Mcgraw Hill, New Delhi, 2007.
3. John H Mathews and Kurtis D Fink, “Numerical Methods using MATLAB”, Prentice Hall, New Delhi, 2005.
4. Ward Cheney and David Kincaid,” Numerical Mathematics and Computing”, Cengage Learning, New Delhi, 2013.
5. Richard T Burden and Douglas Faires J, “Numerical Analysis”, Cengage Learning, New Delhi, 2012.

15MC02 MATERIALS AND MANUFACTURING ENGINEERING 2 2 0 3

MATERIALS AND THEIR PROPERTIES : Stress – strain diagram – brittle, ductile, ceramic, polymer materials – modules of elasticity, poisson’s ratio, shear modules – material strength, resilience & toughness, thermal conductivity, linear thermal expansion coefficient, specific heat capacity, Archard wear constant, two-parameter material charts, selection of material for various requirements (4)

DESIGN CONSIDERATIONS: review of basics of work, energy, torque, power, load analysis, equilibrium equations, free-body diagrams, internal loads, force flow concept, locating critical sections, practical considerations (3)

TYPES OF LOADING, STRESSES AND STRAIN: Area moment of inertia, parallel – axis theorem, section modulus, mass moment of inertia, normal stress & strain, torsion, power transfer, bending stress & strain, curved member, transverse shear stress & strain, stress concentration. (5)

LIGHT CONSTRUCTION: comparison of materials, material saving by form design, possible weight and cost reduction. (2)

GREEN DESIGN PROCESS: Material life cycle, embodied energy, 80-20 rule, carbon footprint, green design in industry, sustainability, biomimetics. (2)

MANUFACTURING PROCESSES: Casting process-sand casting, shell moulding, investment casting, die-casting. Fabrication processes- electric arc welding, gas welding, resistance welding, welding design. Metal forming processes- nature of plastic deformation, rolling, forging, extrusion, wire and tube drawing. Test methods for formability. (4)

MATERIAL REMOVAL PROCESSES: Theory of metal cutting- orthogonal and oblique cutting, Classification of cutting tools, Metal cutting theories-Earnst-Merchant theory-Lee and shaffer’s theory, chip formation, chip thickness ratio, tool failure, factors affecting tool life, cutting fluids. Work done and power required in cutting- problems. Machine tools – turning, milling, drilling, slotting, broaching, Jigs and fixtures. (6)

ABRASIVE PROCESSES: Grinding- wheel specifications and selection, types of grinding process, cylindrical grinding, centre less grinding , surface grinding, honing, lapping, super finishing, polishing and buffing. (2)

NON CONVENTIONAL MACHINING: Principles, processes and parameters - ultrasonic machining, electrical discharge machining, electro chemical machining, electron and laser beam machining, plasma arc machining and water jet machining. (2)

Total L: 30

REFERENCES:

1. Michael Ashby, Hugh Shercliff and David Cebon, "Materials Engineering, Science, Processing and Design", Butterworth-Heinemann, 2009.
2. Gustav Niemann, "Machine Elements: Design & Calculation in Mechanical Engineering", Springer-Verlag, 1978.
3. Myer Kutz, "Environmentally Conscious Mechanical Design", Wiley, 2007.
4. Bernard J Hamrock, Steven R Schmid and Bo O Jacobson, "Fundamentals of Machine Elements", McGraw-Hill 2004.
5. Robert C Juvinall, "Fundamentals of Machine Component Design", Wiley, 2011.

15MC03 COMPONENTS AND ARCHITECTURE OF CIM 3 0 0 3

INTRODUCTION TO FMS, RMS, CIM: Introduction to FMS, FMS equipment, tool management system, system layouts, reconfigurable machines and systems**,** CIM technology issues, CIM Models. (5)

MATERIAL HANDLING, STORAGE & DATA COLLECTION: Different types of material handling and storage system**,** interfacing handling storage with manufacturing. Automatic data collection, bar code technology, Radio Frequency Identification. (6)

PROCESS PLANNING: Approaches to process planning, CAPP- variant approach and generative approach, study of a typical process planning, system. (5)

ERP MODULES: Materials, human resource, production, sales, marketing and finance, dynamic enterprise modeling. (6)

NETWORKS: Computer networks, a perspective, goals, applications, switching techniques, circuit switching, message switching, packet switching, network components, existing network, ARPANET, concepts of network protocol, OSI reference model. (8)

LAN & ACCESS TECHNIQUES: Topologies - star, ring, bus. Ethernet, transmission media, protocols, polling, contention, ALOHA, CSMA, CSMA/CD, token ring protocols, performance comparisons. (5)

INTERNETWORKING DEVICES: Principles, repeaters, bridges, routing with bridges, routers, brouters, gateways, hubs and switches, TCP/IP protocol structure, internet protocol, transmission protocol, applications. (5)

CIM CASE STUDIES: CIM implementation, integration, benefits of CIM. (5)

Total L: 45

REFERENCES:

1. Basandra S K and Jaiswal, "Local Area Networks", Galgotia Publications Pvt. Ltd, New Delhi, 2006.
2. Taylor E D, "Networking Handbook", Tata McGraw Hill Co. Ltd., New Delhi, 2004.
3. Rao P N, "CAD/CAM, Principles and Applications", Tata McGraw Hill Co. Ltd, New Delhi, 2004.
4. Tien-chien Chang and Richard A Wysk, "An Introduction to Automated Process Planning Systems", Prentice Hall Inc., Englewood Cliffs, New Jersey, 1985.
5. Radhakrishnan P and Subramanyan S, "CAD/CAM/CIM", New Age International Ltd., 2003.

15MC04 CNC MACHINES AND ROBOTICS

3 2 0 4

COMPUTER NUMERICAL CONTROL:

INTRODUCTION AND DESIGN FEATURES OF CNC MACHINES TOOLS: Working principles of typical CNC lathes, turning centre, machining centre, CNC grinders, CNC gear cutting machines, wire cut EDM, turret punch press, CNC press brakes. Selection of CNC machine tools. Structure, drive kinematics, gear box, main drive, feed drive, selection of timing belts and pulleys, spindle bearings arrangement and installation. Re-circulating ball screws, linear motion guideways, tool magazines, ATC, APC, chip conveyors, tool turrets, pneumatic and hydraulic control systems. (6)

CONTROL SYSTEMS AND INTERFACING: Open loop and closed loop systems, microprocessor based CNC systems, block diagram of a typical CNC system, description of hardware and software interpolation systems, standard and optional features of a CNC control system, comparison of different control systems. Feedback devices with a CNC system, spindle encoder. (4)

MANUAL PART PROGRAMMING OF A CNC LATHE: Process planning, tooling, preset and qualified tools, typical tools for turning and machining centres. Axes definition, machine and workpiece datum, turret datum, absolute and incremental programming, tape codes - ISO and EIA codes, G and M functions, tool offset information, soft jaws, tool nose radius compensation, long turning cycle, facing cycle, constant cutting velocity, threading cycle, peck drilling cycle, part programming examples. (5)

MANUAL PART PROGRAMMING OF A MACHINING CENTRE: Co-ordinate systems, cutter diameter compensation, fixed cycles-drilling cycle, tapping cycle, boring cycle, fineboring cycle, back boring cycle, area clearance programs, macros, parametric programming, part programming examples. CAD/CAM based NC part programming, features of typical CAM packages. (4)

COMPUTER AIDED PART PROGRAMMING: Concept of computer aided programming, APT language structure, geometry commands, motion commands, CAM systems, generation of CNC program using CAM software, softwares for tool wear compensation. (4)

ROBOTICS:

FUNDAMENTAL CONCEPTS OF ROBOTICS: History, present status and future trends, robotics and automation, laws of robotics, robot definition, robotics systems and robot anatomy, specification of robots. Resolution, repeatability and accuracy of a manipulator. (5)

ROBOT DRIVES: Power transmission systems and control robot drive mechanisms, mechanical transmission method, rotary-to-rotary motion conversion, rotary-to-linear motion conversion, end effectors- types, gripping problem, remote-centered compliance devices, control of actuators in robotic mechanisms. Sensors for robotic applications. (7)

TRANSFORMATIONS AND KINEMATICS: Homogeneous co-ordinates, co-ordinate reference frames, homogeneous transformations for the manipulator, the forward and inverse problem of manipulator kinematics, motion generation, manipulator dynamics, Jacobian in terms of D.H.matrices controller architecture. Robot programming. (10)

Total L: 45 + T: 30 =75

REFERENCES:

1. Radhakrishnan P, “Computer Numerical Control (CNC) Machines”, New Central Book Agency, 2011.
2. Richard D Klafter, Thomas A Chmielewski and Michael Negin, "Robotic Engineering, an Integrated Approach", Eastern Economy Edition, Prentice Hall Pvt. Ltd., 2001.
3. Fu K S, Gonsalez R C and Lee C S G, "Robotics: Control Sensing, Vision, Intelligence", McGraw Hill Book Co., 1987.
4. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, “Industrial Robotics”, McGraw Hill Book Co., NY, 2008.
5. Yoram Koren, “Computer Control of Manufacturing Systems”, Tata McGraw Hill Book Co., 2005.

