

**BE MECHANICAL ENGINEERING**  
**SEMESTER - VII**  
**19M701 FINITE ELEMENT ANALYSIS**

**3 0 0 3**

**STATIC ANALYSIS USING ONE DIMENSIONAL SPAR ELEMENTS** : Basic concepts of FEM, general procedure of FEM, discretization of domain, basic types of elements; Formulation of element stiffness matrices and load vectors: 1D linear spar and quadratic spar elements, plane truss element, treatment of boundary conditions and temperature effects; Solution of problems. (9)

**STATIC ANALYSIS USING ONE DIMENSIONAL BEAM ELEMENTS** : Beam element : Hermite shape functions, formulation of element stiffness matrix and load vectors; Beams on elastic foundation; Problems using one dimensional beam element. (10)

**STATIC ANALYSIS USING TWO DIMENSIONAL ELEMENTS** : Isoparametric formulation, 2D triangular and quadrilateral elements, element stiffness matrices and load vectors, problems using two dimensional elements; Introduction to higher order elements. (10)

**DYNAMIC ANALYSIS** : Equations of motion for dynamic problems using one dimensional spar, truss and beam elements, formulation of consistent and lumped mass matrices, solving free vibration problems using one dimensional elements. (8)

**HEAT TRANSFER ANALYSIS** : Basic equations of heat transfer and fluid flow, finite element formulation and solution of one dimensional heat transfer problems involving steady state heat conduction and convection. (8)

**Total L: 45**

**TEXT BOOKS:**

1. Tirupathi R. Chandrupatla, Ashok D. Belegundu , "Introduction to Finite Elements in Engineering", 4<sup>th</sup> Edition, Pearson, 2011.
2. Daryl L Logan , "A First Course in Finite Element Method", 6<sup>th</sup> Edition, Cengage Learning, 2016.

**REFERENCES:**

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt , "Concepts and Applications of Finite Element Analysis", 4<sup>th</sup> Edition, Wiley India Pvt Ltd, New Delhi, 2007.
2. Bhavikatti S S , "Finite Element Analysis", 1st Edition, New Age International, 2015.
3. Reddy J N , "An Introduction to Finite Element Method", 3rd Edition, McGraw Hill Education, 2015.
4. Dixit U S , "Finite Element Methods for Engineers", 1<sup>st</sup> Edition, Cengage Learning India Pvt. Ltd, 2009.

**19M710 FINITE ELEMENT ANALYSIS LABORATORY**

**0 0 2 1**

**LIST OF EXERCISES :**

1. Static structural analysis using 1D and 2D elements.
2. Static structural analysis using 3D elements.
3. Dynamic (Modal/harmonic/transient dynamic) analysis of mechanical parts.
4. Stress analysis of mechanisms.
5. Steady state thermal analysis of typical components.
6. Transient thermal analysis of components and processes.
7. Thermo-mechanical analysis of components.
8. Fluid flow analysis of pipes, nozzle, diffuser, etc.
9. Topology optimization of material layout for complex parts.
10. Fatigue analysis to ascertain product durability. (26)

**CASE STUDY :**

1. Finite element analysis of sub-systems/complex components of typical mechanical systems followed by design sensitivity analysis. (4)

**Total P: 30**

**REFERENCES:**

1. Department of Mechanical Engineering , "Finite Element Analysis Laboratory Manual", PSG College of Technology, 2019.
2. Nithin S Gokhale, Sanjay S Deshpande, Sanjeev V Bedekar, Anand N Thite , "Practical Finite Element Analysis", 1<sup>st</sup> Edition, Finite to Infinite, Pune, 2008.
3. Tirupathi R. Chandrupatla, Ashok D. Belegundu , "Introduction to Finite Elements in Engineering", 4<sup>th</sup>

Edition, Pearson, 2011.

4. Daryl L Logan , "A First Course in Finite Element Method", 6<sup>th</sup> Edition, Cengage Learning, 2016.

### 19M720 PROJECT WORK – I

0 0 4 2

- Identification of a real life problem in thrust areas
- Review of literature and identification of gaps
- Framing of objectives and methodology of work considering available resources
- Preparation of time line of activities
- Execution of preliminary work
- Preparation of consolidated report

Total P : 60

### SEMESTER - VIII

### 19M820 PROJECT WORK – II

0 0 8 4

Execution of work for the problem identified taking into consideration the following aspects :

1. Development of appropriate analytical/numerical/empirical models
2. Development of prototype wherever applicable
3. Testing and validation of model
4. Analysis and interpretation of results
5. Cost benefit analysis wherever applicable
6. Preparation of consolidated report

Total P:120

### PROFESSIONAL ELECTIVES

### 19M001 GEOMETRIC MODELING

3 0 0 3

**OVERVIEW OF CAD SYSTEMS AND GRAPHICS TRANSFORMATION :** Conventional and computer aided design processes; Subsystems of CAD: CAD hardware and software, graphics packages, CAD workstations; Networking of CAD systems; Generative, cognitive and image processing graphics, static and dynamic data graphics; Transport of graphics data; Graphic standards, generation of graphic primitives, display and viewing, transformations customizing graphics software. (11)

**MATHEMATICAL REPRESENTATION OF CURVES AND SURFACES :** Wireframe modeling and its limitations; Parametric representation of analytic curves, parametric representation of synthetic curves - Cubic spline, Bezier, B-spline, NURBS, curve manipulation; Surface models: Types of surfaces, parametric representation of surfaces, design examples. (9)

**MATHEMATICAL REPRESENTATION OF SOLIDS :** Fundamentals of solid modeling: Boundary representation, constructive solid geometry, solid manipulations, solid modeling based applications. (9)

**VISUAL REALISM AND COMPUTER ANIMATION :** Model cleanup - hidden line removal algorithms; Shading algorithms; Computer animation: Animation systems, design applications. (8)

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

Total L: 45

#### TEXT BOOKS:

1. Ibrahim Zeid , "CAD/CAM Theory and Practice", 2<sup>nd</sup> Edition, McGraw Hill Inc, New Delhi, 2009.
2. Groover M.P, Zimmers, E.W. , "CAD/CAM: Computer Aided Design and Manufacture", Prentice Hall, 1984.

#### REFERENCES:

1. Radhakrishnan P, Subramanyan S and Raju V, "CAD/CAM/CIM", New Age International, 2012.
2. Radhakrishnan P and Kothandaraman C , "Computer Graphics and Design", Dhanpat Rai and Sons, 2015.
3. Rogers D F, Adams, J. A , "Mathematical Elements for Computer Graphics", 2<sup>nd</sup> Edition, McGraw Hill Education, New Delhi, 2002.

4. Michael E Mortenson , "Geometric Modeling", John Wileyand Sons Inc, 1997.

### 19M002 ADVANCED STRENGTH OF MATERIALS

3 0 0 3

**CURVED BEAMS** : Circumferential stress at a point in a curved beam- Wrinkler Bach formula and limitations; Curved beam with restrained ends; Closed ring subjected to concentrated load and uniform load. (8)

**TORSION OF NON CIRCULAR SECTIONS** : Torsion of bar having rectangular section; Elastic membrane analogy for hollow thin walled tubes. (9)

**BEAMS ON ELASTIC SUPPORTS** : Beam with a concentrated load; Use of principle of superposition- beam supported on equally spaced elastic supports, UDL over part of the beam. (9)

**FLAT PLATES IN BENDING** : Flat plates subjected to small deflections; Stresses in a circular plate with UDL - simply supported and fixed edges-concentrated load; Stresses in square and rectangular plates with UDL, concentrated load at center. (9)

**THICK WALLED CYLINDERS AND ROTATING DISKS** : Lamé's solution for principal stresses, maximum stresses, radial deflection, failure theories, applications; Methods of increasing the elastic strength by pre-stressing, analysis of effects of stresses of shrinking a hollow cylinder made of thin walled laminations, auto fretting; Solid disk, disk with a central hole with external and internal pressures, disks of uniform strength, plastic collapse of rotating disks; Rotating circular cylinders, disk of varying thickness. (10)

**Total L: 45**

#### TEXT BOOKS:

1. Boresi AP and Schmidt R J , "Advanced Strength of Materials", John Wiley and Sons, New Delhi, 2002.
2. Sadhu Singh , "Theory of Elasticity", 4<sup>th</sup> Edition, Khanna Publishers, New Delhi, 2015.

#### REFERENCES:

1. Cook R D and Young , "Advanced Mechanics of Materials", 2<sup>nd</sup> Edition, John Wiley, New Delhi, 1999.
2. Den Hartog , "Advanced Strength of Materials", 2<sup>nd</sup> Edition, McGraw Hill Inc, New Delhi, 1987.
3. Rajput R K , "Strength of Materials", 5<sup>th</sup> Edition, S. Chand & Co. Ltd, New Delhi, 2010.
4. Saul K Fenster, Ansel C Ugarwal , "Advanced Mechanics of Materials and Applied Elasticity", 5<sup>th</sup> Edition, Pearson Education, New Delhi, 2011.

### 19M003 ADVANCED FINITE ELEMENT ANALYSIS

3 0 0 3

**AXISYMMETRIC AND HIGHER ORDER ELEMENTS** : Axisymmetric triangular element: Formulation of stiffness matrix and load vectors, problem modelling and boundary conditions, solution of problems; Higher order triangular and quadrilateral elements; Overview of three dimensional elements. (9)

**BENDING OF PLATES AND SHELLS** : Review of elasticity equations; Bending of plates and shells – finite element formulation of plate and shell elements, conforming and non-conforming elements, C0 and C1 continuity elements, degenerated shell elements, application and examples. (10)

**NON-LINEAR ANALYSIS - MATERIAL NON-LINEARITY** : Introduction, non-linear differential equation, solution procedures for non-linear problems, linearization and directional derivative; Material non-linearity: Analysis of axially loaded bars, significance of sampling rate, material models for isotropic, orthotropic, anisotropic and hyper-elastic materials, hardening rules. (10)

**NON-LINEAR ANALYSIS - GEOMETRIC NON-LINEARITY** : Geometric non-linearity: Basic continuum mechanics concepts, governing differential equations and weak forms; Introduction to contact problems. (8)

**TIME-DEPENDENT ANALYSIS** : Numerical integration in time, natural frequencies of one dimensional bar, time dependent one-dimensional bar analysis; Time dependent heat transfer -transient thermal analysis; Solution of one dimensional problems. (8)

**Total L: 45**

#### TEXT BOOKS:

1. Logan D L , "A First Course in the Finite Element Method", 6<sup>th</sup> Edition, Cengage Learning, 2015.
2. M. Asghar Bhatti , "Fundamental Finite Element Analysis and Applications", 1<sup>st</sup> Edition, John Wiley & Sons, USA, 2005.

**REFERENCES:**

1. K J Bathe , "Finite Element Procedures", 2<sup>nd</sup> Edition, Prentice Hall, 2007.
2. Timoshenko S, Woinowsky Krieger , "Theory of Plates and Shells", 2<sup>nd</sup> Edition, McGraw-Hill, 2017.
3. Cook R D, Malkus D S and Plesha M E , "Concepts and Applications of Finite Element Analysis", Wiley India Pvt Ltd, New Delhi, 2007.
4. Bhavikatti S S , "Finite Element Analysis", New Age International, 2015.

**19M004 FAILURE ANALYSIS AND DESIGN****3 0 0 3**

**MATERIALS AND DESIGN** : Factors affecting the behavior of materials in components, effect of component geometry and shape factors, designing with high strength and low toughness materials, designing for hostile environments, the design process; Materials selection in design; Processes and their influence on design, systematic process selection. (10)

**FRACTURE MECHANICS** : Ductile fracture, brittle fracture, cleavage-fractography, ductile-brittle transition, fracture mechanics approach to design-energy criterion, stress intensity approach; Time dependent crack growth and damage; Linear elastic fracture mechanics: Griffith theory, energy release rate, instability and R-curve, stress analysis of cracks-stress intensity factor, K-threshold, crack growth instability analysis, crack tip stress analysis; Elastic plastic fracture mechanics: Crack tip opening displacement (CTOD), J-integral, relationship between J and CTOD. (10)

**DYNAMIC FRACTURE AND DETERMINATION OF FRACTURE TOUGHNESS VALUES** : Dynamic fracture, rapid loading of a stationary crack, rapid crack propagation, dynamic contour integral, creep crack growth-C Integral, viscoelastic fracture mechanics, viscoelastic J integral; Determination of fracture toughness values: Experimental determination of plane strain fracture toughness, K- R curve testing, J measurement, CTOD testing. (9)

**WEAR FAILURES** : Types of wear, different methods of wear measurement, analysis of wear failures, wear at elevated temperatures, wear of different materials, role of friction on wear, stick slip friction, creep, stress rupture, elevated temperature fatigue, environment induced failure. (8)

**FAILURE ANALYSIS TOOLS** : Reliability concept and hazard function, life prediction, life extension, application of Poisson, exponential and Weibull distributions for reliability, bath tub curve, parallel and series systems, MTBF, MTTR, FMEA-design FMEA, process FMEA, analysis of causes of failure modes, ranks of failure modes; Fault tree analysis; Industrial case studies on FMEA (8)

**Total L: 45****TEXT BOOKS:**

1. Anderson T L , "Fracture Mechanics: Fundamentals and Applications", 4<sup>th</sup> Edition, Taylor and Francis, 2017.
2. Michael F Ashby , "Materials Selection in Mechanical Design", 3<sup>rd</sup> Edition, Butterworth – Heinemann, 2016.

**REFERENCES:**

1. ASM Metals Handbook Volume 11 , "Failure Analysis and Prevention", 10<sup>th</sup> Edition, ASM International, 2002.
2. Shigley and Mische , "Mechanical Engineering Design", 5<sup>th</sup> Edition, McGraw Hill, 2011.
3. John M Barsom and Stanley T Rolte , "Fracture and Fatigue Control in Structures", 3<sup>rd</sup> Edition, American Society For Testing & Materials, 1999.
4. Balbir S. Dhillon , "Applied Reliability and Quality: Fundamentals, Methods and Procedures", 1<sup>st</sup> Edition, Springer Series in Reliability Engineering, 2010.

