

SEMESTER - 1

19P101 CALCULUS AND ITS APPLICATIONS

3 1 0 4

DIFFERENTIAL CALCULUS : Function of two variables, limits and continuity, partial derivatives, chain rule, extreme values and saddle points, Lagrange multipliers, Taylor's formula for two variables. (9 + 3)

INTEGRAL CALCULUS : Double integrals — double and iterated integrals over rectangles, double integrals over general regions, Fubini's theorem, area and volume by double integration, reversing the order of integration, polar form. (9 + 3)

FIRST ORDER ORDINARY DIFFERENTIAL EQUATIONS : Basic concepts, separable differential equations, exact differential equations, integrating factors, linear differential equations, modeling - mixing problems, Newton's law of cooling. (9 + 3)

SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS : Homogeneous linear equations of second order, homogeneous linear ODEs with constant coefficients, Euler–Cauchy equations, solution by variation of parameters, free oscillations of mass-spring systems. (9 + 3)

VECTOR CALCULUS : Gradient and directional derivative of a scalar field, divergence and curl of a vector field. Integration in vector field — line integrals, path independence of line integrals, Green's theorem in the plane, divergence theorem of Gauss and Stokes's theorems. (9 + 3)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "Thomas' Calculus", Pearson Education., New Delhi, 2018
2. Erwin Kreyszig "Advanced Engineering Mathematics", Wiley India Pvt Ltd., New Delhi, 2015

REFERENCES:

1. Howard Anton, Irl Bivens, Stephen Davis "Calculus", John Wiley & Sons, INC., USA, 2016
2. Wylie C R and Barrett L C "Advanced Engineering Mathematics", Tata McGraw-Hill., New Delhi, 2019
3. Michael D.Greenberg "Foundations of Applied Mathematics", Dover Publications, INC., New York, 2013
4. Gilbert Strang "Calculus", Wellesley Cambridge Press., USA, 2017

19P102 PHYSICS

3 0 0 3

MECHANICS : Introduction to Vectors-velocity and acceleration vectors in two dimensions, Relative motion, Uniform circular motion, centripetal acceleration . Newton's laws of motion, Mass, inertia and force. Using Newton's second law in two dimensions ; free body Diagram. Work done by a varying force, work- kinetic energy theorem. Systems of Particles: Centre of mass in one and two dimensions. Rotational motion: Radial and tangential acceleration, torque, rotational inertia, rotational energy, conservation of angular momentum Gyroscopes and Precession (10)

FRICTION AND WEAR : Static and dynamic friction, limiting friction. Coefficient of static friction, coefficient of dynamic friction. Rolling friction .Lubrication and lubricants. Surface wear due to friction. Surface treatments for reducing friction. Traction and road friction. Curvilinear motion of Automobiles- centripetal force. Skid, hydroplaning and principle of anti-lock braking mechanisms. (8)

OSCILLATORY MOTION AND WAVE MOTION : Simple harmonic motion, spring mass system, Torsional Oscillator , Vibration of a spring and mass system. Free, damped and forced oscillations and resonance. Wave motion: Definition of a plane progressive wave. Attenuation of waves. Differential equation and solution of a plane progressive wave. Phase velocity. Superposition of waves, group velocity. The Doppler effect and shock waves. (9)

FLUID MOTION : Density and Pressure, Hydrostatic equilibrium, Measurement of Pressure. Compressible and incompressible flow. Applying Pascal's law: A Hydraulic lift. Archimedes' Principle and Buoyancy. Finding the Buoyancy Force: working underwater. Floating objects. Fluid dynamics: Stream lines, Conservation of Mass- Continuity Equation . Conservation of Energy: Bernoulli's Equation. Applications of Fluid dynamics: Draining a tank, Airplane speedometer. Measuring Flow speed: A Venturi Flowmeter. Aerodynamic Flight and lift. Viscosity and Turbulence. (8)

OPTICS : Review of formation of images by lenses, combination of thin and thick lenses, chromatic and spherical aberrations, methods to reduce aberrations. Interference: Superposition principle, intensity distribution, condition for interference, coherent and non coherent source, classification of fringes, system for observing the interference phenomna and engineering application : Interferometric displacement measurement. Diffraction: Fraunhofer diffraction for Single slit and double slit, diffraction grating, resolving power of a grating, image forming system: optical microscope. (10)

Total L: 45

TEXT BOOKS:

1. Richard Wolfson "Richard Wolfson", Pearson Education., Singapore, 2011
2. Gaur R K, Gupta S L "Engineering Physics", Dhanpat Rai Publications., 2013

REFERENCES:

1. Halliday D., Resnick R. and Walker J. "Fundamentals of Physics", Wiley Publications., 2008
2. Raymond A. Serway, John W. Jewett "Physics for Scientists and Engineers", Cengage Learning., 2010
3. Paul M. Fishbane ., Stephen Gasiorowicz, Stephan T Thomson "Physics for Scientists and Engineers", Addison Wesley., 2001
4. Mathur D. S "Elements of Properties of Matter", S Chand and Co., 2013

19P103 CHEMISTRY**3 0 0 3**

THERMODYNAMICS : Review of first law, variation of heat of reaction with temperature, adiabatic flame temperature. Joule Thomson effect and its significance- inversion temperature-liquefaction of gases. Second law- statements- entropy and spontaneity-free energy and spontaneity. Gibbs-Helmholtz equation. Concept of chemical potential-variation of chemical potential with T and P, Gibbs-Duhem equation- Clausius Clapeyron equation- concept of fugacity and activity. (9)

PHASE EQUILIBRIA : Definitions—one component system (water), two component systems-Cu-Ni and Pb-Ag systems-lever rule. Solubility of gas in liquids. Distribution law-principle of extraction—applications. Binary liquid systems-fractional distillation—azeotropic mixtures. (9)

KINETICS : Review of Integrated rate laws. Complex reactions- opposing, parallel and consecutive reactions- steady state approximation- branched chain reactions-mechanism and kinetics of combustion of hydrogen and hydrocarbons. (9)

SURFACE CHEMISTRY : Adsorption - Freundlich and Langmuir adsorption isotherms, application of BET isotherm (Derivation not required). Applications of adsorption- abatement of air and water pollution- automobile catalytic convertors. Surface active agents-surfactants, detergents, emulsifiers, properties- critical micellar concentration, contact angle, wetting and water repellency. Superhydrophobic surfaces. (9)

ELECTROCHEMISTRY : Electrode potential- emf series- standard and reference electrodes — SHE, calomel, Ag/AgCl. Nernst equation-galvanic and concentration cells-Ion selective electrodes- glass electrode-applications. Potentiometric and conductometric titrations. Applied Electrochemistry: electroplating, electropolishing, electrochemical machining, electrophoretic painting, anodization of aluminium. (9)

Total L: 45**TEXT BOOKS:**

1. Peter Atkins, Julio de Paula "Elements of Physical Chemistry", Oxford university press., UK, 2013 , 6th ed
2. B.R. Puri, L.R. Sharma, M.S. Pathania "Principles of Physical Chemistry", Vishal Publishing Company., India, 2017 , 47th ed

REFERENCES:

1. Donald A. McQuarrie, John D. Simon "Physical Chemistry: A Molecular Approach", University Science Books., USA, 1997 , 1st ed
2. Derek Pletcher, Frank C. Walsh "Industrial Electrochemistry", Chapman and Hall., London, 1990 , 2nd ed
3. J. Rajaram, J. C. Kuriakose "Thermodynamics for Students of Chemistry", Shobanlal Nagin Chand Company., India, 1986 , 1st ed

19P104 PROFESSIONAL ETHICS**2 0 0 2**

CONCEPT OF VALUES AND ETHICS : Meaning and Significance — Sources of Individual Values - Value crisis in the Contemporary Indian Society—Moral and Ethical Values. (6)

APPLICATION OF VALUES : Personal Values and Social Values — Role of Codes - Relevance of Values in Profession — Formation and Application of Values for Engineers. (6)

PROFESSIONAL ETHICS: Professional Ethics — Need — Issues — Challenges — Ethical Leadership — Ethical dilemma - Case Study— Application of Personal Core Values in Professional Ethics. (6)

SHARED VALUES IN THE ORGANIZATION AND ITS IMPACT : Need to identify and Construct Shared Values — Promotion of Shared Values and Challenges — Impact of Shared Values in Organization. (6)

SOCIAL EXPERIMENTATION : Engineers as Managers - Impact of Culture and Learning from the Past — Consultant\ and Leaders. (6)

Total L: 30

TEXT BOOKS:

1. Murthy C.S.V "Business Ethics", Himalaya Publishing House., 2010
2. Kiran D. R "Professional Ethics and Human Values", Tata McGraw Hill., New Delhi, 2007

REFERENCES:

1. Subramaniam R "Professional Ethics", Oxford Publishers., New Delhi, 2013
2. Harris, Pritchard, Rabins "Engineering Ethics", Cengage Learning., New Delhi, 2013
3. Danguy, Douglas R Carmichael, Linda A Lach "The CPA's Guide to Professional Ethics", Wiley., 2001
4. Terrence M Kelly "Professional Ethics – A Trust Based Approach", The Rowman and Littlefield Publishing Group., 2018

19G105 ENGLISH LANGUAGE PROFICIENCY

2 1 0 3

LEARNING LANGUAGE THROUGH STANDARD LITERARY AND GENERAL TEXTS : Integrated tasks focusing on language skills ; Training based on Text based vocabulary, tone, register and Syntax features (12 + 0)

GRAMMAR IN CONTEXT : Word Order ; Subject Verb Concord ; Style features - Tenses, Conditionals, Prepositions, Active and Passive Voice, Modals, Cloze and Spotting Error exercises (10 + 0)

GUIDELINES FOR WRITTEN COMMUNICATION : Principles of clear writing, Paragraph writing, Essay writing, Emphasis Techniques, Summarizing and Paraphrasing, Analytical writing (8 + 0)

FOCUS ON SPOKEN ENGLISH : Task — based activities: Graded levels of difficulty and with focus on language functions - Level 1: Self — expression — Greetings in Conversation, Hobbies, Special interests, Daily routine - Level 2: General Awareness — Expression of Concepts, Opinions, Social Issues, Description of a process / picture/chart, news presentation / review - Level 3: Advanced Skills — Making Short Speeches and Participating in Role Plays (0 + 10)

LISTENING ACTIVITY : Task based activities using Language Laboratory (0 + 5)

Total L: 30 +T: 15 = 45

TEXT BOOKS:

1. Faculty Incharge "Course Material on "English Language Proficiency", PSG College of Technology., Coimbatore, 2019

REFERENCES:

1. Jill Singleton "Writers at Work: The Paragraph", Cambridge University Press., New York, 2012
2. Simon Haines, Mark Nettle and Martin Hewings "Advanced Grammar In Use", Cambridge University Press., New Delhi, 2008
3. Anne Laws "Writing Skills", Orient Black Swan., Hyderabad, 2011
4. Sinha DK "Specimens of English Prose", Orient Black Swan., Hyderabad, 2012

19P110 ENGINEERING GRAPHICS

0 0 4 2

INTRODUCTION AND PLANE CURVES :

1. Importance of graphics in Engineering applications, Bureau of Indian Standards (BIS), Drawing Instruments.
2. Types of Lines and Lettering, Methods of dimensioning.
3. Basic Geometrical constructions, Conics — ellipse, parabola and hyperbola.
4. Construction of cycloids, Construction of involutes.
5. Drawing of tangents and normal to the curves, Scales — diagonal and vernier scales. (12)

PROJECTION OF POINTS, LINES AND PLANES :

1. Orthographic projection - Principal planes - First angle projection – Third angle projection.
2. Projection of points.
3. Projection of lines - determination of true lengths and true inclination by rotating line method.
4. Projection of planes. (12)

PROJECTION OF SOLIDS :

1. Types of regular solids, solids in simple positions, projection of solids like prisms, pyramids, cylinder, cone and sphere.
2. Visualization principles of three-dimensional objects, freehand sketching. (12)

PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES :

1. Type of sections, hatching - BIS conventions, section of regular solids.
2. Development of lateral surfaces of simple and sectioned solids.

3. Development of lateral surfaces of solids with cut-outs and holes. (12)

PICTORIAL PROJECTIONS :

1. Isometric projection / view, isometric scale, isometric projections of lines, planes, solids and sectioned solids.
2. Perspective projection of solids – Visual ray method.
3. 2D and 3D part modelling, extraction of 2D views using CAD package. (12)

Total P: 60

TEXT BOOKS:

1. John K.C "Engineering Graphics for Degree", PHI Learning., 2009
2. Jon M. Duff, Warren J. Luzadder "Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production", PHI Learning., 2008

REFERENCES:

1. Venugopal K, Praburaja V "Engineering Graphics", New Age International., 2018
2. Department of Production Engineering & CAD/CAM Centre "A Primer on Engineering Drawing using Pro/Engineer", PSG College of Technology., Coimbatore, 2008
3. Natarajan K. V "A Text Book of Engineering Graphics", Dhanalakshmi Publisher., Chennai, 2018
4. Bhatt N. D, Panchal V. M "Elementary Engineering Drawing", Charotar Publishing House., 2006

19P111 BASIC SCIENCES LABORATORY

0 0 4 2

PHYSICS LIST OF EXPERIMENTS (ANY EIGHT) :

1. Determination of Young's Modulus of a wooden bar — Cantilever method
2. Determination of rigidity modulus of a given material using Torsion pendulum
3. Determination of coefficient of viscosity of water — Poiseuille's method
4. Determination of fibre thickness — air wedge method
5. Determination of wavelength of mercury spectrum using transmission grating
6. Measurement of vibration frequency of electrically maintained tuning fork using Melde's apparatus
7. Determination of velocity of sound — Helmholtz resonator
8. Determination of wavelength and beam divergence of laser
9. Determination of Hysteresis loss of a ferromagnetic material
10. Determination of lattice constant using X-ray powder photograph (30)

CHEMISTRY(ANY EIGHT EXPERIMENTS) :

1. Determination of rate constant of hydrolysis of an ester
2. Construction of eutectic phase diagram
3. Conductometric estimation of acid strength of a pickling bath
4. Electroplating of nickel and copper and determination of cathode efficiency
5. Anodizing of aluminium and determination of thickness of anodized film
6. Determination of kinematic viscosity of lubricating oil using Redwood viscometer
7. Determination of flash and fire point of lubricating oil
8. Analysis of solid fuel by proximate analysis of coal
9. Mechanism of galvanic corrosion—Determination of corrosion rate by corrosion current measurement
10. Estimation of hardness of water by EDTA method (30)

Total P: 60

REFERENCES:

1. Department of Chemistry "Chemistry Laboratory Manual", ., 2019
2. Department of Physics "Physics Practicals", ., 2019
3. Wilson J. D. and Hernandez C. A. "Physics Laboratory Experiments", Houghton Mifflin Company., New York, 2009 7th

19P112 ENGINEERING PRACTICES

0 0 2 1

LIST OF EXPERIMENTS :

1. Foundry - Tools, preparation of moulding sand, patterns, cores, foundry exercises.
2. Welding - Metal arc welding tools and equipment, exercises by Arc welding and TIG welding Processes.
3. Fitting - Tools, operations, exercises Make "T" Joint and "L" Joint, types of joints.
4. Carpentry - Tools, carpentry process, carpentry exercises, types of joints.
5. Plumbing - exercises - external thread cutting and joining.
6. Sheet Metal Work & Soldering - Tools, operations, exercises Make a Rectangular Tray in Galvanized Ironsheet
7. Power Tools - Demonstration of tools and operations.

8. Subtractive Rapid Prototyping - Demonstration of prototype development process.

Total P: 30

REFERENCES:

1. Department of Mechanical Engineering "Engineering Practices Laboratory Manual", PSG College of Technology., Coimbatore, 2010
2. Chapman WAJ "Workshop Technology", Edward Arnold., 2001

19IP15 INDUCTION PROGRAMME

0 0 0 0

As per AICTE guidelines

SEMESTER - 2

19P201 COMPLEX VARIABLES AND TRANSFORMS

3 1 0 4

COMPLEX DIFFERENTIATION : Derivative, analytic function, Cauchy-Riemann equations, Laplace's equation, linear fractional transformations. (9 + 3)

COMPLEX INTEGRATION : Cauchy's integral theorem, Cauchy's integral formula, Laurent series, singularities and zeros, residue integration method (Residue integration of complex integrals only). (9 + 3)

LAPLACE TRANSFORMS : Laplace transform, linearity, first shifting theorem, transforms of derivatives and integrals, ODEs, unit step function, second shifting theorem, Dirac's delta function, periodic functions. (9 + 3)

FOURIER SERIES AND FOURIER TRANSFORMS : Fourier series — arbitrary period, even and odd functions, half range expansions. Fourier transforms, Fourier cosine and sine transforms. (9 + 3)

PARTIAL DIFFERENTIAL EQUATIONS : Basic concepts of PDEs, wave equation, heat equation, steady state two- dimensional heat problems, solution by separating variables and Fourier series. (9 + 3)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

1. Erwin Kreyszig "Advanced Engineering Mathematics", Wiley India Pvt Ltd., New Delhi, 2015
2. Wylie C R and Barret L C "Advanced Engineering Mathematics", Tata McGraw-Hill., New Delhi, 2019

REFERENCES:

1. Dennis G Zill and Patrick D Shanahan "A First Course in Complex Analysis with Applications", Jones and Bartlett Pvt Ltd., New Delhi, 2015
2. Mathews J H and Howell R W "Analysis for Mathematics and Engineering", Narosa Publishing House., New Delhi, 2012
3. Peter V.O Neil "Advanced Engineering Mathematics", Cengage., New Delhi, 2016
4. Dennis G Zill "Advanced Engineering Mathematics", Jones & Bartlett Pvt Ltd., New Delhi, 2017

19P202 MATERIALS SCIENCE

3 0 0 3

CRYSTAL STRUCTURE : Introduction to Quantum Mechanics: Matter waves, Time independent Schrodinger's equation of motion: Energy quantization of free electrons in a metal. Crystalline solids: lattice, unit cell, closed packed structures- FCC, HCP, naming of planes-Miller indices, Crystal imperfections: zero, one and planar defects, Burger vector. (10)

MAGNETIC PROPERTIES : Magnetic dipoles and magnetic field vectors, Dia, para, ferro, anti-ferro and ferrimagnetism, Hard and soft magnets, Hysteresis loss, Low-conducting magnets, super conducting magnets and conducting magnets, magnetorheology, ferrofluids and applications. (9)

ADVANCED MATERIALS : Nanomaterials- Size-dependant properties, applications, Shape Memory Alloys (SMA)- Characteristics, Properties of Ni-Ti alloys, SMA actuated robotics prosthesis, Metallic glasses: properties and applications. Composites: functions of matrix and reinforcement in composites, Polymer, metal and ceramic matrix composites, carbon- carbon composites, Applications of composites in machine tools (9)

LASER PROCESSING OF MATERIALS : Introduction to Laser. Functional requirements for material processing: Wavelength,

Spatial and temporal coherence, spot size, spectral power density, spatial power distribution, beam profile. Properties and Industrial Applications of Carbon-di-oxide, Nd:YAG, laser, Q-switching. Interaction of Laser with matter: absorption spectra of target material, surface reflection, heat affected zone, enhancing thermal outputs by oxidation or pretreatment of the surface, laser machining, marking, drilling, welding and heat treatment. (9)

TESTING OF MATERIALS : Ultrasonic inspection: Properties of Ultrasonic waves, Acoustic impedance, Pulse-echo method, through transmission, Phase-array radiators, Ultrasonic detectors. Microscopic inspection: Electron microscopy, electron waves, STEM, AFM and applications. Principles of Acoustic Emission for health monitoring of engineering structures. (9)

Total L: 46

TEXT BOOKS:

1. William D Callister Jr "Materials Science and Engineering — An Introduction", John Wiley and Sons Inc., New York, 2007
2. Raghavan V. "Materials Science and Engineering — A First Course", Prentice Hall of India., New Delhi, 2009

REFERENCES:

1. Shaffer J P, Saxena A, Antolovich S D, Sanders T H Jr, Warner S B "The Science and Design of Engineering Materials", McGraw Hill Companies Inc., New York, 1999
2. Donald R Askeland, Wendelin J Wright "Essentials of Materials Science and Engineering", Cengage Learning., USA, 2013, 3rd
3. James F Shackelford S "Introduction to Materials Science for Engineers", Macmillan Publishing Company., New York, 1992
4. William M Steen "Laser Material Processing", Springer., London, 2003, 3rd

19P203 CHEMISTRY OF ENGINEERING MATERIALS

2 0 0 2

FUELS AND COMBUSTION : Petroleum - refining, cracking and polymerisation- petrol and diesel knocking-octane and cetane rating of fuels-reforming of gasoline. Coal- carbonization- coke manufacture-Otto-Hoffmann method. Synthetic petrol- Bergius process. Combustion of fuel- calorific value and theoretical air calculations. (6)

BATTERIES AND FUEL CELLS : Batteries- characteristics-construction and working of Leclanche, lead-acid, nickel-cadmium and lithium ion batteries- supercapacitors. Batteries for automobiles, satellites, torpedos, computer standby supplies. Fuel cell-theory, working principle and applications of proton exchange membrane, direct methanol fuel cells and solid oxide fuel cells. (6)

CORROSION AND PROTECTIVE COATINGS : Forms of corrosion and their mechanism- galvanic, atmospheric, pitting, crevice and stress corrosion. Corrosion protection by design, cathodic protection, protective coatings, corrosion inhibitors - mention of types and applications. (6)

MACROMOLECULES : Classification, molecular weight - M_n and M_w . Mechanism of polymerization- structure related to thermal, electrical and mechanical properties of polymers. Compounding of plastics, Moulding of plastics- compression, injection, extrusion and blow moulding techniques. Rubber — structure, vulcanization- fibre and carbon reinforced plastics, types of adhesives and sealants. (6)

MISCELLANEOUS MATERIALS : Lubricants-classification- properties, mechanism of lubrication- additives and improvers. Solid lubricants (graphite and MoS₂). Abrasives: Natural abrasives (diamond and corundum)-synthetic abrasives (silicon carbide and boron carbide). Refractories- characteristics — classification — alumina, magnesite and zirconia bricks- applications. Boiler feed water- requisites -estimation of hardness-demineralization process. Nanomaterials and their applications-Graphene, CNT, ferrofluids. (6)

Total L: 30

TEXT BOOKS:

1. Shashi Chawla "A Text Book of Engineering Chemistry", Dhanpat Rai and Company., New Delhi, 2005, 1st ed
2. SS Dara, SS Umare "A Textbook of Engineering Chemistry", S Chand and Company., India, 2010, 20th ed

REFERENCES:

1. Sharma B. K "Engineering Chemistry", Krishna Prakashan Media (P) Ltd., Meerut, 2005, 1st ed
2. Mary Jane Shultz "Engineering Chemistry", Cengage Learning., USA, 2009, 1st ed
3. P. C. Jain, M. Jain "Engineering Chemistry", Dhanpat Rai Publishing Company., New Delhi, 2005, 1st ed

19P204 ENGINEERING MECHANICS

3 1 0 4

STATIC EQUILIBRIUM OF PARTICLES & RIGID BODIES : Forces Systems of forces - Concurrent forces in plane and space- Resultant - Problems involving the equilibrium of a particle-free body diagram-equilibrium of particle in space. - Rigid bodies:

moment of force about a point and an axis, moment of couple - Equivalent force-couple system, Equilibrium of rigid bodies
- Types of supports - reactions on beams and frames (11 + 4)

FRICITION : Static and kinetic friction, Co-efficient of friction, Laws of dry friction - Friction in wedges, ladder – Friction in Ropes and Belts (6 + 2)

ANALYSIS OF TRUSSES : Types of structures, Simple truss: Assumptions, Roof trusses - Method of joints and Method of sections (6 + 2)

CENTROID AND MOMENT OF INERTIA : Centre of gravity: Location of centroid of composite areas and composite solids, - Moment of inertia: Determination of area moment of inertia of composite plane areas, polar moment of inertia, - mass moment of inertia of solids, radius of gyration - (8 + 3)

DYNAMICS OF PARTICLES : Kinematics: Motion characteristics, uniformly accelerated motion, rectilinear motion - - projectile motion, circular motion, oscillatory motion, - Kinetics: Applications of Newton's II law and D'Alembert's principle, Work done by a force - work energy theorem, conservation of mechanical energy, - Impulse and momentum: conservation of momentum, - Impact of elastic bodies - Direct central impact - oblique central impact (14 + 4)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