15MC05 MECHATRONICS SYSTEM DESIGN

3 2 0 4

INTRODUCTION TO MODELING AND SIMULATION: Definition, Key elements, Mechatronics approach for design process, Transfer functions, Frequency response of systems, Bode plot. Software and hardware in loop simulation. (5)

SENSORS, ACTUATORS & CONTROL VALVES: Sensors for motion and position measurement, proximity & range sensors, force sensors, torque sensors, temperature sensors, gyro sensors, magneto strictive actuators, Memory-metal actuators, Shape memory alloys. Selection of sensors for different applications. Pneumatic, hydraulic and electrical actuators - working principles, control valves – directions, pressure and flow proportional valves, control of servo valves. (15)

FLUIDIC SYSTEM DESIGN: Design of fluid power circuits – Cascade, KV-map and step counter method. PLC ladder logic diagram, programming of PLC, Fringe condition modules, Sizing of components in pneumatic and hydraulic Systems. Analysis of hydraulic circuits, fluidic muscles. (15)

REAL TIME INTERFACING: Introduction to data acquisition and control systems, overview of I/O process, virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, adaptive control, SCADA systems. (5)

MECHATRONIC SYSTEMS: Microcontrollers and micro processors, embedded systems, Case studies of intelligent systems such as automated material handling, CNC machines, consumer mechatronic products. (5)

Total L: 45 + T: 30 =75

REFERENCES:

1. Devdas Shetty and Richard A.Kolk., “Mechatronics System Design”, PWS Publishing Company, USA, 2011.
2. Ramesh S Gaonkar, “Microprocessor Architecture, Programming, and Applications with the 8085”, Penram International, India, 2013.
3. Kenneth J Ayala, “8051 Microcontroller, Architecture, Programming and Applications” Penram International, India, 1996.
4. Anthony Espisito, “Fluid Power with Application”, Prentice Hall, New Jersey, 2003.
5. Sanjay Gupta and Joseoh John, “Virtual Instrumentation using Lab VIEW”, Tata McGraw Hill Publications, Co., Ltd., 2005.

15MC51/15MD53 SENSOR INTERFACE AND ROBOTICS LABORATORY

0 0 4 2

1. Development of strain gauge set up to measure strain in a statically loaded machine structure and calibration of the same.
2. Measurement of damping ratio of a machine tool base from free vibration studies using an impact hammer and an accelerometer pick up with data acquisition system.
3. Interfacing of Proportional flow control valve (PFCV) & hot wire anemometer with data acquisition system to measure the air flow rate and calibration of the same.
4. Interfacing a stepper motor with PC for controlling speed, direction and number of steps using Virtual instrumentation platform.
5. Co-ordinated motion of multiple actuator, electro – pneumatic systems in a desired sequence using Virtual instrumentation platform.
6. Development of an intelligent conveyor system to sort metallic & non-metallic components
7. Development of a pick and place robot
8. Development of an obstacle avoidance robot
9. Development of a path following robot
10. Determining the response time of a control system using PI and PID controllers
11. Determining the positioning accuracy of a linear slide using open loop and closed loop controls
12. Development of embedded system using RIO cards

Total P: 60

15MC61 INDUSTRIAL VISIT & TECHNICAL SEMINAR 0 0 4 2

The student will be required to visit atleast one industry and observe the industry functions.

The student will be taught the guidelines to collect data, literature review and to compile a technical report. In addition, the student will also be taught the guidelines to publish research papers.

The student will be required to present at least two technical presentations during this course– the one based on industry visit and the other on current topics related to his or her specialization. The same will be assessed by a committee appointed by the department. The student is expected to submit atleast two reports based on the above guidelines at the end of each assignment completion.

A quiz covering the above will be conducted at the end of the semester.

Total P: 60

SEMESTER II

15MC06 FEA IN MANUFACTURING

3 0 0 3

INTRODUCTION: Historical background, Concept of finite element method, boundary, initial and eigen value problems, Finite element formulation starting from governing differential equations – Weighted residual method, Finite element formulation based on stationary of a functional. Review of static analysis using 1D elements (7+3)

STATIC ANALYSIS USING 2D AND 3D ELEMENTS: Triangular and quadrilateral elements, Isoparametric formulation, problems using 2D elements, shape functions for axisymmetric and 3D elements, shape functions for higher order elements. Introduction to plates and shells (7+2)

FINITE ELEMENT FORMULATION OF HEAT TRANSFER PROBLEMS: Basic differential equations of heat transfer, one dimensional and two dimensional finite element formulation using variational and Galerkin's method, one dimensional steady state heat transfer problems involving conduction and convection. Analysis of tapered fin, Formulation of thermal stress problems and examples, transient thermal analysis, solidification of casting. (9+3)

THERMOMECHANICAL MODELING: Formulation of thermal stress problem and examples, thermo mechanical modeling of welding using FEA software, concept of moving heat source, use of gaussian distribution, determination of residual stress. (7+2)

NON-LINEAR ANALYSIS: Introduction, Non-linear differential equation, Solution procedures for non-linear problems, Linearization and directional derivative, Material non-linearity-analysis of axially loaded bars, Geometric non-linearity-Basic continuum mechanics

concepts, Governing differential equations and weak forms, Introduction to contact problems. (9+3)

FINITE ELEMENT METHOD FOR BULK METAL FORMING: Solid formulation and flow formulation, concept of plasticity and visco plasticity, extremum principles, strain heat effect, implementation of finite element procedure for non steady state process. (6+2)

Total L: 45

REFERENCES:

1. Chandrupatla T R and Belegundu A D, “Introduction to Finite Elements in Engineering”, Pearson Education, New Delhi, 2007.
2. Logan D L, “A First Course in the Finite Element Method”, Thomson Learning, 2007.
3. Rao S S, “The Finite Element Method in Engineering”, Elsevier, 2005.
4. Rajasekaran S, “Finite Element Analysis in Engineering Design”, S Chand, 2008.
5. Seshu P, “A Text book on Finite Element Analysis”, Prentice Hall of India, New Delhi, 2003.

15MC07 GEOMETRIC MODELING

3 0 0 3

OVERVIEW OF CAD SYSTEMS AND GRAPHICS TRANSFORMATIONS: Conventional and computer aided design processes, subsystems of CAD-CAD hardware and software, analytical and graphics packages, CAD workstations. networking of CAD systems, generative, cognitive and image processing graphics, static and dynamic data graphics. Transport of graphics data. graphic standards, generation of graphic primitives, display and viewing, transformations customizing graphics software. (12)

MATHEMATICAL REPRESENTATION OF CURVES AND SURFACES: Introduction, wireframe models, parametric representation of curves (analytic and synthetic), curve manipulation, surface models, types of surfaces, introduction to parametric representation of surfaces, design examples. (9)

MATHEMATICAL REPRESENTATION OF SOLIDS: Fundamentals of solid modeling, boundary representation, constructive solid geometry, solid manipulations, solid modeling based applications. (8)

VISUAL REALISM AND COMPUTER ANIMATION: Model cleanup, hidden line removal, shading, computer animation, animation systems, design applications. (8)

MASS PROPERTY CALCULATIONS: Introduction, geometrical property formulation, mass property formulation, design and engineering applications. (8)

Total L: 45

REFERENCES:

1. Ibrahim Zeid, "CAD/CAM Theory and Practice", McGraw Hill Inc., New Delhi, 2005.
2. Radhakrishnan P, Subramanyan S and Raju V, “CAD/CAM/CIM”, New Age Internationals, 2012.
3. Radhakrishnan P and Kothandaraman C P, "Computer Graphics and Design", Dhanpat Rai and Sons, 1997.
4. Vera B Anand, “Computer Graphics and Geometric Modeling for Engineers”, John Wiley & Sons, Inc, New York, 1996.
5. Michael E Mortenson, "Geometric Modeling", John Wiley and Sons Inc., 1997.

15MC08 MODELING AND ANALYSIS OF ADVANCED MANUFACTURING SYSTEMS

3 0 0 3

MANUFACTURING SYSTEMS AND MODELS: Types and principles of manufacturing systems, types and uses of manufacturing models, physical models, mathematical models, model uses, model building. (3)

FLOW SHOP SYSTEMS: Assembly lines - reliable serial systems - approaches to line balancing – COMSOAL, ranked positional weight heuristic, branch and bound technique (optimal solution) – sequencing mixed models – unpaced lines. transfer lines and general serial systems – paced lines without buffers, two stage paced lines with buffers, introduction to unpaced lines. (8)

FACILITY LAYOUT: types of layout- advantages, limitation, systematic layout planning, layout design procedure-quadratic assignment approach, graph theoretic approach (6)

CELLULAR SYSTEMS: Group technology – coding schemes – assigning machines to groups – production flow analysis, binary ordering algorithm, single pass heuristic, similarity coefficients, graph partition - assigning parts to machines. (6)

FLEXIBLE MANUFACTURING SYSTEMS: System components – planning and control hierarchy – system design, system setup, scheduling and control – flexible assembly systems. (5)

MATERIAL HANDLING AND STORAGE: material handling principles, equipments - conveyor analysis, AGV systems. Warehousing, warehouse components, analysis of storage and retrieval systems, carousal storage systems. (8)

GENERIC MODELING APPROACHES: Queuing models – notations, performance measures, m/m/1 queue, m/m/m queue, batch arrival queuing systems, queues with breakdowns – queuing networks – open and closed networks, central server model. petri nets modeling – classical petrinets - transformation firing and reachability, reachability graphs – representation schemes – timed Perti nets - modeling of manufacturing systems. (9)

Total L: 45

REFERENCES:

1. Ronald G Askin, "Modeling and Analysis of Manufacturing Systems", John Wiley and Sons, Inc, 1993.
2. Viswanatham N and Narahari Y "Performance Modeling of Automated Manufacturing Systems", Prentice Hall Inc., 1994**.**

15MC09/15MD07/15MN30/15ML23 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 2 0 4

PROCESS CAPABILITY AND TOLERANCES: Geometric tolerances: applications, geometric tolerancing for manufacture as per Indian Standards and ASME Y 14.5 standard, surface finish, review of relationship between attainable tolerance grades and different machining processes. Process capability, mean, process capability metrics, Cp, Cpk, cost aspects. Tolerances: Limits and Fits, tolerance Chains and identification of functionally important dimensions, Statistical tolerance indication in mechanical drawings population parameter zone in the μ, σ plane defined using C_p, C_{pk}. (4+1)