**19M005 VIBRATION AND NOISE ENGINEERING****3 0 0 3**

**VIBRATION CONCEPTS AND SINGLE DEGREE OF FREEDOM SYSTEMS** : Relevance of and need for vibrational analysis; Mathematical modeling of vibrating systems: Discrete and continuous systems; Single degree of freedom systems; Free and forced vibrations; Various damping models. (9)

**TWO DEGREES OF FREEDOM SYSTEMS** : Generalized co-ordinates, principal co-ordinates: Derivation of equations of motion for two degree of freedom systems, co-ordinate coupling, Lagrange's equation. (9)

**MULTI DEGREES OF FREEDOM SYSTEMS** : Derivation of equations of motion, influence coefficients, orthogonality principle; Determination of natural frequencies: Rayleigh, Stodala, Dunkerley, Holzer and matrix iteration methods; Branched systems, geared systems. (9)

**TRANSIENT VIBRATION** : Impulse and arbitrary excitation, base excitation; Laplace transform formulation, response spectrum. (8)

**VIBRATION AND NOISE MEASUREMENTS AND CONTROL** : Free and forced vibration tests; Measurement of vibration: FFT

analyzer; Methods of vibration control: Excitation reduction at source, balancing of rigid, flexible and variable mass rotors; Dynamic properties and selection of structural materials: Viscoelastic polymers, vibration absorbers- tuned absorber, tuned and damped absorber (qualitative treatment only), untuned viscous damper, vibration isolation; Noise: Properties of sound, sound level meter, sound isolation – machine enclosures, silencers and mufflers. (10)

**Total L: 45**

**TEXT BOOKS:**

- 1.Thomson W T , "Theory of Vibration with Applications", 5<sup>th</sup> Edition, CBS Publishers and Distributors, New Delhi, 2008.
- 2.Singiresu S. Rao , "Mechanical Vibrations", 6<sup>th</sup> Edition, Pearson Education, 2008.

**REFERENCES:**

- 1.Tse, Morse and Hinkle , "Mechanical Vibration –Theory and Applications", CBS Publishers & Distributors, 2004.
- 2.Grover G K , "Mechanical Vibrations", New Chand and Brothers, Roorkey, 2009.
- 3.S. Graham Kelly , "Mechanical Vibrations, Schaum's Outline Series", McGraw Hill Book Company, New Delhi, 1996.
- 4.A.G. Ambekar , "Mechanical Vibrations and Noise Engineering", 2<sup>nd</sup> Edition, PHI Learning Private Limited, 2006.

### **19M006 MECHANICAL DESIGN OF CNC MACHINE TOOLS**

**3 0 0 3**

**DESIGN OF MACHINE TOOL STRUCTURES :** Concepts of CNC machine tools, types of CNC machine tools; Design criteria for machine tool structures: Stiffness and rigidity of the individual structural elements and their combined behavior under static and dynamic loads; Basic design procedure for machine tool structures: Bed, column and housing. (10)

**DESIGN OF SPINDLES :** Types of spindles: belt driven spindles, gear driven spindles, direct drive spindles and integral rotor spindles; Functions and requirements of spindles, spindle materials, design of spindles and selection of spindle bearings. (8)

**DESIGN OF GUIDEWAYS AND DRIVE ELEMENTS :** Functions and requirements of guide ways, guideway types; Selection of ball screws; Sizing of servomotor and linear motor. (8)

**MACHINE TOOL PERFORMANCE AND PRECISION :** Accuracy, repeatability and resolution; Sources of errors in machine tools: Thermal errors, CNC interpolation errors, calibration of CNC machines, error compensation; Overview of ISO and Indian standards for calibration of machine tools. (9)

**PROTOTYPE TESTING AND EVALUATION :** Purpose of machine tool testing: Static and dynamic measurements; Experimental modal analysis: Frequency response function measurement, modal curve fitting and modal parameter extraction; Type of geometrical checks on machine tools, use of laser for alignment testing, final alignment inspection. (10)

**Total L: 45**

**TEXT BOOKS:**

- 1.Mehta N K , "Machine Tool Design and Numerical Control", 3<sup>rd</sup> Edition, Tata McGraw Hill publishing Co.Ltd, New Delhi, 2012.
- 2.Lopez de Lacalle L N and Lamikiz A , "Machine Tools for High Performance Machining", 1<sup>st</sup> Edition, Springer- Verlag London Limited, 2009.

**REFERENCES:**

1. Basu S K and Pai D K , "Design of Machine Tools", 5<sup>th</sup> Edition, Oxford and IBH publishing Co. Pvt Ltd, New Delhi, 2009.
2. Radhakrishnan P , "Computer Numerical Control (CNC) Machines", 1<sup>st</sup> Edition, New Central Book Agency (P) Limited, 1992.
3. Sen G C and Bhattacharya A , "Principles of Machine Tools", 2<sup>nd</sup> Edition, New Central Book Agency (P) Limited, Kolkatta, 2009.
4. Koenigsberger F , "Design Principles of Metal-Cutting Machine Tools", 1<sup>st</sup> Edition, Pergamon Press, 1964.

### **19M007 THEORY OF ELASTICITY AND PLASTICITY**

**3 0 0 3**

**ANALYSIS OF STRESS AND STRAIN :** Stress at a point; Stress tensor, stress transformations, principal stresses, octahedral stresses, equations of equilibrium; Strain tensor, principal strains, strain-displacement relations, compatibility conditions; Strain gages and rosettes. (9)

**CONSTITUTIVE EQUATIONS:** General theory: Generalized Hooke's law, theorems of elasticity, equations of elasticity; Plane

stress and plane strain conditions. (8)

**ELASTICITY PROBLEMS** : Formulation of general elasticity problem, boundary conditions, two dimensional problems in rectangular and polar coordinates; Airy's stress function and relations. (8)

**PLASTICITY**: Plastic flow: Microscopic and macroscopic descriptions, stress-strain curves of real materials, definition of yields criterion, and concept of a yield surface in principal stress space; Yield criteria - Tresca and Von Mises criteria. (10)

**PLASTIC STRAIN ANALYSIS** : Prandtl-Reuss and Levy-Mises equations; Deformation in plane stress: Yielding of thin sheet in biaxial and uniaxial tension; Plane strain deformation: Stress tensor, hydrostatic and deviatoric components, plastic potential, plastic instability, effect of strain rates and temperature on flow stress; Introduction to slip line field theory. (10)

**Total L: 45**

**TEXT BOOKS:**

1. Timoshenko S P, Goodier J N. T , " Theory of Elasticity", 3<sup>rd</sup> Edition, Tata McGraw Hill Publications, 2010.
2. Chakrabarthy J , "Theory of Plasticity", 3<sup>rd</sup> Edition, Butterworth-Heinemann, 2012.

**REFERENCES:**

1. Durelli A J, Phillips E A and Tsao C H , "Introduction to Theoretical and Experimental Analysis of Stress and Strain", 1<sup>st</sup> Edition, McGraw Hill Publications, 1958.
2. Martin H Sadd , "Elasticity: Theory, Applications and Numerics", 3<sup>rd</sup> Edition, Elsevier, 2014.
3. Dieter G E , "Mechanical Metallurgy", McGraw Hill, 2017.
4. Calladine C R , "Plasticity for Engineers Theory and Applications", 2<sup>nd</sup> Edition, Woodhead publishing series, 2000.

## 19M008 MECHANICS OF COMPOSITE MATERIALS

**3 0 0 3**

**INTRODUCTION** : Modern materials in design: Types, metals, polymers, ceramics, composites; Polymers: Classification, properties of thermo plastics, properties of thermo setting plastics, applications, merits and demerits; Classification of composites: advantages, applications; Matrices and reinforcements: roles, classification, properties and composite structures. (8)

**PROCESSING AND CHARACTERISTICS OF COMPOSITES** : Manufacture of polymer matrix composites: Layup and curing, open and closed mould processes, bag moulding, filament winding, pultrusion, pulforming, thermoforming, advantages and limitations of different processes; Manufacture of metal matrix and ceramic matrix composites, advantages, limitations and characteristics of ceramic and metal matrix composites. (9)

**MICRO MECHANICAL BEHAVIOUR OF A LAMINA**: Volume and mass fractions: Density and void content, evaluation of elastic moduli, ultimate strengths of unidirectional lamina; Coefficients of thermal and moisture absorption. (8)

**MACRO MECHANICAL BEHAVIOUR OF A LAMINA** : Stress strain relationships: Generalized Hook's Law for different types of materials, 2D unidirectional and angular lamina, co-ordinate transformation, material symmetry; Evaluation of elastic moduli, engineering constants for unidirectional and angular lamina; Strength failure theories of unidirectional and angular lamina. (10)

**MACRO MECHANICAL BEHAVIOUR OF A LAMINATE**: Laminate code, stress - strain behavior in a laminate; Resultant forces and moments in a laminate, inter laminar stresses in laminates; Design of composite structures - Case studies. (10)

**Total L: 45**

**TEXT BOOKS:**

1. Autar K Kaw , "Mechanics of Composite Materials", 2<sup>nd</sup> Edition, CRC Press, 2007.
2. Manoj Kumar Buragohain , "Composite Structures: Design, Mechanics, Analysis, Manufacturing, and Testing", 1<sup>st</sup> Edition, CRC Press, 2017.

**REFERENCES:**

1. Valery V Vasiliev and Evgeny V Morozov , "Advanced Mechanics of Composite Materials and Structural Elements", 3<sup>rd</sup> Edition, Elsevier Ltd, 2013.
2. Mallick P K , "Fiber Reinforced Composites", 2<sup>nd</sup> Edition, CRC Press, 2007.
3. George Z. Voyiadjis and Peter I. Kattan , "Mechanics of Composite Materials with MATLAB", 1<sup>st</sup> Edition, Springer, 2005.
4. Robert M Jones , "Mechanics of Composite Materials", 2<sup>nd</sup> Edition, CRC Press, 2018.

## 19M009 INTRODUCTION TO AIRCRAFT SYSTEMS

3 0 0 3

**INTRODUCTION TO AIRCRAFTS** : Evolution and history of flight; Basic components of an aircraft: Structural members, aircraft axis system, aircraft motions, control surfaces and high lift devices; Types of aircrafts: Conventional design configurations based on power plant location, wing location, intake location, tail unit arrangements, landing gear arrangements. (9)

**BASIC PRINCIPLES OF FLIGHT** : Significance of speed of sound, air speed and ground speed, properties of atmosphere, Bernoulli's equation, forces on the airplane, airflow over wing section, pressure distribution over a wing section, generation of lift and drag, pitching moments, types of drag, lift curve, drag curve, lift/drag ratio curve, factors affecting lift and drag. (9)

**AIRCRAFT SYSTEMS** : Environmental control systems(ECS), pneumatic systems, hydraulic systems, fuel systems, landing gear systems, engine control systems, ice and rain protection systems, cabin pressurization and air conditioning systems, steering and brakes systems, auxiliary power unit; Electrical and electronic systems: Avionics, flight controls, autopilot and flight management systems, navigation systems, communication, information systems, radar system. (10)

**AEROFOIL STABILITY AND CONTROL**: Aerofoil nomenclature, types of aerofoil, center of pressure and its effects; Wing section: Aerodynamic center, aspect ratio, effects of speed, air density on lift and drag; Degree of stability: Lateral, longitudinal and directional stability and controls of aircraft; Effects of flaps and slats and lift coefficients, control tables, stalling, landing, gliding turning, speed of sound, mach number, shock waves. (9)

**AIRCRAFT PERFORMANCE AND MANEUVRES** : Power curves, maximum and minimum speeds of horizontal flight, effects of changes of engine power, effects of altitude on power curves, forces acting on an aeroplane during a turn, loads during a turn, correct and incorrect angles of bank. (8)

**Total L: 45**

### TEXT BOOKS:

1. Kermode AC , "Flight without Formulae", Pearson Education, Singapore, 2008.
2. Kermode AC, D. R. Philpott, R. H. Barnard , "Mechanics of Flight", Prentice Hall, 2006.

### REFERENCES:

1. Anderson John D. Jr , "Introduction to Flight", McGraw Hill Publishers,2007.
2. Kermode A C, D. R. Philpott, R. H. Barnard , "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley, 2008.
3. Houghton, E. L., & Carpenter, P. W , "Aerodynamics for engineering students", Elsevier, 2003.
4. Shevell , "Fundamentals of Flight", Pearson Education,1989.

## 19M010 SYSTEM MODELING AND CONTROL

3 0 0 3

**CONTROL SYSTEM FUNDAMENTALS** : Basic elements of control systems: Open loop and closed loop control, elements of closed loop control system, SISO, MIMO systems, sampled data, digital control systems; Mathematical foundation: Matrix theory, differential equations and Laplace transform. (9)

**MATHEMATICAL BASICS OF CONTROL SYSTEMS**: Block diagrams: Block diagram reduction, signal flow graphs, Mason's gain formula; Transfer function: Translational and rotational mechanical transfer function, electrical and electro-mechanical system transfer functions, DC motor transfer function. (9)

**BASIC CONTROL THEORY** : Poles and zeros: First order systems, second order systems, more than 2 poles and zeros; Nonlinearities and linearization; PID controllers. (9)

**TIME DOMAIN ANALYSIS** : Stability: Routh-Hurwitz criterion, stability analysis, steady state error analysis; Introduction to Root locus: Root locus example, design of transient response using root locus, positive feedback, design through root locus; Error compensation: Steady state error compensation, transient error compensation, transient and steady state error compensation, compensation examples; Feedback compensation and its physical realization, feedback design examples. (9)

**FREQUENCY DOMAIN ANALYSIS**: Frequency response: Bode plots, gain margin and phase margin; Design using the frequency response: Lead, lag, lead-lag compensators; The state-space representation: Solving the state equations in the time and space domains, state equation examples, stability and steady-state error in state space. (9)

**Total L: 45**

### TEXT BOOKS:

1. Norman S Nise , "Nise's Control Systems Engineering", 7<sup>th</sup> Edition, John Wiley, 2018.

2. Katsuhiko Ogata , "Modern Control Engineering", 5<sup>th</sup> Edition, Pearson, India, 2015.

**REFERENCES:**

1. Benjamin C Kuo and Farid Golnaraghi , "Automatic Control Systems", 9<sup>th</sup> Edition, Wiley, 2014.
2. Gopal M , "Control systems: Principles and Design", 4<sup>th</sup> Edition, McGraw-Hill education, 2012.
3. William J Palm III , "System Dynamics", 2<sup>nd</sup> Edition, McGraw-Hill education, 2012.
4. Katsuhiko Ogata , "System Dynamics", 4<sup>th</sup> Edition, Pearson, 2014.