1. Beer F. P. , Johnson E. R. "Vector Mechanics for Engineers: Statics and Dynamics(SIE)", McGraw Hill Education., 2017 , Eleventh edition
2. J.L.Meriam, L.G.Kraige "Engineering Mechanics-Statics & Dynamics", Wiley India Pvt Ltd., 2015 , Seventh Edition

REFERENCES:

1. Russel C.Hibbeler "Engineering Mechanics: Statics and Dynamics", Pearson Education., 2017 , Fourteenth
2. David Halliday, Robert Resnick, Jearl Walker "Principles of physics", Wiley publications., 2014 , Tenth
3. Timoshenko.S, D.H.Young, J.V.Rao "Engineering Mechanics", McGraw Hill Education., 2017 , Fifth Edition
4. Rajasekaran S, Sankarasubramanian G "Engineering Mechanics:Statics and Dynamics", Vikas Publishing House Private Limited., 2011

19P205 BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING

3 0 0 3

ELECTRIC CIRCUITS : Ohm's law, Kirchhoff's Laws, solving simple DC Circuits-single phase AC circuit fundamentals-Power, Power factor-solving simple AC circuits- Introduction to three-phase AC circuits (8)

ELECTRICAL MACHINES : DC MOTORS: Principle of Operation-types-torque equation - speed-torque characteristics-losses and efficiency- speed control of DC motors-Electric Braking AC MACHINES: Single phase Transformers - Construction and working principle, 3 phase Induction Motor-construction–Principle of operation- types-torque equation-speed -torque characteristics-1 phase Induction Motor-Principle of operation-types— Industrial Applications (12)

ELECTRONIC DEVICES : Operation of PN junction diodes, VI characteristics, zener diode, BJT, types-CB, CE, CC configurations, input and output characteristics, JFET - working principle and characteristics - Comparison of BJT and FET. MOSFET-types, principle of operation and characteristics, Opto Electronic Devices - Introduction, types, photo conductive cells, photo diode, phototransistor, Light emitting diode-Principles and Applications (8)

ELECTRONIC CIRCUITS : (Qualitative analysis only) Half wave and full wave rectifier, capacitive filters, zener voltage regulator, RC- coupled amplifier, frequency response, RC phase shift oscillator. LINEAR INTEGRATED CIRCUITS: Operational amplifiers, Ideal op-amp characteristics, Inverting and Non-inverting amplifier, op-amp applications - Adder- Subtractor, integrator, differentiator, comparator, zero crossing detector. (10)

DIGITAL ELECTRONICS : Number systems-representation of signed numbers: 1's complement and 2's complement, logic gates, Half adder, full adder, Flip flops, RS,JK,JK Master slave, D and T type, counters and shift registers. (7)

Total L: 45

TEXT BOOKS:

1. Mehta V K, Rohit Mehta "Principles of Electrical Engineering and Electronics", S.Chand & Co. Limited., New Delhi, 2014
2. Muthusubramanian R, Salivahanan S "Basic Electrical, Electronics and Computer Engineering", Tata McGraw Hill., 2012

REFERENCES:

1. Bhattacharya S K "Basic Electrical and Electronics Engineering", Pearson., 2012
2. Rajput R K "Basic Electrical and Electronics Engineering", University Science Press., 2012 , 2
3. Gupta B R, Singhal Vandana "Electrical and Electronics Engineering", S. Chand and Co., 2010
4. Theraja B L "Fundamentals of Electrical and Electronics Engineering", S. Chand and Co., 2006

19P210 ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY

0 0 2 1

LIST OF EXPERIMENTS :

1. Verification of Ohm's and Kirchhoff's Laws
2. Measurement of Power and Power Factor in Single Phase RLC Circuit
3. Mechanical Characteristics of DC Shunt and Compound Motor
4. Load Test on 3 Phase Induction Motor
5. Electric Braking of 3 Phase Induction Motor (Dynamic Braking / Plugging)
6. Study of Half Wave and Full Wave Rectifiers with and without Filters
7. RC Coupled Amplifier
8. Application of Operational Amplifier : Adder, Subtractor, Integrator, and Differentiator
9. Study of Logic Gates and Implementation of Binary Adder / Subtractor
10. Implementation of Modulo – 16 Counter

Total P: 30

REFERENCES:

1. Department of EEE "Manual Prepared by EEE Department", ., Coimbatore,

19P211 C PROGRAMMING LABORATORY

0 0 4 2

1. Working with RAPTOR Tool — Flowchart Interpreter
2. Simple programs to understand Operators and expressions.
3. Decision making Statements :simple if, if..else, nested if .. else,elseifladder, switch case
4. Loops : while , do..while, for
5. Implementation of one dimensional array
6. Implementation of two dimensional array
7. Working with Strings
8. Functions
9. Recursive functions
10. Structures: Arrays and Structures,Nested Structures
11. Structures and functions
12. Implementation of pointer and pointer arithmetic
13. Types of pointer:const pointer, pointer to a constant, void pointer, null pointer

Total P: 60

REFERENCES:

1. Deitel H. M. and Deitel P. J "C: How To Program", Prentice Hall of India., New Delhi, 2015
2. Ajay Mittal "Programming in C - A Practical approach", Pearson., New Delhi, 2010
3. Gottfried B "Programming with C", McGraw Hill Education., New Delhi, 2018
4. Herbert Schildt "C: The Complete Reference", McGraw Hill., New Delhi, 2017

19P212 INTERNSHIP

0 0 0 2

TRAINING IN CAD PACKAGE: Solid modelling and assembly practice, Extraction of 2D view from 3D modelling, Coloring and shading of 3D models, surface modelling.

INDUSTRY ORIENTED ACTIVITIES:

Factory visit to study the layout, organization structure, and various departments Study of construction, working of the following machine tools and processes

Broaching machine

Boring machine

Grinding machine

Electric discharge machining Study of manufacturing processes.

Pressure die casting

Sand Casting

Rapid prototyping techniques Study of assembly processes

Pump assembly

Motor assembly

Lathe assembly

REPORT PREPARATION

Preparation of a comprehensive report by the students for the industry oriented activities that will be assessed by a committee of faculty members.

REFERENCES:

CAD/CAM Centre "Practice of Machine Drawing using CAD Software", PSG College of Technology., Coimbatore, 2018
Sharma P C "Text Book of Production Technology (Manufacturing Processes)", S Chand & Company Ltd., New Delhi, 2014

SEMESTER - 3

19P301 NUMERICAL METHODS

2 1 0 3

SYSTEM OF LINEAR EQUATIONS, EIGENVALUES AND EIGENVECTORS: Errors - approximations and round-off errors - truncation errors - system of linear equations-Gauss-elimination method, Crout's method, Gauss-Seidel method, eigenvalues and eigenvectors - power method. (6 + 3)

NONLINEAR EQUATIONS: False - position method, Newton-Raphson method, modified Newton-Raphson method, Bairstow's method. (6 + 3)

INTERPOLATION, DIFFERENTIATION AND INTEGRATION: Lagrange interpolating polynomials, equally spaced data-Newton's forward and backward interpolating polynomials, numerical differentiation - evenly spaced data, numerical integration- Newton-Cotes formulae, Trapezoidal rule, Simpson's 1/3 rule. (6 + 3)

NUMERICAL SOLUTION TO ORDINARY DIFFERENTIAL EQUATIONS: Taylor-series method, Euler method, 4th order Runge-Kutta method, multi step method - Milne method. (6 + 3)

NUMERICAL SOLUTION TO PARTIAL DIFFERENTIAL EQUATIONS: Finite difference: elliptic equations - Laplace equation, Poisson equation - Liebmann method, parabolic equations - heat conduction equation - Crank Nicolson's method, hyperbolic equations - vibrating string. (6 + 3)

Total L: 30 +T: 15 = 45

TEXT BOOKS:

1. Steven C Chapra and Raymond P Canale, "Numerical Methods for Engineers", Tata McGraw Hill, New Delhi, 2017.
2. Curtis F Gerald and Patrick O Wheatly, "Applied Numerical Analysis", Pearson, New Delhi, 2017.

REFERENCES:

1. Richard L Burden and Douglas J Faires, "Numerical Analysis", Thomas Learning, NewYork, 2017.
2. G Miller, "Numerical Analysis for Engineers and Scientists", Cambridge University Press, UK, 2014.
3. Amos Gilat and Vish Subramaniam, "Numerical Methods for Engineers and Scientists", Wiley India, New Delhi, 2014.
4. Ward Cheney and David Kincaid, "Numerical Mathematics and Computing", Cengage learning, USA, 2018.

19P302 ENGINEERING METALLURGY

3 0 0 3

STRUCTURE OF ENGINEERING MATERIALS: Amorphous and crystalline materials. Unit cell, lattice, crystal systems and crystal structures - SC, BCC, FCC and HCP structures, Packing factor. Miller indices, crystallographic planes and directions. Crystal imperfections. (8)

CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS: Definition of alloy and alloy system, classification of alloys - characteristics of pure metals, compounds and solid solutions. Need for phase diagrams. Binary phase diagram - isomorphous, eutectic and eutectoid systems. Interpretation of phase diagrams. Iron - Iron carbide equilibrium diagram. (10)

HEAT TREATMENT AND STRENGTHENING MECHANISMS: ASM Definition of heat treatment, classification of heat treatment processes - annealing, normalizing, hardening, austempering and tempering of steel. Time Temperature Transformation (TTT) diagrams - cooling curves superimposed on TTT diagram, critical cooling rate. Hardenability, Jominy end quench test and its interpretation. Strengthening mechanisms - grain size reduction, solid solution strengthening, strain hardening and precipitation hardening. (10)

MECHANICAL BEHAVIOUR AND TESTING: Plastic deformation - slip mechanism, condition for slip, schmid factor, twinning. Fracture - definition, types and characteristics. Introduction to mechanical properties - tensile, hardness, impact, fatigue and creep testing - description of testing and physical interpretation of properties. (10)

FERROUS AND NON FERROUS MATERIALS: Classification of ferrous alloys-low, medium and high carbon steels - properties and applications. Stainless steels, tool steels, effect of alloying additions in steel. Gray, white, malleable and ductile irons - properties and applications. Copper, Aluminium, Magnesium, Titanium, Lead and Tin alloys - composition, properties and applications. (7)

Total L: 45

TEXT BOOKS:

1. Sidney H Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill Book Company, 2015.
2. William D Callister, "Materials Science and Engineering", John Wiley and Sons, 2019.

REFERENCES:

1. Dieter G E, "Mechanical Metallurgy", Tata McGraw Hill Book Company, New Delhi, 2018.
2. Kenneth G Budinski, Michael K Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 2013.
3. Raghavan V, "Materials Science and Engineering", Prentice Hall of India Private Limited, 2018.

19P303 STRENGTH OF MATERIALS

3 1 0 4

STRESSES AND STRAINS IN AXIALLY LOADED MEMBERS: Normal stress and strain, stress - strain diagram of ductile and brittle materials - Hooke's law, Poisson's ratio, shear stress and strain - proof resilience, factor of safety, thermal stress, volumetric strain, relationship between elastic constants. (10 + 3)

PRINCIPAL STRESSES AND PLANES: (Two dimensional only) State of stress at a point - normal and tangential stresses on a given plane, principal stresses and their planes, plane of maximum shear stress - analytical method, Mohr's circle method, application to simple problems - Pressure vessels: Hoop and longitudinal stresses in thin cylindrical and spherical shells under internal pressure. (10 + 3)

SHEAR FORCE AND BENDING MOMENT: Relationship between load, shear force and bending moment - shear force and bending moment diagrams for cantilever, simply supported and overhanging beams under concentrated loads, uniformly distributed loads - maximum bending moment and point of contra flexure. (7 + 3)

FLEXURE IN BEAMS: Theory of simple bending and assumptions - flexure equation, section modulus, normal stresses due to flexure. Torsion: Theory of torsion and assumptions - torsion equation, polar modulus, stresses in solid and hollow circular shafts, power transmitted by a shaft. (9 + 3)

ETERMINATE BEAMS AND COLUMNS: Governing differential equation - Determination of deflection of beams- Macaulay's method - moment area method, application to simple problems (cantilever beams and simply supported beams only) - Buckling of columns-Euler's formula and Rankine's formula. (9 + 3)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

1. James M Gere, Barry J Goodno, "Mechanics of Materials", 9th Edition, Cengage Learning, United States of America, 2016.
2. Russell C Hibbeler, "Mechanics of Materials", 9th Edition, Pearson Higher Education and Professional Group, 2018.

REFERENCES:

1. Igor G Popov, "Engineering Mechanics of Solids", PHI Learning Private Limited, 2011.
2. Ramamrutham S and Narayan R, "Strength of Materials", Dhanpat Rai Publishing Company (P) Limited, 2014.
3. Beer F P and Johnson E R, "Mechanics of Materials", Tata McGraw Hill Publishing Company Limited, New Delhi, 2015.
4. Hearn E J, "Mechanics of Materials- Volume 1", Butterworth-Heinemann, 1997.

19P304 FLUID MECHANICS AND MACHINERY

3 1 0 4

FLUID PROPERTIES AND STATICS: Properties of fluids - pressure field - manometry - forces on submerged bodies - buoyancy - flotation and stability (9 + 3)

FLUID KINEMATICS: Velocity field - flow visualization - Acceleration field - Fluid deformation - Control volume and system representations - Reynolds transport theorem - continuity equation (9 + 3)

FLUID DYNAMICS: Momentum equation - Navier - Stokes equation - Bernoulli equation - energy equation. (9 + 3)

EXTERNAL AND INTERNAL FLOW: Characteristics of a boundary layer - concepts of lift and drag - Friction loss calculation - Darcy-Weisbach equation - use of Moody diagram - types of valves, construction, minor losses, selection of valves - design and layout of piping (9 + 3)

SIMILARITY STUDIES AND FLUID MACHINERY: Buckingham's π theorem - Reynolds - Froude and Mach number and their application in model testing - Classification and Performance characteristics of fluid machines - Selection and Testing of pumps and blowers (9 + 3)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

1. Bruce Munson, "Fundamental of Fluid Mechanics", John Wiley and Sons, 2012.
2. Yunus Cengel, John Cimbala, "Fluid Mechanics Fundamentals and Applications", Tata McGraw Hill Publishing Company Limited, New Delhi, 2013.

REFERENCES:

1. White FM, "Fluid Mechanics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2017.
2. Streeter Wylie, Bedford, "Fluid Mechanics", McGraw Hill Publishing Company Limited, New York, 2008.
3. Robert W Fox, "Introduction to Fluid Mechanics", John Wiley and Sons, Singapore, 2018.
4. Irving H Shames, "Mechanics of Fluids", McGraw Hill Inc, New York, 2013.

19P305 WELDING TECHNOLOGY

3 0 0 3

BASIC WELDING PROCESSES: Comparison between casting and welding processes, definition and classification of welding as per AWS, advantages and disadvantages - basic welding positions, types of joints and weld, fundamental principles - gas welding, arc welding – applications, energy source characteristics, electrodes, flux, safety in welding. principles of soldering, brazing and adhesive bonding. (9)

SPECIAL WELDING PROCESSES: FUSION: TIG and MIG, submerged arc welding, plasma arc welding, electro-slag welding - equipment and operations, laser beam welding, electron beam welding, thermit welding - applications and selection. **NON-FUSION:** resistance welding, friction and friction stir welding, ultrasonic welding, diffusion welding, explosive welding - advantages, limitations, applications and process selection. (9)

WELDING METALLURGY AND WELDABILITY OF METALS: Heat flow and temperature distribution in welding, heat affected zone (HAZ), calculation of heat affected zone width and cooling rate, preheat and post weld heat treatment, weld decay. Weldability of steel, Cast Iron, Aluminum alloys. (9)

DESIGN OF WELDED JOINTS, INSPECTION AND TESTING OF WELDMENTS: Basic principles - weld symbols, design of weldments, welding codes, standards and cost estimation, welding procedure specifications (WPS) and procedure qualification record (PQR), welding defects - causes and remedies, residual stresses and distortion destructive and non-destructive testing of weldments. (9)

AUTOMATION AND CAE IN WELDING: Automation in welding - seam tracking and arc sensing - welding robots. CAE IN WELDING: applications of CAE in modeling welding processes and temperature distributions. (9)

Total L: 45

TEXT BOOKS:

1. Little R L, "Welding and Welding Technology", Tata McGraw Hill, New Delhi, 2017.
2. Parmer R S, "Welding Processes and Technology", Khanna Publishers, New Delhi, 2015.

REFERENCES:

1. Larry Jeffus, "Welding Principles and Applications", Delmar Publishers, New York, 2017.
2. Howard B Cary and, Scott C Hezler, "Modern Welding Technology", Pearson, New Delhi, 2005.
3. Davies A C, "Welding", Cambridge University Press, New York, 2005. AWS, New York, 2011.

19O306 ECONOMICS FOR ENGINEERS

3 0 0 3

INTRODUCTION: Definition - Nature and Scope - Central Problems of an Economy - Positive and Normative Economics – Micro Economics and Macro Economics, Significance of Economics, Economic Assumptions. (9)

THEORY OF CONSUMER BEHAVIOR: Utility – Indifference Curve Analysis - Properties, Consumer's Budget Line - Demand Analysis: Demand Function and Law of Demand, Elasticity of Demand. Demand forecasting using Econometric Techniques. Supply – Factors Affecting Supply, Market Equilibrium Price, Consumer Surplus. (9)

PRODUCTION, COST AND REVENUE: Production Function, Total Product, Average Product and Marginal Product, Returns

to Scale. Costs, Nature of Costs, Short-run and Long-run Cost Curves, Revenue concepts. (9)

MARKET STRUCTURE: Types of Markets - Perfect Competition – Characteristics – Imperfect Competition: Monopoly - Monopolistic Competition - Oligopoly and Duopoly - Price Discrimination and Product Differentiation under Different Markets – Price and Output Determination in Short run and Long run and profit maximization. (9)

PERFORMANCE OF AN ECONOMY (MACRO ECONOMICS): Demand and Supply of Money – Quantity Theory of Money, Banking – Functions of Commercial Banks and Central Bank – Inflation – Causes – Control Measures – National Income – Concepts – Methods of Calculating National Income – Problems in Calculating National Income. (9)

Total L: 45

TEXT BOOKS:

1. Varian H R, "Intermediate Microeconomics", East– West Press, New Delhi, 2014.
2. Dewett K K, Navalur M H, "Modern Economic Theory", S. Chand, New Delhi, 2015.

REFERENCES:

1. William A, McEachern, Simrit Kaur, "Micro ECON", Cengage Learning, Noida, 2013.
2. William A, McEachern, Indira A, "Macro ECON", Cengage Learning, Noida, 2014.
3. Deepashree, "Principles of Economics", Ane Books Pvt. Ltd., New Delhi, 2010.
4. Dwivedi, "Essentials of Business Economics", Vikas Publishing House Pvt. Ltd., New Delhi, 2010.

19P310 MACHINE DRAWING

0 0 4 2

SECTION VIEWS: Introduction to machine drawing. Sectioning, Sectional View - Types, Projection, Representation, Hatching and Importance, solid modeling and sectioning of mechanical elements using CAD Software (12)

CONVENTIONS: Code of practice for engineering drawing, conventional representation of details — drilled, tapped, countersunk and counter bored holes, internal and external threads. Conventions to represent standard components - bolt, nuts, washers, screws, rivets, cotters, pins, keys, circlips, bearings, gears, springs and flanges. (12)

LIMITS, FITS AND TOLERANCES: Limits, fits and tolerances - types, representation of tolerances on drawing, calculation of minimum and maximum clearances and allowances. Geometric tolerance - uses, types of form and position tolerances, symbols, method of indicating geometric tolerances and surface roughness symbols on part drawings. (12)

ASSEMBLY USING SOLID MODELING: Introduction - methods and concepts of assemblies, assembly requirements, importance of bill of materials. Solid modeling - Commands used for modeling and assembly of components using CAD Software, creation of bill of materials and balloons, extraction of 2D views and sections. (12)

PRACTICE SESSION: Various views of the assemblies of following components — Flange coupling, cotter joints, knuckle joint, screw jack, universal coupling, pipe vice and plumber block in drawing sheet and using CAD software. (12)

Total P: 60

TEXT BOOKS:

1. Gopalakrishna K R, "Machine Drawing In 1st Angle Projection", Subhas Publisher, Bangalore, 2017.
2. John K C, "Textbook of Machine Drawing", PHI Learning, New Delhi, 2010.

REFERENCES:

1. Hart K R, "Engineering Drawing with Problems and Solutions", English University Press, London, 1975.
2. Bhatt N D, Panchal V M, "Machine Drawing", Charotar Publishing House, 2014.
3. Faculty of Mechanical Engineering, "Design Data Book", PSG College of Technology, Kalaikathir Achchagam, Coimbatore, 2019.
4. Department of Production Engineering and CAD/CAM Centre, "Practice of Machine Drawing using CAD Software", PSG College of Technology, Coimbatore, 2019.

19P311 METALLURGY AND STRENGTH OF MATERIALS LABORATORY

0 0 2 1

METALLURGY LABORATORY:

1. Study of metallurgical microscope.
2. Preparation of specimen for metallographic examination.
3. Identification and study of microstructure of white cast iron, grey cast iron, SG iron and malleable cast iron.
4. Identification and study of microstructure of low, medium and high carbon steel.

5. Identification and study of microstructure of stainless steel and tool steel.
6. Identification and study of microstructure of aluminium alloy and copper alloy. (15)

STRENGTH OF MATERIALS LABORATORY:

1. Tension test on metals: Stress strain characteristics - ductility - resilience - toughness.
2. Shear test on metals: Shear strength - single shear and double shear.
3. Hardness test on metals: Brinell, Vicker and Rockwell hardness tests.
4. Deflection test on beams: Load deformation characteristics, Young's Modulus, Maxwell's reciprocal law verification.
5. Impact test on metals: Charpy impact toughness test.
6. Test on helical springs: Compression, tension Springs - Load deformation characteristics, stiffness, shear stress, modulus of rigidity - strain energy.
7. Torsion test on beams: Torque and angle of twist characteristics, shear stress, modulus of rigidity - strain energy.
8. Study of strain gauges - various types of strain measurements. (15)

Total P: 30

REFERENCES:

1. Dept of Metallurgical Engineering, "Laboratory Manual", PSG College of Technology, Coimbatore, 2019.
2. Dept of Civil Engineering, "Laboratory Manual", PSG College of Technology, Coimbatore, 2019.

19K312 ENVIRONMENTAL SCIENCE

2 0 0 0

INTRODUCTION TO ENVIRONMENT: Environment - Definition, scope and importance. Types and composition of atmosphere – particles, ions and radicals. Ozone layer- significance, formation and depletion. Ecosystems - Structure and functions, components, energy flow, food chains, food web, Biodiversity-levels, values and threats - India as a mega-diversity nation – hotspots of biodiversity – endangered and endemic species of India – conservation of biodiversity. (6)

ENERGY RESOURCES: Introduction – National and International status- exploitation - sustainable strategies - Fossil fuels- classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas; solar energy - introduction, harnessing strategies. Wind energy - availability, wind power plants, wind energy conversion systems, site characteristics, and types of wind turbines. Supporting renewable energy resources - tidal – geothermal - hydroelectric. (6)

ENVIRONMENTAL POLLUTION: Definition – Sources, causes, impacts and control measures of (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards (h) RF hazards - Role of an individual in prevention of pollution. **DISASTER MANAGEMENT:** Floods, earthquake, cyclone and landslides – Case studies, consequences and rescue measures. (6)

WASTE MANAGEMENT: Wastewater - Characteristics of domestic and industrial wastewater - COD and BOD – Various stages of treatment – primary, secondary, tertiary treatment - Biological and advanced oxidation processes. Solid waste management – Characteristics of municipal solid waste (MSW), biomedical, automobile and e-wastes and their management – landfills, incineration, pyrolysis, gasification and composting. (6)

SOCIAL ISSUES AND THE ENVIRONMENT: Environmentally Sustainable work practices- Rain water harvesting – Role of non-governmental organizations. Human ethics and rights- impact on environment and human health – role of information technology on environment and human kind. Green IT policies, Process of EIA - ISO 14000. Legislation- Environment protection act – Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act – Wildlife protection act – Forest conservation act. (6)

Total L: 30

TEXT BOOKS:

1. Gilbert M Masters, "Introduction to Environmental Engineering and Science", Pearson Education, New Delhi, 2004.
2. De A K, "Environmental Chemistry", New Age International Pvt. Ltd., New Delhi, 2006.