TOLERANCE STACK UP ANALYSIS: Dimensional chain analysis-equivalent tolerances method, equivalent standard tolerance grade method, equivalent influence method. (3)

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, selective assembly, examples. (5+2)

DATUM SYSTEMS AND FIXTURE DESIGN: Degrees of freedom, grouped datum systems - different types, two and three mutually perpendicular grouped datum planes; Grouped datum system with spigot and recess, pin and hole; Grouped datum system with spigot and recess pair and tongue - slot pair - computation of translational and rotational accuracy, geometric analysis and applications. (4)

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, compound assembly. (6+2)

FUNCTIONAL INSPECTION TECHNIQUES: Functional inspection techniques using CMM, optical comparators and paper layout gauging, gauge repeatability and reproducibility (GR & R) calculations. (2)

FORM DESIGN OF CASTINGS, WELDMENTS AND SHEET METAL COMPONENTS: Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, form design aspects of sheet metal components. (6+2)

TOLERANCE CHARTING TECHNIQUE: Operation sequence for typical shaft type of components. Preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples. (6+2)

REDESIGN FOR MANUFACTURE: Design features to facilitate machining: datum features - functional and manufacturing. Component design - machining considerations, redesign for manufacture, examples. (4)

DESIGN FOR THE ENVIRONMENT: Introduction-environmental objectives-global issues-regional and local issues-basic DFE methods-design guidelines-example application. (1)

DFMA TOOLS: Rules and methodologies used to design components for manual, automatic and flexible assembly, traditional design and manufacture Vs concurrent engineering, DFA index, poka-yoke, lean principles, six sigma concepts, DFMA as the tool for concurrent engineering, three DFMA criteria for retaining components for redesign of a product; design for manual assembly; design for automatic assembly; computer-aided design for assembly using software. (4+1)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.
2. Matousek, "Engineering Design - A Systematic Approach", Blackie and Son Ltd., London, 1974.
3. Spotts M F, "Dimensioning and Tolerance for Quantity Production", Prentice Hall Inc., 1983.
4. Oliver R Wade, "Tolerance Control in Design and Manufacturing" Industrial Press Inc., New York, 1967.
5. Boothroyd G, Dewhurst P and Knight W, "Product Design for Manufacture and Assembly", Marcell Dekker.

15MC10 PRODUCT DEVELOPMENT AND REVERSE ENGINEERING

3 0 0 3

INTRODUCTION: Product design, importance of product design, considerations of a good design, phases of design process, challenges of product development, use if IT in product design, concept of CPC, PDM/PLM. (6)

PRODUCT DESIGN APPROACHES AND REVERSE ENGINEERING: Product development versus design, types of design and redesign, quality function deployment, axiomatic design, failure mode and effect analysis concurrent engineering, reverse engineering, scanning methods for reverse engineering, cloud points, NURBS surfaces, reengineering, tear down approach, bench marking. (9)

NEW PRODUCT DEVELOPMENT: Design creativity-innovations in design alternatives, S-curve. Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality. Concept generation**,** Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis. Concept selection, technical feasibility, ranking, measurement theory. (9)

MATERIAL SELECTION FOR PRODUCT DEVELOPMENT: Performance characteristics of materials, the material selection process, economics of materials, methods of material selection, materials performance indices, material selection by expert systems, value analysis, cradle to cradle reuse practices, composites and advanced materials, (9)

RAPID PROTOTYPING: Prototype basics, principles of prototyping, prototyping technologies, concepts of virtual prototyping. (6)

INTELLECTUAL PROPERTY RIGHTS AND PATENTING: Intellectual property, steps in patenting – formulate strategy and plan, study prior inventions, outline claims, write description of invention, refine claims, pursue application, reflect on the results and the process (6)

Total L: 45

REFERENCES:

1. Kevin Otto and Kristin Wood, “Product Design”, Pearson, 2001.
2. Chitale A K and Gupta R C, “Product Design and Manufacturing”, Prentice Hall of India, 2005.
3. Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006.
4. Nigel Cross, “Engineering Design Methods: Strategies for Product Design”, John Wiley and Sons, 2000.
5. Karl T Ulrich and Steven D Eppinger, “Product Design and Development”, Tata McGraw Hill, 2004.

15MC52 COMPUTER AIDED ENGINEERING LABORATORY

0 0 2 1

1. Part modeling, assembly modeling and drafting
2. Static analysis using 1D/2D elements using FEA software.
3. Static analysis of typical industrial components using 3D elements.
4. Dynamic analysis of mechanical systems
5. Steady state thermal analysis of engine/compressor parts
6. Transient thermal analysis of elements such as fins, engine parts, electronic parts, etc.
7. Thermo mechanical analysis of component such as spindle, brake, etc.
8. Estimation of fatigue life of mechanical/automotive components
9. Static structural analysis of composite parts
10. Analysis of internal and external fluid flow (pipes, ducts, aerofoil etc) using CFD software
11. Solution to problems involving plates and shells using MATHEMATICAL MODELING SOFTWARE.
12. FEA for sustainable design using Autodesk Inventor

Total P: 30

15MC53 INDUSTRIAL ENGINEERING LABORATORY 0 0 4 2

1. Design of Experiments / ANOVA using Statistical Software
2. Normality analysis and Hypothesis testing using Statistical Software
3. Solving inventory problems using software
4. Manufacturing system simulation and its performance measurement using modeling software
5. Study on reliability using component/product failure data using reliability life data analysis software
6. Study of Poka-Yoke
7. RFID simulation in lean factory
8. R&R gauges study.

SEMESTER III

15MC71 PROJECT WORK I

0 0 6 3

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

Total P: 90

IV SEMESTER

15MC72 PROJECT WORK II

0 0 28 14

- **The project work involves the following:**
  - **Preparing a project - brief proposal including**
  - Problem Identification
  - A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
  - List of possible solutions including alternatives and constraints
  - Cost benefit analysis
  - Time Line of activities
- **A report highlighting the design finalization [based on functional requirements & standards (if any)]**
  - A presentation including the following:
  - Implementation Phase (Hardware / Software / both)
  - Testing & Validation of the developed system
  - Learning in the Project
- **Consolidated report preparation**

Total P: 420

ELECTIVE THEORY COURSES

(Six to be opted-out of which two may be an open elective from other M.E/M.Tech programmes)

15MC21/15MN04 QUALITY ENGINEERING

3 0 0 3

INTRODUCTION: Definitions of the terms - quality, quality planning, quality control, quality assurance, quality management, Total Quality Management (TQM) as per ISO 8402 - overview on TQM - the TQM axioms - commitment - scientific knowledge - involvement - consequences of total quality. (5)

THE DEMING APPROACH TO TQM: Deming's fourteen points on quality management - five DDs - implementing the deming philosophy - action plan - the deming cycle - questions and opinions of deming. (5)

JURAN ON QUALITY: Developing a habit of quality - Juran quality trilogy - the universal break through sequence - comparison Juran and Deming approaches. (5)

CROSBY AND THE QUALITY TREATMENT: Crosby's diagnosis of a troubled company - Crosby's quality vaccine - Crosby's absolutes for quality management - Crosby's fourteen steps for quality improvement. (4)

KAIZEN: Meaning - Kaizen and innovation - the Kaizen management practices - total quality control (TQC) - approaches of Faigenbaum, Ishikawa - Kaizen and TQC - Kanban systems - small group activities - comparison of Kaizen and Deming's approach. (4)

SUPPORTING TOOLS, ACTIVITIES AND TECHNIQUES IN TQM PROJECTS : Affinity diagram - brainstorming - cause and effect analysis - force field analysis - line graph/run charts - Pareto analysis - quality costing - Quality Function Deployment (QFD). (6)

ISO 9000 SERIES QUALITY SYSTEM STANDARDS: The structure of ISO 9000 series quality system standards - certification process - action plan development for cases. (5)

STRATEGIC QUALITY MANAGEMENT: Integrating quality into strategic management - quality and the management cycle - resources for quality activities - training for quality - self managing teams - role of the quality director - obstacles to achieving successful strategic quality management. (5)

SIX SIGMA: Introduction, definition, methodology, impact of implementation of six sigma, DMAIC method-roles and responsibilities –leaders, champion, black belt, green belts. Implementation of six sigma: do‟s and dont‟s- readiness of organization –planning-management role- six sigma tools – sustaining six sigma. (6)

Total L: 45

REFERENCES:

1. Logothetics N, "Managing for Total Quality - From Deming to Taguchi and SPC", Prentice Hall Ltd., New Delhi, 1997.
2. Juran J M and Gryna, F M, "Quality Planning and Analysis - From Product Development through Use", Tata McGraw Hill Publishing Limited, New Delhi, Third Edition, 2004.
3. Deming W E, “Out of the Crisis," MIT Press, Cambridge, MA, 1982.
4. Juran J M and Juran on “Leadership for Quality" An Executive Handbook, The Free Press, New York, 1989.
5. Salor J H, "TQM-FIeld Manual," McGraw Hill, New York, 1992.