**19M011 FOUNDATION SKILLS IN INTEGRATED PRODUCT DEVELOPMENT**

**3 0 0 3**

**PRODUCT LIFECYCLE MANAGEMENT** : System architecture, scope, characteristics, drivers, stages - introductory stage, growth stage, maturity stage and decline stage, S-Curve, Bathtub curve; Product data structure. (10)

**REQUIREMENT ENGINEERING AND ANALYSIS** : Requirement engineering: Types of requirement, requirement pyramid; PESTEL analysis; SWOT analysis; Product development models. (8)

**CONCEPTUALIZATION AND PROTOTYPING** : Customer needs, problem statement, bench marking and establishing engineering specifications; Idea generation: Brainstorming, mind-map; Concept generation: Systematic exploration, 6-3-5 method, morphological analysis; Prototyping: Methods, types; Case studies. (10)

**PRODUCT DEVELOPMENT APPROACHES AND TOOLS** : Challenges and constraints in product development; Quality function deployment (QFD); Theory of inventive problem solving (TRIZ); Establishing product function: FAST method, subtract and operate procedure; Failure mode and effects analysis (FMEA); Case studies. (9)

**SUSTENANCE ENGINEERING AND IPR** : Maintenance: Activities, objectives, classification; Obsolescence management: Objectives, mitigation measures, design for obsolescence; IPR: Types of IPR, patentability criteria, steps in patenting, formulating claims, pursuing application. (8)

**Total L: 45**

**TEXT BOOKS:**

1. Karl T Ulrich and Steven D Eppinger , "Product Design and Development", 5<sup>th</sup> Edition, Tata McGraw Hill, New Delhi, 2017.
2. Michael Grieves , "Product Life Cycle Management", 1<sup>st</sup> Edition, Tata McGraw Hill, New Delhi, 2005.

**REFERENCES:**

1. Chitale A K and Gupta R C , "Product Design and Manufacturing", 6<sup>th</sup> Edition, Prentice Hall of India, 2014.
2. Kevin Otto and Kristin Wood , "Product Design", 5<sup>th</sup> Edition, Pearson Education, 2013.
3. Nigel Cross , "Engineering Design Methods: Strategies for Product Design", 3<sup>rd</sup> Edition, John Wiley and Sons, 2008.
4. Jonathan Cagan and Craig M. Vogel , "Creating Breakthrough Products: Revealing the Secrets that Drive Global Innovation", 2<sup>nd</sup> Edition, Pearson Education, 2013.

**19M012 DESIGN OF AUTOMOTIVE SYSTEMS**

**3 0 0 3**

**DESIGN OF PROPULSION SYSTEMS** : Review of design considerations for components under static and dynamic loading; Design of I.C engine components - cylinder, piston, connecting rod, crankshaft, flywheel, valves and valve springs; Design principles of electric vehicle, sensors in automobiles, engine management system. (10)

**DESIGN OF TRANSMISSION ELEMENTS AND BRAKES** : Design of single and multi-plate clutches, diaphragm clutch, cone clutch and centrifugal clutch; Design of gear box and drive lines; Concepts of variable transmission systems; Design of power train for vibration; Brakes: Brake power requirements, design of drum and disc brakes, principles of regenerative and anti-lock braking systems. (8)

**DESIGN OF STEERING AND SUSPENSION SYSTEMS** : Design of steering systems, power assisted steering; Suspension systems: Classification of suspension, design of springs – coil springs, leaf springs, air springs; Design of steering and suspension systems for vibration. (7)

**DESIGN OF FRONT AND REAR AXLES** : Design of propeller shaft, design of final drive gearing, design of full floating, semi floating and three quarter floating rear shafts and rear axle housings, analysis of loads-moments and stresses at different sections of front axle, determination of optimum dimensions and proportions for steering linkages, design of front axle beam. (10)

**AUTOMOTIVE BODY DESIGN** : Automotive body structural elements: Design of automotive beam sections, torsion of thin-wall members, thin-wall beam section design in automobiles, buckling of thin-walled members, design for body bending and body torsion- strength and stiffness requirements. (10)

**Total L: 45**

**TEXT BOOKS:**

1. Giancarlo Genta, Lorenzo Morello , "The Automotive Chassis Volume 1, Components Design", 1<sup>st</sup> Edition, Springer International Edition, US,2014.
2. Donald E. Malen , "Fundamentals of Automobile Body Structure Design", 1<sup>st</sup> Edition, SAE International, US, 2011.

**REFERENCES:**

1. Heinz Heisler , "Vehicle and Engine Technology", 2<sup>nd</sup> Edition, SAE International, 2011.
2. Smith J.H , "An Introduction to Modern Vehicle Design", Anniversary edition, Butterworth-Heinmann, US,2002.
3. Robert C. Juvinall and Kurt M. Marshek , "Fundamentals of Machine Component Design", 6<sup>th</sup> Edition, Wiley, 2017.
4. Wolfgang Matschinsky , "Road Vehicle Suspensions", 1<sup>st</sup> Edition, Wiley, US, 1997.

### **19M013 AUTOMOBILE ENGINEERING**

**3 0 0 3**

**AUTOMOBILE ARCHITECTURE AND PERFORMANCE** : Automobile: Definition, overview, subsystems of automobile; Frame: Functions of frame, types; Body: Terminology, types; Engine location and drive system, vehicle performance: Traction, resistance to vehicle motion, solving of simple problems. (9)

**ENGINE ARCHITECTURE AND FUEL INJECTION** : Types of engine: Multi-valve engine, in-line engine, vee-engine; Fuel Injection: Comparison of carburetor and fuel injection system, MPFI, CRDI, GDI; Supercharger and turbocharger; Hybrid vehicle. (9)

**TRANSMISSION SYSTEMS** : Clutch: Single plate clutch, multiplate clutch; Gear box: Sliding mesh, constant mesh and synchromesh gear box; Overdrive, automatic transmission, differential, hydraulic coupling, rear axle arrangement. (9)

**STEERING AND SUSPENSION SYSTEM** : Steering principle: Ackerman and Davis steering mechanisms; Wheel geometry: Caster, camber, toe-in and toe-out; Power steering; Suspension system: Rigid axle, independent suspension system, stabilizer bar, damper, air suspension system. (9)

**WHEELS AND BRAKES** : Wheel construction: Disc and wired wheel; Tyre: Belted bias, radial bias, tubeless tyre; Brake construction: Drum and disc brakes; Brake operating system: Hydraulic and air brakes; Antilock braking system; Stopping distance. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Gupta R B , "Automobile Engineering", 1<sup>st</sup> Edition, Satya Prakashan Publishers, New Delhi, 2016.
2. Kirpal Singh , "Automobile Engineering Vol I and II", 13<sup>th</sup> Edition, Standard Publishers, New Delhi, 2017.

**REFERENCES:**

1. Julian Happian Smith , "An Introduction to Modern Vehicle Design", 1<sup>st</sup> Edition, Butterworth-Heinemann, US, 2001.
2. William Crouse, Donald Anglin , "Automotive Mechanics", 10<sup>th</sup> Edition, McGraw Hill Education, US, 2017.
3. Heinz Heisler , "Vehicle and Engine Technology", 2<sup>nd</sup> Edition, SAE International, 1998.
4. Giri N K , "Automobile Mechanics", 8<sup>th</sup> Edition, Khanna Publishers, India, 2008.

### **19M026 MANUFACTURE AND INSPECTION OF GEARS**

**3 0 0 3**

**PRODUCTION OF CYLINDRICAL GEARS** : Types of cylindrical gears and applications, blank preparation, overview of gear production methods, procedure for cutting gears and attainable quality in hobbing and gear shaping, cutter selection, work holding methods and setting calculations; Rack type gear shaping machine-description and applications; Internal gear cutting methods, CNC gear hobbing and gear shaping machines; Gear skiving: concept, cutting process and applications. (9)

**PRODUCTION OF CONICAL GEARS** : Types of conical gears and applications; Production methods for straight bevel gears: Bevel gear generator, Duplex rotary cutter method; Production methods for spiral bevel and hypoid bevel gears: Gleason spiral bevel generator, Klingelnberg method, machine description, cutter and machine setting. (9)

**GEAR MATERIAL SELECTION AND HARDENING METHODS** : Properties of gear materials; Non-metallic, non-ferrous and

plastic gears; Selection of material for power transmission and high speed applications; Selection of materials for worm and wheel; Hardening methods: Through hardening, case hardening; Carburizing-liquid and gas carburizing, low pressure carburizing; High pressure quenching, nitriding, induction hardening, flame hardening; Hardening defects. (9)

**GEAR FINISHING AND INSPECTION** : Gear finishing: Advantages, finishing of gears by grinding, shaving, lapping and honing methods-process, machine, cutters and setting of process parameters; Gear inspection: Types of error in gears, gear quality standards and allowable limits, tooth thickness and base tangent length measurement, pitch error, radial run out, involute profile error, composite error measurement; Computerized gear inspection; Gear failure reasons and remedies. (9)

**MASS PRODUCTION METHODS AND PRODUCTION SYSTEMS** : Mass production methods: Gear production by stamping, die casting, powder metallurgy process, injection and compression moulding of plastic gears, cold and hot rolling, gear broaching; Gear production systems: Batch production, gear production cells, lean and agile production practices; Automobile gear and gear boxes; Production of heavy engineering gears. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Watson , "Modern Gear Production", 1<sup>st</sup> Edition, Pergamon Press, US, 1984.
2. HMT , "Production Technology", 1<sup>st</sup> Edition, Tata McGraw Hill, 2001.

**REFERENCES:**

1. SAE , "Gear Design Manufacturing Inspection Manual", SAE, 1990.
2. Weck M. , "Hand Book of Machine Tools", Technology & Sons, 1984.
3. Faydor L. Litvin, Alfonso Fuentes-Aznar, Ignacio González-Perez, , Kenichi Hayasaka , "Noncircular Gears: Design and Generation", Cambridge University Press, 2009.

## **19M027 PNEUMATIC AND HYDRAULIC SYSTEMS**

**3 0 0 3**

**FUNDAMENTALS OF FLUID POWER SYSTEMS** : Concepts of fluid power, properties of hydraulic fluid and air, comparison between hydraulics and pneumatics; Actuators: Types and constructional details; Pressure, flow and directional control valves: Types and constructional details. (9)

**PNEUMATIC SYSTEM DESIGN** : Design of sequential multi-actuator circuits: Intuitive, cascade and step counter methods; Integration of start selection, start restriction and emergency stop modules. (9)

**ELECTRO-PNEUMATICS AND PROGRAMMABLE LOGIC CONTROLLERS (PLC)** : Electro-pneumatic circuit design using Karnaugh Veitch map method; PLC: Construction, programming methods, timers and counters; Programming using ladder logic diagrams. (9)

**HYDRAULIC SYSTEM DESIGN AND TYPICAL INDUSTRIAL APPLICATIONS** : Sizing and selection of power pack elements, conduits, actuators, valves and accumulators; Heat generation and estimation of losses; Industrial reliability and noise control; Deceleration circuit, regenerative circuits, high-low circuits, sequencing circuits, synchronizing circuits and fail-safe circuits. (10)

**ADVANCEMENTS IN FLUID POWER ENGINEERING** : Servo and proportional valves: Construction, types and applications; Overview of hydro pneumatics; Industrial internet of things for monitoring, control and diagnostics of systems for fluid power applications. (8)

**Total L: 45**

**TEXT BOOKS:**

1. Anthony Esposito, " Fluid Power with Application", 7<sup>th</sup> Edition, Pearson Education, 2013.
2. Srinivasan R , "Hydraulic and Pneumatic Controls", 2<sup>nd</sup> Edition, Vijay Nicole Imprints Pvt. Ltd, New Delhi, 2010.

**REFERENCES:**

1. Majumdar, S.R. , "Oil Hydraulic Systems: Principles and Maintenance", 28<sup>th</sup> Edition, McGraw-Hill, 2017.
2. Werner Deppert, Kurt Stoll , "Pneumatic Controls : An Introduction to Principles", Vogel-Druck Wurzburg, 1975.
3. Peter Rohner , "Fluid Power Logic Circuit Design – Analysis, Design Method and Worked Examples", Macmillan Press, 1979.

