I SEMESTER

21PP01 ADVANCED OPERATIONS RESEARCH

3 1 0 4

LINEAR PROGRAMMING: Formulation of linear programming – simplex algorithm, phase I and phase II of simplex method - simplex multipliers - revised simplex method - dual and primal, dual simplex method. (11+4)

INTEGER PROGRAMMING: Gomory cutting plane methods for all integers and mixed integer programming problems - branch and bound method (Land - Doig and Dakin algorithms). (11+4)

DYNAMIC PROGRAMMING: Principles of optimality - backward and forward induction methods - calculus method of solution - tabular method of solution - shortest path network problems - cargo loading problem - workforce size model - applications in production. (11+4)

DECISION MODELS: Decisions under uncertainty – decisions under risk - decision trees - game theory – Nash equilibrium – strategic games – best response – dominance - examples from economics - business environment - military. (12+3)

Total L: 45 + T: 15 = 60

REFERENCES:

1. Hamdy A Taha, “Operations Research – An Introduction”, Pearson Education, New Delhi, 2019.
2. Frederick S Hillier and Gerald J Lieberman, “Introduction to Operations Research”, Tata McGraw Hill, New Delhi, 2014.
3. Maurice Sasieni, Arthur Yaspan, "Operations Research: Methods and Problems", Literary Licensing, LLC, United States, 2013.
4. Kambo N.Singh, “Mathematical Programming Techniques”, East-West Press, New Delhi, 2012.
5. Martin J Osborne, “An Introduction to Game theory”, Oxford University Press, 2016.

21PP02 CNC AND AUTOMATION

3 0 0 3

CNC CONSTRUCTION: Types - construction of CNC machines - structures, guideways, ball screws, spindle, turret, ATC, APC - control system - feedback devices - spindle and feed drives - servo motors - types of interpolators - maintenance - testing of CNC machines. (11)

CNC PROGRAMMING: Selection of machines, tools - work holding - job requirements - raw material, tolerances, surface finish, process plan, production costs, machine hour rate - G-codes - M-codes - canned cycles - turning centre programming - machining centre programming - industrial component programming, casting and die casting parts, bar feeder components. (11)

AUTOMATED FLOW LINES: Introduction to CIM - components of CIM - process design for CIM - automated flow lines - methods of work transport, automated flow lines with and without storage buffers - automated guided vehicle system - components of AGVs, control system, routing, design features - AS/RS - components, design of an AS/RS - automated inspection - online and offline inspection. (12)

AUTOMATED ASSEMBLY: Historical perspective - why and when automated assembly - parts of automated assembly system - part feeding and orienting, feed track, escapement and placement devices - robots in assembly - analysis of assembly systems with synchronous transfer and free transfer - economics of automated assembly. (11)

Total L: 45

REFERENCES:

1. Geoffrey Boothroyd, “Assembly Automation and Product Design”, CRC Press, 2005.
2. Michael Mattson, “CNC Programming: Principles and Applications”, Cengage Learning India, New Delhi, 2014.
3. Mikell P Groover, “Automation, Production Systems and Computer-Integrated Manufacturing”, Prentice-Hall, 2018.
4. Nanua Singh, “Systems Approach to Computer - Integrated Design and Manufacturing”, John Wiley & Sons, New York, 1996.
5. Peter Smid, “CNC Programming HandBook”, Industrial Press Inc., New York, 2008.

21PP03 FUTURISTIC MATERIALS AND THEIR PROCESSING

3 0 0 3

AUTOMOBILE MATERIALS AND MANUFACTURING TECHNOLOGIES: Introduction to futuristic requirements of materials and manufacturing methods in the automobile sector - aluminium alloys - high-performance steels - bake hard enable and press hard enable steels - high performance plastics and polymers- automotive composites - GFRP, CFRP- high pressure die casting and injection moulding - laser, electron beam and ultrasonic welding- additive manufacturing techniques - SLS, SLM, stereo lithography, inkjet printing. (12)

AEROSPACE MATERIALS AND MANUFACTURING ROUTES: Introduction to anatomy of an aircraft - distribution of material usage in airframe - aluminium, magnesium, titanium and steel alloys - ceramics - composites - GFRP, carbon and graphene composites, GLARE, digital composites - cellular solids, metal foams - laser beam welding and friction stir welding - additive manufacturing of ceramics - automatic tape laying - automatic fibre placement - resin infusion - resin transfer moulding and resin film infusion processes - challenges and opportunities in material development and process selection. (12)

ENERGY MATERIALS AND SYNTHESIS: Need for high performance energy materials - carbon nanostructure based energy conversion and storage materials - nanomaterials for solar cell applications - next generation energy storage materials – Li and Ni based batteries, fuel cells - introduction to synthesis of nanostructures - top down and bottom up approaches - physical methods - high energy ball milling, physical vapour deposition (PVD), laser ablation, sputter deposition methods (Qualitative), chemical vapour deposition (CVD) - chemical methods - sol gel technique, hydrothermal synthesis. (11)

HEALTHCARE MATERIALS AND MANUFACTURE: Introduction to healthcare materials - diagnosis and therapeutic materials - futuristic implants and prosthetics - polymer, ceramic and metallic based - laser machining of bio materials - micromachining and micro moulding - additively manufactured biomaterials. (10)

Total L: 45

REFERENCES:

1. Cantor Brian, Hazel Assender and Patrick Grant, “Aerospace Materials”, CRC Press, 2015.
2. Omar Faruk, Jimi Tjong, MohiniSain, “Lightweight and Sustainable Materials for Automotive Applications”, CRC Press, 2019.
3. Park Joon and Roderic S. Lakes, “Biomaterials: An Introduction”, Springer Science & Business Media, 2007.
4. Rowe Jason, “Advanced Materials in Automotive Engineering”, Woodhead Publishing, 2016.
5. Yasir Beeran Pottathara, Sabu Thomas, VanjaKokol, Yves Grohens, “Nanomaterials Synthesis: Design, Fabrication and Applications”, Elsevier Publications, 2019.

21PP04 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 1 0 4

TOLERANCE STACKUP ANALYSIS: Introduction to DFM - DFA - standardization - DFA index - cumulative effect of tolerances - worst case method, root sum square method, dimensions following truncated normal distributions, tolerance synthesis, nonlinear tolerance analysis, tolerance cost relationships - process capability - interchangeable part manufacture and selective assembly - deciding the number of groups - control of axial play - introducing secondary machining operations - laminated shims. (13)

GEOMETRIC DIMENSIONING AND TOLERANCING: Introduction to Model Based Definition - ISO 16792 and ASME Y14.41 standards – standards for geometric tolerance ASME Y 14.5 and ISO 1101 - 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. (12)

FORM DESIGN OF CASTINGS AND WELDMENTS: Redesign of castings - based on parting line considerations, minimizing core requirements - redesigning cast members using weldments - form design aspects of sheet metal components, component design - machining considerations - redesign for manufacture. (10)

TOLERANCE CHARTING: Operation sequence for typical shaft type of components - preparation of process drawings for different operations, tolerance worksheets - centrality analysis - examples design features to facilitate machining, datum features - functional and manufacturing. (10)

TUTORIALS:

1. Tolerances stack up analysis of a 2D assembly.
2. Problems on Model I and Model II type selective assembly.
3. Redesign of casting.
4. Redesign for machining
5. Tolerance charting.

Total L: 45 + T: 15 = 60

REFERENCES:

1. Alex Krulikowski, “Fundamentals of Geometric Dimensioning and Tolerancing”, Delmar Cengage Learning International Edition, 2012.
2. Bryan R. Fischer, "Mechanical Tolerance Stackup and Analysis", CRC Press, 2011.
3. Creveling C.M., "Tolerance Design - A Hand Book for Developing Optimal Specifications", Addison Wesley Longman.
4. Harry Peck, “Designing for Manufacture”, Pitman Publications, 1983.
5. James G Bralla, “Hand Book of Product Design for Manufacturing”, McGraw Hill Publications, 1983.
6. Paul J Drake, “Dimensioning and Tolerancing Handbook”, McGraw Hill Publications, 1999.