15MC22/15MN22 ENTERPRISE RESOURCE PLANNING

3 0 0 3

INTRODUCTION TO ERP SYSTEMS: ERP an overview – enterprise an overview – ERP as integrated management information system – evolution of ERP – benefits of ERP – ERP vs. traditional information systems – advantages of ERP – MRP II model and organizational processes. (6)

BUSINESS PROCESS REENGINEERING (BPR): Need and challenges – management concerns about BPR – BPR to build business – model for ERP – basic constituents of ERP – selection criteria for ERP – packages – procurement process for ERP package – features of various modules of ERP. (7)

ERP IMPLEMENTATION: ERP – implementation – lifecycle – implementation methodology – hidden costs in implementation – organizing the implementation – vendors – consultants and users – project management and monitoring – issues in customizing ERP systems for organizations – need for training. (6)

THE BUSINESS MODULES IN AN ERP PACKAGE: Finance – manufacturing – human resource – plant maintenance – materials management – quality management – sales and distribution. (9)

OVERVIEW OF ERP PACKAGES: SAP-R/3 – SAP B1 – MFG/PRO – IFS/AVALON – ORACLE. Comparison between different ERP packages. Survey of Indian ERP packages regarding their coverage, performance and cost – top management concerns and ERP systems – extended ERP (ERP II)/advanced planning systems. (9)

ERP CASE STUDIES: HRM, finance, production, materials, sales and distribution. (8)

Total L: 45

REFERENCES:

1. Alexis Leon, “ERP Demystified”, Tata McGraw-Hill Publishing Company Limited, 2003.
2. Vinod Kumar Garg and Venkitakrishnan N K, “Enterprise Resource Planning-Concepts and Practice”, Prentice Hall of India Private Limited, 2003.
3. David L OLSON, “Managerial Issues of Enterprise Resource Planning Systems”, Tata McGraw Hill Edition, 2004.
4. Rahul V Altekar, “Enterprise Wide Resource Planning – Theory and Practice”, Prentice Hall of India, New Delhi, 2004.
5. http://www.technologyevaluation.com/landing/select.asp

15MC23/15MN09 SUPPLY CHAIN MANAGEMENT

3 0 0 3

INTRODUCTION: Definition, house of supply chain – customer satisfaction, integration, coordination - decision phases in a supply chain, objectives of SCM, examples of supply chains, supply chain drivers, supply chain performance measures. (5)

SUPPLY CHAIN NETWORK DESIGN: Data collection – data aggregation, transportation modes and rates, mileage estimation, warehouse costs, warehouse capacity, potential warehouse locations, service level requirements and future demand. Network design in the supply chain – factors influencing the network design, framework for network design decisions, models for facility location and capacity allocation – capacitated plant location model, gravity location model, allocating demand to production facilitates, simultaneous location of plants and warehouses – impact of uncertainty on network design. (9)

INVENTORY MANAGEMENT: Single warehouse inventory model - cycle inventory – economies of scale to exploit fixed costs, quantity discounts, short term discounting, multi-echelon inventory, example problems. managing uncertainty – safety inventory in the supply chain –safety level estimation, impact of supply uncertainty, impact of aggregation, impact of replenishment policies, managing safety inventory in multi echelon supply chain, managing safety inventory in practice – product availability – optimal level, affecting factors, supply chain contracts – risk pooling – examples. value of information – Bullwhip effect, information and supply chain technology. (10)

DISTRIBUTION NETWORK DESIGN AND STRATEGIES: Role of distribution in supply chain – distribution network design – factors influencing distribution network design. push strategy – pull strategy – Kanban replenishment systems, types, implementation, and push–pull strategy – demand driven strategy – impact of internet on supply chain strategy. distribution networks in practice – direct shipment, cross docking, warehousing, transshipment. (6)

STRATEGIC ALLIANCE: Framework for srategic alliance - 3PL and 4PL – retailer-supplier partnerships – distribution integration – procurement and outsourcing – benefits, make/buy decisions, E-Procurement, supplier relationship management – supplier scoring and assessment, supplier selection and contracts – E-Business and the supply chain. design for logistics – supplier integration into new product development – mass customization. (6)

CUSTOMER VALUE AND GLOBAL SUPPLY CHAINS: Customer value – dimensions, strategic pricing, customer value measures, information technology and customer value – customer relationship management. global supply chains – introduction, driving factors, risks and advantages, issues, regional differences in logistics. (4)

INFORMATION TECHNOLOGY FOR SCM: Goals – standardization – infrastructure – interface devices, communications, databases, system architecture – system components – integrating the supply chain information technology - DSS for supply chain management. (5)

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, 2003.
2. Chopra S and Meindl P, “Supply Chain Management: Strategy, Planning, and Operation”, Prentice Hall India Pvt. Ltd, New Delhi, 2007.
3. Robert B Handfield and Ernest L Nichols, “Introduction to Supply Chain Management”, Prentice Hall, Inc. New Delhi, 1999.
4. Sahay B S, “Supply Chain Management”, Macmillan Company, 2000.
5. David Brunt and David Taylor, “Manufacturing Operations and Supply Chain Management: The Lean Approach”, Vikas Publishing House, New Delhi, 2001.

15MC24/15MD24 MECHANICS OF COMPOSITES AND SMART MATERIALS

3 0 0 3

INTRODUCTION: Modern materials in design, types, metals, polymers, ceramics, composites, Classification of composites, advantages, applications and limiations. Matrix and reinforcement-their roles, principal types of fibre and matrix materials. (6)

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. (6)

MICRO MECHANICAL BEHAVIOUR OF A LAMINA: Volume and mass fractions, evaluation of elastic moduli, strength of unidirectional lamina. (7)

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. (7)

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. (7)

ANALYSIS OF COMPOSITE STRUCTURES: Fatigue, Fracture mechanics-basic principles, fracture initiation, crack growth and crack growth modes, toughening mechanisms, Environmental effects, Composite joints-bonded, bolted and bonded-bolted joints.(6)

SMART MATERIALS: Rheological, piezoelectric, shape-memory and magnetostrictive materials. Material characteristics of smart materials. Application of smart materials for design of intelligent structures. (6)

Total L: 45

REFERENCES:

1. Autar K Kaw, "Mechanics of Composite Materials", Second Edition, CRC Press, NY, 2006.
2. Bhagwan D, Agarwal, Lawrence J and Broutman, “Analysis and Performance of Fibre Composites", John Wiley and Sons Inc.
3. Matthews F L and Rawlings R D, “Composite Materials: Engineering and Science”, Woodhead Publishing,1999.
4. Srinivasan A V and Michael McFarland, “Smart Structures: Analysis and Design”, Cambridge University Press, UK, 2001.
5. Ronald F Gibson, “Principles of Composite Material Mechanics", McGraw Hill Book Co., 2007.

15MC25/15MD26 INDUSTRIAL ROBOTICS

3 0 0 3

INTRODUCTION TO ROBOTICS: History, present and future of robotics, laws of robotics, anatomy of robot, specification of robots, flexible automation vs robotics technology , classification of robots. (5)

ROBOT DRIVES, ACTUATORS & CONTROL: Functions of drive systems, electrical, hydraulic and pneumatic drives, characteristics of actuating systems, Robot controllers, motion control of robots, types of robot controls . (6)

SENSORS FOR ROBOTS: Characteristics of sensors, position sensors, velocity sensors, acceleration sensors, force and pressure sensors, torque sensors, micro switches, light and infrared sensors, touch and tactile sensors, proximity & range sensors, sniff sensors, voice recognition devices, voice synthesizers (8)

VISION SYSTEM FOR ROBOTS: Robot vision systems - Image processing versus image analysis, image acquisition, sampling and quantization, image processing techniques, histogram of images, thresholding, connectivity, noise reduction, edge detection, segmentation by region growing and region splitting, object recognition by features. (8)

ROBOT LANGUAGES AND PROGRAMMING: Robot languages, classification, computer control & robot software, leadthrough programming (6)

ROBOT CELL LAYOUT: Classification of robot cell layout, considerations in workcell design, safety monitoring. (6)

ROBOT INSTALLATION & APPLICATIONS: Feasibility of the robotization plan, investment and evaluation strategies, planning for robot installation, applications of robots, future of robotics in India. (6)

Total L: 45

REFERENCES:

1. Saeed B Niku, “Introduction to Robotics Analysis, Systems , Applications” , Pearson Education (Singapore) Pte. Ltd., 2002
2. Deb S R and Sankha Deb, “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd., 2012.
3. Mikell P Groover, Mitchell Weiss, Roger N Nagel and Nicholas G.Odrey, ”Industrial Robotics”, Tata McGraw Hill Education Pvt.Ltd.”, 2008
4. Richard D Klafter, Thomas A Chmielewski and Michael Negin, "Robotic Engineering, an Integrated Approach", Eastern Economy Edition, Prentice Hall Pvt. Ltd., 2001.

15MC26/15MN05 SIMULATION MODELING AND ANALYSIS

3 0 0 3

INTRODUCTION TO SIMULATION: Definition – history - nature of computer modeling and simulation, limitations of simulation, areas of application. System and environment**:** Components of a system – types of simulation - discrete and continuous systems. (4)

MANUAL SIMULATION: Simulation of Queuing Systems - single channel and multi channel queue - lead time demand - inventory system, reliability problem, time-shared computer model, job-shop model. (5)

RANDOM NUMBER GENERATION AND TESTING: Techniques for generating random numbers - midsquare method - midproduct method - constant multiplier technique - additive congruential method - linear congruential method – combined linear congruential generators – feedback shift register generators - tests for random numbers – frequency test - the Kolmogorov-Smirnov test, the chi-square test. Independence test – runs up and runs down, runs above and below the mean, autocorrelation test, Gap test, Poker test. (7)

RANDOM VARIATE GENERATION: Inverse transform technique - exponential distribution, uniform distribution, Weibull distribution, Triangular distribution. Empirical continuous distribution - generating approximate normal variates - Erlang distribution. empirical discrete distribution - discrete uniform distribution - poisson distribution - geometric distribution - acceptance - rejection technique for poisson distribution - gamma distribution. (6)

INPUT MODELING: Introduction - steps to build a useful model of input data - data collection, identifying the distribution with data, parameter estimation, suggested estimators, goodness of fit tests, selecting input models without data, models of arrival processes. (5)

VERIFICATION AND VALIDATION OF SIMULATION MODELS: Introduction - model building -variance reduction techniques, antithetic variables, calibration and validation of models. (4)

OUTPUT ANALYSIS: Types of simulation with respect to output analysis - stochastic nature of output data, measures of performance and their estimation, output analysis for terminating simulation, output analysis for steady state simulation. (3)

MANUFACTURING SYSTEMS MODELING: Objectives and performance measures – modeling system randomness – sources of randomness, machine downtime. (5)

CASE STUDIES: Simulation of manufacturing systems, Material Handling system, computer systems, service sectors. (6)

Total L: 45

REFERENCES:

1. Jerry Banks, John S, Carson II, Barry L Nelson and David M Nicol, “Discrete Event System Simulation”, Prentice Hall Inc., 2006.
2. Law A M, “Simulation Modeling and Analysis”, Tata McGraw Hill Companies Inc, 2008.
3. Gordon G, “Systems Simulation”, Prentice Hall Ltd., 2006.
4. NarsinghDeo, “System Simulation with Digital Computer”, Prentice Hall of India, 2007.
5. Francis Neelamkovil, “Computer Simulation and Modeling”, John Wiley and Sons, 1987.