REFERENCES:

1. Benny Joseph, "Environmental Science and Engineering", Tata McGraw-Hill, New Delhi, 2006.
2. KoteswaraRao MVR, "Energy Resources: Conventional and Non-Conventional", BSP Publications, New Delhi, 2006.
3. Deswal S and Deswal A, "A Basic Course in Environmental Studies", Dhanpat Rai and Co, New Delhi, 2004.

SEMESTER - 4

19P401 PROBABILITY AND STATISTICS

2 1 0 3

PROBABILITY AND DISCRETE RANDOM VARIABLES: Probability, axiomatic approach to probability, Baye's theorem,

discrete random variables, probability distributions and probability mass functions, cumulative distribution functions, mean and variance, binomial, Poisson and geometric distributions. (6 + 3)

CONTINUOUS RANDOM VARIABLES: Continuous random variables, probability distributions and probability density functions, cumulative distribution functions, mean and variance, uniform, exponential and normal distributions. (6 + 3)

JOINT PROBABILITY DISTRIBUTIONS: Two dimensional discrete and continuous random variables, marginal and conditional probability distributions, independence, covariance, correlation and linear regression. (6 + 3)

STATISTICAL INFERENCE: Point estimation - interval estimation - testing of hypotheses for means - large, small samples and matched pairs tests - testing of hypotheses for proportions, chi square test for goodness of fit and independence of attributes. (6 + 3)

VARIANCE TESTS AND ANALYSIS OF VARIANCE: Testing of Hypotheses for variances - analysis of variance -completely randomized design, randomized block design. (6 + 3)

Total L: 30 +T: 15 = 45

TEXT BOOKS:

1. Douglas C Montgomery and George C Runger, "Applied Statistics and Probability for Engineers", Wiley India, New Delhi, 2018.
2. Richard A Johnson, "Miller and Freund's, Probability and Statistics for Engineers", Prentice Hall, New Delhi, 2017.

REFERENCES:

1. Jay L Devore, "Probability and Statistics for Engineering and the Sciences", Brooks/Cole, USA, 2015.
2. Ronald E Walpole, Raymond H Myers, Sharon L Myers and Keying Ye, "Probability and Statistics for Engineers and Scientists", Pearson, New Delhi, 2016.
3. Robert V Hogg, Elliot Tanis and Dale Zimmerman, "Probability and Statistical Inference", Pearson Education, USA, 2014.
4. Sheldon M Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Academic press, USA, 2014.

19P402 THERMAL SYSTEMS AND HEAT TRANSFER

3 1 0 4

BASIC CONCEPTS OF THERMODYNAMICS: Introduction to thermal systems - properties, state, equilibrium, processes and cycles - forms of energy - temperature and zeroth law of thermodynamics - properties of pure substances - property diagrams - energy transfer by heat and work interactions - applications. (8 + 3)

FIRST AND SECOND LAW OF THERMODYNAMICS: First law - internal energy, enthalpy - first law applied to non-flow systems and flow processes - applications - second law - refrigerators and heat pumps - carnot cycle, entropy and irreversibility - applications. (10 + 3)

POWER CYCLES: Rankine cycle - superheat, reheat and regenerative cycle - steam power plant - boilers - air standard cycles - Otto cycle and Diesel cycle - IC engines - principle of operation - petrol and diesel engines - ignition systems - fuel injection systems, cooling and lubrication systems - calculation of mechanical and thermal efficiencies - heat balance and performances characteristics. (10 + 3)

REFRIGERATION AND AIR CONDITIONING: Refrigeration terminology - vapor compression refrigeration cycle - multistage compression refrigeration and cryogenic systems - psychrometric chart - human comfort - summer and winter air conditioning systems - cooling load calculations. (8 + 3)

HEAT TRANSFER: Modes of heat transfer - heat conduction through planes - cylinder and spherical geometries - critical thickness of insulation - natural and forced convection - radiation heat transfer - Stefan-Boltzmann law - empirical relations for heat transfer coefficients - case studies of manufacturing processes involving application of thermal concepts. (9 + 3)

Total L: 45 + T: 15 = 60

TEXT BOOKS:

1. Yunus A Cengel, "Thermodynamics: an Engineering Approach", McGraw Hill Education, New York, 2015.
2. Frank P Incropera, "Principles of Heat and Mass Transfer", Wiley India Pvt. Ltd., New Delhi, 2018.

REFERENCES:

1. Claus Borgnakke, "Fundamentals of Thermodynamics", Wiley India Pvt. Ltd, New Delhi, 2016.
2. Michael J Moran, "Principles of Engineering Thermodynamics", Wiley India Pvt. Ltd, New Delhi, 2018.
3. Mark W Zemansky, "Heat and Thermodynamics", McGraw Hill Publishing Company, New Delhi, 2011.
4. Nag P K, "Engineering Thermodynamics", Tata McGraw Hill Publishing Company, New Delhi, 2017.

19P403 METAL FORMING PROCESSES

3 0 0 3

MECHANICS OF METAL FORMING: State of stress, components of stress, stress tensor - True stress and true strain - Flow stress, elastic hysteresis and Bauschinger effect - Hydrostatic and deviator stress. Failure theories - Tresca and von-Mises yield criterion. Hot, cold and warm working - effects of strain rate, friction, temperature and residual stresses. (10)

FORGING: Classification of forging process - Hand forging equipments and operations - Types of press and hammer - Slab analysis of plane strain and axisymmetric forging problems - Forging defects, causes and remedies. (8)

ROLLING: Terminology of rolling process - Classifications of rolling mills - Forces and geometrical relationship in rolling, analysis of strip rolling process - Special rolling processes - Rolling defects, causes and remedies. (8)

EXTRUSION AND DRAWING: Classifications of extrusion process and equipments - Analysis of extrusion process - Production of seamless pipes - Extrusion defects, causes and remedies. Methods of drawing, drawing dies, preparation of metals for drawing process - Analysis of wire/rod drawing processes. (8)

SHEET METAL FORMING AND POWDER METALLURGY: Types of bending, calculations of bending allowance and force. Deep drawing, shearing, stretch forming and metal spinning. Special forming methods: High energy rate forming (HERF) - Explosive forming, electromagnetic forming, electro hydraulic forming; High velocity forming (HVF) - petro forge hammer and dynapak process, super plastic forming. Powder metallurgy (PM): Production of metal powders, powder characteristics. Process fundamentals - powder blending, compacting, sintering and secondary operations. PM product design, recent trends and special PM processes. (11)

Total L: 45

TEXT BOOKS:

1. George E Dieter, "Mechanical Metallurgy", McGraw Hill Education (I) Pvt. Ltd., Chennai, 2016.
2. Sharma P C, "Text Book of Production Technology (Manufacturing Processes)", S Chand and Company Ltd., New Delhi, 2014.

REFERENCES:

1. Mikell P Groover, "Principles of Modern Manufacturing (Si Version)", Wiley India Pvt. Ltd., New Delhi, 2017.
2. Nagpal G R, "Metal Forming Processes", Khanna Publishers, New Delhi, 2016.
3. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers, New Delhi, 2015.
4. Rao P N, "Manufacturing Technology: Foundry, Forming and Welding — Volume 1", Tata McGraw Hill, New Delhi, 2013.

19P404 FOUNDRY TECHNOLOGY

3 0 0 3

SAND CASTING: Introduction to metal casting, advantages and limitations of casting process. Sand casting - pattern and core box - types and materials. Moulding and coremaking - moulding and core sand-constituents and characteristics, preparation, properties and sand testing techniques. Moulding methods. (10)

GATING SYSTEM: Elements of a gating system, types of gates - applications, advantages and limitations, classification of gating systems, hydraulics and design of gating systems, influence of gating design on casting quality. (9)

SOLIDIFICATION AND RISERING OF CASTINGS: Solidification of pure metal and alloys, need and functions of a riser, design of risering systems - chaine, naval research laboratory and modulus approaches, risering aids. (9)

MELTING AND INSPECTION: Furnaces - types, description, advantages and limitations. Selection of furnace for a melting application. Types of pouring equipments, melting and pouring practices. Finishing and inspection operations on castings, non destructive testing of castings. (8)

SPECIAL CASTING PROCESSES AND FOUNDRY PRACTICES: Permanent mould casting, die-casting, centrifugal casting, shell moulding, investment casting, squeeze casting, slush casting and continuous casting processes - characteristics, capabilities, advantages and limitations. Discussion on foundry practices for ferrous and nonferrous alloys. Introduction to casting simulation. (9)

Total L: 45

TEXT BOOKS:

1. Heine R W, Loper C R, Rosenthal P C, "Principles of Metal Casting", Tata McGraw Hill, New Delhi, 2017.
2. Taylor H F, Flemings M C, Wulff J, "Foundry Engineering", John Wiley and Sons, New York, 1993.

REFERENCES:

1. ASM Metals Handbook, "Castings", Volume 15, ASM Int. Metals Park, Ohio, 2008.
2. John Campbell, "Castings", Butterworth Heinemann, Oxford, 2012.

- Peter Beeley, "Foundry Technology", Butterworth Heinemann, Oxford, 2012.
- Rao P N, "Manufacturing Technology: Foundry, Forming and Welding – Volume 1", Tata McGraw Hill, New Delhi, 2013.

19P405 MECHANICS OF MACHINES

3 1 0 4

BASICS OF MECHANISMS: Terminology and definitions, degrees of freedom, Grashof's Law - Kinematic inversions – four bar chain, single slider crank chain, double slider crank chain, mechanisms for societal applications - velocity and acceleration analysis of simple mechanisms using graphical method. (11 + 3)

KINEMATICS OF CAM: Classifications, displacement diagrams – parabolic, uniform velocity, simple harmonic paths - layout of plate cam profiles for different types of followers - knife edged and roller. (7 + 3)

STATIC FORCE ANALYSIS: Free body diagram - conditions of equilibrium, two, three and four force members - force analysis of simple mechanisms. (5 + 3)

GEARS AND FLYWHEEL: Spur gear terminology and definitions, types of gears – fundamental law of toothed gearing and tooth forms - interchangeable gears, gear tooth action – interference, pressure angle, undercutting and contact ratio - Need of flywheel, turning moment diagram – fluctuation of energy and speed, weight of flywheel required. (10 + 3)

BALANCING AND VIBRATION: Balancing of rotating masses in single plane and several planes - balancing of reciprocating masses - primary and secondary forces and couples, balancing of multi-cylinder inline engine - Basic features and types of vibratory systems, degrees of freedom, single degree of freedom system – equations of motion and response of undamped and damped free vibration. (12 + 3)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

- Robert L Norton, "Design of Machinery", 4th Edition, McGraw Hill, 2012.
- John Joseph Uicker, Pennock G R, Joseph Edward Shigley, "Theory of Machines and Mechanisms", 4th Edition, Oxford University Press, New Delhi, 2014.

REFERENCES:

- David H Myszka, "Machines and Mechanisms – Applied Kinematic Analysis", PHI Learning Pvt. Ltd., New Delhi, 2009.
- Rattan S S, "Theory of Machines", 4th Edition, Tata McGraw Hill, New Delhi, 2014.
- Ballaney P L, "Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2008.
- Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, New Delhi, 2005.

19P406 MACHINING TECHNOLOGY

3 0 0 3

THEORY OF METAL MACHINING: Introduction to materials and manufacturing, overview of machining, theory of chip formation in metal machining, concept of orthogonal and oblique cutting, force relationship and the Merchant equation, power and energy relationship in machining and cutting temperature. (9)

MACHINING OPERATIONS AND MACHINE TOOLS: Machining and part geometry, turning and related operations, drilling and related operations, milling, machining centres and turning centres, other machining operations, machining operation for special geometries and high speed machining. (10)

CUTTING TOOL TECHNOLOGY: Tool wear, tool life and Taylor's tool life equation. Tool materials: HSS, cemented carbides, coated carbides, cermets, ceramics, diamond, cubic boron nitride. Manufacturing of cutting tools, tool geometry, cutting fluids, machinability, tolerance and surface finish. Selecting feed and depth of cut and optimizing cutting speed. (9)

GRINDING AND OTHER ABRASIVE PROCESSES: Cylindrical, surface, profile grinding machines. Grinding wheel marking and analysis of grinding process. Related abrasive processes: honing, lapping, super finishing, polishing and buffing. (8)

NONTRADITIONAL MACHINING PROCESSES: Mechanical energy processes, electrochemical machining processes, thermal energy processes, chemical machining and application considerations. (9)

Total L: 45

TEXT BOOKS:

- Mikell P Groover, "Principles of Modern Manufacturing", John Wiley and Sons, New Delhi, 2016.
- Serop Kalpakjian and Steven Schmid, "Manufacturing Engineering and Technology", 7th Edition, Pearson Education, New Delhi, 2014.

REFERENCES:

1. P N Rao, "Manufacturing Technology – Machining and Machine Tools", McGraw Hill Education, New Delhi, 2013.
2. Black J T, Ronald A Kosher, "DeGramo's Materials and Processes in Manufacturing", Wiley India, 2018.
3. Milton C Shaw, "Metal Cutting Principles", Oxford, 2012.
4. HMT, "Production Technology", Tata McGraw Hill, 2003.

19P410 THERMAL ENGINEERING AND FLUID MACHINERY LABORATORY**0 0 2 1****LIST OF EXPERIMENTS:**

1. Experimental study on valve timing diagram in 4-stroke engine cut model and experimental study on port timing diagram in 2-stroke engine cut model.
2. Heat balance test on 4-stroke diesel engine.
3. Performance test and determination of air fuel mixture on a variable speed diesel engine.
4. Performance test on reciprocating compressor.
5. Performance test on refrigeration tutor.
6. Performance study on axial flow fan.
7. Calibration of flow meters, venturimeter, orifice meter.
8. Performance test on Pelton and Francis turbines.
9. Determination of drag and lift co-efficient using wind tunnel.
10. Performance test on centrifugal pump.

Total P: 30**REFERENCES:**

1. Department of Production Engineering, "Thermal Engineering and Fluid Machinery Laboratory Manual", PSG College of Technology, Coimbatore, 2019.
2. Yunus A Cengel, "Thermodynamics: an Engineering Approach", McGraw Hill Edu, New York, 2015.

19P411 MACHINING TECHNOLOGY LABORATORY**0 0 2 1****LIST OF EXPERIMENTS:**

1. Study of construction features of Lathe - head stock, tail stock, carriage, apron gear box
2. Exercise in lathe - facing, chamfering and step turning
3. Exercise in lathe - taper turning
4. Exercise in lathe - knurling and drilling
5. Exercise in lathe - grooving, thread cutting
6. Drilling, counter boring, counter sinking and tapping exercise
7. Exercise in milling machine
8. Gear cutting exercise using gear hobbing machine
9. Keyway slotting exercise
10. Exercise in shaping machine

Total P: 30**REFERENCES:**

1. Department of Mechanical Engineering, "Laboratory Manual", PSG College of Technology, Coimbatore, 2019.
2. HMT, "Production Technology", Tata McGraw Hill, New Delhi, 2003.

19Q413 SOFT SKILLS DEVELOPMENT**0 0 2 1****SOFT SKILLS DEVELOPMENT:**

1. Body Language and Professionalism
2. Interpersonal skills
3. Goal setting
4. Impression Management
5. Team Building

6. Time Management
7. Stress Management
8. Convincing Skills
9. Motivation
10. Change Management
11. Communication Confidence
12. Group discussion basics
13. Personal Interview basics
14. Resume writing

Total P: 30

REFERENCES:

1. Jeff Butterfield, "Soft Skills for Everyone", 6th Edition, Cengage Learning, Delhi, 2015.
2. Rao M S, "Soft Skills - Enhancing Employability", LK International Publishing House, New Delhi, 2011.

19O412 INDIAN CONSTITUTION

2 0 0 0

INTRODUCTION: Evolution of Indian Constitution; Significance of Constitution; Composition; Preamble and its Philosophy. (4)

RIGHTS, DUTIES AND DIRECTIVE PRINCIPLES: Fundamental Rights - Writs and Duties, Directive Principles of State Policy. (6)

COMPOSITION OF PARLIAMENT AND FEDERALISM: Union Government, President and Vice President, Houses of the Parliament and their functions; Composition of State Legislature; Powers, Functions and Position of Governor, Function of Chief Ministers, Council of Ministers; The Indian Federal System, Administrative Relationship between Union and States. (8)

BILLS AND CONSTITUTION AMENDMENT PROCEDURE: Types of Bills, Stages of passing of Bill into an Act, Veto Power, Constitution Amendment Procedure, Various Amendments made and their significance for India. (6)

JUDICIARY: Supreme Court and High Court; Functions and powers, Judicial Review. (6)

Total L: 30

TEXT BOOKS:

1. Subash C Kashyap, "Our Constitution", 5th Edition, NBT, India, New Delhi, 2015.
2. Basu D D, "Introduction to the Constitution of India", 20th Edition, Prentice Hall of India, New Delhi, 2011.

REFERENCES:

1. Brij Kishore Sharma, "Introduction to the Constitution of India", 8th Edition, Prentice Hall of India, New Delhi, 2017.
2. Hoshier Singh, "Indian Administration", 1st Edition, Pearson Education, New Delhi, 2011.
3. Jain M C, "The Constitution of India", 5th Edition, State Mutual Book and Periodical Service, Limited, New Delhi, 1988.
4. Shukla V N, "Constitution of India", 13th Edition, Eastern Book Company Limited, New Delhi, 2017.

SEMESTER – 5

19P501 COMPUTER NUMERICAL CONTROL MACHINES

3 0 0 3

CONSTRUCTION: Types of CNC machines, turning centre, machining centre, multitask machines, special purpose machines - structures, guide/slideways, LM guide way, ball screws, spindle, bearings, couplings, hydraulic power pack, actuators, pumps, valves, servo motor - drives, feedback devices – encoder, control system, block processing and interpolation. (10)

PART PROGRAMMING - BASICS: ISO and EIA standards, G and M codes, absolute, incremental positioning, work datum, tool offset, process plan, work positioning, clamping procedures, lathe programming, step turning, programming simple components machining centre programming, compensations, drilling, profile and pocket milling. (9)

PART PROGRAMMING - ADVANCED: Turning centre programming, programming for industrial components – cast iron components, bar feeding components, multi-operation components, canned cycles, thread cutting cycle, machining centre programming, work setups, reducing cycle time, automobile components, engine block, dry run, canned cycles, CAM software programming. (9)

CUTTING TOOLS AND WORK HOLDINGS: Cutting tools for turning, milling, drilling, types, inserts, coated tools, cutting fluids, tool

holders, ISO designation, automatic tool changer, tool magazine, turret, automatic pallet changer, chucks, types, hard jaw, soft jaw, degrees of freedom, clamping principles. (8)

TESTING AND MAINTENANCE: Accuracy, repeatability, ISO standards, geometrical alignment test, test charts, standard test specimen, calibration, laser interferometer, ball bar test, machine tool vibration, isolation, test for thermal stability, process capability, preventive maintenance, centralized lubrication system, remote diagnosis, IIoT. (9)

Total L: 45

TEXT BOOKS:

1. Michael Mattson, "CNC Programming: Principles and Applications", Cengage Learning India P Ltd., New Delhi, 2014.
2. Thyer G E, "Computer Numerical Control of Machine", 2nd Edition, Butterworth-Heinemann, 2014.

REFERENCES:

1. Joshi P H, "Machine Tool Hand Book, Design and Operation", McGraw Hill Education, New Delhi, 2007.
2. HMT, "Mechatronics", McGraw Hill Education, New Delhi, 2000.
3. Radhakrishnan P, "Computer Numerical Control (CNC) Machines", New Central Book Agency, Kolkatta, 2007.
4. Graham T Smith, "Cutting Tool Technology: Industrial Handbook", Springer, 2008.

19P502 PROCESS PLANNING AND COST ESTIMATION

3 0 0 3

PROCESS PLANNING: Production drawing. Process plan - information required, production equipment and tooling selection, selection of process parameters. Process sheet - contents, preparation of process sheet. Group technology and automated process planning - part family, methods of forming part families, classification and coding systems, rank order clustering technique, composite part, cellular manufacturing. Automated process planning - variant and generative approaches. (9)

ESTIMATION AND COSTING: Differences between estimation and costing, qualifications of an estimator. Estimation - types. Classification of costs, cost grid, preparation of cost sheet. Labour cost - estimation of labour cost, introduction to time study and labour norms. Job evaluation, incentive schemes and wage administration, learning curve. (9)

MATERIAL, OVERHEAD COSTS: Material cost estimation - make or buy decision analysis. Overhead cost - elements in overhead cost - factory, administrative, sales and distribution expenses. Methods of absorbing overheads - direct labour, direct material, direct labour hour, machine hour rate methods. Activity based costing. Depreciation - purpose, various methods of depreciation. (9)

COST ESTIMATION: Estimating the cost of machined components, optimum machining conditions - Taylor's equation, optimum cutting speed for minimum cost, model for maximum production. Cost estimation of welded components, forgings and castings. (9)

COST MANAGEMENT: Cost control, variance analysis - labour, material cost variances. Value engineering (VE) - steps, VE job plan, different phases, function analysis system technique (FAST). Target costing. Benefit/cost analysis. Break even analysis - linear, non-linear models, different areas of applications, multi product break even analysis. Time value of money. (9)

Total L: 45

TEXT BOOKS:

1. Peter Scallan, "Process Planning", Butterworth Heinemann, 2004.
2. Sinha B P, "Mechanical Estimating and Costing", Tata McGraw Hill Education, 2015.

REFERENCES:

1. Groover M P, "Automation, Production Systems and Computer-Integrated Manufacturing", Pearson Education, 2015.
2. Lal Nigam B M, Jain I C, "Cost Accounting", Prentice Hall of India, 2007.
3. Richard J Park, "Value Engineering – A Plan for Inventions", CRC Press, 1998.
4. Chang T C, Wysk R A, "An Introduction to Automated Process Planning Systems", Prentice Hall Inc., 1984.

19P503 MANUFACTURING METROLOGY

3 0 0 3

DIMENSIONAL METROLOGY: Terminologies, classification of errors, evaluation of uncertainty, ISO and BIS standards for basic measuring instruments. Linear measurement - line and end standard, slip gauges, micrometers, vernier caliper, dial gauges and comparators - types, principle and applications. Angular measurement - sine bar, angle gauges, autocollimator, angle dekkor and tool maker's microscope. (9)

SURFACE AND FORM METROLOGY: Surface roughness - causes, need to control surface roughness, functional significance of surfaces, elements of surface texture and surface integrity, surface roughness parameters and their measurement. Measurement of form errors-straightness, flatness, circularity and cylindricity. (9)

DESIGN OF LIMIT GAUGES: Types, Taylor's principle of gauge design, principles of limit system, design of limit gauges. (8)

SCREW THREAD AND GEAR METROLOGY: Standard thread profiles, best wire size, measurement of major, minor and effective diameter by two and three wire methods. Gear tooth profile measurement, gear pitch measurement, run out and composite error measurement. (9)

ADVANCES IN METROLOGY: Laser metrology - Interference of light rays, applications of laser interferometer, flatness interferometer, calibration of gauges using interferometer. Coordinate Measuring Machine (CMM) - types, configurations, construction and applications. Machine vision system - construction, working and applications in metrology. Nano measurements. (10)

Total L: 45

TEXT BOOKS:

1. Connie L Dotson, Ronger L Harlow, Richard L Thompson, "Fundamentals of Dimensional Metrology", Cengage Learning (I) Pvt. Ltd., New Delhi, 2016.
2. Gupta I C, "Text Book of Engineering Metrology", Dhanpat Rai Publishers, New Delhi, 2018.

REFERENCES:

1. Anand K Bewoor, Vinay A Kulkarni, "Metrology and Measurement", McGraw Hill Education (I) Pvt. Ltd., New Delhi, 2015.
2. Raghavendra N V, Krishnamurthy L, "Engineering Metrology and Measurements", Oxford University Press, New Delhi, 2017.
3. Francis T Farago, Mark A Curtis, "Handbook of Dimensional Measurements", Industrial Press, New York, 2013.
4. Gayler J F W, Shotbolt C R, "Metrology for Engineers", Cassel and Company, London, 1990.