21PP05 ADVANCED METROLOGY

3 1 0 4

CALIBRATION AND EVALUATION OF UNCERTAINTY: Measurement principle, calibration, standards, environmental conditions required, traceability of measurement, calibration procedure for vernier calliper, micrometer and dial gauge, evaluation of uncertainty of measurement, repeatability and reproducibility (R&R) analysis . (10)

FORM MEASUREMENT AND COORDINATE METROLOGY: Computational metrology-types of filter used in surface roughness measuring instruments and form measuring instruments - geometric data fitting - least-square best-fit line, plane and circle, measurement of straightness, flatness and circularity errors - coordinate measuring machine - need, types of CMM, modes of operation, types of probe, probe calibration, dimensional measurement in CMM - computer-aided inspection planning (CAIP). (12)

NON-CONTACT MEASUREMENT SYSTEM: Computed tomography - machine vision system - need, applications, algorithms for machine vision-based inspection - laser metrology - Interferometry, measurement of displacement, flatness, parallelism and gauge block calibration - micro and nano metrology - atomic force microscopy, scanning electron microscopy, white light interferometry. (13)

MODEL BASED DEFINITION: Need - digital product definition data - creation of model-based definition model - generation of probe path planning for CMM. (10)

TUTORIALS:
1. Calibration of basic measuring instruments and estimation of uncertainty.
2. Evaluation of repeatability and reproducibility (R&R) of measuring instruments.
3. Straightness measurement using autocollimator.
4. Displacement measurement using Michelson interferometer.
5. Object recognition and dimensional metrology using machine vision system.
6. Form measurement using coordinate measuring machine (CMM).

Total L: 45 + T: 15 = 60

REFERENCES:

1. Alexander Hornberg, “Handbook of Machine Vision”, John Wiley & Sons, 2007.
2. Bala Muralikrishnan and Jayaraman Raja, “Computational Surface and Roundness Metrology”, Springer, 2008.
3. Connie Dotson and Roger Harlow, “Fundamentals of Dimensional Metrology”, Cengage Learning, 2016.
4. Gupta S.V., “Measurement Uncertainties: Physical Parameters and Calibration of Instruments”, Springer Berlin Heidelberg, 2014.
5. Herron J.B., “Re-Use Your CAD: The Model-Based CAD Handbook”, Action Engineering, 2013

21PP61 RESEARCH METHODOLOGY AND IPR

vide Automobile Engineering 21AE06

21PP72 AUDIT COURSE - I

vide Automobile Engineering 21AE72

21PP51 OBJECT COMPUTING AND DATA STRUCTURES LABORATORY

0 0 4 2

Object Computing (Using Python)
1. Implementation of Number data types and operations on them.
2. Creation and Implementation of string objects and string methods.
3. Creation and manipulation of list and tuple data types.
4. Implementation of set and dictionary data types.
5. Implementation of simple functions, lambda functions and recursive functions and modules.
6. Implementation of object oriented concepts – classes, objects, methods
7. Implementation of inheritance and polymorphism

Data Structures (Using Python)
1. Implementation of sorting algorithms- Bubble, insertion and selection sort
2. Implementation of Stack.
3. Implementation of queue.
4. Implementation of singly linked list and doubly linked list

Total P: 60

REFERENCES:

1. Martin C. Brown, “PYTHON: The Complete Reference”, McGraw Hill, 2018.
2. Mark Summerfield, “Programming in Python 3: A Complete Introduction to the Python Language”, Addison-Wesley Professional, 2009.
3. Taneja Sheetal, Kumar Naveen, “Python Programming - A Modular Approach”, Pearson, 1st Edition, 2017.
4. Ashok Namdev Kamthane, Amit Ashok Kamthane, “Programming and Problem Solving with Python”, Tata McGraw Hill Education India, 2018.
5. Vijayalakshmi Pai G.A., “Data Structures and Algorithms: Concepts Techniques and Applications”, McGraw Hill, 2017.
6. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, “Data Structures and Algorithms in Python”, Wiley, 2016.

21PP52 ADVANCED MANUFACTURING LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on advanced equipment used for research in manufacturing for a duration of 20 hours. After this orientation, each student is expected to formulate, design and conduct an experiment in an area of interest, derived from the orientation programme, under the guidance of a faculty. Details like background, problem definition, state of technology/knowledge, in a selected area of interest, in the form of literature review (referring a minimum of five latest peer reviewed journal papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments, 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. Experimental and theoretical investigations on the effect of process parameters in deep drawn components.
2. Investigating tensile strength of plastic molded specimen in plastic injection moulding machine
3. Improving the mechanical properties of prototypes prepared using 3D printing and subtractive rapid prototyping processes.
4. Analyzing and optimizing the joint quality of ultrasonically welded components.
5. Study on effect of machining parameters in electro discharge machining.
6. Optimizing the cutting parameters in a machine tool using dynamometer and accelerometer.
7. Experimental investigations on geometrical and surface qualities of machined parts in CNC Lathe.
8. Experimental investigations on geometrical and surface qualities of machined parts in CNC VMC
9. Characterization of mechanical and tribological properties for a material.
10. Investigating surface roughness parameters in machining, grinding and super finishing processes.

Total P: 60

II SEMESTER

21PP06 ENGINEERING ECONOMICS

3 1 0 4

ECONOMIC EQUIVALENCE, EVALUATION OF BUSINESS AND ENGINEERING ASSETS: Present economic policy, liberalization, privatization, and globalization, the scope for industrial growth, Cash-flow diagram, simple interest, compound interest, single payments, uniform series payments, interest factors and interest tables, nominal and effective interest rates, continuous compounding, and uniform continuous payments, linear-gradient series, geometric gradient series, mixed payment series. Methods for evaluation of alternatives: Present worth comparison - equal, unequal lived assets, study period, assets with infinite life, capitalized cost comparison. Equivalent uniform annual cost comparison, Rate of return comparison. (12)

MICROECONOMICS: Scope of microeconomics, tools, themes of microeconomics, uses of microeconomics; economic decision making on production; technology and production - production technologies, production with one variable input, production with two variable inputs, returns to scale, productivity differences and technological change; profit maximization - profit-maximizing quantities and prices, marginal revenue, marginal cost, and profit maximization, supply decisions by price-taking firms, short-run versus long-run supply by price-taking firms, producer surplus, supply by multi product price-taking firms. (11)

COST MANAGEMENT: Cost structure of a product - direct, indirect cost - overheads - factory, administrative, selling and distribution overheads – absorption – activity-based costing - target costing. Cost, volume, profit analysis: Analysis with time value accounting, linear, non-linear, multi-product break-even analysis. Project management, PERT - CPM, crashing, cost system, value analysis - VE job plan - FAST approach. Depreciation: reasons, depreciation accounting, causes of declining value, Methods of depreciation; (11)

PROJECT FEASIBILITY ANALYSIS: Market feasibility: Types of market, identification of investment opportunities, market and demand analysis, secondary sources of information. Technical feasibility: Product design, the concept of concurrent engineering; plant design, make vs buy decisions; 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. (11)

TUTORIALS

1. 'Cash flow diagram modelling' of a given case.
2. Computation of equivalent cash flows using compound interest factors.
3. Tangible evaluation of alternatives.
4. Cost volume profit analysis
5. Accounting manufacturing expenses and preparation of cost sheet of a product.

Total L: 45 + T: 15 = 60

REFERENCES:

1. B. Douglas Bernheim and Michael D. Whinston, "Microeconomics", 2nd Edition, Tata McGraw Hill, 2013.
2. Chan S. Park, "Contemporary Engineering Economics", Global Edition, Pearson, 2016.
3. James L Riggs, David D Bedworth and Sabah U Randhawa, "Engineering Economics", 4th Edition, McGraw Hill Book Company, 2016.
4. Leland T Blank and Anthony J Tarquin, "Engineering Economy", 8th Edition, Tata McGraw Hill, 2018.

