

**ANNEXURE – II**  
**NOTIFICATION NO.06/2016**

**SCHEME AND SYLLABUS FOR RECRUITMENT TO THE POSTS OF ASSISTANT  
EXECUTIVE ENGINEERS VARIOUS ENGINEERING SERVICE  
GAZETTED SERVICES**

**SCHEME OF EXAMINATION**

**WRITTEN EXAMINATION (OBJECTIVE TYPE) BACHELOR'S DEGREE STANDARD**

<b><u>PAPER 1 :</u></b> i) General Studies	150 Marks	150 Questions	150 Minutes
<b><u>PAPER 2 :</u></b> Concerned Subject  Civil & Mechanical (Common) OR Agriculture	150 Marks	150 Questions	150 Minutes
<b><u>PAPER 3:</u></b>  Civil OR Mechanical OR Agriculture	150 Marks	150 Questions	150 Minutes
<b>Total:</b>	<b>450 Marks</b>		

NB: The candidate has to appear for Papers of his / her subject of study at Engg. Degree. i.e B.E / B. Tech (concerned Subject)

**PAPER -I**

**GENERAL STUDIES**

1. Events of national and international importance.
2. Current affairs- international, national and regional.
3. General Science and it applications to the day to day life Contemporary developments in Science & Technology and information Technology
4. Social- economic and political history of modern India with emphases on Indian national movement.
5. Indian polity and governance: constitutional issues, public policy, reforms and e-governance initiatives.
6. Economic development in India since independence.
7. Physical geography of India sub-continent.
8. Disaster management: vulnerability profile, prevention and mitigation strategies, Application of Remote Sensing and GIS in the assessment of Disaster
9. Sustainable Development and Environmental Protection
10. Logical reasoning, analytical ability and data interpretation.
11. Data Analysis:
  - a) Tabulation of data
  - b) Visual representation of data
  - c) Basic data analysis (Summary Statistics such as mean and variance coefficient of variation etc.) and Interpretation
12. Bifurcation of Andhra Pradesh and its Administrative, Economic, Social, Cultural, Political, and legal implications/problems, including
  - a). Loss of capital city, challenges in building new capital and it's financial implications.
  - b). Division and rebuilding of common Institutions.
  - c). Division of employees, their relocation and nativity issues.
  - d). Effect of bifurcation on commerce and entrepreneurs.
  - e). Implications to financial resources of state government.
  - f). Task of post-bifurcation infrastructure development and opportunities for investments.
  - g). Socioeconomic, cultural and demographic impact of bifurcation.

- h). Impact of bifurcation on river water sharing and consequential issues.  
 i). AP REORGANISATION ACT, 2014 on AP and the arbitrariness of certain provisions.

## **PAPER-2: COMMON FOR CIVIL AND MECHANICAL ENGINEERING**

### **Strength of Material:**

Forces, moments, Equilibrium; Applying the Equation of Equilibrium, Planar Trusses; Friction; Forces and Moments Transmitted by Slender members-shear Force and Bending Moment Diagrams; Mechanics of Deformable Bodies-Force –deformation –Relationships and Static Indeterminacy, Uniaxial Loading and Material Properties, Analysis of Statically Determinate and Indeterminate Trusses. Deflection of Statically Determinate Trusses.

Force –Stress- Equilibrium – Multi axial Stress and Strain and their relationship; Linear Elasticity – Material Behaviour – Stress-strain-temperature Relationships and Thin-walled Pressure Vessels. Thick Cylinders. Stress Transformations and Principal Stress, Stress and Strain Transformation, Theories of Failure.

Bending : Stress and Strains; Deflections – Pure Bending, Moment –curvature relationship. Deflection of statically determinate beams using Macaulay's method, Moment-Area Method and Conjugate Beam Method.

Torsion; Energy Methods –Torsion and Twisting, Energy Methods

### **Fluid Mechanic and Machinery**

Basic principles of fluid mechanics – pascal's law, transmission & multiplication of force, basic properties of hydraulic fluids , density , specific weight specific gravity , viscosity and bulk modulus, continuity equation, Bernoulli's eq., Torricelli's theorem laminar v/s turbulent flows ,static head pressure, pressure losses ,hydraulic system; Fluid Statics – Hydrostatics, Fluid forces on planes and curved surfaces, submerged and floating bodies, Buoyancy and stability. Control Volume analysis; Basic laws – Mass conservation law, thermodynamic laws, Newton's laws, Angular-Momentum principle; Flows in a pipes and channels – friction factor; Governing equations of fluid flows – continuity, Euler equations, Navier-stokes equations, internal flows; external flows, Flow separation;

Flow measurement devices – Gross measurement: Venturi meter, Orifice meter, notches and weirs, turbine flow meters, rotameters; Point measurement: pitot tubes, hot wire/film anemometer, their measurement principles and sources of errors; calibration, uncertainty estimation.