15MC27/15MN07 OPTIMIZATION TECHNIQUES

3 0 0 3

NON-LINEAR OPTIMIZATION: Introduction – unconstrained optimization - one-dimensional optimization – elimination methods – Fibonacci method, golden section methods – interpolation methods – quadratic, direct route method – multivariable optimization **-** direct search methods – pattern search methods – univariate method, hooks and jeeves method, simplex method – descent methods – steepest descent, Newton methods. (9)

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

INTEGER AND DYNAMIC PROGRAMMING: Introduction to integer programming – solution techniques - graphical method, the branch and bound technique, gomary‟s cutting plane method, examples on the application in manufacturing / design systems – introduction to dynamic programming - bellman’s principle of optimality, examples on the application on routing problem, inventory problem. (8)

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. (6)

NON-TRADITIONAL OPTIMIZATION – I: Introduction to non-traditional optimization, computational complexity – NP-hard, NP-complete, no free lunch theorem – working principles of simulated annealing, Tabu search, and neural networks, simple applications. (7)

NON-TRADITIONAL OPTIMIZATION – II: Introduction to Genetic Algorithms, Ant Colony Algorithm, Particle Swap Algorithm,TLBO method, Hybrid Algorithms, Simple Applications. (8)

Total L: 45

REFERENCES:

1. Singiresu S Rao, "Engineering Optimization: Theory and Practice", Wiley-Interscience, 1996.
2. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall India Pvt. Ltd., New Delhi, 2000.
3. David E Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison Wesley Pub Co., 1989.
4. Marco Dorigo and Thomas Stutzle, "Ant Colony Optimization", Prentice Hall of India, 2005.
5. Maurice Clerc, "Particle Swarm Optimization", ISTE, 2007

15MC28 ADVANCED METROLOGY AND AUTOMATED INSPECTION

3 0 0 3

GENERAL CONCEPTS OF MEASUREMENT: Definition – Standards of measurement – Errors in measurement – error analysis and classification, rules for estimating error, sources of error , Interchangeability and Selective assembly – Accuracy and Precision – Calibration of instruments. (8)

MEASUREMENT OF SURFACE FINISH AND MEASURING MACHINES: Definitions – Types of Surface Texture: Surface Roughness Measurement Methods- Comparison, Profilometer, 3D Surface Roughness Measurement – Instruments. **(**8)

INTERFEROMETRY: Interferometry – Introduction, Principles of light interference – Interferometers – Measurement and Calibration – Laser Interferometry **(**8)

IMAGE PROCESSING: Overview, Computer imaging systems, Image Analysis, Preprocessing, Human vision system, Image model, Image enhancement, gray scale models, histogram models, Image Transforms**.** (7)

ADVANCED INSPECTION SYSTEM AND LASER METROLOGY: Tool Makers Microscope – Microhite – Co – Ordinate measuring machine – Applications – Laser Micrometer, Laser Scanning gauge, Non contact and in-process inspection, Vision system- Machine vision systems-Solid state camera ,Three-Dimensional vision, Commercial machine vision system. Smart Cameras, systems on line inspections, features. , Ultrasonic sensor for automated inspection, automated inspection for packaging product, Automatic inspection of engine block . Multi-Gauging and automated inspection. (9)

ROBOTIC INSPECTION: Robotic testing and inspection- Automobile body gauging-valve testing-Robot vision system (5)

Total L: 45

REFERENCES:

1. Gupta I C, "A Text Book of Engineering Metrology", Dhanpat Rai and Sons, 1996.
2. Stanley L Robinson and Richard K Miller "Automated Inspection and Quality Assurance", ISBN 0-8247-8002-7.
3. G N Galyer F W and Shotbolt C R, "Metrology for Engineers", ELBS, 1990.
4. Batchelor BG, "Automated Visual Inspection" IFS Publications Limited, 1985.
5. Graham T Smith, "Industrial Metrology", Springer, 2002.

15MC29 MODERN MANUFACTURING PROCESSES

3 0 0 3

ECONOMICS OF MACHINING: Calculation of machining time for turning, drilling, shaping, milling and grinding, cost estimation, general principles of economics of machining, economic tool life, optimal cutting speed for maximum production. Physical machining methods: Applications advantages and comparison of the processes. (6)

ULTRASONIC MACHINING (USM): Process description of ultrasonic machining, process principles, equipments, effect of process parameters, process capabilities, applications and limitations. (6)

ABRASIVE JET MACHINING (AJM): Description of the apparatus, nozzles, metal removal rate and application, water jet machining and applications, abrasive water jet machining, effect of process parameters. (5)

ELECTRON BEAM MACHINING (EBM): Production of electron beam, description of the apparatus, application of electron beam machining, electron beam welding, process principles, equipments, effect of process parameters, processes capabilities. (5)

PLASMA ARC MACHINING (PAM): Generation of plasma arc, description of the equipment, process parameters, applications and limitations. (4)

LASER BEAM MACHINING (LBM): Laser beam production, description of the apparatus, thermal features, cutting speed, accuracy, three dimensional machining, applications, Laser beam welding. (5)

ELECTRICAL DISCHARGE MACHINING (EDM): Description of the EDM equipment, electrical circuits, electrolytes, electrode materials, metal removal rate, applications, EDWC, process principles, equipments, effect of process parameters, process capabilities, applications in diemaking. (5)

ELECTRO CHEMICAL MACHINING (ECM): Description of the equipment, chemistry of the process, electrolytes, metal removal rate, accuracy and surface finish obtained.Electro Chemical Grinding (ECG): Chemical machining, electro chemical grinding equipment, application, electro chemical deburring and honing, chemical etching process, applications. (5)

3D PRINTING: Working principle - description of the equipment benefits - application (4)

Total L: 45

REFERENCES:

1. Battacharya A, "New Technology" - IE Publishers, 1984.
2. ASTME, "High Velocity Forming of Metals", Prentice Hall of India Pvt. Ltd, New Delhi, 1968.
3. Pandey P C, "Modern Machining Systems", Tata McGraw Hill Publication, 1993.
4. HMT, "Production Technology", Tata McGraw Hill, 1992.
5. Gary F Benedict, “Nontraditional Manufacturing Process”

15MC30/15MD30 MICRO ELECTRO MECHANICAL SYSTEMS

3 0 0 3

MEMS AND MICROSYSTEMS: MEMS and microsystem products. Evaluation of microfabrication. Microsystems and microelectronics. Applications of microsystems. Working principles of microsystems-microsensors, microactuators, MEMS and microactuators, microaccelerometers (5)

SCALING LAWS IN MINIATURIZATION: Introduction.Scaling in geometry. Scaling in rigid body dynamics. The trimmer force scaling vector-scaling in electrostatic forces, electromagnetic forces, scaling in electricity and fluidic dynamics, scaling in heat conducting and heat convection. (5)

MATERIALS FOR MEMS AND MICROSYSTEMS: Substrates and wafers-silicon as a substrate material, ideal substrates for MEMS. Single crystal Silicon and wafers crystal structure. Mechanical properties of Si. Silicon compounds-SiO2, SiC, Si3N4 and polycrystalline Silicon. Silicon piezoresistors. Gallium arsenside. Quartz-piezoelectric crystals. Polymers for MEMS. Conductive polymers. (8)

ENGINEERING MECHANICS FOR MICROSYSTEMS DESIGN: Introduction. Static bending of thin plates-circular plates with edge fixed, rectangular plate with all edges fixed and square plates with all edges fixed. Mechanical vibration. Resonant vibration. Microaccelerometers-design theory and damping coefficients. Thermomechanics. Thermal stresses. Fracture mechanics-stress intensity factors, fracture toughness and interfacial fracture mechanics. (6)

BASICS OF FLUID MECHANICS IN MACRO AND MESO SCALES: Viscosity of fluids-flow patterns, reynolds number. Basic equation in continuum fluid dynamics. Laminar fluid flow in circular conduits. Computational fluid dynamics. Incompressible fluid flow in microconducts-surface tension, capillary effect and micropumping. Fluid flow in submicrometer and nanoscale-rarefied gas, Kundsen and Mach number and modelling of microgas flow. Heat conduction in multilayered thin films. Heat conduction in solids in submicrometer scale. Thermal conductivity of thin films, heat conduction equation for thin films. (6)

MICROSYSTEM FABRICATION PROCESS: Photolithography. Photoresist and applications. Light sources. Ion implanation. Diffusion process. Oxidation-thermal oxidation. Silicon diode. Thermal oxidation rates. Oxide thickness by colour. Chemical vapour deposition-principle, reactants in CVD. Enhanced CVD physical vapour deposition. Sputtering. Deposition by epitaxy. Etching-chemcial and plasma etching. (7)

MICROMANUFACTURING AND MICROSYSTEM PACKAGING: Bulk micromachining. Isotropic and anisotropic etching-wet etchants, etch stops, dry etching comparison of wet and dry etching. Surface micromachining-process in general, problems associated in surface micromachining. The LIGA process-description, materials for substrates and photoresists, electroplating, the

SLIGA process. Microsystem packaging-general considerations. The three levels of microsystem packaging-die level, device level and system level. Essential packaging technologies-die preparation-surface bonding, wire bonding and sealing. Three dimensional packaging. Assembly of microsytems-selection of packaging materials. (8)

Total L: 45

REFERENCES:

1. Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2002.
2. Mark Madou "Fundamentals of Microfabrication", CRC Press, New York, 1997.
3. Julian W Gardner, "Microsensors: Principles and Applications", John Wiley and Sons, New York, 2001.
4. Sze S M, "Semiconductor Sensors", McGraw Hill, New York, 1994.
5. Chang C Y and Sze S M, "VLSI Technology", McGraw Hill, New York, 2000.