5. Prasanna Chandra, “Projects – Planning, Analysis, Selection, Financing, Implementation and Review”, 9th Edition, Tata McGraw Hill, 2019.
6. Ronald W. Hilton, Michael W. Maher and Frank H. Selto, “Cost Management: Strategies for Business Decisions”, International Edition, McGraw Hill Education, 2012.

21PP07 COMPUTER AIDED MODELING AND ANALYSIS

3 1 0 4

PARAMETRIC REPRESENTATION OF CURVES AND SURFACES: Introduction to parametric curves - representation of entities, DDA algorithms - transformations, translation, scaling, rotation, reflection, shear - representation of analytic and synthetic curves - interpolation and approximation of curves - representation of analytic and synthetic surfaces, Class A surfaces. (11)

GEOMETRIC MODELING: Fundamentals of solid modelling, properties, set theory, set membership - solid modelling techniques, boundary representation, constructive solid geometry - introduction to features - role of features in design and manufacturing features - features, attributes, types, properties - feature creation techniques - recognizing manufacturing features. (11)

FINITE ELEMENT ANALYSIS OF LINEAR PROBLEMS: Discretization of the domain - interpolation models - higher order and isoparametric formulation of elements - derivation of element matrices and vectors - assembly of element matrices and vectors and derivation of system equations - solving time dependent problems. (11)

FEA IN MANUFACTURING: Material models - contact elements - modeling thermo mechanical problems - Goldak double ellipsoid heat source model - analysis of sheet metal bending - temperature analysis in cooling of casting - analysis of distortion in welding. (12)

Total L: 45 + T: 15 = 60

REFERENCES:

1. Dixit P.M. and U.S. Dixit, “Modeling of Metal Forming and Machining Processes : By Finite Element and Soft Computing Methods”, Springer Science & Business Media, 2008.
2. Ibrahim Zeid, “Mastering CAD CAM”, McGraw Hill Higher Education, 2005.
3. Lewis R.W., Nithiarasu P. and Seetharamu K.N., “Fundamentals of the Finite Element Method for Heat and Fluid Flow”, John Wiley and Son, 2008.
4. Shah J. J. and Mantyla M., “Parametric and Feature-based CAD/CAM”, John Wiley & Sons, New York, 1995.
5. Singerasu S Rao, “The Finite Element Method in Engineering”, Butterworth Heinemann, 2010.
6. Yang Z., “Material Modeling in Finite Element Analysis”, CRC Press, 2019.

21PP82 AUDIT COURSE - I

vide Automobile Engineering 21AE82

21PP53 COMPUTER AIDED MODELING AND ANALYSIS LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following 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. Generation of analytical curves using a programming tool.
2. Exercise on Geometric transformations using a programming tool.
3. Constraint based modeling using CAD software
4. Exercise on assembly of components using CAD software
5. Static analysis of a component in CAE.
6. Transient analysis in CAE.
7. Harmonic analysis of a component in CAE.
8. Exercise on Sheet metal forming simulation
9. Exercise on casting simulation
10. Exercise on Welding problem

Total P: 60

21PP54 AUTOMATION AND SMART MANUFACTURING LABORATORY

0 0 4 2

In this course, students will be provided with an orientation programme on the following equipment/software for 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 concerning 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 the orientation programme

1. Simulation of the pneumatic sequential circuit along with fringe conditions
2. Simulation of the electro-pneumatic sequential circuit
3. Simulation of PLC based sequential circuit
4. Simulation of hydraulic circuits using software
5. Integration of a modular manufacturing system using DIY kits
6. Energy monitoring of hydraulic press and injection moulding machine using IIoT
7. IIoT based integrated system for smart water dispenser
8. Performance monitoring of wind turbine using IIoT
9. Performance monitoring of CNC machine using IIoT
10. Performance monitoring of a modular manufacturing system using IIoT

Total P: 60

21PP63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR

vide Automobile Engineering 21AE63

III SEMESTER

21PP71 PROJECT WORK I

vide Automobile Engineering 21AE71

IV SEMESTER

21PP81 PROJECT WORK II

vide Automobile Engineering 21AE81

PROFESSIONAL ELECTIVE THEORY COURSES (Four to be opted)

21PP21 ADDITIVE MANUFACTURING

3 0 0 3

INTRODUCTION AND DATA PROCESSING: Fundamentals of Additive Manufacturing (AM) - materials used in AM, fundamentals of energy dissipation, classifications of Additive Manufacturing systems, Information workflow in Additive Manufacturing, impact of AM on Product development, reverse engineering - digitization techniques, model reconstruction, data Processing for Additive Manufacturing, Additive Manufacturing data formats - STL Format, STL file problems, consequences of building a valid and Invalid tessellated model, STL file repair. (10)

MATHEMATICAL MODEL FORMULATION: Transport phenomena models - temperature and fluid flow, Buoyancy driven and tension driven free surface flow pool. Numerical modeling of AM and 3D printing processes - case studies, Residual stress, part fabrication time, cost and role of transport simulations. Process optimization - factors influencing accuracy - data preparation errors, part building errors, errors in finishing, influence of part build orientation. (12)

ADDITIVE MANUFACTURING SYSTEMS: Principle, details of processes, process variables, types, products, materials, microstructures and mechanical properties of additive manufactured parts, advantages, applications and case studies: Solid, liquid, powder based and other additive manufacturing processes. (13)

LASER ASSISTED ADDITIVE MANUFACTURING: Fundamental relationship of working curve, intensity profile, profile of scan lines - single-scan line, multi-scan line and layer. Laser scanning in additive manufacturing and powder binding mechanism. Laser assisted additive manufacturing of low cost tools, porous materials and bimetallic components. Mechanical properties of additive manufactured structures. (10)

Total L: 45

REFERENCES:

1. Gibson I., Rosen D.W. and Stucker B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.
2. Chua C.K., Leong K.F. and Lim C.S., "Rapid Prototyping: Principles and Applications", 2nd Edition, World Scientific Publishers, 2010.
3. Majumdar J.D. and I. Manna I, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013.
4. Lu L., Fuh J. and Wong Y.S, "Laser-Induced Materials and Processes for Rapid Prototyping", Kluwer Academic Press, 2001.
5. Zhiqiang Fan and Frank Liou, "Numerical Modeling of the Additive Manufacturing (AM) Processes of Titanium Alloy", InTech, 2012.

21PP22 ADVANCED CASTING AND WELDING TECHNOLOGIES

3 0 0 3

ADVANCED CASTING PROCESSES: Evaporative pattern casting process - vacuum sealed moulding process - investment casting process - ceramic shell investment casting process - shell moulding - low pressure gravity die casting - counter gravity sand casting - squeeze casting - thixo-moulding - resin-bonded moulding process - casting of metal matrix composites - micro casting - inert environment vacuum casting - compocasting - roll casting - casting of intermetallics and rapid sand casting. (12)

CASTING METALLURGY AND DESIGN: Heat transfer between metal and mould - solidification of pure metals and alloys - shrinkage in cast metals - progressive and directional solidification - degasification of the melt - effect of normal elements and alloying elements in cast iron, steel, non-ferrous metals - design principles of gating, riser - design considerations in casting - casting defects - causes, remedies, inspection - specifications - BIS, BS, EN, ASTM standards. (11)

ADVANCED WELDING PROCESSES: Microjoining - nanojoining - wire bonding - advanced gas tungsten arc welding - flux cored arc welding - stud welding - magnetically impelled arc welding - laser beam welding - electron beam welding - thermit welding - pressure welding - diffusion bonding - explosive welding - friction stir welding - ultrasonic welding - electromagnetic pulse welding - high velocity projectile impact welding - principles of robotic welding. (12)

WELDING PROCESS MODELLING AND TESTING: Welding process modelling and optimization - computational welding mechanics for thermo-mechanical and microstructural phenomenon - residual stresses - temperature distribution - heat flux calculation - weld distortion and defects - causes, remedies, inspection, testing of weldments - AWS welding symbols, codes, standards. (10)

Total L: 45

REFERENCES:

1. Campbell J., "Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design", 2nd Edition, Butterworth-Heinemann, 2015.
2. John Norrish, "Advanced Welding Processes: Technologies and Process Control", 1st Edition, Woodhead Publishing, 2016.
3. Richard Heine, Carl Loper and Philip Rosenthal, "Principles of Metal Casting", 2nd Edition, McGraw Hill Education, 2017.
4. Sahoo M. and Sahu S., "Principles of Metal Casting", 3rd Edition, McGraw Hill Education, 2014.
5. Yadav K.S., "Advanced Welding Technology", 2nd Edition, Standard Book House, New Delhi, 2017.