Hydraulic pumps-pumps flow and pressure, pump drive, torque and power, efficiency, types of pumps-gear, vane, piston; pressure compensated pumps, cavitation and aeration, velocity triangles, centerline thermodynamic analysis

Hydraulic Directional Control –Check Valves, Shuttle Valves, two-three- and four-Way Directional Control Valves, Directional Control Valve Actuation

Hydraulic Pressure Control – Pressure Relief Valves, Unloading Valves, Pressure Reducing Valves, Sequence Valves, Counterbalance Valves, Pressure Compensated Pumps

Turbines – performance characteristics for low and high speed machines, centerline thermodynamic analysis, velocity triangles, hydraulic turbines – pelton, Francis and Kaplan turbine

## **AGRICULTURAL ENGINEERING - PAPER-2**

**I. Surveying and Leveling and Theodoliting:** Surveying – objectives, primary divisions, classification, principles of surveying units of measurement, difference between a plan and a map. Scales – representative fraction, types of measuring scales, degree of accuracy. Linear measurements – method of measurement of pacing, chains and their constructional details, chain types, folding and unfolding of chains, measuring tapes, instruments for chain survey. Ranging – chaining on flat and sloping grounds, chain and tape correction. Chain surveying –

definitions, method of booking field notes, offsets, layout of off-sets, cross staff survey, obstacles in chaining, problems on errors in chaining. Computation of areas by planimeter. Compass survey – types of traverse, meridians bearing – types, designation of bearings, fore and back bearings, calculation of included angles from bearings. Description of prismatic and surveyor compass – method of using prismatic compass, magnetic declination, determination of true bearings from magnetic bearings, running a compass traverse. Local attraction – problems on correction of local attraction. Plane table survey – accessories of plane table, basic definitions, setting of plane table, orientation, methods of plane tabling.

Leveling – basic definitions, methods of leveling, classification of direct leveling. Instruments used in leveling – dumpy level, leveling staff. Temporary adjustments of dumpy level. Bench marks. Booking the staff readings – methods of reducing levels. Leveling difficulties and errors in leveling.

Theodolite – components and temporary adjustments of a theodolite – measurement of horizontal angles by direct method, repetition and reiteration method – measurement of vertical and deflection angles. Measurement of deflection angles, magnetic bearings of line – traversing by included angles – traverse computations and volume computations.

**ii. Fluid mechanics and Open Channel Hydraulics:** Fluids – classification, properties and dimensions. Fluid pressure – measurement, manometry, classification of manometers. Fluid static force on submerged surfaces – total force on horizontal, vertical and inclined surfaces, center of pressure and practical applications – kinematics of fluid flow – lines of flow, general types of fluid flow, equation of continuity, flow net boundary layer theory. Dynamic of fluid flow – various forms of energy in fluid flow, frictional loss, general energy equation, Bernoulli's theorem, Euler's equation of motion. Practical applications of Bernoulli's theorem. Venturi meter, Pitot tube, orifice meter. Buoyancy Floatation – meta centric height. Flow through orifices and mouthpieces – vena contracta, hydraulic coefficient and their experimental determination. Flow over weirs and notches – classification, discharge measurement through rectangular, triangular, trapezoidal weirs, broad crested weirs, flow through pipes – laws of head in pipes, pipes in series and compound pipes, equivalent size. Open channel hydraulics, classification of open channels and definitions, most economical sections of regular cross sections, specific energy concepts – Critical depth, energy diagrams, velocity and pressure profiles in open channels, hydraulic jump – types.

**iii. Soil Mechanics:** Soil mechanics – definitions and relationships, Classification of soils – particle size distribution, sieve analysis, sedimentation analysis, Stokes law. Consistency of soils – determination of liquid, plastic and shrinkage limits. Permeability – Darcy's law, discharge velocity and seepage velocity, coefficient of permeability. Seepage of Soils – flownet properties and uses. Elasticity applied to soils – stress distribution, Bousinesq's stress distribution theory, Isobar and pressure bulb, Vertical Pressure under uniformly loaded rectangular area, Comparison of Bousinesq's theory with linear theory, Westergard's theory. Newmark's influence chart, consolidation – process of consolidation relationship between void ratio and pressure, coefficient of volume change, time factor, settlement of soil. Compaction – introduction, factors. Shear strength – definition, Mohr's circle, Mohr Coulomb failure theory, measurement of shear strength. Earth pressure – active and passive earth pressure, Rankine's theory, slip circle method, Coulomb's wedge theory. Design requirements of retaining wall. Stability of slopes – types of failure and remedial measures. Bearing capacity – Rankine's analysis, Terzaghi's analysis, general and local shear failure, plate load test.