## **19M028 NON-TRADITIONAL MACHINING**

**3 0 0 3**

**MECHANICAL ENERGY BASED MACHINING PROCESSES** : Overview of Non-Traditional Machining (NTM): Need, comparison

between traditional and non-traditional machining, classification, performance constraints and selection of NTM process; Ultrasonic machining: Mechanics of machining and working principle; Abrasive jet, water jet and abrasive water jet machining, modeling of mixing process of abrasives and water jet; Process parameters, process capabilities, material removal rate; Limitations and applications. (10)

**THERMAL ENERGY BASED MACHINING PROCESSES** : Laser beam machining: Types of lasers, laser characteristics, working principle; Plasma arc machining: Working principle, various plasma arc torches, comparison with oxy fuel cutting; Electron beam machining: Working principle, electron beam gun, vacuum systems; Components of system and their functions, process parameters, process capabilities; Limitations and applications. (8)

**ELECTRICAL ENERGY BASED MACHINING PROCESSES** : Electrical discharge machining (EDM): Working principle, dielectric fluid flushing techniques, material removal rate; Electrical discharge wire cutting; Focused ion beam machining: Working Principle, machining system; Process parameters; Limitations and applications. (9)

**CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED MACHINING PROCESSES AND HYBRID PROCESSES** : Chemical machining and Electro chemical machining (ECM): Working principle, components and their functions, process parameters, material removal rate; Hybrid processes: Electro chemical and electro chemical discharge grinding, vibration assisted EDM, ultrasonic assisted ECM and wire electrical discharge grinding; Limitations and applications. (9)

**MICROMACHINING PROCESSES** : Abrasive jet micromachining, electrochemical micromachining, electrical discharge micromachining; Micro finishing processes: Abrasive flow finishing, magnetic abrasive finishing, magneto rheological abrasive flow finishing; Applications. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Jain V K , "Advanced Machining Processes", 2<sup>nd</sup> Edition, Allied Publishing Pvt. Ltd., 2007.
2. Pandey P C , "Modern Machining Processes", Tata McGraw Hill Education Pvt. Ltd., 2012.

**REFERENCES:**

1. Gary F Benidict , "Non Traditional Manufacturing Process", 1<sup>st</sup> Edition, CRC Press, 2019.
2. Hong Hocheng , "Advanced Analysis of Nontraditional Machining", Kindle Edition, 2013.
3. Hassan Abdel and Gaward El-Hofy , "Advanced Machining Processes", McGraw Hill Publications, 2005.
4. Carl Sommer , "Non-traditional Machining Handbook", 2<sup>nd</sup> Edition, Advance Publishing Inc, Texas, 2009.

## 19M029 ADDITIVE MANUFACTURING

**3 0 0 3**

**CONCEPTS AND CLASSIFICATION OF AM** : Definition, terminology, generic AM process chain, difference between AM and subtractive processes; Application levels: Direct and indirect processes; New AM classification scheme, development of AM technology. (8)

**AM PROCESSES FOR POLYMERS** : Vat photopolymerization processes: Vector scan, mask projection, two-photon approach, materials, scan patterns; Sheet lamination processes: Bond-Then-Form processes, Form-Then-Bond processes, materials; Fused deposition modeling: Process parameters, influence of process parameters on mechanical properties of the prototype. (10)

**METAL ADDITIVE MANUFACTURING** : Ultrasonic additive manufacturing: Working principle, process parameters, microstructures and mechanical properties; Powder bed fusion processes: Electron beam melting, selective laser melting, selective laser sintering, binder jetting process for metals; Directed energy deposition processes (DED): Laser-based and electron beam-based DED processes, process parameters, materials and microstructures. (10)

**AM PROCESS SELECTION AND APPLICATIONS:** Selection methods for a part: Decision theory, approaches to determining feasibility, challenges in selection; Applications: Automotive industries, aerospace industries, foundry and casting technologies, mold and die making applications, medical applications. (8)

**POST-PROCESSING AND SOFTWARE FOR AM** : Post-processing: Support material removal, surface texture improvements, aesthetic improvements, property enhancement using thermal and non-thermal techniques; Design for additive manufacturing; Software for AM and case studies using AM software. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Ian Gibson, David Rosen, Brent Stucker , "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2<sup>nd</sup> Edition, Springer, 2014.
2. Andreas Gebhardt , "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser, 2012.

**REFERENCES:**

1. John O Milewski , "Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewellery", Springer, 2017.
2. Pham D T and Dimov S S , "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid

- Tooling", Springer Science & Business Media, 2012.
- Chee Kai Chua, Kah Fai Leong, Chu Sing Lim, "Rapid Prototyping: Principles and Applications", World Scientific, 2010.
  - Srivatsan T S and Sudarshan T S, "Additive Manufacturing: Innovations, Advances, and Applications", CRC Press, 2015.

## 19M030 FLEXIBLE MANUFACTURING SYSTEMS

**3 0 0 3**

**PRODUCTION SYSTEMS** : Types of production: Job shop, batch and mass production; Functions in manufacturing; Plant layouts: Process, product, fixed position, cellular layouts; Automated production systems; Automation principles and strategies, automated assembly lines. (8)

**FMS IMPLEMENTATION** : Characteristics, types, equipments and its functions; Types of flexibility and performance measures; Planning phases, integration, system configuration; FMS layouts, simulation, FMS project development steps; Project management: Equipment development, host system development, functions of FMS host computer, FMS host and area controller function distribution, hardware and software development. (10)

**GROUP TECHNOLOGY AND PROCESS PLANNING** : Group technology: Formation of part families-part classification, coding system, OPITZ and multi class coding systems; Production flow analysis-machine cell design, clustering methods, modern algorithms, benefits of GT, system planning; Process planning- approaches to automated process planning, study of a typical process plan; Manufacturing planning and control. (10)

**AUTOMATED MATERIAL HANDLING AND STORAGE** : Automated material handling: Functions, types, analysis of material handling equipment; Design of conveyor and AGV systems; AS/RS; Storage: System performance, carousel storage system, WIP storage system; Interfacing material handling and storage with manufacturing. (8)

**MODELING AND ANALYSIS OF FMS** : Simulation and petrinet modeling techniques; Lean and agile manufacturing concepts: JIT, Kanban, Poke Yoke. (9)

**Total L: 45**

### TEXT BOOKS:

- Mikell P Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 4<sup>th</sup> Edition, Pearson Education, US, 2016.
- Parrish D J, "Flexible Manufacturing", Butter Worth Heinemann Ltd., Oxford, 1993.

### REFERENCES:

- Shivanand H K, Benal M M, Koti V, "Flexible Manufacturing System", 1<sup>st</sup> Edition, New Age International Pvt. Ltd., 2006.
- Radhakrishnan P, Subramanyan S, Raju V, "CAD/CAM/CIM", 4<sup>th</sup> Edition, New Age International Pvt. Ltd., 2018.
- Black J T, "The Design of the Factory with a Future", McGraw-Hill, 1991.
- Joshi S B and Smith J S, "Computer Control of Flexible Manufacturing Systems", Springer, 2012.

## 19M031 ARTIFICIAL INTELLIGENCE AND DEEP LEARNING

**3 0 0 3**

**INTELLIGENT AGENTS** : Agents and environments; Structure of agents: Goal-based agents, utility-based agents; Problem-solving agents; Formulating problems; Infrastructure for search algorithms; Measuring problem-solving performance. (5)

**SEARCH ALGORITHMS** : General tree-search and graph-search algorithms; Uninformed search strategies: Breadth-first search, uniform-cost search, depth-first search, bidirectional search; Informed search strategies; Types: Greedy best-first search, A\* search, graph-search algorithm; Case studies. (10)

**META-HEURISTIC ALGORITHMS** : Types: Genetic algorithms, simulated annealing, ant colony optimization, particle swarm optimization, bee algorithms; Case studies. (8)

**MACHINE LEARNING TECHNIQUES** : Supervised learning: Classification, support vector machines, linear discriminant analysis, naive bayes, k-nearest neighbor; Regression analysis; Unsupervised learning: k-Means clustering, hierarchical clustering; Case studies. (10)

**DEEP LEARNING WITH NEURAL NETWORKS** : Nodes and layers of neural network, training of single layer neural networks, training of multi-layer networks, architectures of deep networks, building deep networks; Case studies. (12)

**Total L: 45**

### TEXT BOOKS:

- OmidBozorg-Haddad, Mohammad Solgi, Hugo A. Loáiciga, "Meta-heuristic and Evolutionary Algorithms for Engineering Optimization", 1<sup>st</sup> Edition, Wiley, 2017.

2. Phil Kim , "MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence",  
1<sup>st</sup> Edition, Apress, 2017.

**REFERENCES:**

1. Josh Patterson , "Deep Learning: A Practitioner's Approach", 1<sup>st</sup> Edition, O'Reilly, 2017.
2. Stuart Russell, Peter Norvig , "Artificial Intelligence: A Modern Approach", 3<sup>rd</sup> Edition, Pearson Education Limited, England, 2016.
3. Ethem Alpaydm , "Introduction to Machine Learning", MIT Press, 2014.
4. Peter Harrington , "Machine Learning in Action", Manning Publications Co, 2012.

**19M032 SOLID STATE JOINING PROCESSES**

**3 0 0 3**

**OVERVIEW OF JOINING PROCESSES :** Fundamental principles and classifications of fusion and solid-state joining processes, ultrasonic welding, ultrasonic spot welding, explosion welding process, Magnetically Impelled Arc Butt (MIAB) welding; Resistance welding processes: Spot welding, seam welding, projection welding, high-frequency resistance welding, resistance butt welding, flash butt welding; Brazing, adhesive bonding, clinching, self-pierce riveting. (8)

**DIFFUSION JOINING PROCESSES :** Principles and applications; Diffusion brazing, braze welding, diffusion welding; Diffusion bonding of metals to ceramics; Solid-state deposition welding processes; Pressure non-fusion welding processes: Cold welding, electromagnetic pulse welding, pressure gas welding, hot pressure welding, forge welding; Roll bonding. (7)

**FRICTION WELDING (FW) PROCESS :** Process parameters, applications, metallurgical, mechanical and tribological characterizations; Spin welding, rotary drive FW , inertia welding, friction taper stitch welding, radial FW, friction plunge welding, third-body FW; Friction seam welding, linear and angular FW, orbital FW, friction brazing, friction stud welding; Study of friction welds and joint quality of FW. (10)

**FRICTION STIR WELDING :** Fundamentals and taxonomy, materials; Heat generation, metallurgical and mechanical characterizations, inspection; Material flow, material change during solid-state joining and its impact, environmental and energy benefits, micro FSW and its applications; Friction stir riveting, friction stir spot welding (FSSW) - process parameters, hybrid FSW, underwater FSW, ultrasonic assisted FSW, and electrically assisted FSW; Friction stir diffusion welding, thermal stir welding; Weld defects; Friction stir processing and friction surfacing. (10)

**TOOL MATERIALS AND INDUSTRIAL APPLICATIONS :** FSW tools: Material selection, tool geometry, pin geometry, load bearing ability, tool wear, deformation and failure, tool cost; FSW of aluminum alloys, magnesium alloys, titanium, steels; Dissimilar metal FSW; Welding of plastics and welding of non-metals; Industrial applications: Shipbuilding, automotive, aerospace, railways and other industry sectors. (10)

**Total L: 45**

**TEXT BOOKS:**

1. R.S. Paramar , "Welding Processes and Technology", 3<sup>rd</sup> Edition, Khanna Publishers, New Delhi, 2010.
2. Daniela Lohwasser, Zhan Chen , "Friction Stir Welding From Basics To Applications", Woodhead Publishing, 2010.

**REFERENCES:**

1. Rajiv Sharan Mishra, Partha Sarathi De, Nilesh Kumar , "Friction Stir Welding and Processing: Science and Engineering", 1st Edition, Springer International Publishing, 2014.
2. Bekir Sami Yilbas, Ahmet Z. Sahin , "Friction Welding: Thermal and Metallurgical Characteristics", Springer Science, 2014.
3. P. Asadi, M.K. Besharati-Givi , "Advances in Friction-Stir Welding and Processing", Woodhead Publishing, 2014.
4. Nilesh Kumar, Rajiv S. Mishra, Wei Yuan , "Friction Stir Welding of Dissimilar Alloys and Materials", Elsevier, 2015.

**19M033 INTERNET OF THINGS FOR MECHANICAL APPLICATIONS**

**3 0 0 3**

**CONCEPTS OF IOT :** IoT: Characteristics, applications, enablers; Comparison between IoT, M2M, and WoT; IoT interdependence; IoT network configurations - comparison between IPv4 and IPv6; IoT components, interoperability, IoT challenges; Comparison between industrial IoT and IoT. (8)

**DATA COLLECTION :** Sensing: Sensors, transducers, sensor resolution, types of sensors; Actuation: Actuator, types of actuators; Communication protocols: 802.15.4, ZigBee, 6lowpan, RFID, NFC, Bluetooth, Z-wave; Embedded systems - Arduino, Raspberry Pi. (10)

**DATA PROCESSING AND DATA HANDLING :** Data processing: MQTT, MQTT components and methods; Data handling: Big data, types of data, flow of data; Cloud computing: Recent trends, service models, managing data in cloud. (9)

**DATA ANALYTICS AND DATA SECURITY :** Data analytics: Types, lifecycle- discovery, preparation, model planning, model building; Data collection; Streaming data analytics: hadoop, hive, hbase; Data security: Data protection, challenges. (9)

**MECHANICAL APPLICATIONS** : Manufacturing: Machine diagnostics and prognosis, robotics and autonomous vehicles and part tracing; Inventory and logistics: Route generation and scheduling, fleet tracking, shipment monitoring, remote vehicle diagnostics; Energy: Smart grids, waste management; Safety and security: Indoor air quality monitoring, noise level monitoring, smoke/gas detections, structural health monitoring. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Alasdair Gilchrist , "Industry 4.0: The Industrial Internet of Things", 1<sup>st</sup> Edition, Apress, 2016.
2. Ulrich Sender , "The Internet of Things: Industrie 4.0 Unleashed", 1<sup>st</sup> Edition, Springer, New York, 2019.

**REFERENCES:**

1. Sabina Jeschke, Christian Brecher, Houbing Song, Dana B. Rawat , "Industrial Internet of Things: Cyber- manufacturing Systems", Springer, 2016.
2. Dieter Uckelmann, Mark Harrison, Florian Michahelles , "Architecting the Internet of Things", Springer, New York, 2011.
3. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", John Wiley and Sons Ltd, UK, 2014.
4. Thomas Er, Dr. Zaigham Mahmood, Professor Ricardo Puttini , "Cloud Computing: Concepts, Technology & Architecture", PHI, 2013.