21PP23 DESIGN OF FLUID POWER SYSTEMS

3 0 0 3

COMPONENTS OF FLUID POWER SYSTEMS: Pneumatic and hydraulics - symbols of fluid power elements - pumps and compressors - types, selection - actuators - types, typical construction details - control valves - direction, flow, pressure, types, typical construction details, applications - logical elements - accumulators - intensifiers - selection of elements based on force, speed, travel and time - sizing of pipes - piping layout and accessories - maintenance and troubleshooting of fluid power circuits - circuit layout - presentation and labelling as per ISO standards. (11)

FLUID POWER CIRCUITS: Typical industrial applications of fluid power systems - metal working, handling, clamping and other industrial applications - general approach for circuit design - travel step diagram, sequential circuit design, cascade method, step counter method, K.V. mapping for minimization of logic equation. (12)

ELECTRICAL AND SERVO CONTROL SYSTEMS: Electrical control circuits - electro-pneumatics, ladder diagram - PLC - construction, types, operation, programming, PLC timers and counters - servo and proportional valves - types, operation, application, hydro-mechanical servo systems. (11)

COMPOUND CIRCUIT DESIGN: Introduction to compound circuit design - fringe condition modules - emergency stop modules, cycle selection modules, start restriction module, typical industrial applications. (11)

Total L: 45

REFERENCES:

1. Anthony Espisito, "Fluid Power with Application", 7th Edition, Pearson Education Private Limited, 2013.
2. David W Pessen, "Industrial Automation – Circuit Design and Components", Wiley India, 2011.
3. Frank D Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw Hill Book Company, New Delhi, 2019.
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.

21PP24 DIGITAL MANUFACTURING

3 0 0 3

TECHNOLOGIES FOR DIGITAL MANUFACTURING: Need for digital manufacturing - informatics platform for designing and developing e-manufacturing systems, information sharing in digital manufacturing, collaborative process planning activities, adaptive setup planning for job shop operations, web based value streams. (12)

CAD/CAE/CAM FOR RAPID MANUFACTURING: CAD for rapid manufacturing, CAD standards - reverse engineering process - reverse engineering hardware and software - computer aided engineering analysis - CNC tool path generation and simulation. (11)

RAPID MANUFACTURING TECHNOLOGIES: Overview of rapid manufacturing - impact of rapid manufacturing on design for manufacture and design for assembly, liquid, powder and solid based rapid manufacturing processes, applications of rapid manufacturing in aerospace, space and automotive industries. (12)

INTERNET OF THINGS (IoT): IoT data management requirements - architecture of IoT, technological challenges, RFID and the Electronic Product Code (EPC) network, the web of things, industrial internet of things (IIoT), IoT based solution for just in time manufacturing, IoT for energy consumption modeling in machine tools, issues in implementing IoT. (10)

Total L: 45

REFERENCES:

1. Adrian McEwan and Hakim Cassimally, “Designing the Internet of Things”, Wiley, 2013.
2. Hopkinson N., Hague R.J.M. and Dickens P.M., “Rapid Manufacturing - An Industrial Revolution for the Digital Age”, John – Wiley and Sons Ltd., 2006.
3. Ibrahim Zeid, “Mastering CAD/CAM”, McGraw Hill Education, 2006.
4. Lihui Wang and Andrew Y.C. Nee, “Collaborative Design and Planning for Digital Manufacturing”, Springer, 2008.
5. Vinesh Raja and Kiran J Fernandes, “Reverse Engineering - An Industrial Perspective”, Springer-Verlag, 2008.

21PP25 FINITE ELEMENT APPLICATIONS IN MANUFACTURING

3 0 0 3

MATHEMATICAL MODELLING: Understanding manufacturing processes as an interaction of material - stress and strain energy - derivation of strain rate matrix-mathematical representation of manufacturing processes - metal casting, metal forming, machining, welding. (13)

METAL FORMING: Basis of finite element method - FEM for linear elasto-static problems - tonti diagram - FEM for plasticity - fundamentals, materials behaviour models, yielding criteria, governing equations, FEM formulation, thermal analysis - friction models- fracture. (12)

CASTING: Introduction - heat conduction analysis, solidification modelling, metal-mould interface heat transfer, effects of convection- mould filling analysis, fluid flow, free surface tracking, temperature solution and solidification effects in mould filling - thermal stress analysis - prediction of air gap and interfacial heat transfer coefficient, result interpretation. (12)

WELDING: Introduction - Definition of thermal problem - finite element formulation, solution scheme, heat source modelling, verification- definition of mechanical problem, melting-solidification behaviour, Lagrangian formulation of the constitutive equations, integration of evolution equation, finite element implementation, model validation - coupling thermal and mechanical problem . (8)

Total L: 45

REFERENCES:

1. David V. Hutton, “Fundamentals of Finite Element Analysis”, The McGraw Hill Companies, 2010.
2. Edward R. Champion, “Finite Element Analysis in Manufacturing Engineering”, McGraw Hill, New York, 1992.
3. Owen D. R. J. and Himton E., “Finite Elements in Plasticity, Theory and Practice”, Pinevidge Press Limited, U.K, 1980.
4. Prakash M. Dixit, Uday S. Dixit, “Modeling of Metal Forming and Machining Processes”, Springer - Verlag London Limited, UK, 2008.
5. Shiro Kobayashi, Soo Ikoh and Taylan Altan, “Metal Forming and the Finite Element Method”, Oxford and IBH Publishing, New Delhi, 1989.
6. Sindo Kou, “Transport Phenomena and Materials Processing”, John Wiley & Sons Inc., New York, 1996.

21PP26 IMAGE PROCESSING AND MACHINE VISION

3 1 0 4

DIGITAL IMAGES AND PREPROCESSING: Image formation- binary, gray and color images - steps in digital image processing - human visual system - image sampling and quantization - relationships between pixels - image enhancement - gray level transformations, histogram processing, image sharpening and smoothing, spatial and frequency domain filters - color image processing, color models, Pseudocolor Image processing, color transformations. (12)

IMAGE RESTORATION AND SEGMENTATION: Image restoration - noise models, noise reduction using spatial and

frequency domain filters - Image segmentation - edge and line detection, thresholding, region-based segmentation. (11)

FEATURE EXTRACTION AND PATTERN RECOGNITION: Image representation - topological attributes, geometrical attributes - spatial moments - deterministic models - k-nearest neighbors algorithm - template matching. (10)

MACHINE VISION: Image acquisition - types of image sensors and their principles - camera calibration - illumination techniques - thin lens model - building a machine vision system - selection of camera, lens and illumination - laser vision system. (12)

TUTORIAL

1. Dimensional measurement
2. Surface finish analysis
3. Defect identification
4. Face recognition
5. Tool wear measurement
6. Robot guidance

Total L: 45 + T : 15 = 60

REFERENCES:

1. Rafael G Gonzalez and Richard E Woods, “Digital Image Processing”, Pearson India, 2018.
2. Alexander Hornberg, “Handbook of Machine and Computer Vision: The Guide for Developers and Users”, John Wiley & Sons, 2017.
3. Scott E Umbaugh, “Digital Image Processing and Analysis: Applications with MATLAB and CVIP Tools”, CRC Press, 2017.
4. Davies E. R., “Computer Vision: Principles, Algorithms, Applications, Learning”, Academic Press, 2018.
5. Bhabatosh Chanda and Dutta Majumder D., “Digital Image Processing and Analysis”, PHI Learning Pvt. Ltd., 2011.