**iv. Electronics:** Photoelectricity – photoelectric emission, laws of photoelectric emission, phototube and photo multiplier tube. Thermo electricity – Seebeck effect, Peltier effect, variation of e.m.f. with temperature, laws of thermo electricity, thermo couple, thermometer. Alternating currents – average value, r.m.s. value of A.C. circuits with resistance, inductance and capacitance, L.C.R. circuits resonance circuits, watt meter, A.C. frequency measurement, transformers. Electronics – types of emission, methods of heating, vacuum tubes, diode, space charge, diode characteristics, Child's law of diode, rectifiers, half wave and full wave rectifiers, filter circuit types. Triode – action of grid, triode characteristics, tube constants, inter electrode capacitance, multi-electrode tubes, triode as an amplifier, classification of amplifiers. Metals semi conductors and insulators – N type, P type, germanium, P N junction diodes, junction triode transistors NPN and PNP.

**v. Fundamentals of soil science:** Nature and properties of soil – soil genesis and classification. Soil clay and organic matter. Physical and chemical properties of soils. Soil fertility and its evaluation. Soil water relations. Acidic, saline and alkali soils and their management.

Determinations of the followings: Total soluble salts by EL method, available nitrogens, available P.K. chlorides by mohars method, sulphates, calcium, (ca + mg), sodium, potassium, computation of SAR, RSC.

**vi. Strength of materials:** Introduction – units and dimensions – simple stresses and strains, elastic limit, compressive stress, tensile stress, principle of super position, stresses in bars of uniform tapering circular section, stresses in composite bars, elastic constants, primary secondary strains, poissions's ratio, volumetric strain, bulk modulus, shear modulus, and their relationships. Principal stresses and strains – analytical and graphical methods. Strain energy and impact loading – strain energy stored in a body gradually applied, suddenly impact, shock load, proof resilience. Shear force and bending moment of beams – cantilever, over handing, simply supported, application of point load, uniformly distributed load. Bending stresses in beams – theory of simple bending, neutral axis, moment of resistance, section modulus, bending stress in unsymmetrical sections. Shearing stresses in beams – loaded beam, distribution of shear stresses, different sections. Deflection of simple beams – relation between slope, deflection and radius of curvature. Methods of determination of slope and deflection and radius of curvature. Methods for determination of slope and deflection – double integration. Macaulay's method.

**vii. Soil Physics:** Dynamic properties of soils – bulk density, particle density, porosity, void ratio, volume expansion, soil consistency, soil compaction, soil strength. Soil texture, soil separates, particle size analysis, stoke's law, derivation, it's applicability and limits of validity. Classification of soil types, significance of soil texture, soil structure – definition, genesis, classification, evaluation of soil structure, indices of soil structure – methods of improving soil structure. Soil water, structure of water, properties of water, potential terminology, soil moisture potentials, soil moisture tensions, pF values, soil moisture constants, loss of soil water movement in saturated and unsaturated conditions, general flow equations, water infiltration into soil profile and its redistribution, infiltration equations, seepage and deep percolation losses. Soil temperature – thermal properties of soils, heat transfer in the soils, modifying the thermal regime of soils. Soil air-composition of soil air, movement of gases through soils, influence of aeration on plant growth, measurement of soil aeration. Soil air management. Physically problematic soils and their management.

**viii. Fundamentals of Agronomy:** Agriculture in India – definition of agriculture and agronomy, development of scientific agriculture, important events in Indian agriculture, important national and international institutes.

Agricultural meteorology – introduction, definition of meteorology, weather and climate and their importance in agriculture. Weather aberrations – inadequate and excess rainfall, unseasonal rains, cyclones, depressions, cold and heat waves, frost, hailstorms, hurricanes. Tornado. Drought and their effect on crop production. Weather forecasting – importance, types of forecasting, synoptic charts, weather forecasting organisations. Agroclimatic zones of Andhra Pradesh. Agricultural seasons in the state.

Tillage and tilth – objectives, characteristics of good tilth, types of tillage, preparatory cultivation, intercultivation, aftercultivation and preparatory cultivation for low land rice. Sowing – Methods of sowing – Time and depth or sowing.

Crops and their classification. Manures and fertilizers – method and time of application, relationship between soil moisture and fertilizer application. Weeds – definitions, their influence on crop production, principles of crop weed competition, critical periods of weed competition in different crops, principles of weed management and methods of weed control. Crop water requirements – critical stages of irrigation in important crops, scheduling of irrigation, methods of irrigation and water use efficiency. Cropping systems – definition. Principles of crop rotation and mixed cropping. Problems of dry land agriculture and water shed management.