19P504 DESIGN OF MACHINE ELEMENTS

3 1 0 4

DESIGN AGAINST STATIC AND FATIGUE FAILURES: Types of stresses, design of eccentrically loaded members and curved beams, theories of failure. Fatigue loads, stress concentration and notch sensitivity factors, S-N curve - design for finite and infinite life. Soderberg, Goodman and Gerber equations, modified Goodmann diagram, Miner's rule. (10 + 4)

BELT DRIVES, SHAFTS, AND COUPLINGS: Basic equations of flat belt drives, design of flat and V-belt drives based on manufacturer's data. Forces on shafts due to gears, belts and chains, estimation of shaft size based on strength and rigidity. Design of keys. Types and applications of couplings, design of rigid couplings and flexible flange couplings. (9 + 3)

DETACHABLE AND PERMANENT JOINTS: Design of bolted joints under static and fluctuating load. Design of riveted joints. Types of welded joints, strength of welds - transverse and parallel fillet welds, design of axially loaded unsymmetrical sections and eccentrically loaded joints. (9 + 3)

GEARS, SPRINGS AND BEARINGS: Design of spur gears - force analysis, tooth stresses, design of spur gears based on strength and wear considerations. Design of helical coil springs under static and fatigue loading. Rolling contact bearings - static and dynamic load carrying capacity, cubic mean load, probability of survival, selection of deep groove ball bearings. Sliding contact bearings - Sommerfield number, dimensionless parameters, design of hydrodynamic bearings. (8 + 2)

CLUTCHES AND BRAKES: Torque transmitting capacity of clutches - uniform pressure and wear theory, design of different types of clutches - single plate, multi-disc, cone and centrifugal clutch. Energy absorbed and heat dissipation in brakes, design of different types of brakes - single shoe, double shoe, pivoted block, band brakes and internally expanding brakes. (9 + 3)

Total L: 45 +T: 15 = 60

TEXT BOOKS:

1. Joseph E Shigley, Charles R Mischke, "Mechanical Engineering Design", Tata McGraw Hill, New Delhi, 2014.
2. Bhandari V B, "Design of Machine Elements", Tata McGraw Hill, New Delhi, 2016.

REFERENCES:

1. Bernard J Hamrock, Jacobson B O, Stern R Schmid, "Fundamentals of Machine Elements", McGraw Hill, New Delhi, 2015.
2. Robert L Norton, "Machine Design - An Integrated Approach", Pearson Education, New Delhi, 2013.
3. C S Sharma, Kamlesh Purohit, "Design of Machine Elements", Prentice Hall India Learning Private Limited, New Delhi, 2015.
4. Faculty of Mechanical Engineering, PSG College of Technology, "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2019.

19P505 APPLIED HYDRAULICS AND PNEUMATICS

3 0 0 3

ELEMENTS OF FLUID POWER SYSTEM: Introduction to fluid power - properties: hydraulic fluids, air - Selection of hydraulic fluids - comparison between hydraulics and pneumatics - Symbols - Compressors, Pumps and Motors: types, characteristics - Cylinders:

types, typical construction details - Valves for control of direction, flow and pressure: types, typical construction details - Servo and Proportional Valves. (9)

HYDRAULIC SYSTEM DESIGN: Power pack: elements, design - Pipes: material, pipe fittings, seals and packing - Maintenance of hydraulic systems - Selection criteria for cylinders, valves, pipes - Heat generation in hydraulic system - Losses in a hydraulic system. (9)

SEQUENCE CONTROL CIRCUITS: General approach - travel step diagram - Sequence control: cascade, step counter method, K. V. Mapping for minimization of logic equation. (9)

FRINGE CONDITION MODULES: Manual, Automatic, Cycle selection, Emergency circuits - Circuits for deceleration, regenerative circuits, differential circuits, feed circuits, sequencing circuits, synchronizing circuits, fail - safe circuits. (9)

FLUID POWER CONTROLS: Electro pneumatics - ladder diagram - PLC: construction, types, operation, and programming - Application with timers and counters. (9)

Total L: 45

TEXT BOOKS:

1. Anthony Esposito, "Fluid Power with Application", Pearson Prentice Hall, New Delhi, 2018.
2. Werner Deppert, Kurt Stoll, "Pneumatic Controls: An Introduction to Principles", Vogel-Verlag, Druck Wurzburg, Germany, 1975.

REFERENCES:

1. Majumdar S R, "Pneumatic Systems: Principles and Maintenance", Tata McGraw Hill, New Delhi, 2017.
2. Majumdar S R, "Oil Hydraulic Systems: Principles and Maintenance", Tata McGraw Hill, New Delhi, 2017.
3. James Sullivan, "Fluid Power: Theory and Applications", 4th Edition, Prentice Hall, New Jersey, 1997.
4. Peter Rohner, "Fluid Power Logic Circuit Design - Analysis, Design Method and Worked Examples", The Macmillan Press Limited, London, 1979.

19P510 MANUFACTURING TECHNOLOGY LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

1. Facing and turning exercise using CNC Lathe.
2. Canned cycle exercise using CNC Lathe.
3. Linear, circular interpolation - Face and end milling exercise using CNC VMC.
4. Canned cycles exercise using CNC VMC.
5. Product development using subtractive rapid prototyping / 3D printing.
6. Improvement of dimensional and geometrical accuracies using milling, surface grinding and lapping processes.
7. Tool and cutter grinding, tool wear measurement and cutting forces measurement using dynamometers.
8. Reduction of circularity and cylindricity error by honing process.
9. Study of weld line and its influence on tensile strength of plastic moulded specimen.
10. Determination of load-deformation, stress-strain relationship in deep drawing process using hydraulic press.
11. Demonstration of welding processes — Ultrasonic and TIG.
12. Demonstration of Internet of Things (IoT) for various machines.

(60)

Total P: 60

REFERENCES:

1. Department of Production Engineering, "Manufacturing Technology Laboratory Manual", PSG College of Technology, Coimbatore, 2019.
2. Mikel P Groover, "Principles of Modern Manufacturing", John Wiley and Sons, New Delhi, 2016.

19P511 METROLOGY AND COMPUTER AIDED INSPECTION LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

1. Calibration of vernier caliper, micrometer and dial gauge.
2. Evaluation of repeatability and reproducibility of comparators.
3. Measurement of angle of taper piece using sine bar and bevel protractor.
4. a) Optical profile projector - Measurement of gear tooth and screw thread parameters. b) Tool maker's microscope - Measurement of cutting tool geometry and screw thread parameters.
5. a) Gear metrology - Base tangent measurement and gear composite error measurement. b) Thread inspection - Measurement of major and effective diameter of external screw thread using floating carriage micrometer.
6. a) Surface finish measurement using electronic surface roughness tester. b) Form measurements: Measurement of

- straightness, flatness, circularity and cylindricity.
7. Straightness measurement using autocollimator.
 8. Measurement of part dimensions using machine vision system.
 9. Measurement of part dimensions using electronic height gauge and coordinate measuring machine.
 10. Displacement measurement using Michelson interferometer. (60)

Total P: 60

REFERENCES:

1. Department of Production Engineering, "Metrology Laboratory Manual", PSG College of Technology, Coimbatore, 2019.
2. Kennedy, Hoffman, Bond, "Inspection and Gauging", Industrial Press, New York, 1987.
3. Hume K J, Sharp G H, "Practical Metrology", Macmillan Company, New York, 1958.

19Q513 BUSINESS AND MANAGERIAL COMMUNICATIONS

0 0 2 1

BUSINESS AND MANAGERIAL COMMUNICATIONS:

1. Advanced Group discussion
2. Advanced Resume writing
3. Mock Group discussion
4. Advanced Personal Interview
5. Mock Personal Interview
6. Cracking special Interviews
7. Essential Grammar for Placements
8. Vocabulary for Placements
9. Email writing
10. Paragraph writing
11. Essay writing

Total P: 30

REFERENCES:

1. Priyadarshi Patnaik, "Group Discussion and Interview Skills", Cambridge, New Delhi, 2011.
2. Hari Mohan Prasad, Rajnish Mohan, "How to Prepare for Group Discussion and Interview", 2nd Edition, Tata McGraw Hill, New Delhi, 2009.

SEMESTER - 6

19P601 QUANTITATIVE METHODS IN MANAGEMENT

3 0 0 3

LINEAR PROGRAMMING: Modeling with linear programming - graphical method - simplex method, two phase simplex method. Primal-dual relations, transportation problem – solution by modified distribution method, assignment problem – solution by Hungarian method. (9)

GAME THEORY: Two person zero sum game, pure and mixed strategies, dominance principle, graphical solution, linear programming solution. (9)

DECISION MAKING THEORY: Decisions under uncertainty, under certainty and under risk, decision trees, expected value of perfect information and imperfect information. (9)

QUEUEING THEORY: Elements of queueing model, relationship between exponential and Poisson queueing models, (M/M/1), (M/M/1/N), (M/M/c) and self-service model. (9)

REPLACEMENT THEORY: Replacement of items that deteriorate, replacement of items that fail, group replacement. (9)

Total L: 45

TEXT BOOKS:

1. Hamdy A Taha, "Operations Research – An Introduction", Pearson, New Delhi, 2018.
2. Maurice Sasiemi and Arthur Yaspan, "Operations Research: Methods and Problems", Literary Licensing, LLC, United States, 2013.

REFERENCES:

1. Hillier F and Lieberman G J, "Introduction to Operations Research", Tata McGraw Hill, New Delhi, 2018.
2. Singiresu S Rao, "Engineering Optimization Theory and Practice", New Age International, New Delhi, 2016.
3. Kambo N S, "Mathematical Programming Techniques", East West Press, New Delhi, 2012.
4. Donald Gross, John F Shortle and James M Thompson, "Fundamentals of Queueing Theory", Wiley India, New Delhi, 2017.

19P602 JIGS, FIXTURES AND DIE DESIGN

3 0 0 3

PRINCIPLES OF LOCATING AND CLAMPING ELEMENTS: Principles of location, planes of movement, locating from flat surface, internal diameter, external diameter and profile, spring stop buttons and types of clamps. (8)

DESIGN OF JIGS: Drill bush, types of bushings - Types of jigs: Plate, latch, channel, box, angle plate, angular post, turnover, pot, trunnion, pump, rack and pinion operated jig and air operated jig - Design of jig for a given component. (9)

DESIGN OF FIXTURES: Types of fixtures: Milling, lathe, boring, broaching, grinding, welding and modular fixtures - Design of fixture for a given component. (8)

DESIGN OF PRESS TOOLS: Power presses, press working terminologies, operations and computation of press capacity. Basics of die cutting operations, cutting action in punch and die operations, die clearance. Types of die construction: Progressive, compound and combination dies. Die design fundamentals: Blanking and piercing die construction, pilots, strippers and pressure pads, strip layout - Drawing and bending die design. Design and development of dies for simple components. (10)

DESIGN OF PLASTIC INJECTION MOULDS: Mould elements and construction. Types of mould: Two plate and three plate moulds. Feed, ejection and cooling systems, mould materials and manufacturing. (10)

Total L: 45

TEXT BOOKS:

1. Cyril Donaldson, George H Lecain and Gool V, "Tool Design", Tata McGraw Hill Education Private Limited, 2012.
2. Joshi P H, "Jigs and Fixtures", Tata McGraw Hill Education Private Limited, 2010.

REFERENCES:

1. Edward G Hoffman, "Jigs and Fixtures Design", Thomson Learning, 2010.
2. Joshi P H, "Press Tools - Design and Construction", S Chand, 2010.
3. Pye R G W, "Injection Mould Design : An Introduction and Design for the Thermoplastics Industry", Affiliated East West Press Private Limited, 2001.
4. Sanjay K Nayak, Pratap Chandra Padhi, Y Hidayathullah, "Fundamentals of Plastics Mould Design", Tata McGraw Hill Education Private Limited, 2012.

19P603 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 0 0 3

TOLERANCE ANALYSIS: DFM approach - DFM guidelines - standardisation - comparison of materials on cost basis - design for assembly - DFA index - Poka - Yoke principle; six sigma concept. Cumulative effect of tolerances - sure fit law - normal law and truncated normal law - obtainable tolerances in axial dimensions for various machining operations - Process capability - process capability metrics - Cp - Cpk - cost aspects - feature tolerances - surface finish - review of relationship between attainable tolerance grades and different machining process. (10)

SELECTIVE ASSEMBLY: Interchangeable and selective assembly - deciding the number of groups-model-I: group tolerances of mating parts equal; model-II: total and group tolerances of shaft - model-III- control of axial play -introducing secondary machining operations - laminated shims – examples. (6)

GEOMETRIC DIMENSIONING AND TOLERANCING: Introduction to GD&T - ASME Y 14.5 standard. Examples for application of geometric tolerances - Feature control frame - Rule 1 and Rule 2 of GD&T - Modifiers - Form tolerances - Orientation tolerances - Location tolerances - Profile tolerances. True Position Theory - virtual size concept - floating and fixed fasteners - projected tolerance zone - zero true position tolerance - functional gauges - paper layout gauging - compound assembly – examples. Datum Systems: 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. (12)

DESIGN FOR MACHINING, FORM DESIGN OF CASTINGS AND WELDMENTS: Design features to facilitate machining - component design, machining considerations - redesign for manufacture - examples. Redesign of castings based on parting line considerations - minimising core requirements - redesigning cast members using weldments - use of welding symbols - design of weldments. (8)

TOLERANCE CHARTING TECHNIQUE: Operation sequence for typical shaft type of components - preparation of process drawings for different operations - tolerance worksheets and centrality analysis – examples. Datum features - functional and manufacturing. (9)

Total L: 45

TEXT BOOKS:

1. Bryan R Fischer, "Mechanical Tolerance Stackup and Analysis", CRC Press, New York, 2011.
2. Paul J Drake, "Dimensioning and Tolerancing Handbook", McGraw Hill, New York, 1999.

REFERENCES:

1. Creveling C M, "Tolerance Design - A Hand Book for Developing Optimal Specifications", Addison Wesley Longman, New York, 1997.
2. Harry Peck, "Designing for Manufacture", Pitman Publications, London, 1983.
3. Spotts M F, "Dimensioning and Tolerance for Quantity Production", Prentice Hall Inc., New Jersey, 1983.
4. Oliver R Wade, "Tolerance Control in Design and Manufacturing", Industrial Press Inc., New York, 1967.

19P604 AUTOMATION AND ROBOTICS

3 0 0 3

MANUFACTURING AND AUTOMATION: Fundamental concepts in manufacturing and automation - Types and Levels of automation - automation strategies - automation migration strategy - 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. (9)

AUTOMATED ASSEMBLY: Parts feeding devices - single and multi-station assembly machines - Performance and Economics of assembly systems - Feasibility study for assembly automation. (9)

AUTOMATED MATERIAL HANDLING AND INSPECTION: Automated guided vehicle system - components of AGVS - control system - routing - design features - AS/RS components - design of an AS/RS - Automated Inspection. (9)

FUNDAMENTALS OF ROBOT: Robot Anatomy - Co-ordinate Systems - Work Envelope - types and classification - Robot Specifications - Drive systems - End Effectors-Types of Grippers-Gripper mechanisms - Selection and Design Considerations. (6)

TRANSFORMATION AND KINEMATICS: Homogeneous transformations - forward solution - inverse solution - motion generation - Jacobian control - Trajectory and path planning. (12)

Total L: 45

TEXT BOOKS:

1. Mikell P Groover, "Automation, Production Systems and Computer - Integrated Manufacturing", Pearson India Education Services, 2016.
2. Mikell P Groover, "Industrial Robotics — Technology, Programming and Applications", Tata McGraw Hill Education, 2017.

REFERENCES:

1. Nania Singh, "Systems Approach to Computer Integrated Design and Manufacturing", John Wiley and Sons, New York, 1996.
2. Roger Hannam, "Computer Integrated Manufacturing: From Concepts to Realisation", Prentice Hall, 1997.
3. Richard P Paul, "Robot Manipulators, Mathematics, Programming and Control", MIT Press, 1981.
4. Saeed Niku, "Introduction to Robotics: Analysis, Control, Applications", John Wiley and Sons, 2011.

19P610 FLUID POWER LABORATORY

0 0 2 1

FLUID POWER LABORATORY:

1. Study of Fluid power symbols and hydraulic elements
2. Design and simulation of systems using single acting actuator, double acting actuator and Pneumatic elements
3. Design and simulation of pneumatic systems with cycle selection and emergency modules
4. Design and simulation of pneumatic systems using electrical control
5. Design and simulation of pneumatic systems using PLC
6. Design and simulation of hydraulic and pneumatic systems using software

Total P: 30

REFERENCES:

1. Peter Rohner, "Fluid Power Logic Circuit Design – Analysis, Design Method and Worked Examples", The Macmillan Press Limited, London, 1979.

2. Department of Production Engineering, "Fluid Power Laboratory Manual", PSG College of Technology, Coimbatore, 2019.

19P611 CAD, CAM AND CAE LABORATORY

0 0 4 2

LIST OF EXERCISES:

1. Constraint based modeling and generation of production drawing
2. Top down modeling
3. Static analysis of a beam
4. Static analysis of a machine tool component
5. Modal analysis of a machine tool component
6. Analysis of a metal casting problem
7. Analysis of simple welding problem
8. Analysis of a sheet metal forming problem
9. NC code generation for prismatic components
10. NC code generation for cylindrical components

(60)

Total P: 60

REFERENCES:

1. Department of Production Engineering, "CAD/CAE/CAM Laboratory Manual", PSG College of Technology, 2019.
2. Saeed Moaveni, "Finite Element Analysis", 3rd Edition, Pearson Education Inc., 2011.
3. Erdogan Madenci, Ibrahim Guven, "Finite Element Methods and Applications in Engineering using ANSYS", Springer, 2015.

19Q613 QUANTITATIVE AND REASONING SKILLS

0 0 2 1

QUANTITATIVE AND REASONING SKILLS:

1. Number System, Time and Work
2. Percentages, Simple and Compound Interests
3. Time, Speed and Distance
4. Permutation, Combination and Probability
5. Ratio and Proportion
6. Profit, Loss and Partnership
7. Logarithms, Progressions, Geometry and Quadratic Equations
8. Coding and Decoding
9. Series, Analogy and Odd Man Out
10. Visual Reasoning
11. Data Arrangements
12. Blood Relations
13. Clocks, Calendars and Direction Sense
14. Cubes, Logical Connectives and Syllogisms
15. Venn Diagrams, Interpretations and solving

Total P: 30

REFERENCES:

1. Aggarwal R S, "Quantitative Aptitude for Competitive Examinations", 3rd Edition, S Chand Publishing, New Delhi, 2017.
2. ETHNUS, "Aptimithra", 1st Edition, McGraw Hill Education Pvt. Ltd., 2013.
3. FACE, "Aptipedia Aptitude Encyclopedia", 1st Edition, Wiley Publications, Delhi, 2016.

SEMESTER - 7

19P701 ENVIRONMENT CONSCIOUS MANUFACTURING

2 0 0 2

ENVIRONMENT CONSCIOUSNESS: The human population's effects on the earth - environmentally conscious Manufacturing - components - system effects and assessment. (6)

AIR POLLUTION IN MANUFACTURING SYSTEMS: Origin of airborne particles in manufacturing - traditional and modern particulates mitigation/elimination techniques. (6)

WATER POLLUTION IN MANUFACTURING SYSTEMS: Metalworking fluids - environmental and health impact - heavy metals in water - MWF pollution prevention through process planning, process modification and in-process recycling - water footprint analysis. (6)

SOLID POLLUTION IN MANUFACTURING SYSTEMS: Origin of solid waste in manufacturing - Industrial solid and hazardous waste management. (6)

ENVIRONMENTAL MANAGEMENT SYSTEMS: Framework and benefits - Concepts of ISO 14001 - requirements of ISO 14001. (6)

Total L: 30

TEXT BOOKS:

1. Daniel B Botkin, Edward A Keller, "Environmental Science", 8th Edition, Wiley India Pvt. Ltd., New Delhi, 2012.
2. Myer Kutz, "Environmentally Conscious Manufacturing", John Wiley and Sons, New York, 2007.

REFERENCES:

1. Paul M Swamidass, "Encyclopedia of Production and Manufacturing Management", Kluwer Academic Publisher, 2000.
2. Davim J P, "Sustainable Manufacturing", John Wiley and Sons, 2010.
3. Erach Bharucha, "Textbook of Environmental Studies for Undergraduate Courses", Orient BlackSwan, 2013.

19P702 PRODUCTION AND OPERATIONS MANAGEMENT

3 0 0 3

FORECASTING AND PLANT DESIGN: Demand forecasting - techniques of forecasting, forecast errors, forecast control. Long range capacity planning - decision tree analysis, plant location factors, location evaluation methods. Plant layout - types, characteristics, layout design techniques - SLP and CRAFT. (9)

AGGREGATE PLANNING AND MASTER PRODUCTION SCHEDULING: Approaches to aggregate planning - graphical, empirical and optimization, development of master production schedule, material requirement planning, MRP Lot sizing, introduction to MRP - II and ERP. (9)

INVENTORY MODELS AND SEQUENCING / SCHEDULING: Classification of fixed order quantity models, deterministic demand models, inventory models with probabilistic demand, price breaks, quantity discount, safety stocks. Selective inventory control techniques - ABC inventory system and vendor managed inventories. Scheduling process - n jobs through one machine, priority dispatching rules, mean flow time, tardiness. Order sequencing - Johnson's algorithm n jobs through 2 machines, extended Johnson's algorithm, n jobs through m machines. (9)

WORK SYSTEMS ENGINEERING AND LEAN TOOLS: Method study - recording tools and techniques, principles of motion economy. Work measurement - standard time, stopwatch time study, rating systems, work sampling and predetermined motion time systems. Value stream mapping - The as-is diagram, the future state map, seven wastes of lean manufacturing. 5S, kaizen, kanban and line balancing. (9)

MAINTENANCE AND PROJECT MANAGEMENT: Types of maintenance, replacement problems, bathtub curve, TPM - pillars of TPM, six big losses, OEE, OOE, TEEP. PERT/CPM - Principles, applications and time - cost / trade-off crashing. (9)

Total L: 45

TEXT BOOKS:

1. Gaither N, Frazier G, "Operations Management", 9th Edition, Cengage Learning, New Delhi, 2009.
2. Jay Heizer, Barry Render, Chuck Munson, Amit Sachan, "Operations Management", 12th Edition, Pearson Education Inc, New Delhi, 2017.

REFERENCES:

1. Hamdy A Taha, "Operations Research", 10th Edition, Pearson Education, New Delhi, 2017.
2. ILO, "Introduction to Work Study", 4th Edition, Universal Book Corporation, New Delhi, 2010.

3. Askin R G, Goldberg J B, "Design and Analysis of Lean Production Systems", 8th Edition, John Wiley and Sons Inc, New Delhi, 2007.
4. Panneerselvam R, "Production and Operations Management", 3rd Edition, PHI Learning Pvt. Ltd., New Delhi, 2010.

19P710 INDUSTRIAL ENGINEERING AND LEAN PRACTICES LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

1. Solving linear programming problem, transportation and assignment problem.
2. Project management using PERT/CPM.
3. Quality assurance using variable and attribute control charts.
4. Planning and analysis of experiments.
5. Physiological ergonomic evaluation.
6. Anthropometry exercises.
7. Exercise on Value Stream Mapping using lean simulation kit.
8. Exercise on Kanban using lean simulation kit.
9. Exercise on Single Minute Exchange of Dies using lean simulation kit.
10. Exercise on Cell layout using lean simulation kit.

Total P: 60

REFERENCES:

1. Department of Production Engineering, "Industrial Engineering and Lean Practices Laboratory Manual", PSG College of Technology, Coimbatore, 2019.
2. Gupta P K, Hira D S, "Introduction to Operations Research", S Chand and Company, New Delhi, 2012.
3. Timothy Joseph Gallwey, "Ergonomic Laboratory Exercises", CRC Press, New Delhi, 2008.
4. Wilson L, "How to Implement Lean Manufacturing", Tata McGraw Hill, New Delhi, 2015.

19P711 INNOVATION PRACTICES

0 0 4 2

INNOVATION PRACTICES LABORATORY IS TO IDENTIFY A CONSUMER PRODUCT AS NEEDED BY THE MARKET AND MAKE A PHYSICAL PROTOTYPE BY FOLLOWING THE PRODUCT DEVELOPMENT METHODOLOGY GIVEN BELOW:

1. Idea generation and concept selection: i) Market survey and concept generation. ii) Patent search for foolproof concept selection. iii) Timeline of activities.
2. Simulation and optimization of the design: i) CAD model development. ii) Simulation in CAE environment. iii) Design optimization. iv) Approximate cost estimation.
3. Model / prototype development.
4. Preparation of a detailed report.
5. In order to enrich the product innovation process this course will be provided with demonstration of the following i) Reverse engineering hardware, software and the procedure. ii) 3D scanning. iii) Rapid prototyping techniques like Fused Deposition Modelling, Selective Laser Sintering, and vacuum casting. iv) Virtual reality hardware, software and their applications in virtual prototyping. v) Failure Mode and Effect Analysis (FMEA) approach

Total P: 60

REFERENCES:

1. Kevin Otto, Kristin Wood, "Product Design", Pearson, New Delhi, 2013.
2. Karl T Ulrich, Steven D Eppinger, "Product Design and Development", Tata McGraw Hill, New Delhi, 2011.