15MC31/15MD31 NANOMATERIALS AND NANOTECHNOLOGY

3 0 0 3

ZERO – DIMENSIONAL NANOSTRUCTURES: Nanoparticles through homogenous nucleation, nanoparticles through the heterogeneous nucleation, kinetically confined synthesis of nanoparticles, epitaxial core – shell nanoparticles. (5)

ONE DIMENSIONAL NANOSTRUCTURE- NANOWIRES AND NANORODS: Spontaneous growth, template based synthesis, electro spinning, and lithography. (5)

TWO-DIMENSIONAL NANOSTRUCTURES-THIN FILMS: Fundamentals of film growth, vacuum science, physical vapor deposition(PVD), Chemical Vapor Deposition(CVD), Atomic Layer Deposition (ALD), Electrochemical Deposition, Sol-Gel films. (6)

NANOSTRUCTURES FABRICAITON: Lithography, nano manipulation and nanolithography, soft lithography, assembly of nanoparticels and nanowires, other methods of micro fabrication. (5)

NANOMECHANICS: A high speed review of motion: Displacement, velocity, acceleration and force, nano mechanical oscillation, feeling faint forces. (5)

NANO ELECTRONICS: Electron energy bands, electrons in solids: conductors, insulation and semi conductors, fermi energy, the density of states for solids, quantum confinement, tunneling, single electron phenomenon, molecular electronics. (6)

NANOSCALE HEAT TRANSFER: Nanoscale heat, conduction, convection, radiation. (4)

NANOPHOTONICS: Photonics properties of nanomaterials, near-field light, optical tweezers, photonic crystals. (4)

NANOSCALE FLUID MECHANICS: Fluids at the nanoscale: major concepts, flow fluids flow at the nanoscale, applications of nanofludics. (5)

Total L: 45

REFERENCES:

1. Rogers, Pennathur and Adams, "Nanotechnology: Understanding Small System", CRC Press, 2008.
2. Guozhong Cao, "Nanostructures and Nanomaterials", Imperial College Press, 2006.

15MC32/15MN11 ENGINEERING ECONOMIC ANALYSIS

3 0 0 3

INTRODUCTION: Present economic policy - liberalisation - privatisation - globalisation - scope for industrial growth **- i**nterest and time value of money cash-flow diagram, simple interest - compound interest - single payments - uniform series payments - interest factors and tables - nominal and effective interest rates - continuous compounding - uniform continuous payments (7)

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. (7)

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. (6)

RISK AND MULTI STAGE SEQUENTIAL DECISION ANALYSIS: Recognizing risk - including risk in economic analysis – expected value - payoff table - decision tree - discounted decision tree. (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)

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: Product design - concept of concurrent engineering - make Vs buy decisions – BPO – value analysis – FAST approach – product life cycle management. (4)

FINANCIAL FEASIBILITY: Means of financing - financial institutions - all India - state level - profitability - cash flows of a project –. tax factors in investment analysis effects of inflation in economic analysis. (5)

Total L: 45

REFERENCES:

1. James L Riggs, David D Bedworth and Sabah U Randhawa, “Engineering Economics”, McGraw Hill Book Company, New Delhi, 2004.
2. Prasanna Chandra, “Projects Preparation, Appraisal and Implementation", Tata McGraw Hill, New Delhi, 2004.
3. Norman N Barish "Economic Analysis for Engineering and Managerial Decision Making", McGraw Hill Book Company, 1983.
4. Leland T Blank and Anthony J Tarquin, "Engineering Economy", McGraw Hill Book Company, 1998.
5. John A White et. al, "Principles of Engineering Economic Analysis", John Wiley and Sons, New York, 1998.

15MC33/15MN03 STATISTICS AND RELIABILITY ENGINEERING

3 0 0 3

RANDOM VARIABLES AND PROBABILITY DISTRIBUTIONS: Sample spaces **–** events, probability axioms - conditional probability - independent events - Baye's formula. Distribution functions - marginal distributions - conditional distributions - stochastic independence. Expectation - conditional expectation and conditional variance. Moment generating functions - cumulant generating functions – probability distributions - binomial, poisson, geometric, uniform, normal, Gamma, Beta, (generating function, Mean, Variance and simple problems. (7)

ESTIMATION: Point estimation - characteristics of estimation - interval estimation - interval estimates of mean, standard deviation, proportion, difference in means and ratios of standard deviations. Probability density function and properties of t, F and Chi-square distributions. Test for means, variances and attributes using the above distributions, a large sample tests - tests for means, variances and proportions. (6)

CORRELATION AND REGRESSION: Multiple and partial correlation – regression - linear, non-linear, logistic, multiple regression (only problems). (5)

DESIGN OF EXPERIMENTS AND ANALYSIS OF VARIANCE: Experimental designs – full factorial, partial factorial, Taguchi"s orthogonal array method, completely randomized block, latin square design (only problems). ANOVA - One way and two way classifications, Multiway ANOVA (Only Problems) (5)

INTRODUCTION TO 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- exponential, Weibull distribution. (5)

RELIABILITY OF SYSTEM AND MODELS: Serial configuration – parallel configuration – combined series parallel systems- system structure function, minimal cuts and minimal paths – load sharing systems, standby system, degraded systems, three state devices – covariate models , static models, dynamic models, physics of failure models . (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 – design methods - availability concepts and definitions – system (7)

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. (5)

Total L: 45

REFERENCES:

1. Trivedi K S, “Probability and Statistics with Reliability, Queuing and Computer Applications”, Prentice Hall, New Delhi, 1982.
2. Arnold O Allen, “Probability, Statistics and Queuing Theory with Computer Science Applications”, Academic Press, 1978.
3. Charles E Ebling, “An Introduction to Reliability and Maintainability Engineering”, Tata McGraw Hill, 2000.
4. Doughlas C Montgomory and Lynwood A Johnson, “A Forecasting and Time series Analysis”, McGraw Hill book Company, 1976.
5. Daleh Bester Field, “Quality Control”, Prentice Hall, 1986.

15MC34 PRECISION ENGINEERING

3 0 0 3

ACCURACY: Concept of accuracy – accuracy of numeric control systems, acceptance test for machine tools. (6)

FACTORS AFFECTING ACCURACY: Static stiffness and its influence on machining accuracy, inaccuracies due to thermal effects, influence of forced vibrations on accuracy, dimensional wear of cutting tools and its influence on accuracy. (7)

MICRO FINISHING PROCESS: Surface roughness, bearing area curves, surface texture measurement, methods of improving accuracy and surface finish, finish boring, finish grinding, precision cylindrical grinding, micro machining, precision micro drilling. (8)

UNCONVENTIONAL MACHINING: EDM machining, electro mechanical grinding, electron beam machining, laser beam machining. micro EDM and its applications, micro machining with laser (7)

MICRO ELECTRO MECHANICAL SYSTEMS: Introduction to silicon processing, wafer cleaning, diffusion and ion implantation, oxidation, photolithography, photo resist, resist strip, electron beam and X-ray lithography, thin film deposition, evaporation, sputtering, molecular beam epitaxy, chemical vapour deposition, electro plating. (8)

BULK MICRO MACHINING AND NANO TECHNOLOGY: Wet etching, isotropic etching, anisotropic etching, dry etching, physical etching, reactive ion etching, Nano Technology, nano-grating system, nano-lithography, fabrication of CCDS, nano processing of materials for super high density ICs, nano-mechanical parts. (9)

Total L: 45

REFERENCES:

1. Murthy R L, “Precision Engineering in Manufacturing”, New Age International Publishers, 1996.
2. Mark J Madou, “Fundamentals of Micro Fabrication”, CRC Press, 2002.
3. Niño Tanigudi, “Nanotechnology”, Oxford University Press, New York, 2003.
4. Davidson, “Handbook of Precision Engineering”, Vol. 1, 12, McMillan, 1972.
5. Jaeger R C, “Introduction to Micro Electronics Fabrication”, Addison Wesley, England, 1988.