**ix. Hydrology:** Hydrology – definition, hydrologic cycle and its components. Forms of precipitation – rainfall, measurement and analysis, point rainfall analysis, probability analysis, determination of net effective rainfall, phi index. Runoff – components, factors affecting runoff, estimation of design peak runoff rates, rational method, curve number method, rainfall runoff relations. Hydrographs – components, factors affecting hydrographs, separation of hydrographs for simple and complex storms. Unit hydrographs – concept and derivation, conversion of unit hydrographs, superposition method, S curve method. Synthetic units hydrographs – Necessary and derivation, Snyder's method and applications, instantaneous unit hydrograph. Flood routing – introduction, basic equations, hydrologic storage routing, modified Puls's method.

**x. Thermodynamics and Heat Engines:** Basic concepts of thermodynamics – thermodynamic equilibrium, energy and forms of energy, heat and work, thermal capacity and specific heat. Ideal gases – introduction, laws of perfect gases. Specific heats of gases. Laws of thermodynamics – zeroth law, first law, thermodynamic processes based on first law, entropy, second law of thermodynamics, refrigerator & heat pump, reversibility and irreversibility, Carnot's theorem. Gas cycles – efficiencies. Air standard cycles – efficiencies. Fuels types, calorific values of fuels, Bomb calorimeter, Boy's gas calorimeter, properties of fuels, apparatus for determination of fuel properties. Combustion of fuels– combustion equations, carbon analysis, flue gas analysis, Orsat apparatus. Heat engines – E.C. and I.C. engines, classification of I.C. engines, principles of operation, S.I. and C.I. engines, two stroke and four stroke engines, valve timing diagrams. Testing of I.C. engines – IHP, BHP, air consumption, fuel consumption, air-fuel ratio, efficiencies, heat balance sheet. Reciprocating air compressors – working, workdone. Horse power, volumetric efficiency, isothermal efficiency, multistage air compressors, inter cooling, condition for maximum power, P V diagrams. Formation and properties of steam, entropy of steam.

**xi. Electrical Engineering and Farm Electrification:** Basic electrical quantities – specific resistance temperature coefficient. Network theorems – Kirchoff's laws, Maxwell's loop method. Nodal analysis – superposition theorem, Thevenin's theorem. Star delta transformation. D.C. generators – classification, lap and wave wound generators, E.M.F. equation of a generator, losses, condition for maximum efficiency, armature reaction, commutation. D.C. motors – maximum power, armature torque, shaft torque, speed regulation. Motor characteristics – series motors, shunt motors, compound motors. Motors starters. Farm electrification and load estimation. Transformers – introduction, working principles. A.C. motors – types of motors, starting torque, running torque, starting of induction motors. Types of single-phase motors.

**xii. Computer Programming in 'C':** Computers – introduction, types, generation of computers, input output devices, central processing unit, memory devices, processors, key board, printers, 'C' Language – introduction, importance of 'C' basic structure of 'C' programme, algorithms, flow charts, programming translation. Programming preliminaries and fundamentals – constants, variables, data types, operators and expressions, input and output in 'C' decision making and branching, decision making and looping, arrays, functions, common programming errors. Writing of complete programmes - programme on mean, standard deviation and coefficient of variation, summation of series, quadratic equations, matrices addition, subtraction and multiplication, correlation and linear regression. Application of 'C' language for solving the problems related to agricultural engineering.

**xiii. Engineering Mechanics:** Introduction – units and dimensions. Classification of force system – coplanar, colinear, concurrent, coplanar parallel forces, resolution of forces. Condition of equilibrium - action and reaction, free body diagram. Support reactions – types of supports, types of loading, finding reactions of simply supported, overhanging, roller and hinged beams, analytical and graphical methods. Analysis of perfect frames – types, reaction of supports of a frames – types, reaction of supports of a frame by method of joints, method of sections and graphical method. Center of gravity and moment of inertia – determination by method of moments, theorems of parallel and perpendicular axes, product of inertia. Friction – definitions, types, laws of friction, angle of repose, equilibrium of a body, analysis of ladder and wedge friction. Lifting machines – definitions, law of machine, study of important lifting machines. Virtual work – principle, units and applications.

**xiv. Refrigeration and Air Conditioning:** Principles of refrigeration – units, terminology, production of low temperatures, air refrigerators working on reversed Carnot cycle and bell

Coleman cycle. Vapour compression refrigeration – mechanism, PV, PS, PH diagrams, vapour compression cycles, dry and wet compression, superheating and sub cooling, Vapour absorption refrigeration system. Common refrigerants and their properties. Design calculations for refrigeration systems. Cold storage plants.

Air conditioning – factors of human comfort, equipment used in A/C cycle, classification of A/C system, winter, summer and central A/C system, design calculations for air conditioning systems.