19P720 PROJECT WORK I

0 0 4 2

- Review of fundamentals
- Identification of a problem domain
- Need for the current study
- Literature survey and patent/design registration /trademarks search
- Problem formulation based on the literature survey
- Objectives and feasibility study

- Methodology and Time Line of activities
- Progress of the work
- Conclusions
- Report and technical paper preparation

Total P: 60

SEMESTER - 8

19P820 PROJECT WORK II

0 0 8 4

- Identification of a problem domain
- Need for the current study
- Literature survey and patent/design registration /trademarks search
- Problem formulation based on the literature survey
- Objectives and feasibility study
- Methodology and Time Line of activities
- Progress of the work
- Detailed analysis and interpretation of results
- Validation of results
- Conclusions
- Report and technical paper preparation

Total P: 120

LANGUAGE ELECTIVES

19G001 COMMUNICATION SKILLS FOR ENGINEERS

0 0 4 2

COMMUNICATION CONCEPTS :

Process of Communication
Inter and Intrapersonal Communication
Inter and Intrapersonal CommunicationActivities

(9)

FOCUS ON SOFT SKILLS :

Etiquette — Work Place etiquette — Telephone etiquette
Body Language
Persuasive Communication
Public Speaking
Critical Reasoning and Conflict Management based on Case Studies
Group Communication
Meetings
Interview Techniques

(14)

TECHNICAL WRITING :

Technical Writing Principles
Style and Mechanics
Technical Definitions – Physical, Functional and Process Descriptions
Technical Report Writing
Preparing Instructions and Manuals
Interpretation of Technical Data

(15)

BUSINESS CORRESPONDENCE :

Writing Emails
Preparing Resumes
Memos
Technical and Business Proposals

(7)

TECHNICAL COMMUNICATION :

Seminars
Process Description and Group Discussions
Use of Visual Aids

(15)

Total P: 60

TEXT BOOKS:

1. Faculty Incharge "Course Material on "Communication Skills for Engineers"", PSG College of Technology., Coimbatore, 2019

REFERENCES:

1. Jeff Butterfield "Soft Skills for Everyone", Cengage Learning., New Delhi, 2013
2. Jean Naterop B and Rod Revell "Telephoning in English", Cambridge University Press., Cambridge, 2011
3. David A Mc Murrey and Joanne Buckley "Handbook for Technical Writing", Cengage Learning., New Delhi, 2011
4. Simon Sweeney "English for Business Communication", Cambridge University Press., New Delhi, 2012

19G002 GERMAN- LEVEL A1.1**0 0 4 2****GUTEN TAG! :**

1. To greet, learn numbers till 20, practice telephone numbers & e mail address, learn alphabet, speak about countries & languages
2. Vocabulary: related to the topic
3. Grammar: W— Questions, Verbs & Personal pronouns I. (10)

FREUNDE, KOLLEGEN UND ICH :

1. To speak about hobbies, jobs, learn numbers from 20; build dialogues and frame simple questions & answers
2. Vocabulary: related to the topic
3. Grammar: Articles, Verbs & Personal pronouns II, sein & haben verbs, ja/nein Frage, singular/plural (10)

IN DER STADT :

1. To know places, buildings, question, know transport systems, understand international words; build dialogues and write short sentences
2. Vocabulary: related to the topic
3. Grammar: Definite & indefinite articles, Negotiation, Imperative with Sien verbs (12)

GUTEN APPETIT! :

1. To speak about food, shop, converse; Vocabulary: related to the topic; build dialogues and write short sentences
2. Grammar: Sentence position, Accusative, Accusative with verbs, personal pronouns & prepositions, Past tense of haben & sein verbs (13)

TAG FÛR TAG/ZEIT MIT FREUNDEN :

1. To learn time related expressions, speak about family, about birthdays, understand & write invitations, converse in the restaurant; ask excuse, fix appointments on phone
2. Vocabulary: related to the topic
3. Grammar: Time related prepositions, Possessive articles, Modalverbs (15)

Total P: 60**TEXT BOOKS:**

1. Dengler Stefanie "Netzwerk A1.1", Klett-Langenscheidt GmbH., München, 2013
2. Sandra Evans, Angela Pude "Menschen A1", Hueber Verlag., Germany, 2012

REFERENCES:

1. Stefanie Dengler "Netzwerk A1", Klett-Langenscheidt GmbH., München, 2013
2. Hermann Funk, Christina Kuhn "Studio d A1", Goyal Publishers & Distributors Pvt. Ltd., New Delhi, 2009
3. Rosa-Maria Dallapiazza "Tangram Aktuell 1 (Deutsch als Fremdsprache)", Max Hueber Verlag., Munchen, 2004
4. Christiane Lemcke und Lutz Rohrmann "'Grammatik Intensivtrainer A 1", Goyal Publishers & Distributors Pvt. Ltd., New Delhi, 2012

19G003 FRENCH LANGUAGE LEVEL 1**0 0 4 2****PARTS OF SPEECH :**

1. inviter et répondre à une invitation, Pronoms sujets
2. L'article définis, l'article indéfinis
3. Conjugation : présent, adjectifs possessifs
4. interrogation, décrire les personnes
5. La vie de quatre parisiens de professions différentes (12)

ELEMENTS OF GRAMMAR :

1. Exprimer l'ordre et l'obligation demander et commander

2. l'adjectif possessifs, l'article partitif, l'article démonstratif, négation ne
3. pas, l'article contracté
4. verbe pronominaux
5. prepositions (12)

SENTENCE STRUCTURE :

1. Raconter et reporter-donner son avis
2. Futur simple, pronom complètement d'objet direct, passé composé
3. Plusieurs région de France, imparfait, pronom y/en, imparfait (12)

TENSES AND NUMBERS :

1. Demander l'autorisation-passé récent, futur proche
2. La vie administrative et régionale, Pluriel des noms, moyens de transport (12)

DISCOURSE :

1. le discours rapporté, décrire un lieu, exprimer ses préférences
2. décrire la carrière, discuter d'système éducation de France
3. parler de la technologie de l'information (12)

Total P: 60

TEXT BOOKS:

1. Christine Andant étal "À propos (livre de l'élève", LANGER., NEW DELHI, 2012
2. Myrna Bell Rochester "Easy French Step By Step", MCGrawhill Companies., USA, 2008

REFERENCES:

1. Michael D. Oates "Entre Amis: An Interactive Approach", Houghton Mifflin., 2005 , 5th
2. Bette Hirsch, Chantal Thompson "Moments Literaries : An Anthology for intermediate French", .,
3. Simone Renaud, Dominique van Hooff "En bonne forme", ..

19G004 BASIC JAPANESE

0 0 4 2

JAPANESE PEOPLE AND CULTURE :

1. Basic greetings and responses
2. Basic script— Method of writing hiragana and katakana — Combination sounds and simple words
3. Selfintroductions: "Hajimemashite" -Demonstratives "Kore", "Sore", "Are"— Demonstrative "Kono", "Sono", "Ano"
4. Possessive noun particle "no"— Japanese apartments: Greeting your neighbor (12)

PARTICLE "NI (AT)" FOR TIME :

1. kara (from) ~ made(until) — Particle "to (and)"
2. Time periods: Days of the week, months, time of day –Verbs (Present / future and pasttense)
3. Telephone enquiry: Asking for a phone no. And business hours- Destination particle "e". (12)

LIKES AND DISLIKES :

1. Potential verbs (wakarimasu and dekimasu) — "Kara (~ because)"
2. Adverbs — Asking some one out over the phone-Verbs denoting presence
3. Introduction to Adjectives (na and ii type) -Verb groups — I, II and III — Exercises to group verbs- Please do (te kudasai)
4. Present continuous tenses (te imasu) — Shall I? (~ mashou ka) — Describing a natural phenomenon (It is raining) (12)

DIFFERENT USAGES OF ADJECTIVES :

1. Comparison — Likes and dislikes — Going to a trip- Need and desire (ga hoshii) — Wanting to . . . (Tabeti desu)- Going for a certain purpose (mi -ni ikimasu)
2. Choosing from a menu-Adjectives ("i" and "na" type) — Adjectives (Positive and negative useage) (12)

ROLE PLAYS IN JAPANESE :

1. Framing simple questions & answers
2. Writing Short paragraphs & Dialogues
3. A demonstration on usage of chopsticks and Japanese tea party (12)

Total P: 60

TEXT BOOKS:

1. Minna no Nihongo, Honsatsu Roma "ji ban (Main Textbook Romanized Version)", . International publisher — 3A Corporation., Tokyo, 2012

REFERENCES:

1. Eri Banno et.al "Genki I: An Integrated Course in Elementary Japanese I -Workbook", ., 1999
2. Tae Kim "A Guide to Japanese Grammar: A Japanese Approach to Learning Japanese Grammar", ., 2014
3. Minna No Nihongo "Translation & Grammatical Notes In English Elementary", .,

PROFESSIONAL ELECTIVES

19P001 MECHATRONICS

3 0 0 3

INTRODUCTION TO MECHATRONICS SYSTEM: Key elements - Mechatronics Design process - Types of Design - Traditional and Mechatronics designs – Advanced approaches in Mechatronics - Man machine interface, industrial design and ergonomics, safety. (9)

REAL-TIME INTERFACING: Introduction - Elements of data acquisition and control - Overview of I/O process, Analog signals, discrete signals and Frequency signals – Over framing. (9)

CASE STUDIES ON DATA ACQUISITION: Introduction – Cantilever Beam Force Measurement system – Testing of Transportation bridge surface materials – Transducer calibration system for Automotive applications – Strain gauge weighing system – Solenoid Force - Displacement calibration system – Rotary optical encoder – Controlling temperature of a hot/cold reservoir – pick and place robot. (9)

CASE STUDIES ON DATA ACQUISITION AND CONTROL: Introduction – Thermal cycle fatigue of a ceramic plate – pH control system – DC - Icing Temperature Control system – Skip control of a CD Player – Autofocus Camera, exposure control. Case studies of design of mechatronic products - Motion control using D.C Motor and Solenoids - Car engine management systems. (9)

ADVANCED APPLICATIONS IN MECHATRONICS: Sensors for condition Monitoring – Mechatronic Control in Automated Manufacturing – Artificial intelligence in Mechatronics – Fuzzy Logic Applications in Mechatronics – Microsensors in Mechatronics. (9)

Total L: 45

TEXT BOOKS:

1. Devdas Shetty, Richard A Kolk, "Mechatronics System Design", 2nd Edition, Cengage Learning, 2010.
2. W Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson Education, 2015.

REFERENCES:

1. S Brian Morriss, "Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics", McGraw Hill International Edition, 1995.
2. D A Bradley, D Dawson, N C Burd, A J Loader, "Mechatronics: Electronics in Products and Processes", Chapman and Hall, London, 1993.
3. Richard C Dorf, Robert H Bishop, "Modern Control Systems", 12th Edition, Pearson, 2010.

19P002 MODELING AND CONTROL OF DYNAMIC SYSTEMS

3 0 0 3

INTRODUCTION TO CONTROL SYSTEMS: Introduction - need for control systems. Open-loop and closed-loop systems - Components of feedback control systems - effect of feedback control - types of feedback control systems. Transfer function: Block diagram reduction - Signal flow graphs. (8)

MATHEMATICAL MODELS OF PHYSICAL SYSTEMS: Mechanical translational and rotational systems - Fluid and Thermal systems - D.C. generator and motor; Transportation Lag Systems. (8)

TRANSIENT RESPONSE: Typical inputs - Time domain specifications - First and second order systems - steady state errors. **STABILITY:** Concept of stability - necessary and sufficient conditions of stability - Routh Hurwitz Criterion. Lead - Lag - Lag-Lead Compensation using time domain analysis. (11)

FREQUENCY RESPONSE: Bode Plot - Polar Plot - Nyquist stability criterion - Stability analysis - Control system design using Frequency domain analysis - Lead - Lag - Lag-Lead Compensation. (12)

CASE STUDIES: Servo motor - Mathematical Modelling of Servo Motor - Analysis of Servo motor system using Routh Hurwitz criterion - Root locus - Bode Plot - Polar Plot and stability analysis - Implementation of P - PI – PD and PID controllers for servo motor and analysis. (6)

Total L: 45

TEXT BOOKS:

1. Ogata K, "Modern Control Engineering", Pearson Education, 2015.
2. Benjamin C Kuo, "Automatic Control Systems", 9th Edition, Prentice Hall of India, 2014.

REFERENCES:

1. J Nagrath, M Gopal, "Control System Engineering", New Age International Publishers, 2018.
2. M Nakamura S Gata and N Kyura, "Mechatronic Servo System Control", Springer 2009, 2009.
3. Norman S Nise, "Control Systems Engineering", 6th Edition, 2018.
4. Richard C Dorf, Robert H Bishop, "Modern Control Systems", Addison – Wesley, 2015.

19P003 MAINTENANCE AND SAFETY ENGINEERING

3 0 0 3

MAINTENANCE: Types of maintenance - breakdown, preventive, predictive, condition based maintenance, total productive maintenance, maintenance prevention, reliability centered maintenance - MTBF, MTTR - elements of preventive maintenance - checklist, schedule, procedure. (9)

TOTAL PRODUCTIVE MAINTENANCE: Principles - preparatory stages of TPM implementation - TPM organization structure, TPM policies and aids, master plan - small group activities, autonomous maintenance, establishing planned maintenance, training, developing equipment management program. (11)

SAFETY SYSTEMS ANALYSIS: Introduction of safety systems, safety information system, industrial safety engineering, job safety analysis, OSHA regulations - design for safety, lock out / tag out system, work permit system - safety in power press, cranes and boiler operations - safety in foundry, forging, welding, hot working, cold working and electroplating. (10)

FIRE PROTECTION SYSTEM: Chemistry of fire - water sprinkler - fire hydrant - alarm and detection system - fire suppression system - CO₂ system, foam system, Dry Chemical Powder (DCP) system, halon system, portable extinguisher. (8)

SAFETY AND LAW: Provisions in factory act for safety - explosive act - workmen compensation act – compensation calculation - boiler act and pollution control act. (7)

Total L: 45

TEXT BOOKS:

1. John Ridley, John Channing, "Safety at Work", 7th Edition, Butterworth-Heinemann Publications, UK, 2008.
2. Charles J Robinson, Andrew P Ginder, "Implementing TPM: The North American Experience", Productivity Press, Portland, Oregon, 2007.

REFERENCES:

1. Dhillon B S, "Maintainability, Maintenance and Reliability for Engineers", Taylor and Francis, London, 2006.
2. Heinrich H W, "Industrial Accident Prevention", National Safety Council, Chicago, 1998.
3. Gary R Krieger, John F Montgomery, "Accident Prevention Manual for Industrial Operations", 11th Edition, National Safety Council, Chicago, 1997.
4. Patrick A Michaud, "Accident Prevention and OSHA Compliance", CRC Press, USA, 1995.

19P004 FINITE ELEMENT APPLICATIONS IN MANUFACTURING

3 0 0 3

BASIC CONCEPTS: Background study on Finite Element Method (FEM) - need for application of FEM in various engineering domains - transforming physical model in to mathematical model - strong and weak form of 1D physical problems - approximation using interpolation or trial functions - solving 1D structural and thermal problem - approach to solve 2D and 3D models. (12)

DISCRETIZATION: Introduction, concept of elements - 1D, 2D and 3D elements - plane stress and plane strain models - shape functions - direct stiffness approach - stiffness matrix - element assembly - solving for unknowns - global and natural coordinate systems and Jacobian for transformations. (9)

GOVERNING EQUATIONS: Mathematical modeling of manufacturing processes - metal casting, metal cutting, metal forming, welding - heat treatment and injection molding - use of partial differential equations – interpretation of boundary conditions and initial conditions. (6)

FEA OF METAL FORMING PROCESSES: Review of theory of plasticity applied to metal forming processes - flow curve - models for friction and heat transfer - modelling of simple forging operations - plane strain upsetting - computer implementation - modelling of rolling and extrusion processes. (9)

FEA OF METAL CASTING AND WELDING PROCESSES: Overview of transport phenomena in metal casting - simple case studies on sand mould casting using CAE software - introduction to Computer-aided design and analysis of Injection moulded components using CAE software - model for manual metal arc welding - FEA analysis of welding distortion and residual stress using CAE software. (9)

Total L: 45

TEXT BOOKS:

1. J Fish, "A First Course in Finite Elements", John Wiley and Sons Ltd., England, 2007.
2. Shiro Kobayashi, Soo-ik Oh, Taylan Altan, "Metal Forming and the Finite Element Method", Oxford and IBH Publishing, New Delhi, 1989.

REFERENCES:

1. Reddy J N, "Introduction to Finite Element Method", Tata McGraw Hill, 2005.
2. Edward R Champion, "Finite Element Analysis in Manufacturing Engineering", McGraw Hill, 1992.
3. Dantzig J A, Rappaz M, "Solidification", EPFL Press, Laussane, Switzerland, 2009.
4. Sindo Kou, "Transport Phenomena and Materials Processing", John Wiley and Sons Inc, New York, 1996.

19P005 DESIGN AND MANUFACTURE OF GEARS

3 0 0 3

INTRODUCTION TO GEARS: Types of gears, classification, application of gears, gearboxes, gear drawing. Review of gear fundamentals - Law of gearing, nomenclature, interference, minimum number of teeth, gear correction - So and S, Gear tooth forces. (7)

GEAR DESIGN: Design of spur gears, design of helical gears, design of worm and worm wheel, design of bevel gears. (11)

GEAR MATERIAL SELECTION AND HARDENING METHODS: Properties of gear materials, non-metallic, non-ferrous and plastic gears, selection of material for power transmission, high-speed application, hardening by through hardening, case hardening, induction hardening, flame hardening, nitriding and tuffriding, hardening defects. (8)

PRODUCTION OF CYLINDRICAL AND CONICAL GEARS: Procedure of cutting gears and obtainable quality in hobbing and gear shaping- cutter selection and work holding methods, setting calculations. Rack type gear shaping machine description and application. Internal gear cutting methods, CNC gear hobbing and gear shaping machines. Production of straight bevel gears by bevel gear generator, duplex rotary cutter method – Gleason Reva cycle method - spiral and hybrid bevel gear generation, Gleason Tri-AC, description of machine. (10)

GEAR FINISHING AND OTHER PRODUCTION METHODS: Gear finishing advantages, finishing of gears by grinding, shaving, lapping and honing methods, cold rolling of gears - description of process, machine, cutters and process parameters setting. Gear production by stamping, die casting, powder metallurgical process, injection and compression moulding of plastic gears, cold and hot rolling. Mass production methods - shear speed shaping, gear broaching. (9)

Total L: 45

TEXT BOOKS:

1. HMT, "Production Technology", Tata McGraw Hill Co., 2004.
2. Maitra G M, "Handbook of Gear Design", Tata McGraw Hill, 2001.

REFERENCES:

1. Chawathe D D, "Hand Book of Gear Technology", New Age International, 2009.
2. Darle W Dudley, "Handbook of Practical Gear Design", CRC Press, Washington D.C, 2009.
3. Dennis P Townsend, "Dudleys Gear Handbook: The Design, Manufacture and Application of Gears", 2nd Edition, Tata McGraw Hill, New Delhi, 2011.
4. Faculty of Mechanical Engineering, "Design Data Book", PSG College of Technology, M/s. DPV Printers, 2012.

19P006 PRODUCT LIFECYCLE MANAGEMENT

3 0 0 3

PRODUCT DEVELOPMENT AND PRODUCT LIFECYCLE: Product development process and functions, present market constraints, need for collaboration, collaborative product development, use of internet class technologies and data transfer, various developments on internet technology that support product development and its impact on business. Concept of product lifecycle - different phases of product lifecycle and corresponding technologies, its uses and examples. (9)

PRODUCT DATA MANAGEMENT (PDM): PDM functions, PDM system and importance, architecture of PDM systems, document management, representation of lifecycle of business objects, concepts on roles, users and project management, system administration, access control and its use in lifecycle. (9)

AUTOMATING BUSINESS PROCESSES: Product Lifecycle Management (PLM) architecture, components of PLM, lifecycle problems to resolve, Workflows - lifecycle and work flow integration, product configuration, bill of materials management, product structure, configuration management and engineering change management. Introduction to Product Manufacturing Information (PMI) and Model Based Definition (MBD). (10)

PRODUCT VISUALISATION: Use of CAD neutral approach and visualization techniques in product development, capabilities of PLM visualization software - light weight representations, markup method, representation information repository, use of visualization in different stages of lifecycle, case studies. Introduction to virtual reality, digital mock-up, virtual testing and validation. (9)

INTEGRATION OF PLM WITH OTHER SYSTEMS: Benefits of integrating PLM system with other systems, different ways to integrate PLM systems with other systems, integration with CAD and ERP - use of middleware in integrating business applications in product development. PLM software customisation. (8)

Total L: 45

TEXT BOOKS:

1. Michael Grieves, "Product Lifecycle Management", Tata McGraw Hill, 2006.
2. Faisal Hogue, "E-Enterprise Business Models Architecture and Components", Cambridge University Press, 2000.

REFERENCES:

1. Alexis Leon, "Enterprise Resource Planning", Tata McGraw Hill, 2002.
2. Danier Amor, "The E-Business Revolution", Pearson Education Asia, 2000.
3. David Ferry, Larry Whipple, "Building an Intelligent e-Business", Prima Publishing, 2000.
4. David Bedworth, Mark Hederson, Phillip Wolfe, "Computer Integrated Design and Manufacturing", McGraw Hill Inc., 1991.

19P007 SURFACE ENGINEERING AND TRIBOLOGY

3 0 0 3

SURFACE ENGINEERING: Significance of surfaces - nature of surfaces contact - surface energy - surface topography - surface texture evaluation techniques - surface integrity - Instruments and techniques for surface analysis - scanning electron microscopy and atomic forces microscopy - surface zone layers - structure of superficial layers - characteristics of superficial layer obtained by manufacturing processes - strength properties - tribological properties. (9)

SURFACE COATINGS: Structure of coatings - classification of coatings - need for technical and technological coatings - techniques for producing surface layers - thermal spraying - electron beam technology – laser based technology - ion implantation techniques - CVD methods and PVD techniques. (9)

SURFACE HARDENING: Surface hardening by flame and induction - laser and electron beam hardening - selection and applications - surface diffusion process - carbonitriding - aluminizing - silicizing - chromizing - sursulf - selection of diffusion process. (7)

TRIBOLOGY: Scope of Tribology - Tribology in metal working - surface effects on tribology - liquid lubricants and lubrication - lubrication by solids - mechanism and effects of lubrication - film parameter - selection criteria for lubricants - basics of hydrodynamic - elasto-hydrodynamic - boundary and extreme pressure lubrication - tribological components - bearings - gears and piston rings - Introduction to Nano tribology. (11)

FRICTION AND WEAR: Laws of dry friction - mechanism of friction - sliding friction of metals and polymers - stick slips in machine tool slides - frictional heating and contact temperature - wear mechanisms - abrasive - erosive and cavitation wear - effects of adhesion between wearing surfaces - seizure and scuffing - corrosive wear and fatigue wear - wear analysis and measurement. (9)

Total L: 45

TEXT BOOKS:

1. Bharat Bhushan, "Principles and Applications of Tribology", John Wiley and Sons, 2003.
2. Tadeusz Burakowski, Tadeusz W, "Surface Engineering of Metals : Principals, Equipments and Technologies", CRC Press, 2000.

REFERENCES:

1. Sengupta S N, Ahuja D B, Basu S K, "Fundamentals of Tribology", Prentice Hall of India, 2011.
2. Bharat Bhushan, "Nano-Tribology and Nanomechanics: An Introduction", Springer, 2008.
3. Rajan, Sharma, "Heat Treatment Principals and Techniques", Prentice Hall of India, 2004.
4. Ernest Rabinowicz, "Friction and Wear of Materials", John Wiley and Sons, 1995.