15MC35/15MN06 OPERATIONS MANAGEMENT

3 0 0 3

INTRODUCTION: Operations function, globalization, factors affecting operation management, exciting new trends in operation management. Operations strategy – forming operation strategies, strategy deployment, world class manufacturing practices. (3)

UNDERSTANDING PROCESSES: Design of processes – types of production processes, major factors affecting process design decisions. Process Planning- steps in process planning, make-or-buy decision, process analysis, automated process plan. Product Development Process – organization for product development, performance measure, management accounting. (6)

DESIGNING OPERATIONS: Facilities layout – globalization of operations, factors affecting location decisions, location planning methods, other issues, basic layout, designing product, process layout, hybrid layout, layout design procedures- CRAFT, ALDEP, CORELAP, layout design for services. Capacity Planning – capacity and strategy, managing demand, break-even analysis. (8)

PLANNING AND CONTROL OF OPERATIONS: Forecasting – strategic role of forecasting, components of forecasting demand,, forecasting methods- time series methods, regression methods, seasonal forecasting, cyclic forecasting, accuracy of forecasts. Aggregate Production Planning - framework, basic strategies, approaches to aggregate planning, graphical, empirical, and optimisation. Resource Planning –basic building blocks - MRP-I, MRP-II, ERP. (8)

INVENTORY ANALYSIS AND CONTROL: Definitions, elements of inventory management, Inventory classification & control systems - ABC, XYZ, FSN, VED. Material management, inventory control, Lot sizing techniques, models of inventory, purchase model with instantaneous replenishment and without shortages, manufacturing models without shortages, purchase model with shortages, inventory models with price breaks, quantity discounts, inventory order policies, Inventory models under uncertainty. (8)

SCHEDULING AND PROJECT PLANNING: Objectives in scheduling , major steps involved , dispatching rules. Project planning - network planning techniques - critical path method (CPM), project evaluation and review technique (PERT), cost crashing, resource leveling. (7)

LEAN MANUFACTURING: Introduction, elements of JIT, uniform production rate, pull Vs push method, Kanban system, small lot size, quick & inexpensive set-up, continuous improvement. (5)

Total L: 45

REFERENCES:

1. Norman Gaither, Greg Frazier, “Operations Management”, Cengage Learning, New Delhi, 2009.
2. Roberta S Russell and Bernard W Taylor III, “Operations Management”, Prentice Hall of India, New Delhi, 2007.
3. Jay Heizer and Barry Render, “Operations Management”, Pearson Education.
4. Bedworth D D, “Integrated Production Control systems Management, Analysis, Design”, John Wiley and Sons, New York, 1982.
5. Dilworth B James, “Operations Management, Design, Planning and Control for Manufacturing and Services”, McGraw Hill, Inc, New Delhi, 1992.

15MC36/15MD36 COMPUTATIONAL FLUID DYNAMICS 3 0 0 3

INTRODUCTION: Basic concepts of fluid flow-derivation of the governing equations, conservation of mass, momentum and energy. Mathematical classification of flow - hyperbolic, parabolic, elliptic and mixed flow types. (7)

DISCRETISATION: Finite difference method - forward, backward and central difference schemes, explicit and implicit methods. Properties of numerical solution methods - stability analysis, error estimation, difference between the FDM and FVM methods. (9)

INTRODUCTION TO GRID GENERATION: Choice of grid – structured, unstructured grid, Irregular structured grids, unstructured grids, staggered and collocated arrangements, adaptive grids. (7)

CFD TECHNIQUES: Lax - Wendroff technique - MacCormack’s technique, relaxation technique. Artificialviscosity, ADI technique, Pressure correction technique, simple algorithm. Upwind schemes - flux vector splitting. (9)

TURBULENCE MODELING: Need for turbulence modeling, Direct Numerical Simulation (DNS), RANS equation, Large Eddy Simulation, Turbulence energy equation- one-equation model, Two equation models - the k-ω model, the k- ε model. (7)

WALL BOUNDED FLOWS: Velocity profiles – inner, outer and overlap layers, Dimensionless profiles, Applications – channel and pipe flow, Separated flow. (6)

Total L: 45

REFERENCES:

1. John D Anderson, “Computational Fluid Dynamics – The Basics with Applications”, TATA McGraw Hill, New Delhi, 2012.
2. Muralidhar K and Sundararajan T, “Computational Fluid Flow and Heat Transfer”, Narosa Publications, 2003.
3. Chung T J, “Computational Fluid Dynamics”, Cambridge University Press, London, 2010.
4. David C Wilcox, “Turbulence Modeling for CFD”, DCW Industries, Inc., 2006.
5. Oleg Zikanov, “Essential Computational Fluid Dynamics”, Wiley India Pvt. Ltd., 2010.

15MC37/15ML06 INFORMATION TECHNOLOGY IN MANUFACTURING APPLICATIONS

3 0 0 3

INTRODUCTION: Role of information technology in manufacturing – Role of Internet, Intranet and Extranet - Present market constraints - Extended enterprises - B2C and B2B – PDM, CPC and PLM – ERP & ERP II – Virtual manufacturing. (4)

INFORMATION TECHNOLOGY BACKGROUND: Introduction to world wide web – www vs traditional application – Web communication protocols - Types of server – Client/Server – Client/Server architectures - Database – Data model – DBMS – Basic Entity-Relation (ER) diagram – Primary and Foreign Keys – Normalization – Data association - Security – Data backup – Clustering – Cloud computing – Network basics - Tools to develop client/server models – CASE tools – Role of Business analysts - Direct link to manufacturing applications. Exercises of above concepts. (10)

FUNDAMENTALS OF NETWORKING: Networking concepts, networking devices – repeaters, bridges, routers, gateways, hubs and switches. MAP, TOP, LAN, WAN. Network topologies – star, bus, ring. Wireless: 902, 802.11 a, b, g, n, n2. OSI – layers of OSI model – TCP/IP. (3)

PRODUCT DEVELOPEMENT AND ISSUES: Product lifecycle - Sequential engineering vs concurrent engineering - Global product - Product development and its complexity – Quality assurance issues - Information technology tools to easy. (3)

USE OF CAD, CAE AND CAM: Reverse engineering - Modeling of geometry of parts - Modeling of assemblies and disassemblies – Sustainable engineering - Different modeling packages - Data exchange standards between different software - Use of analysis software (FEA) - Use of manufacturing process simulation software – Case studies – Practical exercises from industry. (7)

MANUFACTURING MODELS: Engineer to order - Make to order - Assemble to order - Made to stock - Configure to order. Case studies. (2)

AUTOMATED PROCESS PLANNING: Process planning - Structure of process planning software - Information requirements for process planning - Operation to a typical computer aided process planning software – Case studies. (3)

PLANNING OF RESOURSES FOR MANUFACTURING THROUGH IT: Background – Role of MRP, MP-II, ERP, ERP II – Software packages of each: Manufacturing applications - Engineering applications - Financial applications - Marketing applications - Dynamic enterprises. (5)

COLLABORATIVE ENGINEERING: Faster design throughput - Web based design - Changing design approaches - Engineering change management - Product configuration management - Extended enterprises - Enterprise application integration for PLM – Case studies. (4)

PROJECT: Practical execution of a project based on above tools from industry. (4)

Total L: 45

REFERENCES:

1. John Stark, “Global Product Strategy, Product Lifecycle Management and Billion Customer Question”, Springer Publisher, 2007
2. John Stark, “Product Lifecycle Management: 21 century for Product Realisation”, Springer Publisher, 2005.
3. Radhakrishan P, Subramanyan P and Raju V, “CAD/CAM/CIM”, New Age International Publishers, 2012.
4. Cornelius Leondes, “Computer Aided Design – Vol 2; Computer Integrated Manufacturing”, CRC Press, 2001.
5. MIkell P Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall, 1998.

15MC38 INDUSTRIAL DESIGN AND APPLIED ERGONOMICS

3 0 0 3

INTRODUCTION: Definition, human technological system, multidisciplinary engineering approach, human–machine system, manual, mechanical, automated system, human system reliability, conceptual design, advanced development, detailed design and development, human system modeling. (7)

INFORMATION INPUT: Input and processing, text, graphics, symbols, codes, visual display of dynamic information, auditory, tactual, olfactory displays, and speech communications. (5)

HUMAN OUTPUT AND CONTROL: Physical work, manual material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices. (5)

WORKPLACE DESIGN: Applied anthropometry, workspace design and seating, arrangement of components within a physical space, interpersonal aspects of work place design, and design of repetitive task, design of manual handling task, work capacity, stress, and fatigue. (6)

ENVIRONMENTAL CONDITIONS: Illumination, climate, noise, motion, sound, vibration. (5)

BIOMECHANICS: Biostatic mechanics, statics of rigid bodies, upper extremity of hand, lower extremity and foot, bending, lifting and carrying, biodynamic mechanics, human body kinematics, kinetics, impact and collision, human activity analysis, ergonomic tools, RULA, REBA, NIOSH lifting equation. (6)

BIOTHERMODYNAMICS AND BIOENERGITICS: Biothermal fundamentals, human operator heat transfer, human system bioenergetics, thermoregulatory physiology, human operator thermo regularity, passive operator, active operator, heat stress. (6)

HUMAN FACTORS APPLICATIONS: Human error, accidents, human factors and the automobile, organizational and social aspects, steps according to ISO/DIS6385, OSHA's approach, virtual environments. (5)

Total L: 45

REFERENCES:

1. Chandler Allen Phillips, "Human Factors Engineering", John Wiley and Sons, New York, 2000.
2. Mark S Sanders, "Human Factors in Engineering and Design", McGraw Hill, New York, 1993.
3. Bridger R S, "Introduction to Ergonomics", Taylor and Francis, London, 2003.