**xv. Mechanical Measurements and Instrumentation:** Measurement and its significance – methods of measurement, instruments, classification of instruments, elements of a generalised measurement system, errors in measurement and their uncertainty. Detector transducer elements – introduction, primary and secondary transducers, classification, signal conditioning and data presentation elements, static performance characteristics of instruments. Measurement of pressure – introduction, types of pressure measuring devices, ranges and their application. Measurement of strain – introduction, strain gauge, resistance strain gauge theory, strain gauge circuits, strain gages arrangement for the measurement of axial force, bending force, torque and pressure. Measurement of temperature – introduction, classification of temperature measuring devices, methods of measuring temperature, Measurement of sound – introduction, measurement of sound using microphones. Measurement of vibration – introduction, seismic transducers, types of accelerometers. Study of miscellaneous instruments – tachometers, stroboscope, proving ring, LVDT.

**xvi. Theory of structures:** Theory of structures – introduction, moment, slope, deflection equations and applications of propped, fixed and continuous beams, theorem of three moments. Stresses in thin walled vessels – cylindrical and spherical. Combined bending and axial thrust of columns – Euler's formulae for long struts, practical applications, empirical column formula.

**xvii. Heat and Mass Transfer:** Heat transfer – modes of heat transfer. Heat transfer by conduction – through tubes, composite tube section, plain and composite walls, overall heat transfer coefficient, critical insulation thickness, unsteady state heat conduction with known temperature distribution, with negligible internal thermal resistance, application of Heisler chart heat transfer by convection free and forced convection, determination of Nusselt's number with dimensional analysis. Heat transfer by radiation – black body concept, Planck's law, Stefan Boltzmann's law, gray body, emissive power of gray body, emissivity, Kirchoff's law, combined heat transfer coefficient, fouling factor, LMTD and NTU method of heat exchanger analysis.

Mass Transfer – molecular diffusion in gases, liquids and solids, unsteady state diffusion, convective mass transfer coefficients.

### **PAPER – 3 : OPTIONAL FOR CIVIL ENGINEERING**

1. BUILDING MATERIALS: Timber: Different types and species of structural timber, density – moisture relationship, strength in different directions, defects, preservations, plywood.

Bricks: Types, Indian standard classification, absorption, saturation factor, strength in masonry, influence of mortar strength on masonry strength.

Cement: Compounds of different types, setting times, strength.

Cement mortar: Ingredients, proportions, water demand, mortars for plastering and masonry.

Concrete: Importance of w/c ratio, strength, ingredients including admixtures, workability, testing for strength, mix design methods, non-destructive testing.

2. STRUCTURAL ANALYSIS: General theorems : theorems relating to elastic structures, principles of virtual work, strain energy in elastic structures, complementary energy, Castigliano's theorem, Betti's and Maxwell's reciprocal theorems.

Analysis of determinate structures – Deflection of determinate beams by double integration Macaulay's movement area and conjugate beam methods, Analysis of indeterminate skeletal frames-Moment distribution, Slope deflection, Kani's, Stiffness and force methods, Energy methods, Plastic analysis of indeterminate beams and simple portal frames..

3. DESIGN OF STEEL STRUCTURES: Principles of working stress method. Design of bolted and welded connections, axially and eccentrically loaded joints, Simple connection of bracket plates to columns, beam to beam and beam to column connections, design of framed, unstiffened and stiffened seat connections Design of industrial roofs. Principles of ultimate load design. Design of simple members.

4. DESIGN OF CONCRETE AND MASONRY STRUCTURES: Limit state design for bending, Shear, Axial compression and combined forces. Codal provision for slabs, Beams, Columns and footings. Working stress method of design of R.C. members. Principles of pre-stressed concrete design, Materials, Methods of pre-stressing, losses. Design of simple members and determinate structures. Design of brick masonry as per IS codes.

5. CONSTRUCTION PLANNING AND MANAGEMENT: Bar chart, Linked bar chart, Work break down structures, Activity – on – arrow diagrams. Critical path, Probabilistic activity durations, Event based networks. PERT network: Time-cost study, Crashing, Resource allocation.

6. HYDROLOGY AND WATER RESOURCE ENGINEERING: Hydrological cycle, Precipitation and related data analysis, Unit hydrographs, Evaporation and transpiration. Floods and their management, Stream gauging, Routing of floods, Capacity of reservoirs. Multi purpose uses of water: Soil-plant – Water relationships, Irrigation systems. Water demand assessment: Storages and their yields. Ground water yield and well Hydraulics. Water logging and drainage design. Design of rigid boundary canals, Lacey's and tractive force concepts in canal design, Lining of Canals, Sediment transport in canals, Non-overflow and overflow dams and their design, Energy dissipaters, Design of head works, Distribution works, Falls, Cross-drainage works, Outlets, River training.