19P008 MANUFACTURE OF AUTOMOTIVE COMPONENTS

3 0 0 3

ENGINE AND ENGINE COMPONENTS: Casting of engine block - conventional and expendable pattern, machining of engine block - casting of cylinder heads, forging of crank shaft, connecting rod and gudgeon pin, machining and heat treatment - casting of piston by gravity casting, squeeze casting, forging of valves, heat treatment and surface improvement - cylinder liners and piston ring manufacturing. (9)

CLUTCH AND GEARBOX COMPONENTS: Principles and types - friction lining materials, requirements and its manufacturing - casting of gear box casing, guide lines - precision forging of spur and helical gears, bevel and worm gear manufacturing - orbital forming of gears, heat treatment and finishing, examples. (9)

PROPELLER SHAFT, AXLES, SPRINGS AND BODY PANELS: Casting and extrusion of propeller shaft, extrusion dies and its materials, heat treatment - forging of front axle and rear axle, casting of rear axle casing - leaf spring materials and its requirements, manufacturing of leaf spring - forming of body panels-hydro forming and press forming, welding of body panels - injection moulding of instrument panel, moulding of bumper, tooling and requirements. (10)

AUTOMOTIVE COMPONENTS USING COMPOSITES: Need for composites in automotive parts, types of composite and its characteristics - ceramic matrix piston rings - chemical vapour deposition, physical vapour deposition - composite molding of friction lining, composite propeller shaft manufacturing, composite leaf springs and process for making composite panels. (9)

MISCELLANEOUS COMPONENTS: Tyre and tube manufacturing, materials and its requirements - painting booth and coach work - safety aspects in component manufacturing, guide lines - case study examples. (8)

Total L: 45

TEXT BOOKS:

1. Heldt P M, "High Speed Combustion Engines", Oxford IBH Publishing Company, Calcutta, 1996.
2. Kirpal Singh, "Automobile Engineering, Volume I & II", Standard Publishers, New Delhi, 2014.

REFERENCES:

1. Serope Kalpakjian, Steven R Schmid, "Manufacturing Processes for Engineering Materials", Prentice Hall India Private Limited, New Delhi, 2007.
2. Phillip F Ostwald, Jairo, Munoz, "Manufacturing Processes and Systems", Wiley India Private Limited, New Delhi, 2008.
3. Sanjay K Mazumdar, "Composites Manufacturing: Materials, Product and Process Engineering", CRC Press, LLC Publisher, New York, 2002.
4. Kalpakjian, "Manufacturing Engineering and Technology", Pearson Publishing Company, Noida, 2014.

19P009 LEAN MANUFACTURING

3 0 0 3

ORIGIN AND CHARACTERISTICS OF LEAN PRODUCTION: Craft production – mass production – Ford system – growing dysfunction – origin and history of lean production - necessity of lean production – systems and systems thinking – construction of lean production - lean image and lean activities – Muda and its types – Mura – Muri. (8)

STABILITY AND STANDARDIZED WORK: Standards in lean system – visual management – 5S – Total Productive Maintenance - key measures - six big losses - hidden losses - machine loss pyramid - small group activity - comparison of methods engineering and lean thinking – elements to be managed - necessity and prerequisites of standardized work – elements of standardized work - charts - production capacity chart - standardized combination table - standardized work analysis chart – manpower reduction – comparison of overall efficiency with individual efficiency – kaizen – common layouts. (12)

JUST IN TIME (JIT): Definition - principles of JIT - continuous flow - pull – JIT system – kanban – six kanban rules - expanded role of conveyance – production levelling – three types of pull systems – value stream mapping - symbols - current state VSM and future state VSM. (10)

JIDOKA: Development and necessity – poke yoke - common errors – inspection system and zone control – using poke jokes – jidoka implementation. (7)

LEAN INVOLVEMENT AND CULTURE: Necessity of involvement – waste of humanity – activities supporting involvement – kaizen circle activity – practical kaizen training – key factors in practical Kaizen training – lean culture - 'Five Why' analysis. (8)

Total L: 45

TEXT BOOKS:

1. Devadasan S R, Mohan Sivakumar V, Muruges R, Shalij P R, "Lean and Agile Manufacturing: Theoretical, Practical and

- Research Futurities", Prentice Hall of India Learning Limited, 2012.
2. Dennis P, "Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System", Productivity Press, 2007.

REFERENCES:

1. Gopalakrishnan N, "Simplified Lean Manufacture: Elements, Rules, Tools and Implementation", Prentice Hall of India Learning Private Limited, 2010.
2. Bill Carreira, "Lean Manufacturing that Works: Powerful Tools for Dramatically Reducing Wastes and Maximizing Profits", Prentice Hall of India Learning Private Limited, 2007.
3. Don Tapping, Tom Luyster, Tom Shuker, "Value Stream Management: Eight Steps to Planning, Mapping and Sustaining Lean Improvements", Productivity Press, 2002.
4. James P Womack, Daniel T Jones, Daniel Roos, "The Machine That Changed the World", 1st Edition, Free Press, New York, 2007.

19P010 MATERIAL HANDLING SYSTEMS

3 0 0 3

INTRODUCTION: Definition and Scope of Material Handling - Importance of Material Handling - Basic Classification of Materials - Definition of Unit Loads - Advantages and Disadvantages - Load Utilization Processes and Handling Methods - Pallets, Skids and Containers - Alternative Method of Handling - Packaging for Materials Handling - Industrial Trucks: Classification - Hand Trucks - Power Trucks - Fork Lift Trucks - Tractors. (9)

CONVEYORS: Belt Conveyors: Definition - General Characteristics - Types - Parts - Design Aspects – Pneumatic Conveyors: Definition - Advantages and Disadvantages - Types - Parts of Pipeline Conveyors. - Hydraulic Conveyors: Definition and Uses - Advantages and Disadvantages - Design Considerations. (9)

HOIST AND WINCHES: Hoists – Definition - Characteristics and Uses - Constructional Features - Specification - Parts of Hoisting Equipments - Chain and Chain Sprockets - Steel Wire Ropes and Drums - Pulleys and Pulley Systems - Arresting Gears and Breaks - Load Handling Attachments - Winches - Definition and Uses - Constructional Features. (9)

ELEVATORS: Definition - Bucket Elevators - Definition, Specification and Uses - Types of Bucket Elevators - Selection of Elevators - Design of Buckets for Bucket Elevators - Skip Hoists - Freight Elevators - Lifts. (9)

CRANES: Definition - Basic Principles - Types of Cranes - Jib Cranes - Overhead Travelling Cranes/Bridge Cranes - Gantry Cranes - Wharf Cranes - Pillar Cranes - Tower Cranes - Truck And Wagon Cranes - Crawler Cranes - Railroad/Locomotive Cranes - Floating Cranes - Derricks. (9)

Total L: 45

TEXT BOOKS:

1. Siddhartha Ray, "Introduction to Materials Handling", New Age International Private Limited, New Delhi, 2010.
2. Charles D Reese, "Materials Handling Systems", Taylor and Francis, New York, 2000.

REFERENCES:

1. Rudenko N, "Materials Handling Equipment", MIR Publishers, 1969.
2. Chowdary R B, Tagore G R N, "Materials Handling Equipment", Khanna Publishers, New Delhi, 1996.
3. Spivakovsky A O, Dyachkov V K, "Conveying Machines Volume I & II", MIR Publishers, 1985.
4. Alexandrov M, "Materials Handling Equipments", MIR Publishers, 1981.

19P011 NON-TRADITIONAL MACHINING TECHNIQUES

3 0 0 3

MECHANICAL ENERGY PROCESSES: Need - types of non-traditional machining processes - hybrid processes - applications - Ultrasonic Machining (USM): Process description - equipments - mechanics of cutting - hammering and throwing model - typical problems - factors affecting material removal rate - dimensional accuracy and surface quality - applications. (9)

ABRASIVE MACHINING PROCESSES: Introduction - description - equipment - nozzles - material removal rate - typical problems - parametric analysis - process capabilities and applications of Abrasive Jet Machining (AJM) and Abrasive Water Jet Machining (AWJM) processes. (9)

THERMAL ENERGY PROCESSES: Electron Beam Machining (EBM): Principle - equipments - vacuum system - process parameters - characteristics and applications - Laser Beam Machining (LBM): Types of lasers - characteristics - material removal mechanism - process characteristics - applications - three dimensional machining and advantages - Plasma Arc Machining (PAM): Generation of plasma - elements - torch design types and its characteristics - effect of process parameters - applications. (9)

ELECTRICAL DISCHARGE MACHINING: Introduction - mechanism of material removal - description - electrodes - dielectric fluids - different types of flushing - material removal rate - process characteristics and applications – Wire - Electric Discharge Machining (Wire-EDM): Equipments - process variables - process capabilities and applications in die making. (9)

CHEMICAL ENERGY PROCESSES: Electro Chemical Machining (ECM): Principle of electrolysis - theory of ECM - description of the equipment - electrodes - modeling of material removal rate - accuracy and surface finish - advantages and limitations - various applications - Electro Chemical Grinding - Electro Chemical Deburring - Chemical etching process and its applications. (9)

Total L: 45

TEXT BOOKS:

1. Hassan Abdel, Gawad El-Hofy, "Advanced Machining Processes: Non Traditional and Hybrid Machining Process", 1st Edition, McGraw Hill, New York, 2005.
2. Jain V K, "Advanced Machining Processes", 1st Edition, Allied Publishers Pvt. Ltd., London, 2017.

REFERENCES:

1. James Brown, "Advanced Machining Technology Hand Book", 1st Edition, McGraw Hill, New Delhi, 1998.
2. Benedict G F, "Advanced Manufacturing Processes", 2nd Edition, Jain V K, New Delhi, 2016.
3. Pandey PC, "Advanced Methods of Machining", 2nd Edition, Chapman and Hill, New York, 2011.
4. Jain V K, "Modern Machining Processes", 1st Edition, Tata McGraw Hill, New Delhi, 1981.

19P012 SUPPLY CHAIN MANAGEMENT

3 0 0 3

SUPPLY CHAIN MANAGEMENT AND INVENTORY CONTROL: Meaning and definition - development chain - key issues in supply chain management (SCM) - introduction to inventory control- single stage inventory control - single period models - initial inventory - multiple order opportunities - risk pooling - centralized and decentralized systems - managing inventory in the supply chain - forecasting. (8)

VALUE OF INFORMATION: Introduction - bullwhip effect - information sharing and incentives - information for coordination of systems - information and supply chain trade-offs - supply chain integration - push, pull and push-pull system - demand driven strategies - impact of internet on supply chain strategies - benefits and risks of outsourcing. (12)

LOGISTICS AND INTERNATIONAL SUPPLY CHAIN MANAGEMENT: Logistics related business function - framework for strategic alliance - third-party logistics - retailer supplier partnerships - distributor integration - procurement and out servicing strategies - e-procurement - global market forces - managing global risks - requirements for global strategy implementation - issues in international supply chain management. (10)

COORDINATED PRODUCT AND SUPPLY CHAIN DESIGN: General framework - design for logistics – supplier integration into to new product development - mass customization - the dimensions of customer value. (7)

INFORMATION TECHNOLOGY FOR SCM: Goals of supply chain information technology - information technology standards - information technology infrastructure - Radio Frequency Identification (RFID) - point of sale data - benefits - supply chain efficiency. (8)

Total L: 45

TEXT BOOKS:

1. Simchi-Levi Davi, Kaminsky Philip, Simchi-Levi Edith, "Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies", Tata McGraw Hill, 2008.
2. Chopra S, Meindl P, "Supply Chain Management: Strategy, Planning and Operation", 2nd Edition, 2005.

REFERENCES:

1. Robert Jacobs F, William Berry, Clay Whybark D, "Manufacturing Planning and Control for Supply Chain Management", Tata McGraw Hill, 2011.
2. Michael Hugos, "Essentials of Supply Chain Management", John Wiley and Sons, Inc, New Jersey, 2011.
3. David Blanchard, "Supply Chain Management Best Practices", 2nd Edition, John Wiley and Sons Inc, 2010.
4. Michael H Hugos, "Essentials of Supply Chain Management", 4th Edition, John Wiley and Sons Inc, 2018.

19P013 PLC PROGRAMMING AND APPLICATIONS

3 0 0 3

PLC HARDWARE: Introduction – Internal architecture - IEC standard – Input / Output devices – signal conditioning serial and parallel communications, standards and protocols – distributed control – network standards – industrial communication systems. (8)

LADDER AND FUNCTIONAL PROGRAMMING: Ladder diagrams – logic functions – internal relays – latching – functional blocks – application of timers and counters. (12)

SUB-ROUTINES AND DATA HANDLING: Jump and Call – sub routines – shift registers – data handling – arithmetic functions – closed loop controls – applications. (8)

DESIGNING PLC SYSTEMS: Program development – safety systems – commissioning – fault detection – documentation. (8)

APPLICATIONS OF PLC: Material handling applications - Automatic control of warehouse door - Automatic lubricating oil supplier - Conveyor belt motor control - Automatic car washing machine - Bottle label detection - Process control application – industrial case studies. (9)

Total L: 45

TEXT BOOKS:

1. W Bolton, "Programmable Logic Controllers", 6th Edition, Elsevier, 2015.
2. Frank D Petruzella, "Programmable Logic Controllers", McGraw Hill Book Company, 2017.

REFERENCES:

1. John W Webb, Ronald A Reis, "Programmable Logic Controllers: Principles and Applications", Prentice Hall India, 2003.
2. William I Fletcher, "An Engineering Approach to Digital Design", Prentice Hall of India Limited, 1999.
3. Charles H Roth Jr, "Fundamentals of Logic Design", 6th Edition, Jaico Publishing House, New Delhi, 2007.

19P014 MECHANICAL VIBRATIONS

3 0 0 3

INTRODUCTION: Relevance of and need for vibrational analysis - mathematical modelling of vibrating systems - discrete and continuous systems - single degree of freedom systems - free and forced vibrations – various damping models. (8)

TWO DEGREES OF FREEDOM SYSTEMS: Generalized co-ordinates - principal co-ordinates - derivation of equations of motion - co-ordinate coupling - Lagrange's equation - dynamic vibration absorbers. (9)

MULTI DEGREES OF FREEDOM SYSTEMS: Derivation of equations of motion - influence coefficients – orthogonality principle - calculation of natural frequencies by Matrix, Rayleigh, Stodala, Dunkerley and Holzer methods. (10)

TRANSIENT VIBRATION: Impulse and arbitrary excitations - base excitation - laplace transform formulation - response spectrum. (6)

VIBRATION MEASUREMENT AND CONTROL: Tests and measurements of vibration - modal analysis - Fast Fourier Transform (FFT) analyzer - vibration measuring sensors and exciters - methods of vibration control - excitation reduction at source - balancing of rigid, flexible and variable mass rotors - viscoelastic polymers - condition monitoring of machines. (12)

Total L: 45

TEXT BOOKS:

1. Rao S S, "Mechanical Vibrations", Pearson Education, 2018.
2. Thomson W T, "Theory of Vibration with Applications", Pearson Education, 2008.

REFERENCES:

1. Raveesh Pratap, V P Singh, "Mechanical Vibrations", Dhanpat Rai Publishing Company (P) Ltd., New Delhi, 2014.
2. Ashok Kumar Mallik, "Principles of Vibration Control", Affiliated East- West Press Private Limited, 1990.
3. Seto, "Mechanical Vibrations", Schaum Outline Series, 1990.
4. Grover G K, "Mechanical Vibrations", Nem Chand and Brothers, Roorkey, 2009.

19P015 PRECISION MANUFACTURING

3 0 0 3

PRECISION ENGINEERING: Introduction - accuracy and precision - general concept of machine tool accuracy - four classes of achievable machining accuracy - examples - spindle rotation accuracy - influence of geometric accuracy of machine tools - applications - case studies. (9)

PRECISION MACHINING: Introduction - concepts of precision machining - turning - boring - drilling - milling - grinding - honing and lapping - examples - cutting tools - materials - classification - characteristics - examples. (8)

PRECISION AND ULTRA PRECISION MACHINE ELEMENTS: Introduction - guide ways - types - requirements - drive systems - classification-linear motor drive - spindle drive - rolling elements - hydrostatic and hydrodynamic bearings - pneumatic bearings - characteristics - examples. (9)

MICRO-MANUFACTURING: Bulk and surface machining - Lithographie, Galvanoformung, Abformung (LIGA) process - advances in lithography - dry and wet etching - thin film technology-sputtering - PVD-CVD - diamond turning - Electrolytic in-Process Dressing (ELID) grinding - mirror finish grinding of ceramics - micro extrusion - micro forming - laser micro welding - case studies. (10)

PRECISION MEASUREMENT TECHNIQUES: Classification of measuring system - laser based system - interference methods - surface profilers - S E M - Scanning Tunneling Microscope (STM) - AFM and on line measurement of dimensional features - examples. (9)

Total L: 45

TEXT BOOKS:

1. Murthy R L, "Precision Engineering in Manufacturing", 1st Edition, New Age International, New Delhi, 2009.
2. Venkatesh V C, Izman S, "Precision Engineering", 1st Edition, Tata McGraw Hill, New Delhi, 2007.

REFERENCES:

1. Jain V K, "Introduction to Micromachining", 2nd Edition, Varosha Publishers, New Delhi, 2010.
2. Joseph McGeough, "Micromachining of Engineering Materials", 1st Edition, CRC Press, New York, 2001.
3. Mark J M, "Fundamentals of Micro Fabrication", 1st Edition, CRC Press, New York, 2011.
4. Nakazawa H, "Principles of Precision Engineering", 1st Edition, Oxford University, 1994.

19P016 PRODUCT DEVELOPMENT STRATEGIES

3 0 0 3

CONCEPT GENERATION: Introduction - product design vs development - need - classification - product life cycle - cost - quality and servicing - customer need and analysis - concept generation - concept selection – product architecture - architecture types - product modularity and their types - examples. (9)

CONCEPT ENGINEERING: QFD - FMEA - Fault tree analysis - Design for six sigma - DFMA - design for safety, reliability and environment - product tear down approach - bench marking - Reengineering: Scanning methods - cloud points - NURBS surfaces - examples. (9)

PROTOTYPE AND TESTING: Prototype development - digital prototyping - physical prototyping - rapid prototyping - dimensional analysis and similitude - assembly and testing - Task: Types - selecting team members - collaborators and consultants - examples. (9)

MODERN TOOLS AND INDUSTRIAL DESIGN: Internet - concept of CPC - PDM/PLM - need for PLM - importance of PLM - Ergonomics: Anthropometric data - visual effects of line and form - color - Aesthetic concepts: Style – styling and design studio - examples. (9)

INTELLECTUAL PROPERTY RIGHTS: Introduction to IPR - Patent search and application - Patent ownership and transfer - Patent Infringement - new developments and International Patent Law - case studies. (9)

Total L: 45

TEXT BOOKS:

1. Karl T Ulrich, Steven D Eppinger, "Product Design and Development", 5th Edition, Tata McGraw Hill, New Delhi, 2004.
2. Kevin Otto, Kristin Woodd, "Product Design", 2nd Edition, Pearson, New Delhi, 2013.

REFERENCES:

1. Michael Grieves, "Product Life Cycle Management", 1st Edition, Tata McGraw Hill, New Delhi, 2006.
2. Chitale A K, Gupta R C, "Product Design and Manufacturing", 5th Edition, Prentice Hall of India, New Delhi, 2005.
3. George E Dieter, "Engineering Design", 1st Edition, Tata McGraw Hill, New York, 2009.

19P017 COMPOSITE MATERIALS PROCESSING

3 0 0 3

POLYMER MATRIX COMPOSITES: Need for composite development, classification of composite materials and advantages. Types and role of reinforcement. Characteristics of polymer matrix composites, matrix materials, rule of mixtures. Processing methods - manual lay-up, automated lay-up using tape laying machines, fibre placement machines, vacuum bag moulding, spray - up, filament winding, pultrusion and resin transfer moulding. (9)

MICROMECHANICS OF POLYMER MATRIX COMPOSITES: Evaluation of elastic moduli - strength of unidirectional and angle composite lamina. (9)

MACROMECHANICS OF POLYMER MATRIX COMPOSITES: Macro mechanical analysis of unidirectional and angle polymer matrix composite lamina - evaluation of stiffness matrices of polymer matrix composite laminates. (10)

METAL MATRIX COMPOSITES: Characteristics of metal matrix composites, matrix materials, processing methods solid state, liquid state and vapour deposition methods - applications. (8)

CERAMIC MATRIX COMPOSITES AND SECONDARY OPERATIONS ON COMPOSITES: Characteristics of ceramic matrix composites, matrix materials, processing methods - conventional mixing and pressing, slurry techniques, matrix transfer molding, sol-gel processing and deposition methods - applications. Secondary operations - cutting, machining and drilling to fabricate composite parts - adhesive bonding and mechanical fastening methods - challenges involved in secondary processing of composites. (9)

Total L: 45

TEXT BOOKS:

1. Autar K Kaw, "Mechanics of Composite Materials", 2nd Edition, CRC Press, New York, 2018.
2. Sanjay K Mazumdar, "Composites Manufacturing: Materials, Product and Process Engineering", CRC Press, New York, 2010.

REFERENCES:

1. Deborah D L Chung, "Composite Materials: Science and Applications Functional Materials for Modern Technologies", Springer, Verlag, London, 2009.
2. F L Matthews, R D Rawlings, "Composite Materials : Engineering and Science", CRC Press, New York, 2007.
3. Kishan K Chawla, "Composite Materials Science and Engineering", Springer, New Delhi, 2015.
4. Robert M Jones, "Mechanics of Composite Materials", Taylor and Francis, 2014.

19P018 INDUSTRIAL ERGONOMICS

3 0 0 3

INPUT MODALITIES: Ergonomics for productivity, safety, health and comfort, history of ergonomics, multi- disciplinary engineering, human-machine system - characteristics, information theory, coding, compatibility, memory, decision making, attention, text, graphics, symbols, selection of display modality - visual and auditory display, representational display, tactual and olfactory display, design of controls. (10)

ANTHROPOMETRY: Need for anthropometry, sources of human variability, data collection methodology, measuring procedures and tools, statistical analysis of measured data - percentile calculation, principles of applied anthropometry, ergonomic design guidelines for products, equipment and accessories, applications of anthropometry. (8)

WORK ERGONOMICS: Work station design for standing and seated workers, manual material handling, design of hand tools, muscles, structure, function and capacity, physical work capacity, measurement of physiological work, stress and fatigue, work-related musculoskeletal disorders, ergonomic interventions to prevent injuries, human thermoregulation, measurement, protection and thermal comfort. (10)

ILLUMINATION, NOISE AND VIBRATION: Vision and the eye, measurement of light, lighting design, visual fatigue, eyestrain, psychological aspects of indoor lighting, the ear, measurement of sound, ear protection, design of acoustic environment, industrial noise control, auditory environment outdoors, effects of noise on task performance and health, vibration, human error, safety and equipment design. (9)

VIRTUAL ERGONOMICS: Digital Human Modeling (DHM), anthropometric models, models for production design, biomechanical and anatomical models, DHM packages – selection strategies and functionalities, virtual ergonomics evaluation techniques – Rapid Upper Limb Assessment (RULA), field of vision, reach envelopes, accessibility and clearance analysis, discomfort analysis, applications of DHM. (8)

Total L: 45

TEXT BOOKS:

1. Bridger R S, "Introduction to Human Factors and Ergonomics", CRC Press, Taylor and Francis Group, 2017.
2. Martin Helander, "A Guide to Human Factors and Ergonomics", CRC Press, Taylor and Francis Group, 2005.

REFERENCES:

1. Christopher Nemeth, "Human Factors Methods for Design", CRC Press, Taylor and Francis Group, 2004.
2. Chakrabarthy D, "Indian Anthropometric Dimensions for Ergonomic Design Practice", National Institute of Design, Ahmedabad, 1997.
3. Duffy V G, "Hand Book of Digital Human Modelling: Research for Applied Ergonomics and Human Factor Engineering", CRC Press, Taylor and Francis Group, 2009.
4. Mark S Sanders, "Human Factors in Engineering and Design", McGraw Hill Education, 2013.