21PP27 INDUSTRIAL ERGONOMICS

3 0 0 3

ANTHROPOMETRY: History of ergonomics - interdisciplinary nature - ergonomics for productivity - safety, health and comfort - need for anthropometry - body planes - body movement ranges - measuring procedures - measurement tools - anthropometric measurements - percentile calculation - ergonomic guidelines for design use - anthropometry in applications. (11)

INDUSTRIAL DESIGN: Manual lifting - revised NIOSH lifting equation - material handling devices - work posture - sitting, standing or sit-standing - horizontal work surface design - console design for standing operator - seat design - hand tool design - fitting the task - designing for the user - design guidelines for hand tools - design of VDT workstations - information display modalities - design of controls - coding of controls, compatibility. (12)

RISK ASSESSMENT: Physical methods - QEC, RULA, REBA, strain index, Borg rating - psycho-physiological methods - electromyography, heart rate, heart rate variability, energy expenditure - cognitive methods - focus groups, hierarchical task analysis, SHERPA - environmental methods - thermal conditions measurements, cold and heat stress indices, thermal comfort analysis. (12)

ENVIRONMENTAL ERGONOMICS: Illumination - measurement of light - concept of visibility - effects of lighting on performance - recommended levels of illumination - distribution of light - glare - noise - measurement of sound - noise and loss of hearing - analysis and reduction of noise - effect of noise on performance - noise exposure limits - handling noise problems - whole body vibration - attenuation - amplification and resonance - effects of vibration - limits for exposure to whole-body vibration. (10)

Total L: 45

REFERENCES:

1. Bridger R.S., “Introduction to Human Factors and Ergonomics”, CRC Press, 2017.
2. Debkumar Chakrabarti, “Indian Anthropometric Dimensions for Ergonomic Design Practice”, NID, 1997.
3. Mark S Sanders, “Human Factors in Engineering and Design”, McGraw Hill, 1993.
4. Martin Helandar, “A Guide to Ergonomics of Manufacturing”, Taylor and Francis, 2005.
5. Neville Stanton, “Handbook of Human and Ergonomics Methods”, CRC Press, 2004.

21PP28 INDUSTRIAL INTERNET OF THINGS

3 0 0 3

IOT ARCHITECTURE: Introduction to IoT - IoT vs industrial IoT (IIoT) - M2M architecture - IoT architecture, definitions and functional requirements - sensing - actuation - wireless sensor networks - future developments - possible architecture for the future IoT use cases. (9)

BASICS OF COMMUNICATION AND NETWORKING PROTOCOLS: Internet communication - IP addresses - MAC addresses - wifi - zigbee - low energy bluetooth - long range radio (LoRa) - low power wireless personal area networks (6LoWPAN) - transmission control protocol (TCP) and user datagram protocol (UDP) - message queuing telemetry transport (MQTT). (12)

ELECTRONIC PROTOTYPING: Prototypes and production - open source versus closed source - prototyping embedded devices - embedded computing basics - prototyping IoT projects - industrial IoT case studies. (12)

IOT DATA ANALYTICS: Sensor - cloud - types of cloud - edge analytics and fog computing - sensor data aggregation - sensor data mining techniques - big data analytics - predictive analytics. (12)

Total L: 45

REFERENCES:

1. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley & Sons Ltd., UK, 2014.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2017.
3. David Boswarthick, Omar Elloumi and Olivierhersent, "M2M Communications: A Systems Approach", John Wiley & Sons Ltd, UK, 2012.
4. Dieter Uckelmann, Mark Harrison and Florian Michahelles, "Architecting the Internet of Things", Springer, New York, 2011.
5. Olivier Hersent, David Boswarthick and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", John Wiley & Sons Ltd., UK, 2012.

1PP29 LEAN SIX-SIGMA

3 0 0 3

LEAN MANUFACTURING: Origin of lean manufacturing at Ford - Lean manufacturing from Toyota production system - wastes to be eliminated in the Lean manufacturing paradigm - tools and techniques applied to eliminate wastes - value stream mapping (VSM) – symbols - current state VSM and future state VSM. (11)

SIX SIGMA: Definition – DMAIC and DMADV deployment models - project reporting - Six Sigma teams - team membership - stages in group development - member roles and responsibilities. (11)

LEAN SIX SIGMA THROUGH DEFINE, MEASURE AND ANALYZE PHASES: Project charter-project decomposition - Pareto analysis - critical to quality metrics - Kaizen-SIPOC - analyzing the source of variation-cause and effect diagram – correlation - design of experiments. (11)

LEAN SIX SIGMA THROUGH IMPROVE AND CONTROL PHASES: Improvement decisions - category importance weights- fault tree analysis – FMEA - visual management – 5S-total productive maintenance - Poka Yoke-common errors - use of Poka Yoke - tools and techniques useful for control planning - process audits - selecting process control elements - Jidoka - theory and implementation. (12)

Total L: 45

REFERENCES:

1. Bill Carreira, "Lean Manufacturing that Works: Powerful Tools for Dramatically Reducing Wastes and Maximizing Profits", Prentice Hall of India Learning Private Limited, India, 2007.
2. Dennis P., "Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System", Productivity Press, New York, 2007.
3. 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 Learning Limited, New Delhi, 2012.
4. Jay Arthur, "Lean Six Sigma – Demystified", Tata McGraw Hill Companies Inc, 2010.
5. Michael L George, David T Rowlands, and Bill Kastle, "What is Lean Six Sigma", McGraw Hill, New York, 2004.

21PP30 LOGISTICS AND SUPPLY CHAIN MANAGEMENT

3 0 0 3

LOGISTICS: Definition of logistics and supply chain management - 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. (10)

COORDINATED PRODUCT AND SUPPLY CHAIN DESIGN: Decision phases in a supply chain - objectives of SCM - examples of supply chains - supply chain drivers-supply chain integration - supply chain performance measures. 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. (10)

STRATEGIC ALLIANCES AND INVENTORY MANAGEMENT: Framework for strategic alliances - third party logistics - 3PL issues and requirements - 4PL-retailer - supplier partnerships - issues in retailer - supplier partnerships - distributor integration - types and issues of distributor integration- cycle inventory- economies of scale to exploit fixed cost - quantity discounts, example problems - multi-echelon inventory - safety inventory in supply chain - safety level estimation, managing safety inventory in practice - product availability - optimal level - affecting factors - supply chain contracts - bullwhip effect. (15)

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. (10)

Total L: 45

REFERENCES:
1. Donald Bowersox M. Bixby Cooperand David Closs, “Supply Chain Logistics Management”, McGraw Hill, Education, New Yorks, 2012.
2. Sadler I., “Logistics and Supply Chain Integration”, Sage Publishers, 2007.
3. Simchi-Levi Davi, Kaminsky Philip and Simchi-Levi Edith, “Designing and Managing the Supply Chain”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2012.
4. Sunil Chopra, Peter Meindl and Dharam VirKalra, “Supply Chain Management”, Pearson India Education Services Private Limited, New Delhi, 2016.
5. Martin Christopher, ‘Logistics & Supply Chain Management’, Prentice Hall- Financial Times, New York, 2016.