7. ENVIRONMENTAL ENGINEERING:

- Water Supplying Engineering: Sources of supply, Yields, Design of intakes and conductors, Estimation of demand. Water quality standards, Control of water borne diseases. Primary and secondary treatment. Conveyance and distribution systems of treated water, Leakages and control. Rural water supply. Institutional and industrial water supply.
- Waste Water engineering: Urban rain water disposal, Systems of sewage collection and disposal. Design of sewers and sewerage systems, Pumping. Characteristics of sewage and its treatment. Disposal of products of sewage treatment. Plumbing systems. Rural and semi-urban sanitation.
- Solid Waste Management: Sources and effects of air pollution, Monitoring of air pollution, Noise pollution, Standards, Ecological chain and balance. Environmental assessment.

8. SOIL MECHANICS AND FOUNDATION ENGINEERING: Properties and classification of soil, Compaction, Permeability and Seepage, Flow nets, Compressibility and consolidation. Stress distribution in soils, Shearing resistance, Stresses and failure. Soil testing in laboratories and in-situ, Earth pressure theories, Soil exploration. Types of foundations, Selection criteria, Bearing capacity, Settlement, Laboratory and field tests, Design of shallow foundations. Types of piles and their design and layout. Foundations on expansive soils.

9. SURVEYING AND TRANSPORT ENGINEERING: Classification of surveys, Scales, Accuracy, Measurement of distances, Direct and indirect methods, Optical and electronic devices, Measurement of directions, Prismatic compass, Local attraction, Theodolites, Types, Measurement of elevations, Spirit and trigonometric leveling, Contours, Digital elevation modeling concept, Establishment of control by triangulations and traversing, Measurement and adjustment of observations, Computation of coordinates, Field astronomy, Concept of global positioning system, Map preparation by plane tabling and by photogrammetry, Remote sensing concepts, Map substitutes. Planning of Highway systems, Alignment and geometric design, Horizontal and vertical curves, Grade separation, Highway Materials and construction methods for different surfaces and maintenance. Principles of pavement design, Drainage. Traffic surveys, Intersections, Signaling, Mass transit systems, Accessibility, Networking.

### **Paper-3 OPTIONAL FOR MECHANICAL ENGINEERING**

#### ***Thermodynamics***

Definition of system & control volume, properties and state of a substance, units of mass, length, time, force, energy and work; Equality of temperature, Zeroth Law; Properties of Pure Substances – Pure substance; phase change and phase equilibrium; properties tables and diagrams; Ideal gas law, deviation from ideal law and compressibility factor; Work & Energy – Definition of work and energy; First Law of Thermodynamics; internal energy, enthalpy and

specific heat of gases, liquids and solids; energy analysis of closed system; mass and energy analysis of control volumes; Second of Thermodynamics – Thermal efficiency and coefficient of performance; Kelvin-Planck and Clausius statements and their equivalence; reversibility and its departure; Carnot cycle; thermodynamic temperature scale; Entropy – Clausius inequality; entropy change for pure substance; entropy generation and principle of entropy increase; entropy change for reversible process; entropy change for ideal gases; Exergy – Work potential of energy; reversible work and irreversibility; Second Law efficiency; Exergy change of a system; Exergy transfer by heat, work and mass; Exergy balance for closed system and control volumes; Power & Refrigeration Cycles – Air standard power cycles: Otto Cycle, Diesel Cycle, Stirling & Ericsson Cycle; Brayton Cycle and its variants; Second law analysis of gas power cycles; Rankine Cycle and its variants; Vapour Compression Cycle; Second law analysis of vapour power cycles

### **Heat Transfer**

Steady state conduction in one and two-dimensional systems – one dimensional unsteady state conduction; analytical and numerical methods. Extended surface heat transfer (Fins). Convection: Basic equations, Dimensional analysis, Boundary layers; Forced convections: External and internal flows, correlations, Natural convection and Mixed convection. Design of heat exchangers: LMTD and NTU methods. Radiation heat transfer: Basic laws, properties of surfaces, view factors, network method and enclosure analysis for gray – diffuse enclosures containing transparent media, engineering treatment of gas radiation; boiling and condensation

### **Refrigeration and Air Conditioning**

Refrigerating machines, heat pump, vapour compression system, second law efficiency of vapour compression cycle, refrigerants – selection of a refrigerant; thermodynamic, chemical and physical requirements, substitutes of CFC refrigerants; Multi-stage systems, components of a refrigerator – Compressor, condensers, expansion devices, evaporators; Gas cycle refrigeration; Vapour absorption

system; Properties of moist air and psychrometric chart; psychrometry of air-conditioning processes; solar radiation, heat transfer through buildings and load calculations; Component design of airconditioning units.