### **19M034 PRODUCTION TOOLING**

**3 0 0 3**

**SINGLE POINT CUTTING TOOLS** : Materials and their properties, classification, selection, insert and coated tools, tool wear and tool life; Recent developments in cutting tool technology; Nomenclature, types and styles, design and manufacture of HSS and carbide insert type tools for turning, boring, shaping, planning and slotting operations; Design of form tools; Tools and holders for CNC applications. (8)

**MULTIPOINT CUTTING TOOLS** : Nomenclature, classification and selection, construction methods, cutter setting, design and manufacture of drills, reamers, milling cutters, broaches and gear hobs; Grinding-wheel specification and selection. (8)

**JIGS AND FIXTURES** : Degrees of freedom, principles of location and clamping, principles of jig design, fool proofing, elements of jigs, classification of jigs, design of jigs for drilling and reaming; Principles of fixture design, locators and different types of clamps, elements of fixtures, provision for tool setting, design of fixtures for milling, turning, boring and grinding operations; Fixtures for turning centers and machining centers; Modular fixturing-concepts and applications. (10)

**PRESS TOOLS** : Design of sheet metal press tool parts, Design and manufacture of die sets for sheet metal components-Simple, compound and progressive dies for punching and blanking operations; Dies for drawing and bending operations; Selection of press tools. (10)

**DESIGN OF DIE CASTING DIES , INJECTION MOULDING DIES AND LIMIT GAUGES** : Product and mould, thermal considerations, design of two plate mould, runner and gate design, mould cooling and ejection; Overview of shrinkage and warpage analysis; Design of plug, ring and snap gauges. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Donaldson.C, and LeCain.C.H , "Tool Design", Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.
2. Bhattacharyya.A , "Metal Cutting Theory and Practice", New Central Books Agency (P) Limited, Calcutta, 2012.

**REFERENCES:**

1. Arshinov.V, Alekseev.G , "Metal cutting Theory and Cutting Tool Design", MIR Publishers, Moscow, 1976.
2. Kempster , "Introduction to Jig and Tool Design", VIVABooks, New Delhi, 1998.
3. Cracknell.P.C, Dyson.R.W , "Handbook of Thermoplastics Injection Mould Design", Chapman and Hall, 1993.
4. Paquin.J.R, Crowley , "Die Design Fundamentals", Industrial Press, Newyork, 2006.

### **19M051 LEAN MANUFACTURING**

**3 0 0 3**

**LEAN MANUFACTURING CONCEPTS** : Origins and objectives of lean manufacturing : Ford and Toyota production systems, lean process, 3M concept, key principles and implications; Characteristics of traditional manufacturing and lean manufacturing, lean building blocks, road map for lean implementation, lean benefits, value creation and waste elimination, seven types of waste; Pull production : Models, kanban, continuous flow, single piece flow, kaizen. (9)

**GROUP TECHNOLOGY AND CELLULAR LAYOUT** : Part families, production flow analysis, composite part concept, machine cell design, quantitative analysis, case studies. (9)

**VALUE STREAM MAPPING** : Value stream, benefits, mapping process; Current state map, mapping icons, mapping steps, takt time calculations; VSM case studies. (8)

**LEAN MANUFACTURING TOOLS AND METHODOLOGIES** : Standardized work, standard work sequence, timing and work in progress; Quality at source, autonomation / Jidoka, visual management system, mistake proofing / Poka-yoke; 5S technique: Elements and waste elimination through 5S, advantages and benefits, 5S audit; Visual control aids for improvement. (10)

**TOTAL PRODUCTIVE MAINTENANCE** : Goals and benefits, hidden factory, the six big losses, types of maintenance, overall equipment effectiveness, pillars of TPM and implementation; Changeover and setup time reduction techniques, temple of quality, OEE calculations. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Micheal Wader , "Lean Tools: A Pocket guide to Implementing Lean Practices", 2<sup>nd</sup> Edition, Productivity and Quality Publishing, 2013.
2. Lonnie Wilson , "How to Implement Lean Manufacturing", 2<sup>nd</sup> Edition, McGraw Hill Education, 2015.

**REFERENCES:**

1. Gopalakrishnan N , "Simplified Lean Manufacture : Elements, Rules, Tools and Implementation", PHI Learning Pvt Ltd, 2012.
2. Taiichi Ohno , "Toyota Production Systems; Beyond Large Scale Production", Productivity Press, 1992.
3. S R Devadasan, V. Sivakumar , "Lean and Agile Manufacturing; Theoretical, Practical and Research Futurities", PHI, 2012.
4. Askin R G, Goldberg J B , "Design and Analysis of Lean Production Systems", John Wiley and Sons, 2007.

## **19M052 SUPPLY CHAIN MANAGEMENT**

**3 0 0 3**

**SUPPLY CHAIN NETWORK DESIGN** : Definition, global optimization, objectives of SCM, drivers of supply chain; Logistics networks : Data collection, model and data evaluation, solution techniques. (8)

**INVENTORY MANAGEMENT AND FORECASTING** : Introduction to inventory and multi order opportunities, inventory policy; Periodic review, continuous review, effect of demand uncertainty; Risk pooling, centralized and decentralized system, managing inventory in the supply chain; Forecasting: Role of forecasting in a supply chain, risk management in forecasting; Case studies. (10)

**SIGNIFICANCE OF INFORMATION IN SC** : Bullwhip effect, information and supply chain technology; Supply chain integration: Push, pull and push-pull systems; Demand driven strategies, impact of internet on SCM, distribution strategies. (9)

**STRATEGIC ALLIANCES AND SUSTAINABILITY IN SUPPLY CHAIN** : Framework for strategic alliance, third party logistics, retailer - supplier partnership, distributor- integration, procurement and out sourcing strategies, role of sustainability in a supply chain, key pillars of sustainability, closed-loop supply chain. (9)

**INFORMATION TECHNOLOGY IN GLOBAL SCM** : Role of IT in supply chain, IT framework, internal supply chain management, supplier relationship management, future of IT in the supply chain, risk management in IT, supply chain IT in practice, DSS for supply chain management; Overview of application of block chain and IoT in supply chain. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Simchi – Levi Davi, Kaminsky Philip and Simchi-Levi , "Designing and Managing the Supply Chain Concepts Strategies and Case Studies", 3<sup>rd</sup> Edition, McGraw-Hill Education, US, 2017.
2. Sunil Chopra, Peter Meindl and DharamVirKalra , "Supply Chain Management: Strategy, Planning, and Operation", 3<sup>rd</sup> Edition, Pearson, New Delhi, 2017.

**REFERENCES:**

1. Erik Hofmann, Nicola Bosia and Urs Magnus Strewe , "Supply Chain Finance and Blockchain Technology -The Case of Reverse Securitisation", Springer International Publishing AG, 2018.
2. Roberta S Russell, Bernard W Taylor III , "Operations and Supply Chain Management", Wiley India pvt Ltd, 2017.
3. Jay Heizer, Barry Render, Chuck Munson , "Operations Management: Sustainability and Supply Chain Management", Pearson, 2017.
4. Hsiao Fan Wang, Surendra M Gupta , "Green Supply Chain Management: Product Life Cycle Approach", Mc Graw hill, 2011.

## 19M053 QUALITY ENGINEERING

3 0 0 3

**CONCEPT OF QUALITY ENGINEERING** : Quality value and engineering, overall quality system, quality engineering in product design, quality engineering in design of production processes, quality engineering in production, quality engineering in service. (8)

**LOSS FUNCTION** : Loss function for products and system - derivation, improvements and justification, loss function and inspection, quality evaluations and tolerances; Types of tolerances - S type, L type. (8)

**ON-LINE QUALITY CONTROL** : Online feedback quality control : Variable characteristics, control with measurement interval, one unit, multiple units control systems - lot and batch production; Online process parameter control : Variable characteristics, tolerances, feedback control systems, measurement error. (10)

**QUALITY ATTRIBUTES AND PROCESS IMPROVEMENT METHODS** : Checking intervals, frequency of process diagnosis; Production process improvement method, process diagnosis improvement method; Process adjustment and recovery improvement methods. (10)

**PREVENTIVE MAINTENANCE** : Preventive maintenance schedule: Functional characteristics , large scale systems; Quality tools, fault tree analysis, event tree analysis, failure mode and effect analysis quality systems. (9)

**Total L: 45**

### TEXT BOOKS:

1. De Feo J A and Barnard W W , "Six Sigma: Breakthrough and Beyond", 1<sup>st</sup> Edition, Tata McGraw-Hill, US,2005.
2. Pyzdek T and Berger R W . , "Quality Engineering Handbook", 2<sup>nd</sup> Edition, Tata-McGraw Hill, 2000.

### REFERENCES:

1. Kaniska Bedi , "Quality Management", Oxford University Press, 2007.
2. Brue G , "Six Sigma for Managers", 2<sup>nd</sup> Edition, Tata-McGraw Hill, 2002.
3. Taguchi G, Elsayed E A and Hsiang., T.C , "Quality Engineering in Production Systems", 1<sup>st</sup> Edition, Mc-Graw- Hill, 1989.
4. Dale. H. Besterfield , "Total Quality Management", 4<sup>th</sup> Edition, Pearson Publications, 2017.

## 19M054 ENGINEERING ECONOMICS

3 0 0 3

**INTEREST AND TIME VALUE OF MONEY** : Reasons for interest, simple interest, compound interest, time-value equivalence, compound interest factors, nominal and effective interest rates, use of interest tables, continuous compounding, calculation of time-value equivalents for single and multiple-payment cash flows involving uniform continuous payment and uniform gradient. (10)

**COMPARISON OF ALTERNATIVES** : Present worth comparisons: Situations for present-worth comparisons - equal, unequal lived assets, study period, assets with infinite life, bond valuation; Equivalent uniform annual-worth comparison method: Situations for EUAC, asset life, unequal life, perpetual life, sinking fund; Rate of return comparisons: IRR, MARR. (10)

**REPLACEMENT ANALYSIS** : Items deteriorating with time and items that fail completely, replacement with and without time value of money, replacement policy for new and old machines with infinite horizon, group replacement. (8)

**DEPRECIATION AND BREAK-EVEN ANALYSIS** : Depreciation: Reasons, depreciation methods; Break-even analysis: Cost and competitiveness, breakeven comparisons, breakeven charts, linear and non-linear breakeven analysis, breakeven analysis with time value of money, multi product breakeven analysis. (9)

**PROJECT FEASIBILITY AND RISK ANALYSIS** : Project feasibility: Marketing, technical, financial feasibilities; Risk analysis: Risk, decision trees, formulation of discounted decision trees. (8)

**Total L: 45**

### TEXT BOOKS:

1. James L Riggs, David D Bedworth, Sabah U Randhawa , "Engineering Economics", 4<sup>th</sup> Edition, Tata McGraw Hill, New Delhi, 2017.
2. Prasanna Chandra , "Projects", 9<sup>th</sup> Edition, Tata McGraw Hill, New Delhi, 2002.

### REFERENCES:

1. Chan S Park , "Contemporary Engineering Economics", 5<sup>th</sup> Edition, Pearson, Chennai, 2015.

- Leland Blank, Anthony Tarquin , "Engineering Economy", 7<sup>th</sup> Edition, Tata McGraw Hill, New Delhi, 2013.
- William G Sullivan, Elin M Wicks, Patrick Koelling C , "Engineering Economy", 14<sup>th</sup> Edition, Pearson, New Delhi, 2011.
- Gerald Thuesen J, Fabrycky W J , "Engineering Economy", 9<sup>th</sup> Edition, Prentice Hall, New Delhi, 2002.

## 19M055 ENTERPRISE RESOURCE PLANNING

3 0 0 3

**MRP AND INTRODUCTION TO ERP** : Introduction - overview of MRP I and MRP II, capacity requirements planning, history of ERP, evolution of ERP, comparison of ERP with traditional systems, benefits of ERP, need for ERP, overview of modules in ERP. (8)

**ERP IMPLEMENTATION:** Traditional approach to information system design, new approach to system development; ERP implementation : Requirement analysis, alternatives, life cycle, implementation methodology; Selection of an ERP package for suitability for manufacturing, hidden costs; Case studies. (10)

**BUSINESS MODULES IN ERP** : Accounts, production planning, human resources, plant maintenance, materials management, quality management, sales and distribution, ware house and supply chain; Case studies. (10)

**ERP MARKET** : Market place, dynamics, SAP R3 , Oracle, JD Edwards, QAD Inc, SSA Global; Open source ERP software: OODO, ERP Next, cloud computing with ERP, SAP HANA. (9)

**ERP CASE STUDIES** : HRM, finance and costing, production planning, materials management, sales and distribution, integration of modules. (8)

**Total L: 45**

### TEXT BOOKS:

- Alexis Leon , "ERP Demystified", 2<sup>nd</sup> Edition, Tata McGraw Hill, India,2008.
- Mary Sumner , "Enterprise Resource Planning", 2<sup>nd</sup> Edition, Pearson Education, 2007.

### REFERENCES:

- Jim Mazzullo , "SAP R/3 for Everyone", 1<sup>st</sup> Edition, Pearson, 2007.
- Jose Antonio Fernandz , "The SAP R /3 Handbook", 1<sup>st</sup> Edition, Tata McGraw Hill, India, 1998.
- Biao Fu , "SAP BW: A Step-by-Step Guide", 1<sup>st</sup> Edition, Pearson Education, 2004.
- David L OLSON , "Managerial Issues of ERP Systems", 1<sup>st</sup> Edition, Tata-McGraw Hill, India,2004.