21PP31 MECHANICS OF POLYMER MATRIX COMPOSITES

3 0 0 3

MANUFACTURE OF COMPOSITE COMPONENTS: Definitions and classification - matrix and reinforcement, their roles, principal types of fibre and matrix material - processing of PMC - layup 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. (11)

M**ICRO MECHANICAL BEHAVIOUR OF A LAMINA:** Volume and mass fractions - evaluation of elastic moduli-strength of unidirectional lamina. (11)

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. (11)

MACRO MECHANICAL BEHAVIOUR OF A LAMINATE: Classical lamination theory – lamina stress - stress strain behavior – resultant forces and moments in a laminate, strength and stiffness of laminates – inter laminar stresses in laminates. (12)

Total L: 45

REFERENCES:
1. Autar K Kaw, “Mechanics of Composite Materials”, CRC Press, NY, 2005.
2. Matthews F. L. and Rawlings R. D., “Composite Materials: Engineering and Science”, Woodhead Publishing, 1999.
3. Robert M Jones, “Mechanics of Composite Materials”, Taylor and Francis, 1999.
4. Ronald F Gibson, “Principles of Composite Material Mechanics”, CRC press, 2016.
5. Chawla N and Chawla KK, “Metal Matrix Composites”, Springer, 2006

21PP32 MECHANICS OF ROBOT

3 0 0 3

ROBOT: Definition - robot anatomy - coordinate systems - work envelope - types and classification - specifications - joint notations - speed of motion - payload - spatial transformations - homogeneous coordinates - homogeneous transformation - forward solution - inverse solution. (12)

JACOBIAN: Joint velocities - motion generation - singularity - static forces in the manipulator - transformations of velocities and static forces in Cartesian space. (11)

DYNAMICS: Newton’s equation - Euler’s equation - closed-form dynamic equations - lagrangian formulation - manipulator dynamics in Cartesian space. (11)

TRAJECTORY GENERATION: Joint space - Cartesian space - collision free path generation - path planning - mechanism design - manipulator mechanism - actuation schemes - stiffness and compliance - position and force sensing. (11)

Total L: 45

REFERENCES:
1. John Craig, “Introduction to Robotics, Mechanics and Control”, Pearson Education, 2010.
2. King Sun Fu, Rafael C. Gonzalez, C. S. George Lee, “Robotics - Control, Sensing, Vision, and Intelligence”, McGraw Hill Education, 2017.
3. Mikell P Groover, “Industrial Robotics - Technology, Programming and Applications”, McGraw Hill Education, 2017.
4. Paul Richard, “Robot Manipulators: Mathematics, Programming and Control”, MIT Press, 1981.
5. Richard D Klafter, Thomas Achmielewski and Mickael Negin, “Robotic Engineering - An Integrated Approach”, Prentice-Hall India, New Delhi, 2001.
6. Saeed B. Niku, “Introduction to Robotics: Analysis, Control, Applications”, Wiley, 2020.

21PP33 MECHATRONICS SYSTEM

3 0 0 3

MECHATRONICS: Need and applications - elements of mechatronic systems - the role of mechatronics in automation - manufacturing and product development - 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 - linear and rotary drives - types and selection criteria. (11)

MECHANICAL SYSTEMS AND DESIGN: Mechatronic approach - control program - 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. (12)

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 of single-channel and multichannel data acquisition system - digital filtering - data logging - data conversion - introduction to digital transmission systems - PC-based data acquisition system. (11)

MECHATRONICS SYSTEM INTEGRATION: 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 the design of mechatronic products - motion control using DC motor - AC motor and solenoids - car engine management - barcodes and QR codes. (11)

Total L: 45

REFERENCES:

1. Brian Morriss, “Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics”, McGraw Hill International Edition, 1995.
2. David Allan Bradley, Alan Loader, N.C. Burd, David Dawson and Bradley Dawson D., “Mechatronics: Electronics in Products and Processes”, CRC Press, 1993.
3. Devdas Shetty and Richard A Kolk, “Mechatronics System Design”, 2nd Edition, Cengage Learning, 2010.
4. Sabri Cetinkunt, “Mechatronics with Experiments”, 2nd Edition, Wiley, 2015.
5. William Bolton, “Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering”, 6th Edition, Pearson Education, 2019.

21PP34 NON-TRADITIONAL MACHINING PROCESSES

3 0 0 3

MECHANICAL MACHINING PROCESSES: Abrasive jet machining (AJM)-Abrasive water jet machining(AWJM) - Abrasive flow machining(AFM), principles, process variables, mechanism of material removal, process capabilities, applications and limitations - ultrasonic machining, mechanics of cutting, process parameters, grain growing model, grain hammering model, analysis, capabilities. (11)

THERMO-ELECTRIC PROCESSES: Electro discharge machining (EDM), principle, components and functions process parameters, electrical circuit, material removal rate, process characteristics and application - Wire EDM - characteristics and applications - Electron beam machining (EBM),elements and their functions, process parameters and applications- Laser beam machining (LBM), laser production, types, process characteristics and applications - Plasma arc machining (PAM), elements, plasma arc torches, parameters, process capabilities. (12)

CHEMICAL AND ELECTRO CHEMICAL MACHINING: Chemical machining, principle, masks, etchants, applications, advantages and limitation - Electro chemical machining (ECM), principle, components and functions, process parameters, material removal rate, inter electrode gap, tool design, electrolyte, applications, typical problems and limitations. (10)

ADVANCED PROCESSES: Magneto rheological finishing (MRF), Magneto rheological abrasive flow finishing (MRAFF) - hybrid processes - micromachining, classifications - Electrochemical spark micromachining (ECSMM), equipments, process parameters, capabilities and applications. (12)

Total L: 45

REFERENCES:

1. Gary F Benedict, “Non Traditional Manufacturing Process”, Routledge, 2017.
2. Hassan Abdel and Gaward El-Hofy, “Advanced Machining Processes”, McGraw Hill, Publications, 2017.
3. Jain V.K., “Introduction to Micromachining”, Alpha Science International Ltd., 2014.
4. McGeough J.A., “Advanced Methods of Machining”, Springer, 2011.
5. Pandey P.C. and Shan H.S., “Modern Machining Processes”, McGraw Hill, 1980.
6. Vijay K Jain, “Advanced Machining Processes”, Allied Publications Private Limited, 2016.

21PP35 OPTIMIZATION TECHNIQUES

3 0 0 3

UNCONSTRAINED NONLINEAR PROGRAMMING: Unimodal function, single variable optimization algorithms – exhaustive search, region – elimination method – interval halving method – Fibonacci method. Multivariable optimization algorithms – Direct search method – univariate method, pattern search methods – Hooke and Jeeves method, descend method - conjugate gradient method. (12)

CONSTRAINED NONLINEAR PROGRAMMING: Characteristics of constrained problem – constrained optimization algorithms – Khun-Tucker conditions, direct search methods – complex search and random search, linearized search techniques – cutting plane method. (11)

DYNAMIC PROGRAMMING: Principle of optimality, backward and forward recursion, calculus method of solution, tabular method of solution, shortest-route problem, knapsack model. (11)

NON-TRADITIONAL OPTIMIZATION ALGORITHMS: Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization – algorithms and examples. (11)

Total L: 45

REFERENCES:

1. David E Goldberg, "GA: In Search Optimization and Machine Learning", Pearson, New Delhi, 2017.
2. Hamdy A Taha, "Operations Research – An Introduction", Pearson Education, New Delhi, 2017.
3. Jasbir S Arora, "Introduction to Optimum Design", Elsevier, New Delhi, 2017
4. Kalyanmoy Deb, "Optimization for Engineering Design, Algorithms and Examples", PHI Learning Pvt. Ltd., New Delhi, 2016.
5. Kambo N. S., "Mathematical Programming Techniques", East-West Press, New Delhi, 2012.
6. Singiresu S. Rao, "Engineering Optimization Theory and Practice", John Wiley & Sons, USA, 2020.

21PP36 PLASTICITY OF METAL FORMING

3 0 0 3

THEORY OF PLASTICITY: Theory of plastic deformation - engineering stress and strain relationship – stress tensor - strain tensor - yield criteria's - plastic stress strain relationship – plastic work - equilibrium conditions - incremental plastic strain, uniaxial tension test - mechanical properties - work hardening, compression test, bulge test, plane strain compression stress, plastic instability in uniaxial tension stress, plastic instability in biaxial tension stress. (11)

ANALYSIS OF METAL FORMING: Slab analysis - slip line method - upper bound solutions - statistically admissible stress field, numerical methods, contact problems - effect of friction - elasto-plastic behaviour - analysis of forging, rolling, extrusion and wire drawing processes - experimental techniques of the evaluation of metal forming. (12)

ANALYSIS OF SHEET METAL FORMING: Bending theory - cold rolling theory - anisotropic theory - general yield theory - sheet metal forming - elements used, mesh generation and formulation, equilibrium equations, consistent full set algorithm, numerical solutions procedures, examples of simulation of simple parts, benchmark tests, forming limit diagrams. (11)

ADVANCES IN METAL FORMING: Orbital forging - isothermal forging - warm forging - hot and cold isotropic pressing - high speed extrusion - rubber pad forming - micro blanking - superplastic forming - overview of powder metal techniques - powder rolling - tooling and process parameters. (11)

Total L: 45

REFERENCES:

1. Andrzej Sluzalec, "Theory of Metal Forming Plasticity", Springer Berlin Heidelberg, 2013.
2. David Rees., "Basic Engineering Plasticity: An Introduction with Engineering and Manufacturing Applications", Elsevier Science, 2012.
3. George E. Dieter and David Bacon, "Mechanical Metallurgy", McGraw Hill, 2017.
4. Hoffman O. and Sachs G, "Introduction to the Theory of Plasticity for Engineers", McGraw Hill Book Co., 2012.
5. Hosford. W. F. and Caddell RM, "Metal Forming Mechanics and Metallurgy", Cambridge University Press, 2011.