### **Turbomachines**

Dimensional analysis – incompressible and compressible fluid analysis, performance characteristics for low and high speed machines, cavitation; 2D Cascades – cascade geometry, flow characteristics, forces, performance, turbine cascades; Axial flow turbines – mean line analysis, velocity vector diagram, thermodynamic analysis, multistaging and losses per stage of axial turbines, effect of reaction on efficiency, turbine blade cooling; axial compressor – mean line analysis, velocity diagram, thermodynamic analysis, multistage analysis, high Mach number compressors, stall and surge phenomenon; Centrifugal Pumps, fans and compressors – their definitions and differences, Thermodynamic analysis, diffuser performance, slip factor, Performance analysis, choking in a compressor; Hydraulic Turbines – Pelton, Francis and Kaplan turbines, cavitation

### **Theory of Machines**

Basic Kinematic concepts: Introduction to mechanisms, Links, Kinematic pairs, Kinematic chains, Mechanism and Inversions, Kennedy's theorem, Velocity and acceleration in mechanism, Relative velocity methods, Instantaneous center of rotation, Acceleration diagram, Acceleration center. Cams: Synthesis of translating flat-face, translating roller and oscillating roller follower cams. Gears: terminology, fundamental law of gearing, involute profile, Interference and undercutting, minimum number of teeth, contact ratio, bevel helical, spiral and worm gears, Gear Trains – simple, compound and epicyclic gear trains; sliding gear boxes and synchronous gear boxes.

Dynamics of machines: Dynamics of Rigid Bodies in Plane Motion; Dynamic Force Analysis of Machines. Balancing of inertia forces: Balancing of rotors, balancing of inline internal combustion engines. Friction Devices: Introduction to friction, Belt, chain and rope drive, Transmission of Power through friction clutch



## **Machine Design**

Design consideration – limits, fits, tolerances, and standardization, a brief introduction to strength of materials, modes of failure, failure theories, design of shafts under static and fatigue loadings, design of springs – helical, compression, tension, torsional and leaf springs, design of joints – threaded fasteners, preloaded bolt joints, welded and glued joints, design and analysis of sliding and rolling contact bearings, analysis and applications of power screws and couplings, analysis of clutches and brakes, design of belt and chain drives, design of spur and helical gears

## **Machine Drawing and Solid Modelling**

Principle of drawing. Introduction to machine drawing, production drawing, assembly drawing. Different sectional views. Fits, limits, tolerances and surface finish. Introduction to computer aided design, fundamentals of computer graphics; geometric modelling of synthetic curves: Hermite, Bezier, B-spline, NURBS. Parametric representation of surfaces: plane, ruled, revolution; Part modelling techniques: wireframe, surface and solid modelling, data representation and exchange formats, geometry and topology. Three-dimensional transformations and projections. Solid modelling of different machine elements. Example, threads, bolts, and nuts, welded and riveted joints, shafts, keys, cotter, and pin joints; couplings and clutches, springs, belts, and pulleys; bearings, gears. Assembly of different components of IC engine

## **Engineering Materials**

Concepts of metallurgy and materials science, types of materials (metals, ceramics, polymers, hybrids), material properties (structural and functional), application orientated material design, some case studies: biomaterials, automotive, aerospace, etc. Structure of metals, Determination of structure and chemical composition, concepts of alloys, phase and phase diagrams. Imperfections in

crystals-point defects, dislocations and voids, theory of dislocations, strengthening mechanisms, diffusion in solids, heat treatments and phase transformations, mechanical response and microstructure-property relationship.

## **Manufacturing Science**

Introduction to Manufacturing and its evolution, Net and near-net shape manufacturing; Metal Casting: Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Product Design; Metal Forming: Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axisymmetric bulk deformation processes, Analysis of Deep Drawing and Bending, Introduction to High velocity forming processes; Powder Processing (Metals and Ceramics), Polymer Part Manufacturing, Introduction and properties of polymer melts and Visco-elasticity, Processing of Thermoplastics (Extrusion, Injection Molding, Blow Molding, Rotational Molding) and Thermosets (compression and transfer molding), Tool and product design principles; Rapid Manufacturing: Need for RP/RT/RM, Introduction to Processes for Prototyping, Tooling and Manufacturing; Joining and Welding: Introduction, Solid State and Fusion Joining, Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining; Metrology: Tolerancing (Dimensional and Geometric) principles and their measurements (Geometrical tolerances using point data), Interferometry – principles, flatness testing using optical flat, optical interferometers, Moire fringe system measurements.