## 19M056 SIX SIGMA IN MANUFACTURE AND SERVICE

3 0 0 3

**FOUNDATION PHASE** : Six sigma: Definition, need, laws , types - DMAIC vs. DMADV; Six sigma as strategic initiative, internal communication strategy and tactics, formal launch, organizational structure, training plan, project selection, selection of team members, team stages, roadmap for implementation, common pitfalls. (9)

**DEFINE PHASE:** Meaning and purpose, types of customers, problem identification, voice of customer, collect VOC data, CTQ, applications of seven QC tools, SIPOC, QFD, project charter. (8)

**MEASURE PHASE** : Meaning and purpose, types of measures, types of data, data collection; Quality cost, cost of poor quality; Measure tools- measurement system analysis, process capability calculations. (9)

**ANALYSE PHASE** : Meaning and purpose, process analysis, statistical testing for normal data, failure mode and effects analysis, root cause analysis, case studies. (9)

**IMPROVE AND CONTROL PHASE** : Meaning and purpose, process redesign, methods of generating improvement alternatives, TRIZ, pilot experiments, Taguchi DOE, cost benefit analysis, implementation plan; Control phase: Meaning and purpose, selection of control charts – visual controls, control plan, process score card. (10)

**Total L: 45**

### TEXT BOOKS:

- Betsi Harris Ehrlich , "Transactional Six Sigma and Lean Servicing", 1<sup>st</sup> Edition, St. Lucia Press, US,2002.
- Jay Arthur , "Lean Six Sigma – Demystified", 2<sup>nd</sup> Edition, Tata McGraw Hill Companies Inc, 2017.

### REFERENCES:

- Daniel J. Zrymiak, Govindarajan Ramu, Roderick A. Munro , "The Certified Six Sigma Green Belt Handbook",

2<sup>nd</sup> Edition, 2015.

2. Donald W Benbow and Kubiak T M , "Certified Six Sigma Black Belt Handbook", 2<sup>nd</sup> Edition, Pearson Education, 2013.
3. Michael L George , "Lean Six Sigma for Service", McGraw-Hill Education, 2003.
4. Joseph Defeo , "Juran's Quality Handbook", 6<sup>th</sup> Edition, McGraw Hill Education,2010.

## 19M057 STATISTICAL PROCESS ANALYSIS AND OPTIMIZATION

3 0 0 3

**STATISTICAL PROCESS CONTROL** : Definition of quality and its evolution, causes of variation in quality, statistics and parameters, variables and attributes, frequency distribution, histogram; Construction and interpretation, use of software; Statistical basis of control chart, anatomy of control charts, selection and implementation of control charts, control charts for variables and attributes, simple case studies on applications of various types of control charts, use of software. (10)

**PROCESS CAPABILITY ANALYSIS**: Process capability: Definition, assumptions, metrics, methodology of process capability assessment, case studies, use of software. (8)

**REGRESSION** : Definition and need, simple linear probabilistic model, assumptions, method of least squares, ANOVA for linear regression, coefficient of determination, multiple regression, general linear model and assumptions; ANOVA for multiple regression, interpretation of results, polynomial regression, limitations of regression, simple applications, use of software. (9)

**EXPERIMENTAL DESIGN** : Classical design of experiments, single factor and multi-factor experiments, analysis of experimental results; Taguchi design of experiments - phases, analysis and interpretation; Case studies, use of software. (9)

**RESPONSE SURFACE METHODOLOGY** : Response surfaces, two-level factorial designs, addition of centre points, method of steepest ascent, central composite and Box-Behnken designs, analysis of first order response surface; Case studies, use of software. (9)

**Total L: 45**

### TEXT BOOKS:

1. Grant E M and Leavenworth R L , "Statistical Quality Control", 7<sup>th</sup> Edition, Tata McGraw Hill, New Delhi, 2010.
2. Hines W W, Montgomery D C, Goldsman D M and Borror C M , "Probability and Statistics in Engineering", 4<sup>th</sup> Edition, Wiley, US,2009.

### REFERENCES:

1. Myers R H, Montgomery D C and Anderson-Cook , "Response Surface Methodology: Process and Product Optimization using Designed Experiments", 4<sup>th</sup> Edition, Wiley,2016.
2. Ross P J , "Taguchi Techniques for Quality Engineering", Tata McGraw Hill,2005.
3. Duncan A J , "Quality Control and Industrial Statistics", Irwin, 1986.
4. Davies O L , "Design and Analysis of Industrial Experiments", Oliver and Boyd,1978.

## 19M058 VALUE ANALYSIS AND VALUE ENGINEERING

3 0 0 3

**CONCEPTS OF VA AND VE** : Meaning and purpose, historical background, status of VE in India, types of values; Function: Types, function identification on product, feature function matrix, function analysis; Cost: Elements of costs, calculation of costs, cost allocation to function, examples. (8)

**WORTH ANALYSIS** : Meaning and importance of worth, evaluation of worth, determining worth, guide lines to find worth, case studies; Team dynamics: Structure, team transformation, interpersonal relationship. (8)

**GENERAL VE TOOLS** : Brainstorming, Gordon technique, feasibility ranking, morphological analysis, ABC analysis, probabilistic approach, make or buy decision, case studies. (9)

**SPECIAL TECHNIQUES** : Function cost, worth analysis, function analysis system techniques, technically oriented FAST, customer oriented FAST, weighted evaluation method, forced decision technique, quantitative method, predetermined minimum method, evaluation matrix, break even analysis, life cycle cost, case studies. (10)

**VE JOB PLAN** : Orientation phase- ABC analysis, information phase - observation checklist, function phase - function cost worth analysis, creative and evaluation phase - evaluation of alternatives, cost benefit analysis, recommendation phase and implementation phase - recommendation plan, audit phase - operational audit, financial audit, applications of VE Job Plan; Case studies. (10)

**Total L: 45**

**TEXT BOOKS:**

1. R G Chaudhari , "Techniques of Training in Value Engineering - Trainers Manual", 2<sup>nd</sup> Edition, Notion Press Inc, 2018.
2. Mukhophadhya AK , "Value Engineering", 1<sup>st</sup> Edition, Sage Publications Pvt. Ltd, New Delhi, 2003.

**REFERENCES:**

1. Richard J Park , "Value Engineering – A plan for inventions", St.Lucie Press, London, 1998.
2. Kassa Abate O , "Value Analysis and Engineering Reengineered", Taylor & Francis Inc, 2015.
3. Larry W Zimmesman. P E , "Value Engineering-A Practical approach for owners designers and contractors", CBS Publishers, New Delhi, 1992.
4. Del Younker , "Value Engineering Analysis and Methodology", 1<sup>st</sup> Edition, CRC Press, 2003.

**19M076 COMPUTATIONAL FLUID DYNAMICS****3 0 0 3**

**GOVERNING EQUATIONS OF FLUID FLOW AND HEAT TRANSFER** : Derivation of governing equations of fluid flow: 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. (9)

**DISCRETIZATION SCHEMES AND METHODS OF FLUID FLOW ANALYSIS** : 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)

**SOLUTION TECHNIQUES IN CFD ANALYSIS** : Impact of non-conservation terms over the solution, artificial viscosity, up-wind schemes, cell Reynolds number, Courant number, Lax Wendroff technique, MacCormack's technique, relaxation technique, ADI technique. (9)

**CFD ANALYSIS OF INCOMPRESSIBLE FLOWS** : Checker board distribution, staggered grid, pressure correction technique, SIMPLE algorithm. (9)

**APPLICATIONS** : 2D steady and unsteady heat transfer and fluid flow problems. (9)

**Total L: 45****TEXT BOOKS:**

1. John D Anderson , "Computational Fluid dynamics – The Basics with Applications", TATA McGraw Hill, 2016.
2. Versteeg H K, Malalasekara W , "An Introduction to Computational Fluid Dynamics - The Finite Volume Method", Longman, 2008.

**REFERENCES:**

1. Jiri Blazek , "Computational Fluid Dynamics: Principles and Applications", Butterworth-Heinemann, 2015.
2. Muralidhar K, Sundararajan T , "Computational Fluid Flow and Heat Transfer", Narosa Publications, 2014.
3. Chung T J , "Computational Fluid Dynamics", Cambridge University Press, 2010.
4. Joel Freziger H, Milovan Peric , "Computational Methods for Fluid Dynamics", Springer Publications, 2002.

**19M077 REFRIGERATION AND AIR CONDITIONING****3 0 0 3**

**VAPOUR COMPRESSION REFRIGERATION** : Creation of low temperature: Methods and application; Refrigerants: Properties , selection of refrigerants, alternative refrigerants; Aircraft refrigeration, single stage cycle, performance analysis for various operating conditions, use of P-h chart, multi stage cycle, multi compressor, multi evaporator and cascade system. (9)

**VAPOUR ABSORPTION REFRIGERATION** : Ammonia-water system, lithium bromide-water system, use of P-x-T and h-x-T chart, performance calculation, steam jet refrigeration and solar refrigeration systems. (9)

**AIR CONDITIONING** : Psychrometry for air conditioning processes, bypass factor, apparatus dew point, grand and room sensible heat factor, selection of inside and outside design conditions, effective temperature; Psychrometric calculation for cooling loads. (9)

**DUCT DESIGN AND AIR DISTRIBUTION** : Dynamic and frictional pressure drop in ducts, fan total pressure, methods of duct design, fan characteristics in duct systems, air conditioning systems control. (9)

**BALANCING OF COMPONENTS** : Condensers: Air cooled, water cooled and evaporative condensers and selection; Evaporator: Flooded, dry expansion, shell and tube and double pipe; Compressors: Reciprocating, rotary and centrifugal types, expansion devices; Cooling towers; Sensors used in R&AC systems. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Stoecker W F, Jones J W , "Refrigeration and Air Conditioning", McGraw-Hill India, 2014.
2. Manohar Prasad , "Refrigeration and Air Conditioning", New Age International Publishers, 2011.

**REFERENCES:**

1. Arora C P , "Refrigeration and Airconditioning", Tata McGraw Hill, 2017.
2. Carter Stanfield, David Skaves , "Fundamentals of HVACR", Pearson, 2012.
3. Roy J Dossat, Thomas J Moran , "Principles of Refrigeration", Pearson, 2001.
4. Jones W P , "Air Conditioning Engineering", Butterworth-Heinemann, 2001.

**19M078 RENEWABLE ENERGY****3 0 0 3**

**SOLAR ENERGY** : Basic concepts on solar radiation, potential of solar energy; Solar collectors: Flat plate collectors, evacuated tubes, concentrators; Solar plant configurations, photovoltaic systems, environmental aspects of solar energy. (9)

**WIND ENERGY** : Principles of wind power, wind turbine operation, site characteristics, horizontal and vertical axis types, aerodynamics of wind turbine, performance analysis, design principles of wind turbine blades, tower design, small and large machines, storage systems. (9)

**BIO-ENERGY** : Concepts and systems, biomass production, energy plantations, biomass resources and processing, environmental factors; Pyrolysis, gasification and liquefaction, types of gasifiers; Bioconversion: Biogas, fermentation and wet processes; Biofuels: Manufacturing methods and properties. (9)

**OCEAN ENERGY** : Wave energy: Offshore and shoreline energy systems, tidal energy, types of OTEC power plants, design and performance evaluation. (9)

**OTHER ENERGY SOURCES** : Geothermal energy, magneto hydrodynamic system (MHD), thermionic and thermos- electric generator, micro-hydel systems, hybrid systems and applications; Fuel cells: Classification, reactions and performance; Hydrogen production and storage methods. (9)

**Total L: 45****TEXT BOOKS:**

1. Aldo Vieira da Rosa , "Fundamentals of Renewable Energy Processes", 3<sup>rd</sup> Edition, Elsevier Academic Press, 2012.
2. Rai G D , "Non-Conventional Sources of Energy", 6<sup>th</sup> Edition, Khanna Publishers, New Delhi, 2017.

**REFERENCES:**

1. Bent Sorensen , "Renewable Energy", 5<sup>th</sup> Edition, Academic Press, 2017.
2. Kothari P, Singal K C, Rakesh Ranjan , "Renewable Energy Sources and Emerging Technologies", 2<sup>nd</sup> Edition, PHI Learning, 2011.
3. Sukhatme S P, Nayak J K , "Solar Energy - Principles of Thermal Collection and Storage", 3<sup>rd</sup> Edition, Tata McGraw Hill, 2009.
4. Abbasi S A, Naseema Abbasi , "Renewable Energy Sources and their Environmental Impact", Prentice-Hall of India, 2004.

**19M079 SOLAR ENERGY CONVERSION SYSTEMS****3 0 0 3**

**SOLAR RADIATION**: Solar constant, solar charts, sun path diagram, diffuse, global and direct solar radiation, pyranometer, pyrheliometer, sunshine recorders, greenhouse effect. (7)

**SOLAR COLLECTORS** : Classification: Air, liquid heating collectors, testing of flat plate collectors; concentrator collectors: classification, analysis of concentric tube collector, focusing solar concentrators, heliostats, parabolic and dish. (10)

**PHOTO-VOLTAIC SYSTEMS** : Physics, material and characteristics, cell arrays, circuits for output of solar panels, choppers, inverters, batteries, charge regulators, stand alone and off/on grids, hybrid systems, performance analysis and applications. (8)

**APPLICATIONS** : : Solar powered absorption air conditioning system, solar cooler, solar power station, water pump, chimney, dryer, dehumidifier, still, desalination, furnace, solar energy economics, performance analysis. (12)

**SOLAR ENERGY STORAGE** : Sensible heat, latent heat and thermo-chemical storage materials for phase change, solar ponds, economic analysis. (8)

**Total L: 45**

**TEXT BOOKS:**

1. Sukhatme S P, Nayak J P , "Solar Energy- Principles of Thermal Collection and Storage", TATA McGraw-hill, 2017.
2. Yogi Goswami D, Frank Kreith, Jan Kreider F , "Principles of Solar Engineering", Taylor & Francis, 2015.

**REFERENCES:**

1. Edward E Anderson , "Fundamentals for Solar Energy Conversion", Addison Wesley Publ. Co, 1983.
2. Duffie J A, Beckman W A , "Solar Engineering of Thermal Process", John Wiley, 2013..
3. Tiwari G N, Ghosal MK , "Fundamentals of Renewable Energy Sources", Narosa Publishing House,, 2007..
4. Shepherd W, Shepherd D W , "Energy Studies", Imperial College Press, 2014.