21PP37 PRECISION MACHINING

3 0 0 3

CLASSIFICATION AND MACHINE ELEMENTS: Principle - need for precision machining - development perspective - classes of achievable machining accuracy, conventional machining, precision machining, ultra precision machining, examples – elements - guide-ways, nut and screw transmission, linear motor drive, direct spindle drive, capabilities. (12)

TOOLING FOR PRECISION MACHINING: Collet chucks tool holders - work holding devices, fixtures, step and toe clamp - cutting tool materials - characteristics - alignment of machine tool elements. CAD/CAM integration - tool path generation – simulation - post processing - examples. (12)

HIGH SPEED MACHINING: Principle - need for high speed/high velocity machining - determinants, fast machining, smart machines, tools and processes, characteristics - high speed spindle elements - machining parameters - precision tooling interface - dry and near dry machining process. (11)

MICROMACHINING: Classification, size effect, tool based micromachining - micro turning, micro milling, micro drilling, principles, applications - Electrolytic InProcess Dressing (ELID) grinding, case study examples, sustainability issues - Introduction to nano-machining, diamond turning. (10)

Total L: 45

REFERENCES:

1. Bert P Erdel, "High-Speed Machining", Society of Manufacturing Engineers, 2003.
2. Dale Mickelson, "Guide to Hard Milling and High Speed Machining", Industrial Press Inc., 2007.
3. Murty R.L., "Precision Engineering in Manufacturing", New Age International Pvt. Ltd., 2015.
4. Venkatesh V. C. and Sudin Izman, "Precision Engineering", McGraw Hill Education Pvt. Ltd., 2014.
5. Vijay K Jain, "Advanced Machining Processes", Allied Publications Private Limited, 2016.

21PP38 PRODUCT DEVELOPMENT STRATEGIES

3 0 0 3

CUSTOMER NEED GATHERING AND ESTABLISHING PRODUCT FUNCTION: Product development versus design - types of design and redesign - product development process-S-curve-gathering and prioritizing customer needs - establishing product function - FAST method - quality function deployment - house of quality - benchmarking and establishing engineering specifications - product portfolios. (12)

CONCEPT DEVELOPMENT AND EMBODIMENT DESIGN: Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis - concept selection – pugh chart, weighted decision matrix - embodiment design, system modelling, FMEA, fault tree analysis, design verification. (12)

PHYSICAL PROTOTYPES AND EXPERIMENTATION: Types of prototypes and uses - rapid prototyping techniques - scale, dimensional analysis and similitude - physical model and experimentation - analysis, performance verification and validation - product teardown methods. (11)

TOOLING FOR PRODUCT DESIGN: Reverse Engineering: Data collection, mesh reconstruction, surface fitting, computer vision - reverse engineering hardware and software, applications - Product life cycle management (PLM), Product data management (PDM) - Collaborative product commerce (CPC) - sustainability in product design, guidelines. (10)

Total L: 45

REFERENCES:

1. Ali Jamnia, “Introduction to Product Design and Development for Engineers”, 1st Edition, Taylor & Francis, 2018.
2. George E Dieter, Linda C. Schmidt, “Engineering Design”, McGraw Hill Education, 2017.
3. Karl T Ulrich and Stephen D Eppinger, “Product Design and Development”, 7th Edition, McGraw Hill, 2020.
4. Kevin Otto and Kristin Wood, “Product Design - Techniques in Reverse Engineering and New Product Development”, Pearson Education, 2016.
5. Vignesh Raja, Kiran J. Fernandes, “Reverse Engineering: An Industrial Perspective”, Springer 2010.

21PP39 PRODUCTION AND OPERATIONS MANAGEMENT

3 0 0 3

CAPACITY PLANNING: Long range capacity planning - economies of scale - facility location - factors influencing facility location, single facility location problem, multi facility location problem, minimax location problem, gravity location problem, Euclidean distance location problem - facility layout - classification of layout, systematic layout design procedure, CRAFT. (11)

PRODUCTION PLANNING AND INVENTORY MANAGEMENT: Aggregate planning - graphical, heuristic and transportation model - development of a master production schedule - make-to-stock, assemble-to-order, make-to-order/engineer-to-order - material requirement planning - lot sizing in MRP - manufacturing resource planning - enterprise resource planning - need for inventory - types of inventory, continuous and periodic review policies, EOQ, EMQ models, inventory model with purchase discounts, inventory models with uncertain demand and lead times, selective inventory control techniques. (12)

SEQUENCING AND SCHEDULING: Single machine models - priority rules, mean flow time, weighted mean flow time, number of tardy jobs, mean tardiness - parallel machine models - minimizing makespan, weighted mean flow time - flow shop models - johnson’s algorithm - job shop models - branch and bound approach - line balancing – largest candidate rule, kilbridge and wester’s method, ranked positional weights method. (11)

LEAN PRODUCTION AND SUPPLY CHAIN MANAGEMENT: Elements of lean production - mrp vs jit - cycle time - takt time - kanban - smed - 5s - theory of constraints - agile manufacturing - maintenance management - statistics of failure, time to failure, probability distributions, bathtub curve, weibull’s probability distribution, reliability engineering, preventive maintenance, total productive maintenance, overall equipment effectiveness - supply chain management - definition, global optimization, bullwhip effect, push pull supply chain, delayed differentiation, downward substitution, product modularity, process modularity, mass customization. (11)

Total L: 45

REFERENCES:

1. Jay Heizer, Barry Render, Chuck Munson, “Operations Management: Sustainability and Supply Chain Management, 13th Edition, Pearson Education, 2020.
2. Martand T Telsang, “Industrial Engineering and Production Management”, 3rd Edition, S Chand and Company Limited, New Delhi, 2018.
3. Norman Gaither, Greg Frazier “Operations Management: Concepts, Techniques & Applications”, 9th Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2015.
4. Panneerselvam R., “Production and Operations Management”, 3rd Edition, Prentice Hall India, New Delhi, 2012.
5. Richard B. Chase, Ravi Shankar F. Robert Jacobs, Nicholas J. Aquilano, “Operations and Supply Management”, 15th Edition, McGraw Hill Education (India) Private Limited, 2019.

21PP40 STATISTICAL QUALITY CONTROL AND FACTORIAL EXPERIMENTS

3 0 0 3

STATISTICAL QUALITY CONTROL: Methods and philosophy of statistical process control – chance and assignable causes of quality variation - statistical basis of control charts - control charts for variables - control charts for attributes. (10)

ACCEPTANCE SAMPLING: Lot-by-Lot acceptance sampling for attributes – single sampling plans for attributes, double and sequential sampling plans - acceptance sampling by variables - chain sampling - continuous sampling - skip-lot sampling plans. (12)

DESIGN OF EXPERIMENTS: Fundamentals of experimental design - guidelines for designing experiments - analysis of variance - completely randomized design - randomized block design - Latin square design. (12)

ESPONSE SURFACE METHODOLOGY: Empirical models – linear regression models, estimation of parameters in linear regression models - confidence interval in multiple regression - 2-level factorial design – 2^3 design for fitting second order models – class of central composite design. (11)

Total L: 45

REFERENCES:

1. Amitava Mitra, "Fundamentals of Quality Control and Improvement", John Wiley and Sons, New Jersey, 2016.
2. Douglas C Montgomery, "Introduction to Statistical Quality Control", John Wiley & Sons, New York, 2019.
3. Eugene L Grant, Richard S Leavenworth, "Statistical Quality Control", Tata McGraw Hill, New Delhi, 2016.
4. Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson Cook, "Response Surface Methodology: process and product optimization using experimental designs", John Wiley and Sons, 2016.
5. Ronald E Walpole, Raymond H Myers, Sharon L Myers and Keying Ye, "Probability and Statistics for Engineers and Scientists", Pearson Education, New Delhi, 2016.