19P019 COMPUTATIONAL FLUID DYNAMICS

3 0 0 3

BASICS OF FLUID FLOW: Derivation of fluid flow governing equations - conservation of mass, momentum and energy - relationship between mathematical terms and characteristics of fluid flow, mathematical classification of flow, hyperbolic, parabolic, elliptic and mixed flow types. (9)

DISCRETISATION: Choice of grid - finite difference method – finite volume method- forward, backward and central difference schemes, explicit and implicit methods - properties of numerical solution methods, stability analysis, error estimation. (9)

NEED FOR CFD TECHNIQUES: Impact of non-conservation terms over the solution, artificial viscosity, upwind schemes, Cell Reynolds number, Courant number- Lax - Wendroff technique, MacCormack's technique, relaxation technique, ADI technique. (9)

CFD TECHNIQUE FOR INCOMPRESSIBLE FLUID FLOW: Checker board distribution, staggered grid – pressure correction technique, SIMPLE algorithm. (9)

APPLICATIONS: In heat transfer and fluid flow problems (9)

Total L: 45

TEXT BOOKS:

1. John D Anderson, "Computational Fluid Dynamics — The Basics with Applications", 1st Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2012.
2. Versteeg H K, Malalasekara W, "An Introduction to Computational Fluid Dynamics - The Finite Volume Method", 2nd Edition, Pearson Education India, 2007.

REFERENCES:

1. Muralidhar K, Sundararajan T, "Computational Fluid Flow and Heat Transfer", 2nd Edition, Narosa Publications, 2003.
2. Chung T J, "Computational Fluid Dynamics", 2nd Edition, Cambridge University Press, 2010.
3. Joel H Freziger, Milovan Peric, "Computational Methods for Fluid Dynamics", 3rd Edition, Springer Science and Business Media, 12.

19P020 SIX SIGMA

3 0 0 3

INTRODUCTION: Six sigma definition – DMAIC and DMADV deployment models – project reporting - project budgets - project records - six sigma teams – team membership - stages in group development - member roles and responsibilities - facilitation technique. (8)

DEFINE PHASE: Project charter - project decomposition – work breakdown structure - pareto analysis - deliverables – critical to quality metrics - critical to schedule metrics - critical to cost metrics - project scheduling – gantt charts - PERT - CPM. (8)

MEASURE AND ANALSE PHASES: Process definition – flowcharts - SIPOC - metric definition - capability analysis - SPC techniques - control chart selection - control chart interpretation - distributions - measurement system evaluation – Gage R & R - analyzing the source of variation – cause and effect diagram - box plots – statistical interference - regression - correlation - Design of Experiments (DOE). (11)

IMPROVE AND CONTROL PHASES: Improvement decisions – category importance weights - optimization using simulation - risk assessment tools - design review - fault - tree analysis - safety analysis - FMEA. Control phase - business process control planning – maintaining gains - tools and techniques useful for control planning - preparing the process control plan - process control planning for short and small runs - process audits – selecting process control elements. (11)

DESIGN FOR SIX SIGMA (DFSS): Design for six sigma quality - Quality Function Deployment (QFD) - TRIZ. (7)

Total L: 45

TEXT BOOKS:

1. Thomas Pyzdek, Paul Keller, "Six Sigma Handbook: Complete Guide for Greenbelts, Blackbelts and Managers at All Levels", Tata McGraw Hill Companies Inc, 2014.
2. Jay Arthur, "Lean Six Sigma – Demystified", Tata McGraw Hill Companies Inc, 2010.

REFERENCES:

1. Joseph De Feo, William Barnard, Juran Institute, "Juran Institute's Six Sigma Breakthrough and Beyond", The McGraw Hill Companies, 2004.
2. Michael L George, David T Rowlands, Bill Kastle, "What is Lean Six Sigma", McGraw Hill, New York, 2004.

3. Kai Yang, Basem El-Haik, "Design for Six Sigma", McGraw Hill, New York, 2004.
4. Donald W Benbow, Kubiak T M, "Certified Six Sigma Black Belt Handbook", Pearson Education, 2007.

19P021 ADDITIVE MANUFACTURING

3 0 0 3

BASICS AND CLASSIFICATION OF ADDITIVE MANUFACTURING: Fundamentals of Additive Manufacturing (AM) - historical development of AM - classifications of AM systems - information workflow in AM - impact of AM on product development - reverse engineering - digitization techniques - model construction. (9)

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 - other translators - newly proposed formats standard for representing layered manufacturing objects. (9)

SOLID AND LIQUID BASED ADDITIVE MANUFACTURING SYSTEMS: Fused Deposition Modeling (FDM) - Laminated Object Manufacturing (LOM) - Stereolithography (SLA) - Solid Ground Curing (SGC) - Shape Deposition Manufacturing (SDM) - JP-System 5 - polyjet printing - principle, details of processes, process variables, types, products, materials, advantages and applications. (9)

POWDER BASED AND OTHER ADDITIVE MANUFACTURING SYSTEMS: Selective Laser Sintering (SLS) - Selective Laser Melting (SLM) - Electron Beam Melting (EBM) - powder based beam deposition processes - printing processes - Three Dimensional Printing (3DP) - droplet formation technology - printing process modeling - principle, details of processes, process variables, types, products, materials, advantages and applications. (9)

ADDITIVE MANUFACTURING APPLICATIONS AND RAPID TOOLING: Applications of AM in aerospace industry, automotive manufacturing industry, biomedical field - magics software - rapid tooling - direct and indirect tooling - soft tooling vs hard tooling - process optimization - factors influencing accuracy - data preparation errors - part building errors - errors in finishing - influence of part build orientation. (9)

Total L: 45

TEXT BOOKS:

1. Gibson I, Rosen D W, Stucker B, "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.
2. Frank W Liou, "Rapid Prototyping and Engineering Applications: A Tool Box for Prototype Development", CRC Press, 2019.

REFERENCES:

1. Chua C K, Leong K F, Lim C S, "Rapid Prototyping: Principles and Applications", 2nd Edition, World Scientific Publishers, 2010.
2. Hilton P D, Jacobs P F, "Rapid Tooling: Technologies and Industrial Applications", CRC press, 2011.
3. Pham D T, Dimov S S, "Rapid Manufacturing", Verlag, 2011.

19P022 MEASUREMENT SYSTEMS

3 0 0 3

PRINCIPLES OF MEASUREMENT: Measurement systems, generalized configuration and functional descriptions of measuring instruments - examples - Static and Dynamic performance characteristics - Sources of error, Classification and elimination of error - Resistive potentiometers - Resistance strain gauge - Linear variable differential transformer - Variable inductance and variable reluctance pickups - Capacitive pickups - Eddy current non contacting transducers - Piezoelectric transducers - Ultrasonic transducers (10)

MOTION MEASUREMENT: Linear and rotary encoders - Linear and angular velocity measurements - Seismic motion transducers - Seismic instrument for vibrational displacement and velocity - Seismic accelerometer - Piezo electric accelerometers (8)

FORCE AND TORQUE MEASUREMENT: Measuring methods - Elastic transducers - Strain gauge load cells - Piezoelectric load cells - Hydraulic and pneumatic systems - Torque measurement by mechanical, hydraulic and electric dynamometers - Transmission dynamometers. (9)

TEMPERATURE MEASUREMENT: Liquid-in-glass thermometers - Bi-metal temperature sensing elements - thermistors - Thermocouples - RTD and thermopiles - Pyrometry - Optical and total radiation pyrometer - Infrared thermography - Calibration of temperature measuring devices (8)

FLOW AND PRESSURE MEASUREMENT: Variable area meter - Turbine type meter - Magnetic flow meter - Pulse producing methods - Pressure probes - Anemometry - Static and dynamic pressures - Elastic transducers - Secondary transducers used with elastic transducers - Strain gauge pressure cells - High pressure measurement gauges - Low pressure measurement (10)

Total L: 45

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems: Applications and Design", Tata McGraw Hill, New Delhi, 2006.
2. Beckwith T G, Marangoni and Lienhard, "Mechanical Measurements", Pearson Education, New Delhi, 2004.

REFERENCES:

1. Nakra B C, Choudhry K K, "Instrumentation, Measurements and Analysis", Tata McGraw Hill, New Delhi, 2005.
2. Richard S Figliola, Donald E Beasley, "Theory and Design of Mechanical Measurements", Wiley India, New Delhi, 2004.
3. Holmen J P, "Experimental Methods for Engineers", Tata McGraw Hill Publications Company Limited, New Delhi, 2004.
4. John G Webster, "Mechanical Variables Measurements", CRC Press, New York, 2000.

19P023 STATISTICAL QUALITY CONTROL

3 0 0 3

BASIC STATISTICS FOR QUALITY CONTROL: Introduction to quality - definition of quality - basic and modern quality tools - measures of location and dispersion - statistics and parameters - causes of variation and their characteristics - constant and variable system of chance causes - patterns of variation. (9)

CONTROL CHART FUNDAMENTALS AND APPLICATIONS: Variables and attributes - defects and defectives - statistical basis of the control chart - purpose of control charting - anatomy of a control chart - two types of errors - rational subgrouping - sensitizing rules - guidelines for implementing control charts - control chart for variables and attributes. (9)

ACCEPTANCE SAMPLING: Importance of sampling - weakness of certain traditional practices in acceptance sampling - single sampling - Operating Characteristic (OC) curve of an ideal sampling plan - Average Outgoing Quality (AOQ) and Average Outgoing Quality Limit (AOQL) - double sampling, multiple sampling, and sequential sampling - use of Dodge-Romig Tables in sampling inspection. (9)

REGRESSION: Definition - need for regression - simple linear probabilistic model for regression - assumptions - method of least squares - estimation of constants - ANOVA for linear regression - testing the usefulness of the model - coefficient of determination - checking the assumptions - multiple regression - general linear model and assumptions - ANOVA for multiple regression - interpretation of results - polynomial regression - limitations of regression. (9)

DESIGN AND ANALYSIS OF EXPERIMENTS: Classical design of experiments - single factor experiments - multiple factor experiments - randomized block design - latin square design - analysis of experimental results - Taguchi design of experiments - planning, analysis and conducting phases, analysis and interpretation of experimental results. (9)

Total L: 45

TEXT BOOKS:

1. Grant E M, Leavenworth R L, "Statistical Quality Control", Tata McGraw Hill, New Delhi, 2017.
2. Montgomery D C, "Design and Analysis of Experiments", Wiley India, New Delhi, 2012.

REFERENCES:

1. Ross P J, "Taguchi Techniques for Quality Engineering", Tata McGraw Hill, New Delhi, 2005.
2. Montgomery D C, "Statistical Quality Control: A Modern Introduction", Wiley India, New Delhi, 2010.
3. Mahajan M, "Statistical Quality Control", Dhanpat Rai and Co Pvt. Ltd., New Delhi, 2018.
4. Krishnaiah K, "Applied Statistical Quality Control and Improvement", PHI Learning Pvt. Ltd., New Delhi, 2014.

19P024 AUTOMATED ASSEMBLY SYSTEM DESIGN

3 0 0 3

AUTOMATED ASSEMBLY: Assembly process - historical perspective - why and when automated assembly - parts of automated assembly system (5)

PART FEEDING AND ORIENTING: Vibratory and mechanical feeder - mechanics - design parameters - feed rate considerations - Design of orientor - performance analysis of orienting system (12)

FEED TRACK, ESCAPEMENT AND PLACEMENT: selection and design of feed tracks - analysis - Types of escapements - placing mechanisms - robots in assembly (8)

QUANTITATIVE ANALYSIS OF ASSEMBLY SYSTEMS: Analysis of assembly systems with synchronous transfer - free transfer - Economics of automated assembly (10)

DESIGN FOR ASSEMBLY: Manual assembly design guidelines - handling time considerations - Automated assembly feeding orienting - insertion. Design rules for automated assembly - design for robot assembly - Feasibility study (10)

Total L: 45

TEXT BOOKS:

1. Geoffrey Boothroyd, "Assembly Automation and Product Design", CRC Press, 2005.
2. Mikell P Groover, "Automation, Production Systems and Computer - Integrated Manufacturing", Prentice Hall, New Delhi, 2007.

REFERENCES:

1. Geoffrey Boothroyd, Peter Dewhurst, Winston A Knight, "Product Design for Manufacture and Assembly", CRC Press, 2011.
2. Edwin H Zimmerman, "Getting Factory Automation Right (the First Time)", Manufacturing Engineers, 2001.
3. James A Rehg, "Introduction to Robotics in CIM Systems", Prentice Hall of India, 2002.

19P025 SUSTAINABLE MOBILITY AND LOGISTICS

3 0 0 3

EVOLUTION OF MOBILITY AND LOGISTICS: Need for sustainability in mobility and logistics - Multidisciplinary approach - Traffic and transport system - Accessibility - Travel behavior and travel resistance - Evolution of Indian road and rail network - Significance of Metro and Mono rails in mobility - role of ship, rail and air cargo in logistics - loading and unloading of goods - E-commerce: Authenticity and related policies. (12)

MOBILITY DETERMINANTS: Travel needs and demands - Demographical - Spatial and economic factors - Brevier law - Growth rate of sustainable mobility - Calibration of Green Technologies - ECO score - Model choice determinants - Traffic simulation models. (9)

LOGISTICS AND TRENDS: Requirement - General framework - Trends, Determinants, Indicators - Pre and post liberalization in India - Globalization and interdependency of economy - Centralization and rationalization of production and distribution - Changes in consumption patterns - Technological innovations (9)

INDICATORS: Link between GDP and transport - Competition between Traffic modes - Growth rate of sustainable logistics - Transported weight - Transport performance - Vehicle kilometer (6)

ENVIRONMENTAL ASSESSMENT: Environmental impacts - Contribution of vehicles to environmental stresses – External costs - Importance of vehicle emission norms - Alternate vehicle technologies - Life Cycle assessment of vehicles. (9)

Total L: 45

TEXT BOOKS:

1. Cathy Macharis, Joeri Van Mierlo, "Sustainable Mobility and Logistics", VUB Press, Brussels, 2013.
2. Anbalagan P, "Urban Development and Sustainable Transport", Bookwell publications, 2012.

REFERENCES:

1. Jo van Nunen, Paul Huijbregts, Piet Rietveld, "Transition towards Sustainable Mobility: New solutions and Approaches for Sustainable Transport systems", Springer, Berlin, 2014.
2. Ian J Kerr, "27 Down: New departures in Indian Railway Studies", Orient Blackswan Publications, 2007.
3. Erling Holden, "Achieving Sustainable Mobility - Everyday and Leisure-Time Travel in the EU", Ashgate Publishing, United Kingdom, 2007.
4. Werner Brilon, Felix Huber, Micheal Schreckenberg, "Traffic and Mobility: Simulation - Economics - Environment", Springer, New York, 1999.

19P026 WORK SYSTEM DESIGN

3 0 0 3

Productivity: Concept and importance of productivity – work-study and productivity - Taylor's scientific management - Gilbreth's contributions to work measurement –Types - measurement of productivity – models of productivity – scope of motion and time study – working conditions – OSHA - occupational safety – accidents –work methods design. (10)

Method study: Steps in method study - the movement of workers and material - string diagram, flow process chart, multiple activity chart, travel chart - principles of motion economy - classification of movements - two-handed process chart, micromotion study, THERBLIGS, cyclegraph and Chrono cyclegraph, SIMO chart.c (10)

Work measurement I: Purpose - uses -basic procedure - techniques of work measurement -steps involved in time study - time study equipment - stopwatch time study - performance rating - allowances - computation of standard time - case studies. (10)

Work measurement II: Work sampling and group timing technique, predetermined motion time system (PMTS), methods time measurements (MTM), Maynard Operation Sequence Technique (MOST). (7)

Ergonomics: Industrial ergonomics – anthropometry – man-machine system – layout of equipment – organization and methods – work analysis - job evaluation – merit rating – incentive schemes and wage administration. (8)

Total L: 45

TEXTBOOKS:

1. Lakhwinder Pal Singh, "Work Study and Ergonomics", Cambridge University Press, 2018.
2. International Labour Office (ILO), "Introduction to Work Study", CBS Publishers and Distributors Pvt. Ltd INDIA, 2015.

REFERENCES:

1. Barnes R M, "Motion and Time Study, Design and measurement of work", John Wiley Sons (Asia), Seventh edition, 2009.
2. Benjamin W. Niebel and AndrisFreivalds, "Methods, standards and Work Design", McGraw-Hill Education, 2013.
3. Bridger R S "Introduction to Human Factors and Ergonomics", CRC Press, 2017.
4. MartandTelsang, "Industrial Engineering and Production Management", S. Chand and Company Ltd, 2006.

ONE-CREDIT COURSES

19PF01 PRECISION MACHINING

1 0 0 1

CNC TURNING: Principles, types, machines, tools. (2)

CNC MILLING: Basic principles of milling, concepts of 3/4/5 axes, high speed milling, machine and controller types. (2)

ELECTRIC DISCHARGE MACHING (EDM): Wire and sinking EDM, principles, application. (1)

WORK AND TOOL HOLDING: Types, applications. (1)

COMPUTER-AIDED MANUFACTURING (CAM): Principles, softwares, examples. (2)

METROLOGY: Principles, measurements, examples. (1)

GEOMETRIC DIMENSIONING AND TOLERANCING (GD&T): Principles, examples. (1)

QUALITY MANAGEMENT: Principles, purpose, ISO, process orientation, non-quality dispositions. (1)

CONVENTIONAL PRECISION MANUFACTURING METHODS: For jig boring, jig milling, jig surface and cylindrical grinding. (2)

PRODUCTIVITY IMPROVEMENT: Types, measurement, overall equipment effectiveness /total effective equipment performance OEE/TEEP measurements, machine utilisation. Shop visit. (2)

Total L: 15

TEXT BOOKS:

1. Material Provided by "M/s. L&T", Coimbatore.
2. David A Dornfeld and Dae-Eun Lee, "Precision Manufacturing", Springer, 2007.
3. Murty R L, "Precision Engineering in Manufacturing", New Age International, 2005.

19PF02 NON DESTRUCTIVE TESTING OF AIRCRAFT STRUCTURES

1 0 0 1

INTRODUCTION TO NON DESTRUCTIVE TESTING: Liquid penetrant testing, magnetic particles testing, ultrasonic testing, eddy current testing, radiography, thermography, working principle, procedure of testing and analysis. (6)

RECENT TRENDS IN NDT: Vibration monitoring, holography and speckle methods, acoustic emission technique, other emerging methods, working principle and procedure of testing. (4)

NDT OF COMPOSITES: Various methods of testing, procedure and results, case studies. (2)

NDT IN MANUFACTURING AND MAINTENANCE: Importance of aircraft maintenance, procedure, critical issues and case studies. (2)

NDT AND DAMAGE TOLERANCE PHILOSOPHY: Importance of damage tolerant design and case studies. (1)

Total L: 15

REFERENCES:

1. Grandt Jr A F, "Fundamentals of Structural Integrity: Damage Tolerant Design and Nondestructive Evaluation", Wileys, October 2003.
2. Dowling N E, "Mechanical Behaviour of Materials", Pearson Education, 2014.
3. Halmshaw R, "Non-destructive Testing", Edward Arnold, London, 1987. Published in nine volumes by the American Society for Non-Destructive Testing.

19PF03 INTRODUCTION TO DESIGN AND MANUFACTURE OF ARMOUR SYSTEMS

1 0 0 1

- INTRODUCTION:** Historical perspective, basic concepts of armour systems (3)
- MECHANICAL BEHAVIOUR:** Dynamic behaviour of materials, dynamic impact testing, projectile characteristics. (3)
- MECHANICS:** Penetration mechanics, stress waves and shock behaviour. (3)
- ARMOUR MATERIALS:** Metallic armour, ceramic armour, composite armour, hybrid systems, personnel armour - design and testing. (3)
- ARMOUR FOR VEHICLES:** Design and testing, reactive armour systems, blast and ballistic testing (3)

Total L: 15

REFERENCES:

1. Paul J. Hazell, Armour: Materials, Theory and Design; 1st Edition, CRC Press, 2015, ISBN 978-1482238297.
2. Ian Crouch (Eds.), The Science of Armour Materials; 1st Edition, Woodhead Publishing, 2016, ISBN 978-0081010020.
3. T. Balakrishna Bhat and Vemuri Madhu, Composite Armour Materials and Modules, DRDO Monographs/Special Publications Series, 2017, ISBN: 978-8186514900.

19PF04 ADVANCED MATERIALS FOR ARMOUR APPLICATIONS

1 0 0 1

- INTRODUCTION:** Basic concepts, early applications of armour, fundamentals of materials and structures. (3)
- MECHANICAL BEHAVIOUR:** Static and Dynamic Behaviour of Materials, Projectile Materials and Behaviour. (3)
- METALLIC ARMOUR MATERIALS:** Processing and Properties of Steel, Aluminium, Mg and Ti. (3)
- CERAMIC ARMOUR MATERIALS:** Processing and Properties. (3)
- COMPOSITES ARMOUR MATERIALS:** Processing and Properties, Hybrid Armour Materials. (3)

Total L: 15

REFERENCES:

1. Paul J Hazell, "Armour: Materials, Theory, and Design", 1st Edition, CRC Press, 2015.
2. T Balakrishna Bhat, Vemuri Madhu, "Composite Armour Materials and Modules", DRDO Monographs/Special Publications Series, 2017.
3. Ian Crouch, "The Science of Armour Materials", 1st Edition, Woodhead Publishing, 2016.
4. Autar K Kaw, "Mechanics of Composite Materials", 2nd Edition, CRC Press, 2005.

HUMANITIES

19OFA1 EXPORT – IMPORT PRACTICES

1 0 0 1

INTRODUCTION : Export – Import Business – Preliminaries for starting Export – Import Business Registration. (3)

EXPORT PROCEDURES : Obtaining an Export License – Export Credit Insurance – Procedures and Documentation (4)

FOREIGN EXCHANGE : Finance for Exports – Pricing - Understanding Foreign Exchange Rates. (3)

IMPORT PROCEDURES : Import Policy – License - Procedure and Documentation. (3)

EXPORT INCENTIVES : Incentives - Institutional support (2)

Total L: 15

REFERENCES:

1. Ramagopal C , "Export Import Procedures - Documentation and Logistics", New Age International, 2014.
2. Cherian and Parab , "Export Marketing", Himalaya Publishing House, New Delhi, 2008.
3. Parul Gupta , "Export Import Management", MC-Graw Hill, 2017.
4. Justin Paul, Rajiv Aserkar , "Export Import Management", Oxford, 2013.

19OFA2 INSURANCE - CONCEPTS AND PRACTICES

1 0 0 1

INTRODUCTION TO INSURANCE AND RISK MANAGEMENT : Origin, History, Nature and Scope of insurance – Meaning, types and significance of risk. (3)

INSURANCE LAWS AND REGULATIONS : Insurance Act, IRDA Act, Consumer Protection Act, Ombudsman Scheme. (2)

INSURANCE UNDERWRITING AND RISK MANAGEMENT : Meaning of underwriting and underwriter, guidelines and steps in the process of underwriting – characteristics, significance and principles of risk management. (4)

FINANCIAL ASPECTS OF INSURANCE MANAGEMENT : Role and functions of financial institutions, determination of premium for various insurance products. (3)

SETTLEMENT OF INSURANCE CLAIMS : Documents needed during various claims, Factors affecting insurance claims (3)

Total L: 15

REFERENCES:

1. Scott Harrington, Gregory Niehaus , "Risk Management and Insurance", McGraw Hill Education, 2017.
2. George E Rejda , "Principles of Risk Management & Insurance", Pearson Education, 2017.
3. John Hull , "Risk Management & Financial Institution", John Wiley and Sons, 2018.
4. Arjun Mittal, D D Chaturvedi , "Insurance and Risk Management", Scholar Tech Press, 2017.

19OFA3 PUBLIC FINANCE

1 0 0 1

INTRODUCTION: Nature and Scope of public finance – Principles of taxation. (2)

PUBLIC REVENUE AND TAXATION: Sources of Revenue – Tax and non-tax revenue – Classification of Taxes, GST. (4)

PUBLIC EXPENDITURE: Importance – Types – Causes of increase in public expenditure – Effects of public expenditure in India. (3)

DEFICIT FINANCING AND BUDGET: Sources of public debt – Debt redemption – Budget – Types – Preparation of Budget in India. (3)

FEDERAL FINANCE: Centre-State financial relations – Finance commissions. (3)

TOTAL: 15

REFERENCE BOOKS:

1. Richard A Musgrave and Peggy B Musgrave, "Public Finance in Theory and Practice" – Tata McGraw Hill Education, New Delhi, 2004.
2. Bhatia H.L, "Public Finance" – Vikas Publishing House, 29th Edition, New Delhi, 2012.
3. David N Hyman, "Public Finance: A contemporary application of theory and policy", Cengage Publication, 11th Edition, Noida, 2014.
4. Santhosh Dalvi and Krishnan Venkatasubramanian, "An introduction to Goods and Service Tax: The biggest tax reform in India", CCH Publisher, New Delhi, 2015.