**19M080 ENERGY CONSERVATION AND MANAGEMENT****3 0 0 3**

**ENERGY MANAGEMENT** : Scope of energy audit, types of energy audit, energy audit methodology, role of energy managers; Energy management system (EnMS): ISO standards, implementing energy efficiency measures, detailed project report, energy monitoring and targeting, identification of energy conservation measures / technologies, economic and cost benefit analysis, energy service companies (ESCOS). (9)

**MECHANICAL ENERGY SYSTEMS** : Energy sources, classification, fuel supply and demand, energy conversion efficiencies; Mechanical energy conversion: Hydraulic, steam and gas turbines-performance characteristics and evaluation. (9)

**ENERGY EFFICIENCY IN THERMAL UTILITIES** : Steam engineering in thermal and cogeneration plants; Efficient utilization of steam: Piping, traps, flashing, condensate recovery, pinch analysis; Boiler: Losses and efficiency calculation methods, controls; Furnaces: Heat balance and efficiency calculations, energy conservation opportunities, insulation and refractories. (9)

**ENERGY EFFICIENCY IN ELECTRICAL UTILITIES** : Electrical system efficiency improvements: Motor, diesel generator, centrifugal pumps, fans, blowers, lighting systems; Air compressor: Line loss, leakage test, optimum pressure. (9)

**PERFORMANCE ASSESSMENT** : Industrial case studies: Assessment of energy generation/consumption in thermal station, steel industry, cement industry, textile industry. (9)

**Total L: 45****TEXT BOOKS:**

1. Alan P R, Beth P J , "Energy Management and Efficiency for the Process Industries", Wiley Publications,, 2015.
2. Abbi Y P, Shashank , "Handbook on Energy Audit and Environment Management", , The Energy and Resources Institute, 2009.

**REFERENCES:**

1. Donald R Wulfinhoff , "Energy Efficiency Manual", Energy Institute Press, 2011.
2. Bureau of Energy Efficiency , "Energy Manager Training Manual", Government of India, 2015.
3. Eastop T D, Croft D R , "Energy Efficiency for Engineers and Technologists", Logman Scientific and Technical, 1990.
4. Reay D A, "Industrial Energy Conservation", Pergamon Press, 1979.

**19M081 ADVANCED HEAT AND MASS TRANSFER****3 0 0 3**

**CONDUCTION AND DIFFUSION** : Review of steady state governing equations and boundary conditions; Transient conduction: Method of separation of variables, similarity variable method, Laplace transforms, Heisler charts, Green's functions and Duhamel's Theorem; Numerical methods: Implicit, explicit and Crank Nicholson methods, finite element method; Introduction to inverse heat conduction. (12)

**CONVECTION HEAT AND MASS TRANSFER** : Derivation of the full energy equation, boundary layer approximations for momentum, heat and mass transfer, similarity of boundary layers, momentum, heat and mass transfer analogy, Blasius similarity solution, Karman-Pohlhausen integral solution; Internal flow: Fully developed flow for constant heat flux and constant temperature boundary conditions, viscous dissipation and compressibility effects, developing flow, Graetz problem, free convection, heat transfer from vertical and horizontal surfaces, similarity solution. (15)

**BOILING AND CONDENSATION** : Pool boiling heat transfer, nucleate boiling and bubble growth, critical heat flux, film boiling and Leidenfrost point, convective boiling; Condensation: Film wise condensation and drop wise condensation, Nusselt model. (5)

**DESIGN OF HEAT AND MASS TRANSFER EQUIPMENT** : Selection and design of heat exchangers, cooling towers and scrubbers; Heat transfer enhancement methods. (4)

**RADIATION HEAT TRANSFER** : Rayleigh and Wien distribution, Planck's distribution, Stefan Boltzmann law and derivation; Spectral, total, hemispherical and directional emission; Irradiation, reflection, absorption and transmission; Emissive power,

black body and grey body, radiation heat transfer between surfaces, shape factor, radiation shield; Introduction to gas radiation. (9)

**Total L: 45**

**TEXT BOOKS:**

1. K. Cole, J. V. Beck, A. Haji-Sheikh, B. Litjkouhi , "Heat Conduction using Green's Functions", CRC Press, 2011.
2. Schlichting H , "Boundary Layer Theory", Springer, Berlin, Heidelberg, 2017.

**REFERENCES:**

1. Frank M White , "Viscous Fluid Flow", McGraw-Hill Education, 2011.
2. Frank P Incropera David P Dewitt , "Fundamentals of Heat and Mass Transfer", Wiley India Private Limited, 2017.
3. Shah RK, Sekulic D , "Fundamental of Heat Exchanger Design", John Wiley, 2011.
4. Necati Ozisik M, "Heat Transfer: A Basic Approach", McGraw Hill, 1985.

## **19M082 ENERGY AND CLIMATE CHANGE**

**3 0 0 3**

**ENERGY AND ECONOMY :** Energy production, consumption and economic growth, current energy scenario, trends in energy usage, peak oil, economics of non-renewable resources, energy balance, Sankey diagram, Fish-bone diagram. (9)

**ENERGY AND ENVIRONMENT :** Fossil fuels and carbon emissions, air pollution, global warming; Non carbondioxide GHGs , thermal pollution, environmental impact assessment, need for energy efficiency, energy paradox, energy, economy and environment interaction. (9)

**CLIMATE CHANGE :** Carbon emissions and greenhouse effect: Sources, trends, warming potential of gases, impacts of global warming, life cycle assessment of greenhouse gas emissions, climate change modeling and general circulation models, positive and negative feedback loops. (9)

**CLIMATE CHANGE MITIGATION :** Carbon neutral and carbon negative cycles, emission reduction and its impacts, carbon sequestration and geo-engineering technologies, solar radiation management (SRM), carbon dioxide removal (CDR), green energy concept. (9)

**MITIGATION POLICIES :** Kyoto protocol, UNFCCC, IPCC, geopolitics of GHG control, CDM and other emission trading mechanisms, relevance for India and developing countries. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Wei-Yin Chen, Toshio Suzuki, Maximilian Lackner , "Handbook of Climate Change Mitigation and Adaptation", Springer, 2017.
2. Botkin D B, Keller E A, "Environment Science: Earth as a Living Planet", John Wiley & Sons Inc, 2014.

**REFERENCES:**

1. Philander S G , "Encyclopedia of Global Warming and Climate Change", SAGE Publications, 2012.
2. Bhattacharyya S C , "Energy Economics: Concepts, Issues, Markets and Governance", Springer, 2011.
3. Chris Martenson , "The Crash Course: The Unsustainable Future of Our Economy, Energy, and Environment", John Wiley & Sons, 2011.
4. Miller Jr G T , "Environmental Science: Working With the Earth", Wadsworth Publishing Company, 2005.

## **19M083 POWER PLANT ENGINEERING**

**3 0 0 3**

**CONVENTIONAL POWER PLANTS :** Layouts of steam, diesel, hydroelectric, gas turbine and nuclear power plants; Hydroelectric power plant: Runoff river plants, pumped storage plants, underground stations; Hydrel plant auxiliaries and plant operation; Nuclear power plant: Nuclear fuels, elements and types of nuclear reactor, radiation hazards, radioactive waste disposal. (9)

**INDUSTRIAL POWER PLANTS :** Gas and steam power cycles, super critical and ultra-super critical cycle, combined cycle, binary cycles, cogeneration, tri-generation. (9)

**COMBUSTION AND HEAT RECOVERY EQUIPMENT :** Types of combustion equipment, fuel and ash handling equipment, selection of fans; Emission control: Flue gas, particulate and gaseous emission; Draft: Forced, induced and balanced; Heat recovery equipment: Economizers, air preheaters and re-heaters, superheaters and de-superheaters. (9)

**STEAM GENERATOR AND CONDENSER :** Steam generators: Natural circulation, forced circulation, high pressure boilers

and super critical boilers, fluidized bed boiler, boiler accessories and mountings, boiler testing, process flow diagram; Condensers: Types, design factors, air removal, performance calculation; Cooling towers: Natural and mechanical systems. (9)

**RENEWABLE ENERGY SOURCES AND PLANT ECONOMICS** : Concentrating collectors, photovoltaic cell, horizontal and vertical types of wind turbines, geothermal plants, tidal power plant, biomass and biogas plants, OTEC plants; Power plant economics: Plant load factor, utilization factor, tariff rates, demand charges, load distributions, energy conservation and audit. (9)

**Total L: 45**

**TEXT BOOKS:**

1. Nag P K , "Power Plant Engineering", Tata McGraw Hill, 2016.
2. El-Wakil MM, "Power Plant Technology", McGraw Hill Book Company Inc, 2017.

**REFERENCES:**

1. Rajput R K , "Power Plant Engineering", Laxmi Publications (p) Ltd, 2016.
2. Rudramoorthy R , "Thermal Engineering", Tata McGraw Hill, 2010.
3. Arora S C and Domkundwar S , "Power Plant Engineering", Dhanpat Rai and Sons, 2013.
4. Ashok V Desai , "Non-Conventional Energy", Wiley Eastern Limited, 2011.

### **19M084 ADVANCED FLUID DYNAMICS**

**3 0 0 3**

**FLUID MECHANICS AND KINETICS** : Properties of fluids: Viscosity, compressibility, stress in a fluid and relation to pressure; Stability of floating and immersed bodies, Lagrangian and Eulerian analysis: Velocity field, stream lines, streak lines, path lines. (8)

**INTEGRAL AND DIFFERENTIAL ANALYSIS** : Control mass and control volume analysis; Integral and differential analysis, Reynolds transport theorem, material derivative, moving control volume; Conservation of mass, conservation of momentum, conservation of energy in integral and differential forms, Bernoulli's equation and restrictions. (8)

**POTENTIAL FLOW** : Bernoulli's equation for irrotational flow, velocity potential, stream function and stream lines, complex potential for a flow, Cauchy - Riemann conditions, basic potential flows, circulation, lift, drag, Blasius integral formula, superposition of potential flows, D'Alembert paradox, conformal mapping, Joukowski transformation, Schwarz-Christoffel transformation; Flow over cylinders and ellipses, basic aerofoil analysis. (12)

**VISCOUS FLOW AND BOUNDARY LAYER THEORY** : Viscous flow: Derivation of Navier-Stokes Equation, closed form solutions, Plane Poiseuille flow, Couette flow, Hagen-Poiseuille flow, boundary layer theory- Prandtl's boundary layer equations, Blasius solution, Karman-Pohlhausen integral momentum equation, boundary layer separation and control; Stream lined and bluff bodies: Flow around circular bodies and aerofoils, calculation of lift and drag. (12)

**INTRODUCTION TO TURBULENCE** : Turbulence: Introduction, derivation of time averaged equations, turbulence models, simple analysis of the turbulent boundary layer velocity profile. (5)

**Total L: 45**

**TEXT BOOKS:**

1. Currie I G , "Fundamental Mechanics of Fluids", CRC Press, 2012.
2. Young D F, Okiishi T H, Munson B R , "Fundamentals of Fluid Mechanics", John Wiley & Sons, 2015.

**REFERENCES:**

1. Gersten K, Schlichting H , "Boundary Layer Theory", Springer, 2017.
2. Frank M White , "Viscous Fluid Flow", McGraw-Hill Education, 2011.
3. Krishnamurthi Karamcheti , "Principles of Ideal Fluid Aerodynamics", John Wiley and Sons, 1966.
4. Ascher H Shapiro , "National Committee for Fluid Mechanics Films, Cambridge", University of Cambridge, .

### **ONE-CREDIT COURSES**

#### **19MF01 SIMULATORS FOR INTEGRATED PRODUCTS**

**1 0 0 1**

**SIMULATOR COMPONENTS** : Introduction to simulator; definition, objectives of simulator, elements of a simulator; Types of simulators - product simulator, process simulator, functional simulator, training simulator (4)

**DESIGN AND INTEGRATION OF SIMULATOR** : Design principles of a simulator; Tools; Hardware and software; Resources; Integrated product development approach; interfaces - mechanical, electrical, electronic and software; Configuring a simulator to a specific application; Testing; Trouble shooting. (5)

**APPLICATIONS OF SIMULATOR** : Importance, advantages, cost reduction in various areas viz, training, operations, testing; Safety and entertainment; Environmental simulation; Use in academic, research and defense fields – case studies. (6)

**Total L: 15**

**REFERENCES:**

1. Annalisa Milella Donato Di Paola, Grazia Cicirelli , "Mechatronic Systems: Simulation Modeling and Control", InTech, 2010.
2. Sankar Sengupta , "System Simulation and Modeling", Pearson Education India, 2014.
3. Klee Harold , "Simulation of Dynamic Systems with Matlab and Simulink", CRC Press Inc, New York, 2007.
4. Peter A. Hancock, Dennis A. Vincenzi, John A. Wise, Mustapha Mouloua , "Human Factors in Simulation and Training", CRC Press, New York, 2008.

## **19MF02 CORROSION SCIENCE AND ENGINEERING**

**1 0 0 1**

**BASIC ASPECTS OF CORROSION** : Introduction, classification, economics, emf series, Galvanic series. corrosion theories : Derivation of potential – current relationships of activation controlled and diffusion controlled corrosion processes; Potential – pH diagrams Fe-H<sub>2</sub>O system, application and limitations; Passivation. (5)

**FORMS OF CORROSION** : Definition, factors and control methods of various forms of corrosion : Uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement. (5)

**CORROSION CONTROL METHODS** : Atmospheric corrosion – classification, factors influencing atmospheric corrosion, temporary corrosion preventive methods ; Organic coating, corrosion inhibitors, cathodic protection, anodic protection. (5)

**Total L: 15**

**REFERENCES:**

1. E.E. Stansbury, R.A. Buchanan , "Fundamentals of electrochemical corrosion", ASM International, 2000.
2. M.G.Fontana, N.D. Greene , "Corrosion Engineering", 3<sup>rd</sup> Edition, McGraw Hill, New York, 2005.
3. S.N.Banerjee , "An Introduction to Science of Corrosion and its Inhibition", Oxonian Press, New Delhi, 1985.
4. Zaki Ahmad , "Principles of Corrosion Engineering and Corrosion Control", Butterworth Heinemann, London, 2006.