21PP41 SUSTAINABLE MANUFACTURING

3 0 0 3

CONCEPTS AND TOOLS OF SUSTAINABILITY: Concept of sustainability - sustainability for manufacturing - manufacturing for sustainability - Sustainable Development Goals (SDG) set by UN-Triple Bottom Line Approach - Life Cycle Assessment, Life Cycle Impact Assessment Methods. (10)

SOCIO ECONOMIC SUSTAINABILITY: Role of Manufacturing in Sustainable Economic Development- Corporate social responsibility, Labour practice Indicators. Risk/benefit assessment & Corporate Social Responsibility, Maximization of customer satisfaction, Improvement of safety and health of employees, Green Supply chain. (10)

ENVIRONMENTAL CONSCIOUS MANUFACTURING: Environment conscious Product, process, technology, Energy efficiency of manufacturing processes, Waste water Reduction, Emissions reductions, Waste generation reduction. Government schemes for Environmental Consciousness. (15)

SUSTAINABLE MANUFACTURING SYSTEM: Concepts of ISO 14001 - requirements of ISO 14001 – Environmental Management System – framework and benefits. Effect of ISO 14000 certification on sustainability, Sustainability assessment. (10)

Total L: 45

REFERENCES:

1. Davim J. Paulo, Ed. "Sustainable Manufacturing", John Wiley & Sons, 2013.
2. Dornfeld D., "Green Manufacturing", 1st Edition, Springer, 2013.
3. Erach Bharucha," Textbook of Environmental Studies for Undergraduate Courses", Orient BlackSwan, 2013.
4. Madu C.N., "Handbook of Environmentally Conscious Manufacturing", Kluwer Academic Publisher, 2001.
5. Stark Rainer, Günther Seliger and Jérémy Bonvoisin, "Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives", Springer Nature, 2017.
6. Vinodh S., "Sustainable Manufacturing", 1st Edition, CRC Press, 2020.

21PP42 TOOL DESIGN

3 0 0 3

CUTTING TOOLS: Cutting tool materials - single point cutting tool - form tool - hole making cutting tools - milling cutter - broaching tool - grinding wheel - ISO standard for inserts, tool holders - selection of inserts and tool holders for specific applications - gear shaper and gear hob design. (11)

JIGS AND FIXTURES: Principles of location - clamping and support - drill bushes - general considerations for design of jigs and fixtures - types of drill jigs - milling fixture - turning fixture - welding fixture - modular fixture - broaching fixture - grinding fixture - design of drill jig and fixture. (12)

PRESS TOOLS: Power presses - press operations - press tonnage - elements of press tool die - types of dies - clearance - methods of reducing cutting forces - strip layout - selection of standard die set - centre of pressure - design of blanking and piercing die - sheet metal bending methods - bending force - bend allowance - spring back - design of bending die - drawing operations - metal flow during drawing - drawing force - design of drawing die. (11)

INJECTION MOULDS: Elements of mould - types of injection mould - mould material - number of cavities - selection of mould and moulding machine - parting line and surface - feed system - ejection system - temperature control system - design of two plate and three plate mould. (11)

Total L: 45

REFERENCES:

1. Cyril Donaldson, George H LeCain, Goold V.C. and Joyjeet Ghose, "Tool Design", 5th Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2012.
2. Edward G Hoffman, "Jigs and Fixture Design", 5th Edition, Cengage Learning, New Delhi, 2012
3. Joshi P.H., "Jigs and Fixtures", 3rd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2017.
4. Sanjay K Nayak, Pratap Chandra Padhi, Y Hidayathullah, "Fundamentals of Plastics Mould Design", 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2012.
5. Vukota Boljanovic, Paquin J.R, and Robert E Crowley, "Die Design Fundamentals", 3rd Edition, Industrial Press INC, New York, 2006.

21PP43 RESEARCH METHODOLOGY

3 0 0 3

REVIEW OF LITERATURE AND RESEARCH PROBLEM: Reviewing of literature in the area of study, preparing a list of reference materials, methods to search information effectively, Reference management software like Mendeley/ Zotero, Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem. (12)

DATA ANALYSIS: Statistical data, statistical measures, regression and correlation analysis, curve fitting, independence of attributes - analysis of contingency table, common scientific software for computation and analysis. (10)

RESEARCH ETHICS AND TECHNICAL RESEARCH: Ethical issues related to publishing, Online journal system, peer reviewed journals, Citation counting, Impact Factor, Scopus, SCI, H-index, G-index, SCIE, ORCID, DOI, Intellectual property rights (IPR), plagiarism. (12)

REPORTING AND THESIS WRITING: Writing of research articles and research proposals, structure of a manuscript, publication process of a manuscript, structure of a PhD thesis, Latex software for thesis formatting and effective presentation, software for detection of Plagiarism. (11)

Total L: 45

REFERENCES:

1. Kothari C.R. and Gaurav Garg, "Research Methodology: Methods and Techniques", New Age International Publishers, 2019.
2. Ranjit Kumar, "Research Methodology: A Step by Step Guide for Beginners", Pearson Education, 2005.
3. Richard A. Johnson, Miller & Freund„s, Probability and Statistics for Engineers", Prentice Hall, New Delhi, 2019.
4. Ramakrishna B and Anil Kumar H. S., "Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers", Notion Press, 2017.
5. Kate LTubain, "A Manual for writers of research papers, Theses and Dissertations", The University of Chicago Press, Chicago, 1996.

Open Electives (one to be opted)

21PP91 LEADERSHIP QUALITIES FOR ORGANIZATION

3 0 0 3

LEADER: Definition - traits of leader in ancient literature - historical leaders in industry - classification - born or nurtured leader - leadership in transition - leadership models - leadership trait theory - leadership behaviour theory - contingency theory and situational leadership theory - leadership style - authoritarian - democratic - free-rein style. (11)

LEADERSHIP CHARACTER: Integrity - communication - conflict resolution - transparency - clarity - learning leadership skills-soft skills - hard skills - emotional intelligence - behaviour - distinctive characters of past, present and future leaders. (11)

LEADERSHIP CHALLENGES: Critical leadership competencies - interpersonal skills - controlling - decision-making - role in change management - quality management - business ethics on leadership - future leader's commitments and challenges - overcoming technical - political and cultural changes - challenges in quality systems - industrial act - environment and safety. (12)

BUILDING LEADERSHIP CAPACITY: Level of leadership - building volunteer leaders - training, development - empowerment - coaching - collaboration - economic development - professional leaders - leader vs. manager - accountability - outcome based-facilitator and consensus builder. (11)

Total L: 45

REFERENCES:

1. Gary A. Yukl, "Leadership in Organizations", 8th Edition, Pearson 2013.
2. Hesselbein, Frances et. al., "The Leader of the Future", San Francisco CA: Jossey-Bass Publishers, 2006.
3. Hornsby, Tom and Warkoczeski, Larry, "New Roles for Leaders", Franklin TN, Hillsboro Press, 2000.
4. Maxwell, John C., "The 21 Irrefutable Laws of Leadership", Nashville TN, Thomas Nelson, 2013.
5. Northouse P.G., "Leadership: Theory and Practice", Thousand Oaks, CA, Sage Publications, 2012.
6. Subramaniam R.K., "How Modern Managers Follow Ancient Tirukkural", Shanlax Publications, 2016.

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