19OFA4 SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT**1 0 0 1****INVESTMENT ENVIRONMENT** : Financial Markets - Classification - Financial Instruments – Security Trading. (2)**TYPES OF SECURITIES** : Trading – Orders, Margin Trading – Clearing and Settlement Procedures. (5)**SECURITY ANALYSIS I** : Industry Analysis –Estimation of Rates of Return. (2)**SECURITY ANALYSIS II** : Company Analysis — Estimation of Rates of Return. (2)**PORTFOLIO MANAGEMENT** : Measuring Risk and Returns and Treatment in Portfolio Management. (4)**Total L: 15****REFERENCES:**

1. William F Sharpe, Gordon J. Alexander, Jeffery V Bailey , "Investments", Prentice Hall, 2012.
2. Prasanna Chandra , "Investment Analysis and Portfolio Management", TATA McGraw Hill Publishing, 2011.
3. Ranganathan , "Investment Analysis and Portfolio Management", Pearson, 2004.
4. Bhalla V K , "Investment Management", TATA McGraw Hill Publishing, 2011

19OFA5SOCIAL ENTREPRENEURSHIP**1 0 0 1****INTRODUCTION TO SOCIAL ENTREPRENEURSHIP:** Social Entrepreneur - Meaning, qualities and skills. Social Entrepreneurship – Characteristics, process and ecosystem – Case Studies. (3)**SOURCES OF FUNDING FOR SOCIAL ENTREPRENEURSHIP:** The Social Entrepreneurship Frame work. Start-ups and funding - Internal and External. Schemes for social entrepreneurship. (4)**STRATEGIES IN SOCIAL ENTREPRENEURSHIP:**Industry and Market Analysis, Business planning, concepts of value creation,new ideas and risk taking. (4)**PROSPECTS AND PROBLEMSIN SOCIAL ENTREPRENEURSHIP:** Opportunities for Social entrepreneurs, an overview of legal structure, tax structure and other liabilities. (4)**TOTAL: 15****REFERENCE BOOKS:**

- 1.S.S.Khanka, "Creativity and Innovation in Entrepreneurship", Sultan Chand & Sons, 2021.
- 2.C. Paramasivan, "Social Entrepreneurship", New Century Publications, 2016.
- 3.Robert A. Philips Margret Bonefiel Ritesh Sharma, "Social entrepreneurship, the next big business opportunity", Global Vision Publishing House, 2011.
- 4.Drucker, Peter, "Innovation and Entrepreneurship", Harper Business, 2006.

ENGLISH

19GF01 INTERPERSONAL AND ORGANIZATIONAL COMMUNICATION

1 0 0 1

INTRA ORGANIZATIONAL COMMUNICATION : Communication Networks in an Organization; Intra- organizational communication (2)

INTER ORGANIZATIONAL COMMUNICATION : Flow Nomenclature; Workplace diversity and intercultural aspects of communication (2)

COMMUNICATION FUNCTIONS IN ORGANIZATIONS : Teamwork and team dynamics; Conflict resolution strategies and styles; Leading and influencing others-facilitation skills (3)

WRITTEN COMMUNICATION : Email Writing, Professional Reports, and Memos (4)

INTERPERSONAL SKILLS : Nature and Dimensions of Interpersonal Communication; Personality and Communication styles; Active listening and intentional responding; Working with emotional intelligence (4)

Total L: 15

REFERENCES:

1. Bagchi Subroto , "The Professional", Penguin Publications, UK, 2011.
2. PMBOK guide , "A Guide to the Project Management Body of Knowledge", Project Management Institute Inc, USA, 2013.

19GF02 HUMAN VALUES THROUGH LITERATURE

1 0 0 1

PROSE : Kalam's vision of college education in Wings of fire - Emerson's advocacy of independence of Human will in Self-reliance - Harmony in Education-views of Betrand Russel (4)

POETRY : Maintaining Human relations in Robert Frost's Mending Wall - Quest for identity and freedom in Kamala Das's An Introduction (2)

DRAMA : Statesmanship and friendship in Girish Karnad's Tughlaq (3)

ONE-ACT PLAY : The theme of love in Chekhov's The Bear (3)

SHORT STORY : Empathy in Somerset maugham's Mr. Know-all - Family bond in Anita Desai's Devoted son (3)

Total L: 15

TEXT BOOKS:

1. Faculty - Department of English , "Course materials", PSG College of Technology, Coimbatore, 2019.

REFERENCES:

1. Abrams M .H, Harpham , "A Glossary of Literary Terms", Cengage, Boston, 2015.
2. Scholes R, et.al. , "Elements of Literature", IV, Indian Rpt. OUP, New Delhi, 2013.

19P100 INDUSTRIAL TRAINING I

0 0 10 5*

MODULE 1 – INTRODUCTION TO INDUSTRIAL ENVIRONMENT AND PRACTICES: Definition of industry, types of industry - product, process, hybrid; Different scales of operations - large, medium, small, tiny; Industry definitions and examples; Organizational structure and various departments, functions within an industry; Equipment and personal industrial safety (general and electrical) and discipline outside industries. [10]

MODULE 2 - FAMILIARIZATION OF MECHANICAL HAND TOOLS: Screw drivers, spanners, pliers, hammers, chisels and wrenches; Dismantling and assembly - CPU, pump, etc. [10]

MODULE 3 - FAMILIARIZATION OF ELECTRICAL AND ELECTRONICS TOOLS: Tester, clamp meter, multi meter, crimping, wire cutter, Philip screw drivers, soldering iron etc; Simple exercises - checking the fuse, junction box wiring, soldering a circuit, crimping of wires and USB socket. [10]

MODULE 4 - FAMILIARIZATION OF CARPENTRY HAND TOOLS: Chisel, mallets, jack planes, mortise gauge, hand saw, etc; Simple exercises - sawing and planning, nailing a wooden box, making of different type of joints, making a table /wooden box/ models. [10]

MODULE 5 - FAMILIARIZATION OF FITTING TOOLS: Files, hacksaw, tri-square, rulers, punches, chisel, etc; Simple exercises - filing, marking, cutting, fitting, forming. [10]

MODULE 6 - FAMILIARIZATION OF MEASURING TOOLS AND INSTRUMENTS: Measuring tape, foot ruler, vernier, micrometer, calipers, bore-dial, gauges, anemometer, hygrometer/sling psychrometer, thermo-couples, pyranometer, etc; Measurement of various pump components, wind speed, humidity, temperature, and radiation. [10]

MODULE 7 - FAMILIARIZATION OF PLUMBING TOOLS: Pipe wrench, threading die, etc; Simple exercises - threading of pipes, construction of water line using GI and PVC fittings etc. [20]

MODULE 8 - FAMILIARIZATION OF FOUNDRY TOOLS: Moulding boxes, board, trowels, riser and sprue pins, vent wires, strike bar, bellows, rammers, etc; Simple exercises - moulding of solid pattern, split pattern, core making, gate, runner and riser cutting, casting of simple component with aluminum etc. [20]

MODULE 9 - FAMILIARIZATION OF CIVIL TOOLS: Trowels, plumb block, water level, spirit level, etc; Simple exercises - making of small model with cement mortar, stacking of bricks as a wall, fabrication of reinforcement structures in MS, etc. [20]

MODULE 10 - CONCEPTS OF BASIC SCIENCE: Hands-on experiments relating to concepts of Basic Physics and Chemistry – Forces, Hooke's Law, Newton's Law, Work Energy Theorem, gyroscope, flow sensors, models mimicking human mechanisms – applications in industry. [20]

MODULE 11 - INDUSTRIAL VISITS: Motor and pump manufacturing, engineering machinery manufacturing and foundry. [10]

Total: P: 150

REFERENCES:

1. Module-wise "Industrial Training Manual" prepared by Training Department, PSG Industrial Institute.

19P200 INDUSTRIAL TRAINING II

0 0 10 5*

MODULE 1 – INTRODUCTION TO INDUSTRIAL SAFETY: Procedure, equipment, safety programme, safety standards, OSHA act, first aid and safety symbols. [10]

MODULE 2- DISMANTLING AND ASSEMBLY OF DOMESTIC APPLIANCES - Wet grinder, mixie, electric iron box, fan, etc. [10]

MODULE 3 – EXPOSURE AND HANDS ON EXERCISES ON DOMESTIC ELECTRICAL WIRING - Tube light fitting, two-way switch, fan and regulator, motor starter, etc. [10]

MODULE 4 – HANDS ON EXERCISES ON ELECTRONIC COMPONENTS: PC boards, bread boards, gates, microprocessors and other electronic components. [20]

MODULE 5 - DISMANTLING AND ASSEMBLY OF HYDRAULIC COMPONENTS - Water taps, flush tanks, hand pump and gear pump, valves, etc. [20]

MODULE 6 - HANDS ON EXERCISES ON ROTATING MACHINES – MONOBLOCK PUMPS - Winding, assembly, stator and rotor fabrication, inspection, painting, testing, balancing, and machining etc. [10]

MODULE 7 - HANDS ON EXERCISES ON ROTATING MACHINES – SUBMERSIBLE PUMPS - Winding, assembly, stator and rotor fabrication, inspection, painting, testing, balancing, and machining etc. [10]

MODULE 8 - HANDS ON EXERCISES – BASIC FOUNDRY PRACTICES – Understanding of fundamental Foundry processes and practices – melting, pouring, pattern-making, machining, testing and inspection. [10]

MODULE 9 - HANDS ON EXERCISES - BASIC LATHE ASSEMBLY – Headstock, tailstock, apron and feedbox, gearbox assembly. [10]

MODULE 10 – BASIC SCIENCE CONCEPTS: Hands-on experiments with wireless sensors – acceleration, pressure, light, current, voltage, heart rate, conductivity, spirometer, CO₂, O₂ - applications in Industry. [20]

MODULE 11 – INDUSTRIAL VISITS TO VARIOUS PROCESS INDUSTRIES [20]

Total: P: 150

REFERENCES:

1. Module-wise "Industrial Training Manual" prepared by Training Department, PSG Industrial Institute.

19P300 INDUSTRIAL TRAINING III

0 0 10 5*

MODULE 1 - POWER TRANSMISSION SYSTEMS I: Exposure to different modes of power transmission using V-belt and flat belt, rope, chain and sprocket, etc.; Development of schematic diagrams and models for typical applications. (10)

MODULE 2 - POWER TRANSMISSION SYSTEMS II: Familiarization of gear drive systems comprising spur gears, helical gears, bevel gears, worm and worm wheel and rack and pinion; Development of schematic diagrams and models for typical applications such as speedometer, wall clock mechanism, etc. (20)

MODULE 3 - MECHANISMS: Hands-on exercises on building replica of machines, mechanisms, bridges, and vehicles using miniature assembly kits, foam, wood, etc. (20)

MODULE 4 - SHEET METAL WORKING: Familiarization of sheet metal tools and processes; Making of simple sheet metal objects like dust pan, measuring jar, coin bank, etc., taking into consideration aesthetic, safety and ergonomic design aspects. (10)

MODULE 5 - WELDING I: Familiarization of welding tools and welded joints; Fabrication of simple objects like letter shapes, desk stand, window frame, ladder, etc. (20)

MODULE 6 - MACHINING: Hands-on exercises on machining of industrial components using operations like facing, plain turning, step turning, taper turning, chamfering, grooving, drilling, reaming, tapping, counter boring, countersinking, etc. (20)

MODULE 7 - METROLOGY: Measurement of geometrical parameters such as straightness, flatness, angularity and perpendicularity; Measurement of surface roughness; Calibration of instruments using slip gauges. (10)

MODULE 8 - ELECTRONIC CIRCUITS II: Assembly of simple electronic systems like electronic doorbell, digital clock, electronic horn, water level indicator, etc. (20)

MODULE 9 - E-LEARNING USING MANUFACTURING SOFTWARE PORTAL: Online manufacturing related certification modules on engineering drawing, joining processes, safety, and electrical systems. (10)

MODULE 10 - INDUSTRIAL VISITS: Visit to various process industries associated with food, milk, textiles etc. (10)

Total: P: 150

REFERENCES:

2. Sharma PC, "Machine Tools and Tool Design", S. Chand and Company, 2004.
3. Faculty of Mechanical Engineering, PSG College of Technology, "Design Data", Kalaiathir Achchagam, 2012.
4. HMT, "Production Technology", Tata McGraw Hill Ltd., 2009.
5. Daniel E Puncochar Ken Evans, "Interpretation of Geometric Dimensioning and Tolerancing", Industrial Press, 2011.

19P400 INDUSTRIAL TRAINING IV

0 0 10 5*

MODULE 1 - PREPARATION OF PROCESS CHART: Interpretation of production drawings, identification of part features and their corresponding manufacturing processes, tooling and inspection gauges; preparation of process chart. (10)

MODULE 2 - PREPARATION OF PRODUCTION DRAWING I: Creation of geometric models based on 2D drawings; Assigning limits, fits and tolerances, and surface finish based on the specified functional requirements; Preparation of production drawing using modeling software. (20)

MODULE 3 - MACHINING USING SPECIAL PURPOSE MACHINES: Introduction to jigs, fixtures, work and tool holding equipment; Hands-on exercises on machining typical engineering components using milling, grinding and shaping operations. (20)

MODULE 4 - CNC PART PROGRAMMING I: Generation of CNC codes for a given part using manual programming and automated programming using CAM software, and cycle time estimation. (20)

MODULE 5 - ADDITIVE MANUFACTURING TECHNIQUES: Building prototype models using additive manufacturing techniques. (10)

MODULE 6 - WELDING II: Familiarization of MIG and TIG welding techniques, fabrication of components and assemblies. (10)

MODULE 7 - DISMANTLING AND ASSEMBLY I: Dismantling and assembly of machine sub-assemblies like headstock, tailstock, apron box, thread and feed gear box. (10)

MODULE 8 - DISMANTLING AND ASSEMBLY II: Dismantling and assembly of automotive vehicles-two wheeler and BAJA vehicles. (20)

- MODULE9 - METALLURGICAL AND NON-DESTRUCTIVE TESTING:** Microstructure study on spheroidal graphite and steel castings; Hardness testing of various materials such as mild steel, cast iron, aluminium, brass, bronze, rubber and plastics; Ultrasonic, magnetic particle and die penetrant testing on shafts. (10)
- MODULE10 - E-LEARNING USING MANUFACTURING SOFTWARE PORTAL:** Online manufacturing related certification modules on machining, casting, heat treatment, plating, etc. (10)
- MODULE 11 - INDUSTRIAL VISITS:** Visit to various process industries such as cement, paper, automated foundries, dyeing industries. (10)

Total: P: 150

REFERENCES:

1. Daniel E Puncochar, Ken Evans, "Interpretation of Geometric Dimensioning and Tolerancing" Industrial Press, 2011.
2. Hoffman EG, "Jigs and Fixtures Design", Thomson Learning, 2005.
3. Pham D T, Dimov SS, "Rapid manufacturing", The technologies and applications of rapid prototyping", Springer-Verlag, 2001.
4. Little R L, "Welding and Welding Technology", Tata McGraw Hill, New Delhi, 2004.

19P500 INDUSTRIAL TRAINING V

0 0 10 5*

- MODULE 1 - DEVELOPMENT OF FREE HAND DRAWINGS:** Free hand sketching of orthographic views and sectional views of the parts of a typical assembly like pump assembly; Dimensioning the sketches after measurement of size of the features of the part and assembly. (10)
- MODULE 2 - DEVELOPMENT OF GEOMETRIC MODELS:** Conversion of free hand sketches of the selected assembly into geometric models using any solid modeling software; Preparation of bill of materials. (20)
- MODULE 3 - PREPARATION OF PRODUCTION DRAWING II:** Identification of fits and tolerances based on the application of the selected assembly; Determination of dimensional and geometrical tolerances, and surface finish for the part features. (10)
- MODULE 4 - PROCESS PLANNING AND COST ESTIMATION:** Identification of suitable manufacturing processes for various parts of the selected assembly; Preparation of process plans that highlight necessary tooling, spindle speeds and feeds; Cost estimation of parts and assembly. (20)
- MODULE 5 - MACHINING TIME CALCULATION:** Estimation of machining time for various parts of the selected assembly; Preparation of PERT/CPM charts. (10)
- MODULE 6 - CNC PART PROGRAMMING II:** Manual part programming for simple parts; Generation of part programs for complex parts of the selected assembly using CAM software; Cycle time analysis. (10)
- MODULE 7 - SHEET METAL MODELING:** Basics of sheet metal fabrication; Introduction to any one sheet metal modeling software; Design and modeling of sheet metal components for automotive, aerospace and naval applications. (20)
- MODULE 8 - FAMILIARIZATION OF SENSORS AND IOT:** Familiarization of types of sensors, signal amplifiers, A/D and D/A converters used in engineering applications; Measurement and control of parameters of equipment such as fan, motor, air-conditioner, etc., through mobile phone/internet. (20)
- MODULE9 - eLEARNING USING DIGITAL RESOURCE:** Learning and assessment through on-line manufacturing engineering related certification modules on metal forming, polymer processing, Industry 4.0 and additive manufacturing. (20)
- MODULE10 - INDUSTRIAL VISITS:** Visit to industries such as foundries with modern equipment, industries with automated production lines, etc. (10)

Total: P: 150

REFERENCES:

1. Kevin Otto, Kristin Wood, "Product Design: Techniques in Reverse Engineering and New Product Development", Pearson Education, 2006.
2. James D Meadows, "Geometric Dimensioning and Tolerancing", Marcel Dekkar, 2010.
3. Peter Smid, "CNC Programming Handbook", Industrial Press, Inc, 2007.
4. ASME, "Manufacturing Planning and Estimation - Hand Book", McGraw Hill, New York.

19P600 INDUSTRIAL TRAINING VI

0 0 10 5*

- MODULE 1 - MATERIAL PROCUREMENT:** Procurement of raw materials as per the bill of materials prepared for the selected assembly during Industrial Training V (MODULES 1 to 6). (10)
- MODULE 2 - MANUFACTURE OF PARTS:** Manufacture of the parts as per the process plans for the selected assembly using conventional and CNC machines. (90)
- MODULE 3 - ASSEMBLY OF PARTS:** Assembly of mechanical, electrical and electronic parts; Inspection of the assembly to ascertain the fits and tolerances; Painting / coating of parts. (30)
- MODULE4 - PERFORMANCE TESTING:** Testing of the completed assembly to evaluate the performance. (10)

MODULE5 - eLEARNING USING DIGITAL RESOURCE: Learning and assessment through on-line manufacturing engineering related certification modules on engine, compressor, axles, bearing and oil seal, brake, tire, mechanical power transmission. (10)

MODULE6 - INDUSTRIAL VISIT: Visit to industries involved in the manufacture of agricultural equipment, stone crusher, etc. (10)

Total: P: 150

REFERENCES:

1. Harry Peck, "Designing for Manufacturing", Pitman Publications, 1983.
2. Igor Karassik, Joseph Messina, Paul Cooper, Charles Heald, "Pump Handbook", McGraw Hill Professional, 2000.
3. Robert Matousek, "Engineering Design", London Blackie and Son (India) Ltd., 1974.
4. K C John, "Machine Drawing", PHI Learning Pvt. Ltd., 2009.

19P700 INDUSTRIAL TRAINING VII

0 0 10 5*

EXTERNAL INTERNSHIP: Internship at a suitable manufacturing industry and / or university within India or overseas as per the timeline indicated in the scheme of syllabus. (150)

NORMS AND GUIDELINES FOR INTERNSHIP:

The students of seventh semester will undergo Internship as detailed below.

No. of working hours - 8 hours per day or as instructed by the industry; students will strictly follow the industry norms and timings.

During the course of internship, students will study the following with respect to the industry, with specific emphasis on work allocation as provided by the Industry supervisor: Industry profile, product range, catalogue, infrastructure, turnover, labor force, industrial structure, location, layout, ISO9000 and other standards, product development, manufacturing and material handling systems, and quality systems.

Evaluation of students' performance during the internship will be carried out through faculty visit to industry, presentation, viva-voce and technical report.

Students will identify the scope for future assignments which could be extended as projects.

Total: P: 150

REFERENCE:

1. As this is an industry-oriented course, students will be governed by the regulations of the industry they are assigned to, and hence no specific reference books are prescribed.

19P800 INDUSTRIAL TRAINING VIII

0 0 10 5*

MODULE 1 - OVERVIEW OF NEW PRODUCT DEVELOPMENT (NPD): Overview of NPD process structure, NPD models, fuzzy front-end (FFE), product design, product implementation, fuzzy back-end, Intellectual property rights. (10)

MODULE 2 - CONCEPTUALIZATION OF NOVEL IDEA/PRODUCT: Conceptual design, performing design sensitivity analysis, idea screening and evaluation, SWOT analysis; Conceptualization of a novel idea/product. (10)

MODULE3 - DETAILED DESIGN: Design of the product/system – development of geometrical models of parts / assemblies, calculation of mechanical loads, loads on individual parts using free body diagrams, material selection, functional simulation of product/assembly, design for sustainability, ergonomics and aesthetics, development of production drawing. (50)

MODULE4 - FABRICATION AND TESTING: Fabrication of the product / assembly, testing and refinements. (60)

MODULE5 - INDUSTRIAL VISIT: Visit to industries involved in non-traditional machining, sheet metal process, composite material product manufacturing, etc. (10)

MODULE 6 – E-LEARNING USING MANUFACTURING SOFTWARE PORTAL: On-line manufacturing related certification modules in areas of gear, belt, transmission, quality and business excellence. (10)

Product should be exhibited and demonstrated at the end of the semester

Total: P: 150

REFERENCES:

1. Kevin Otto, Kristin Wood, " Product Design: Techniques in Reverse Engineering and New Product Development", Pearson Education, 2006.
2. Karl T Ulrich, Steven D Eppinger, "Product Design and Development", Tata McGraw Hill, New Delhi, 2016.
3. Michael Asbhy, "Material Selection in Mechanical Design", Butterworth-Heinemann, 2016.
4. Kenneth B Kahn, "The PDMA Handbook of New Product Development", John Wiley and Sons, Inc, 2013.

19P900 INDUSTRIAL TRAINING IX

0 0 10 5*

MODULE 1 - ENVIRONMENTAL AND SOCIETAL IMPACT OF INDUSTRY: Corporate social responsibility relevant to an industry, societal and environmental issues relating to industry and their possible solutions; regional, state, national and global statistics relating to manufacturing and industry. (20)

MODULE 2 - PREPARATION OF INDUSTRY ANNUAL REPORT: Factors and parameters relating to various aspects of industry, and preparation of an industry annual report. (10)

MODULE 3 - INDUSTRIAL STATUTES AND GOVERNANCE: Governance aspects of an industry, wages and salary administration, welfare benefits - ESI, PF, bonus, incentive schemes; statutes and labor law, standing orders, disciplinary action and domestic enquiry, negotiations with unions on wages and bonus, representation before tribunals, labor court; training and development, career planning and performance appraisals, rewards and incentive schemes, counselling and attrition planning, exit interviews, pollution norms and workmen's compensation act. (20)

MODULE 4 - INDUSTRY OPERATIONS AND FINANCIAL INDICES: Industry operational parameters and indices, financial performance indicators, assets and capital management, balance sheets and annual reports, pollution compliance reports. (10)

MODULE 5 - ENTREPRENEURIAL SKILL: Entrepreneurial competencies, creative and idea generation, out of the box thinking, spin-off and knowledge transfer, fund generation, government norms and support for entrepreneurs, Intellectual property rights. (20)

MODULE 6 - SALES: Identification of prospective buyers, handling objections, competition management sales forecasting, planning and analysis - on field sales of products in campus and nearby. (20)

MODULE 7 - MARKETING: Preparation of brochures and promotional materials, online marketing of a product, lead generation for sales team. (10)

MODULE 8 - INDUSTRIAL ENGINEERING: Design of experiments, statistical data analysis and hypothesis testing, inventory analysis, manufacturing systems simulation, line balancing of systems, poka-yoke, radio frequency identification techniques. (30)

MODULE 9 - INDUSTRIAL VISIT: Visit to specific theme oriented industry, sales and marketing departments in industries. (10)

REFERENCES:

1. R K Jain, Sunil S Rao, "Industrial Safety, Health and Environment Management Systems", Khanna Publishers, 2000.
2. Taxmann, Labour Laws, Taxmann's Store, 2019.
3. James Riggs, David Bedworth, Sabah Randhawa, "Engineering Economics", 4th Edition, Tata McGraw Hill, 2004.
4. Nandan H, "Fundamentals of Entrepreneurship", Prentice Hall India, New Delhi, 2013.