## **19MF03 NON-DESTRUCTIVE TESTING OF AIRCRAFT STRUCTURES**

**1 0 0 1**

**INTRODUCTION TO NON DESTRUCTIVE TESTING** : Brief history; Terminologies; Common methods; Quality of inspection and reliability; Essentials of NDT system; Advantages and Limitations. (4)

**DESCRIPTION OF NDT METHODS** : Liquid penetrant testing; Magnetic particles testing; Ultrasonic testing; Eddy current testing; Radiography; Thermography; Vibration monitoring; Holography and speckle methods; Acoustic emission technique. (7)

**EMERGING METHODS** : NDT of composites; NDT in manufacturing and maintenance; NDT and damage tolerance philosophy. (4)

**Total L: 15**

**REFERENCES:**

1. Halmshaw R , "Non-destructive Testing", Edward Arnold, London, 1991.
2. American Society for Non-Destructive Testing , "Nondestructive Testing Handbooks", 3<sup>rd</sup> Edition, American Society for Non-Destructive Testing, 2012.
3. Grandt Jr. A F , "Fundamentals of Structural Integrity: Damage Tolerant Design and Nondestructive Evaluation", Wileys, 2003.
4. Dowling N. E , "Mechanical Behaviour of Materials", 4<sup>th</sup> Edition, Pearson Education, 2014.

## **19MF04 COOLING OF ELECTRONIC EQUIPMENT**

**1 0 0 1**

**ELECTRONICS COOLING AND AIR FLOW MANAGEMENT:** Needs, goals and levels; Fundamentals of heat transfer: Extended surfaces, contact resistance; Air flow management: Fan characteristics, system characteristics and fan performance. (5)

**HEAT ANALYSIS, HEAT EXCHANGES AND COLD PLATES** : Heat analysis: System level, board level and package level

thermal analysis; Heat sink technologies: Air cooled components and boards; Experimental methods; Heat exchanges and cold plates: Thermal design process, analytical techniques and thermal design of multi-chip module. (5)

**HEAT SINK DESIGN AND OPTIMIZATION** : Free convection, liquid cooling and advanced cooling; Numerical methods: Case study. (5)

**Total L: 15**

**REFERENCES:**

1. Incropera.F.P, DeWitt.D.P , "Fundamentals of Heat Transfer", John Wiley and Sons, 2007.
2. Steinberg.D.S , "Cooling Techniques for Electronic Equipment", John Wiley and Sons, 1980.
3. Lian- Tuu Yeh, Richard C Chu, Dereje Agonafer , "Thermal Management of Microelectronic Equipment: Heat Transfer Theory, Analysis Methods and Design Practices", ASME Press, 2002.
4. Tony Kordyban , "Hot Air Rises and Heat Sinks: Everything You Know about Cooling Electronics is Wrong", ASME Press, 1998.

## **19MF05 EXPERIMENTAL METHODS IN THERMAL AND FLUID SCIENCES**

**1 0 0 1**

**INTRODUCTION TO EXPERIMENTAL METHODS:** Experimental program, calibration, measurement of uncertainty, flow visualization methods and techniques, fluid property measurement. (3)

**TEMPERATURE MEASUREMENT** : Design and selection of thermocouples to measure temperatures of a fluid, observation of sensitivity, accuracy, uncertainty in observations. (3)

**FLOW MEASUREMENT** : Particle image velocimetry, Laser induced fluorescence, Schlieren technique - Components, integration and processing of the raw images. (9)

**Total L: 15**

**REFERENCES:**

1. Ronald J. Adrian and Jerry Westerweel , "Particle Image Velocimetry", Cambridge University Press, 2011.
2. Smits A.J. and Lim T.T , "Flow Visualization: Techniques and Examples", Imperial College Press, 2000.
3. Holman J P , "Experimental Methods for Engineers", Mcgraw-Hill Series in Mechanical Engineering, 2011.
4. M.D. Kelleher, R.K. Shah, K.R. Sreenivasan, Y. Joshi , "Experimental Heat Transfer, Fluid Mechanics and Thermodynamics", Elsevier Science Publisher B.V,1993.

## **19MF06 CHALLENGES IN IMPLEMENTING LEAN MANUFACTURING**

**1 0 0 1**

**LEAN TOOLS** : Value stream mapping-Sections of VSM ,symbols of VSM, applications of VSM for an industrial process; Establishing lean metrics: Identifying the wastes, applying lean principles, measure productivity. (4)

**FAILURE MODE AND EFFECTS ANALYSIS** : Applying the principles of FMEA: Understand severity, detection and occurrence, develop FMEA based on process flow, prioritize the activities; Principles of control plan- understand sections of control plan, establish parameters driven by product and process; Need for verification before start of process. (8)

**ERROR PROOFING** : Error proofing techniques,principles and applications. (3)

**Total L: 15**

**REFERENCES:**

1. APQP , "Automotive Industry Action Group", Pearson Education, New Delhi, 2008.
2. Stephen A Ruffa , "Going Lean. How the Best Companies Apply Lean Manufacturing Principles", 2<sup>nd</sup> Edition, AMACOM, A division of American Association, New York, 2008.
3. Womach , "Lean Tools and Techniques", Pearson,2001.
4. Jones , "Lean Tools: A Pocket Guide", Wily, 1996.

## **19MF07 PROCESS ENGINEERING AND COSTING**

**1 0 0 1**

**PROCESS ENGINEERING** : General manufacturing process and its types, selection of manufacturing process - size and dimensional accuracy of parts. (4)

**MANUFACTURING PROCESS SELECTION AND PLANNING** : Fundamental rules of the manufacturing process, basic design of the product, influence of process engineering on product design, rechecking specifications, influence of material type on product cost - economical usage of materials, material cost balance sheet, process planning and its

types.

(6)

**SELECTION OF PROPER TOOLING** : Classification, sources of tooling, tool holders, work piece holders, molds, patterns, core boxes, dies and gauges; Availability of equipment, effect of process parameters on product performance and cost. (5)

**Total L: 15**

**REFERENCES:**

1. Serope Kalpakjian and Seven R Schmid , "Manufacturing Processes for Engineering Materials", Pearson Education, New Delhi,2000.
2. Donald F Eary and Gerald E Johnson , "Process Engineering for Manufacturing", Prentice Hall, New York, 2003.
3. Groover , "Principles of Modern Manufacturing", Wilsy,1999.
4. Sharma , "Manufacturing Processes", Pearson,2000.

## 19MF08 APPLICATIONS OF VALUE ENGINEERING

**1 0 0 1**

**CONCEPTS OF VALUE ENGINEERING** : Introduction and impact of VE application, types of values, types of function; Function identification on product, feature function matrix, function analysis. (5)

**COST** : Elements and components of product cost, calculation of various fabrication cost, determining worth, guidelines to find worth, feasibility ranking. (5)

**VALUE ENGINEERING IN JOB PLAN** : Phases: Orientation phase, information phase, function analysis, creative phase, evaluation phase, presentation phase, implementation phase and audit phase; Case studies. (5)

**Total L: 15**

**REFERENCES:**

1. Larry W Zimmelman. P E , "VE ,A Practical approach for owners designers and contractors", CBS Publishers, Delhi, 1992.
2. Arthus E Mudge , "Value Engineering", McGraw Hill Book Company, 1971.
3. Richard J Park , "Value Engineering: A plan for inventions", St.Lucie Press, London, 1998.
4. Arthus E Mudge , "Value Engineering", McGraw Hill Book Company, 1971.

## 19MF09 PRESSURE VESSEL AND PIPING

**1 0 0 1**

**INTRODUCTION** : Rationale behind development of codes and standards, highlights of national and international codes, theoretical background of pressure vessel and piping design as per ASME codes and RCC-MR codes; Engineering aspects in pressure vessel design - failure criteria, material selection, geometrical considerations and weld inspection. (4)

**STRESSES IN PRESSURE VESSEL AND PIPING** : General theory of membrane stresses in vessel under internal pressure and its application to shells - cylindrical, conical and spherical and end closures, stress concentration, thermal stresses, pressure vessel fatigue, stresses in pipes. (6)

**DESIGN OF PRESSURE VESSEL AND PIPING** : Pressure vessel and piping design considering excessive elastic deformation, plastic instability, buckling, ratcheting, rupture and creep; High temperature design; Problems and case studies. (5)

**Total L: 15**

**REFERENCES:**

1. John F. Harvey , "Theory and Design of Pressure Vessels", 1<sup>st</sup> Edition, CBS Publishers, New Delhi, 2001.
2. ASME - BPVC , "Pressure Vessel and Boiler code",ASME, USA, 2019.
3. Henry H Bednar , "Pressure Vessel Design Handbook", 2<sup>nd</sup> Edition, Krieger Publishing Company,USA, 1990.
4. Peter Smith , "The Fundamentals of Piping Design", 1<sup>st</sup> Edition, Gulf Publishing Company,USA, 2007.

## 19MF10 DESIGN VALIDATION AND QUALIFICATION: TESTING AND EVALUATION

**1 0 0 1**

**OVERVIEWS OF DESIGN VALIDATION AND QUALIFICATION:** Classes of structures, systems, components and equipment; Generic mechanical design basis and method; Design by analysis methodology; Design by experimental methodology; Verification, validation and qualification methods. (4)

**EXPERIMENTAL STRESS ANALYSIS:** Strain gauges: Types, sensitivity, rosettes, performance, temperature compensation, two-wire and three-wire circuits, selection; Photo-elastic methods, case studies. (5)

**VIBRATION TESTING AND EVALUATION :** Introduction to vibration analysis and synthesis, mode superposition, experimental modal analysis, sources of vibration-mechanically induced and flow induced vibrations; Dynamic amplification; Basics of dynamic instability; Signature analysis, random vibration, case studies. (6)

**Total L: 15**

**REFERENCES:**

1. James W. Dally and William F. Riley , "Experimental Stress Analysis", 3<sup>rd</sup> Edition, McGraw-Hill Publication, USA, 1991.
2. Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard , "Mechanical Measurements", 6<sup>th</sup> Edition, Pearson Education, India, 2013.
3. William T. Thomson , "Theory of Vibrations with Applications", 5<sup>th</sup> Edition, Pearson Education, 2008.
4. L.Meirovitch , "Elements of Vibration Analysis", 2<sup>nd</sup> Edition, McGraw Hill, USA, 1986.

## **19MF11 HIGH TEMPERATURE MATERIALS FOR ENERGY APPLICATIONS**

**1 0 0 1**

**HIGH TEMPERATURE MATERIALS, CREEP RESISTANCE AND THERMAL FATIGUE :** Characteristics of high temperature materials (HTMs): Ferrous and non ferrous materials; Creep, creep resistant materials in energy related components; Fatigue, thermal fatigue, ageing, structural changes at elevated temperature, material damage, crack propagation, damage mechanics, life time analysis. (5)

**OXIDATION AND HOT CORROSION :** Oxidation, high temperature corrosion, erosion and effect of alloying elements on hot corrosion. (5)

**SUPER ALLOYS AND OTHERS MATERIALS IN POWER PLANT APPLICATIONS :** Iron, nickel and cobalt base super alloys, high temperature ceramics and polymer for high temperature applications; Role in power plant applications and extreme environments. (5)

**Total L: 15**

**REFERENCES:**

1. Evans, R.W and Wilshire , "Creep of metals and alloys", Institute of metals, 1985.
2. J.R. Davis , "ASM Specialty Handbook: Heat- resistant materials", ASM International, 2001.
3. Raj. R , "Flow and Fracture at Elevated Temperatures", American Society for Metals, 1985.
4. Neil Birks, Gerald H. Meier, Frederick S. Pettit , "Introduction to the High Temperature Oxidation of Metals", 2<sup>nd</sup> Edition, Cambridge University Press, 2009.

## **19MF12 NANOTECHNOLOGY FOR CLEAN ENERGY APPLICATIONS**

**1 0 0 1**

**ENERGY STORAGE AND FUEL CELLS :** Introduction to battery materials and batteries: Lithium Ion based batteries; Super capacitor characterization, types of super capacitor and applications; Fuel cell: Principle, types - Polymer electrolyte membrane fuel cell (PEMFC), direct methanol fuel cells (DMFC), solid oxide fuel cell (SOFC). (5)

**NANOTECHNOLOGY IN RENEWABLE ENERGY SYSTEMS :** Developments and implementation of nanotechnology based renewable energy technologies, solar cell structures, quantum well and quantum dot solar cells, photo-thermal cells for solar energy harvesting. (5)

**COMMERCIALIZATION OF NANOTECHNOLOGY :** Process in nanotechnology, commercialization model, innovation, challenges and opportunities for nanotechnology. (5)

**Total L: 15**

**REFERENCES:**

1. J.Twidell, T. Weir , "Renewable Energy Resources", 3<sup>rd</sup> Edition, Routledge, 2015.
2. W. Vielstich, A.Lamm, H. A. Gasteiger , "Handbook of Fuel Cells: Fundamentals, Technology, and Applications", 1<sup>st</sup> Edition, John Wiley and Sons, 2003.
3. Martin A Green , "Solar cells: Operating principles, technology and system applications", Prentice Hall Inc, 1987.
4. Ling Zang , "Energy Efficiency and Renewable Energy Through Nanotechnology", Springer - Verlag Ltd, London, 2011.

## 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.

## 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.

## **190FA2 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.

## **190FA3 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.

## **190FA4 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

**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 FÜR 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 onphone
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'un système éducation de France
  - a. 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)

**PATICLE "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:**

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