15MC39/15ML09 LEAN SIX SIGMA IN MANUFACTURING AND SERVICING 3 0 0 3

INTRODUCTION: Overview - Six sigma definition – Background – Six sigma compared to total quality management (quality) – traditional vs. Manufacturing lean six sigma – Common terms, foundations of lean six sigma – four keys, five laws of Lean six sigma – Lean six sigma tools – COPQ – Total quality cost – Understanding variation – Lean VSM – Types of Lean six sigma: DMAIC vs DFSS – Lean six sigma project selection. (6)

PREPARATION PHASE: Organizational success factors **–** leadership, six sigma as strategic initiative, internal communication strategy and tactics, formal launch, organizational structure, six sigma training plan, project selection, assessing organizational readiness, pitfalls. work as a process – vertical functions and horizontal processes. Project management – challenges, culture, project management processes, selection of team members, team typing, team stages, characteristics of effective teams. (8)

DEFINE PHASE: Overview – Customer identification, feedback, requirements – Problem statement - Voice of customer – importance, collect VOC data, critical to quality CTQ – Affinity process – Pareto diagrams – BRD – Project scope - Project charter – Voice of the customer – High level process map – Project team – SIPOC – Process map – Practice exercises using statistical software. (6)

MEASURE PHASE: Overview – Types of measures – Introduction to statistical methods – Sampling plan – Population or sample – Central limit theorem - Types of data - Data collection – Choosing statistical software – Measure tools – Cause and effect diagrams – Line , bar, stacked bar graphs – Pie chart – Histograms - Control charts. Six sigma measurements – Quality cost - Cost of poor quality – Quality loss function. Measurement system analysis –Process capability calculations – Short-term vs long-term capability – Process performance vs specification - Practice exercises using statistical softwares. (6)

ANALYSE PHASE: Overview – Process analysis – Correlation coefficient – Regression - Hypothesis testing applications (DOE/ANOVA, Chi square test) – Failure mode and effects analysis - Statistical tests and tables – Tools for analyzing relationships among variables – Gap analysis – Root cause analysis – Waste analysis - Survival analysis - Practice exercises using statistical software. (3)

IMPROVE PHASE: Overview – Process redesign – Generating improvement alternatives – Design of experiments – Waste elimination – Cycle time reduction – Theory of constraints - Pilot experiments – Cost/benefit analysis – Implementation plan – Risk analysis and mitigation. (3)

CONTROL PHASE: Overview – Process scorecard – SPC: selection of chart and selection of analysis – TPM – Visual controls – Sustain improvement - Final project report and documentation. Roadmap to implementation. (3)

DESIGN FOR SIX SIGMA (DFSS): Overview – DFSS methodologies: DMADV vs DMADOV - overview of Quality Function Deployment (QFD) - Theory of Inventive Problem Solving (TRIZ) - overview of Failure Modes and Effects Analysis (FMEA) - Design for XDFX – Robust design and process – Software tools for DMAIC and/or DFSS. (3)

LEAN SERVICING: Lean production – Overview – Lean history – Manufacturing vs service – Lean servicing case study. (4)

LEAN SIXSIGMA IMPLEMENTATION: Roadmap for implementation. Common Implementation issues and management strategies. (3)

Total L: 45

REFERENCES:

1. Joseph De Feo, William Barnard and Juran Institute, “Juran Institute’s Six Sigma Breakthrough and Beyond”, The McGraw-Hill Companies, 2004.
2. Betsiharris Ehrlich, “Transactional Six Sigma and Lean Servicing”, St. Lucia Press, 2002.
3. Jay Arthur, “Lean Six Sigma – Demystified”, Tata McGraw Hill Companies Inc, 2007.
4. Michael L George, David T Rowlands and Bill Kastle, “What is Lean Six Sigma”, McGraw Hill, New York, 2004.
5. Kai Yang and BasemEl, Haik, “Design for Six Sigma”, McGraw Hill, New York, 2004.

15MC40 ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS 3 0 0 3

HUMAN AND MACHINE INTELLIGENCE: Concepts of fifth generation computing , programming in AI environment, developing artificial intelligence system, natural language processing, neural networks. (8)

KNOWLEDGE REPRESENTATION FOR SMART SYSTEMS: Forward chaining, backward chaining, use of probability and fuzzy logic. Semantic nets, structure and objects, ruled systems for semantic nets; certainty factors, automated learning. (8)

LANGUAGES USED IN AI: Using PROLOG to design expert systems, converting rules to PROLOG, conceptual example, introduction to LISP, function evaluation, lists, predicates, rule creation. (8)

EXPERT SYSTEM DEVELOPMENT: Definition, choice of domain, collection of knowledge base, selection of inference mechanism, case studies of expert system development in design and manufacturing. (6)

EXPERT SYSTEM TOOLS: Expert systems, controlling reasoning, rule based system, canonical systems, rules and meta rules, associative nets and frame systems, graphs trees and networks, representing uncertainity, probability in expert systems-learning, forms of learning, inductive learning, decision trees, knowledge in learning, heuristic classification, heuristic matching, case studies in expert systems, MYCIN, Meta-Dendral, general structure of an expert system shell, examples of creation of an expert system using an expert system tool, fundamentals of object oriented programming, creating structure and object, object operations, invoking procedures, programming applications, object oriented expert system. (9)

INDUSTRIAL APPLICATION OF AI AND EXPERT SYSTEMS: Robotic vision systems, image processing techniques, application to object recognition and inspection, automatic speech recognition. (6)

Total L: 45

REFERENCES:

1. Robert Levine et al., "A Comprehensive Guide to AI and Expert Systems", McGraw Hill Inc, 1986.
2. Henry C Mishkoff, "Understanding AI", BPB Publication, New Delhi, 1986.
3. Peter Jackson, “Introduction to Expert Systems”, First Indian Reprint, 2000, Addison, Wesley.
4. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall, 1995.
5. Elaine Rich et al., “Artificial Intelligence”, McGraw Hill, 1995.

15MC41 SHEET METAL CUTTING AND BENDING TECHNOLOGIES

3 0 0 3

INTRODUCTION : Introduction, applications, growth of sheet metal industry. Understanding the basics terms- strip, sheet and plate. Thickness measurement methods - thickness gauges, laser thickness detectors. Development of unfold of a sheet metal part, calculation of bend allowances and bend deduction, k-factor, spring-back. Understanding the kerf-width, micro-joints, bridge-width. (6)

SHEET METAL STAMPING: Punching, blanking, perforating, embossing, louvering, slotting, notching, lancing, slitting etc. Specification of punch presses, calculation of tonnage, operation of punch press, types of presses, features and elements of presses. (8)

SHEET METAL CUTTING: Shearing, profile cutting – continuous nibbling process. Constructional features of CNC turret presses. Complex profile cutting methods – laser cutting, water-jet cutting, plasma cutting, oxy-fuel cutting, machine features. Specifications, selection of the cutting process, process parameters. (9)

NESTING PROCESS: Introduction, factors to be considered, objectives, strategies, evaluation of different layout generation and optimization algorithms using heuristic and Artificial Intelligent methods, features of commercial CAM packages (8)

SHEET METAL BENDING: V-bending, partial bending, bottoming, coining, R-bending, hemming, U-bending, beading, step bending, z bending, curling etc. Types of press brake, constructional features, specifications, features. Press brake tooling –ram, punch holder, punch, die, die holder. Types of punches – standard, gooseneck, straight, sash, acute angle punch, R-punch, hemming punch. Selection of Die (7)

SHEET METAL BENDING PLAN: Bending sequence generation methods, tooling stages and setup, back-gauge positioning, collision check methods, optimization concepts, software packages. (4)

POST PROCESSING TECHNIQUES: Product handling methods, protection and packaging methods (3)

Total L: 45

REFERENCES:

1. Steve D. Benson, "Press Brake Technology", Society of Manufacturing Engineers, 1 edition, 1997
2. "Bending Technique: New Knowhow on Sheet-metal Fabrication", Amada Sheet Metal Working Research Association, Machinist Publicaitons,1980
3. Ramesh Babu A and Ramesh Babu N, "Effective Nesting of Complex Two Dimensional Shapes - Genetic and Heuristic Approaches, LAP LAMBERT Academic Publishing, GMBH & Co. Germany, 2012, ISBN No: 978-3-659-10975-1
4. David J. Gingery, "Sheet Metal Technology", David J Gingery Publishing; First edition (15 December 2005)
5. Vukota Boljanovic, "Sheet Metal Forming Processes and Die Design", Industrial Press Inc.,U.S.; 2nd Revised edition edition (1 February 2014).

15MC42 PRECISION AND MICRO MANUFACTURING

3 0 0 3

INTRODUCTION: Basic definition, size scales, scaling analysis, technology change, Challenges in Meso, Micro and Nano manufacturing. Traditional Micromachining: Microturning, Microgrinding. Lithographic Processes- Optical and X-ray (3)

PRECISION ENGINEERING AND PRACTICES: Definitions, sources of error, basic concepts of machining, machine tool variables accuracy, stiffness, spindle vibration, flatness, straightness and smoothness of motion, 1-2 DOF systems, feedback variables, cutting tool variables, workpiece variables, environment effects and thermal errors. (5)

INTRODUCTION TO MACHINING ANALYSIS: Geometry of cutting edge, energy models, comparison with micro-scale machining (5)

DIAMOND MICROMACHINING: Introduction, diamond as a tool material, compatible materials, diamond performance, diamond machining, micro-mechanical applications, ductile regime grinding.

MICROMILLING: Micro-milling tools, process results and micro-milling applications- micromechanically milled X-ray masks, micromilled mask materials, mask absorption quantification, exposure quantification (5)

MICRODRILLING: Micro-drilling and Macro-drilling techniques (2)

LASER MICROMACHINING: Laser optics, laser ablation, heat affected zone and laser polymerisation. LIGA, S-LIGA (3)

MICRO JOINING: Micro welding in similar and dissimilar materials; welding processes like ultrasonic, EB, LB; applications. (3)

MICRO CASTING: Casting processes like vacuum, semi-solid state; applications (3)

MICROFORMING: Micro- and nanostructured surface development, nano plastic forming and roller imprinting, microextrusion, microbending with laser. (5)

MISCELLANEOUS: Micro EDM, Micro ECM. Processing of integrated circuits, clean rooms, crystal growing and shaping of wafers, etching, photo and other lithography techniques, impurity introduction, thermal oxidation, CVD, metallisation etc. IC packaging. Dimensional metrology for micro/mesoscale manufacturing. (6)

Total L: 45

REFERENCES:

1. Muammer Koc, Tugrul Ozel, "Micro-Manufacturing: Design and Manufacturing of Micro- Products", Wiley, 2011
2. Jain V K, "Micro manufacturing processes", CRC press, 2015
3. Mahalik, Nitaigour P, "Micromanufacturing and Nanotechnology", Springer, 2006
4. Y Qin, "Micromanufacturing Engineering and Technology", Elsevier, 2015

ONE CREDIT COURSES

For the detailed Syllabi of all the one credit courses offered by Mechanical Engineering department which are listed in this programme scheme refer to the syllabi of M.E Engineering Design programme.

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.