Conventional Removal and Finishing Processes: Importance of Material Removal and allied processes, classification; Chip Formation; Types of Chips; Tool Specification: Coordinate and Orthogonal Systems; Mechanics of Metal Cutting: Merchant's Circle Diagram, Stress, Strain and Strain Rate, determination of Shear Plane Angle; Tool Wear and Tool Life; Variables affecting Tool Life; Practical Machining Operations: Turning, drilling, milling; Finishing Operations: Grinding (MRR estimation, Wheel Specifications, Wheel Wear) and other processes; Economics of machining: Minimum Production Cost Criterion, Maximum Production Rate and Maximum

Profit Rate Criteria; Unconventional Removal and Finishing Processes: Abrasive Jet Machining, Ultrasonic Machining; Electro Discharge Machining; Abrasive Jet Machining; Electron Beam Machining; Laser Beam Machining, Finishing processes (AFM and other variants); MicroManufacturing and Scaling Laws: Miniaturization and its importance, MicroManufacturing Processes (Additive, formative and Removal), Scaling laws with emphasis on microManufacturing.

### **Computer Integrated Manufacturing**

Current developments in CAD- feature based modeling, design by feature, function, feature linkages, application of feature based models, parametric modeling; Computer Aided Manufacturing: fundamentals of part programming, path generation, post processing and verification; Group Technology, Computer aided process planning (CAPP), computer aided inspection and reverse engineering, manufacturing process simulation, virtual and distributed manufacturing, computer integrated manufacturing.

### **Industrial Engineering**

Basics of probability and statistics, Linear Programming and applications, Queuing theory and its applications, forecasting approaches, Monte Carlo simulation procedure (OR). Inventory models discussion (deterministic and probabilistic Models), Newsvendor model, Inventory Planning and Control, Decision support system tools, Economic Order Quantity (EOQ). Product Design: Design for Manufacture and Assembly (DFM), Concurrent engineering Work systems design: Work study and classifications, Method study – work measurement, work sampling, Cost Estimation, Calculation of Machining Times, Cost Depreciation, Productivity, Productivity Measurement, Time study, Recording Techniques for Work Study, Information Collection Techniques, Job Evaluation, Ranking system,

Incentive Schemes, Individual/Group-Company-wide Bonus Schemes, Behavioural aspects of Incentives Plant layout, Ergonomics, CRAFT, Cellular Manufacturing, Scheduling, Assembly Line Balancing, Future directions in Production. Quality management and control: Quality Improvement, Cost of Quality, Statistical Process Control, Central Tendency and Dispersion, Control Charts, Acceptance Sampling, New Quality Concepts, Taguchi Methods, Design of Experiments (DoE), Robust Design, Ishikawa Diagram, ISO certification, Kaizen, Zero Defects Program, Total Quality Management (TQM), Six Sigma; Maintenance Management: Preventive and breakdown maintenance approaches, reliability, Work study for Maintenance, Total Productive Maintenance (TPM), Spare Parts Management, Characteristics and classification of Spare parts; Supply Chain design, scheduling, layout design: Materials Requirement Planning (MRP), MRP-II, Enterprise Resource Planning (ERP), Logistic, Distribution and Supply chain Management, Applications of Newsvendor model in supply chain

### **Modelling and Simulation**

Introduction to modelling and simulation, introduction to symbolic and numerical computations, degrees of freedom, modelling in dependent and independent coordinates, Lagrange equations, state space formulation, Newton-Raphson method, explicit integrator, implicit integrator, dynamics of constrained mechanical systems as differential algebraic equations, Baumgaurte stabilization, Gauss principle, and inverse problems

### **PAPER-3: OPTIONAL ONLY FOR AGRICULTURAL ENGINEERING**

**I. Agricultural process Engineering (Unit Operations):** Introduction to unit operations – classification, conservation of mass and energy SI system of units, consistency of units. Size reduction – principles of comminution, characteristics, particle size distribution, energy and power requirements, crushing efficiency, Rittinger's, Kick's and Bond's laws of crushing. Size reduction equipments – crushers, hammer mills, attrition mills and ball mills. Mixing – mixing of solids, pastes and liquids, characteristics of mixtures, blending, emulsification, mixing index, mixing and blending equipments. Evaporation – single and multiple effect evaporators steam economy, vacuum evaporation, vapour compression, boiling point elevation. Evaporation equipments – open pan, short and long tube evaporators, forced circulation evaporators. Mechanical separations – filtration filter cake resistance, filtration equipment, sedimentation, gravitational sedimentation of particles in fluid and gas, setting under combined forces, cyclone

separator, centrifugal separator. Moisture content – determination methods, equilibrium moisture content. Psychrometry – terms, chart and application. Drying process – theories in drying, methods of drying, classification of dryers. Contact equilibrium separation process – concentrations, extraction, rate of extraction, stage equilibrium extraction. McCabe and Theile plot. Distillation – stage distillation, steam, vacuum and batch distillation, distillation equipment.

**II. Process Engineering for agricultural produce:** Engineering properties of agricultural produce – physical, thermal and aerodynamic properties, force deformation curve of food grains. Principles of threshing – threshing equipment, types, care and maintenance. Principles of winnowing – winnower types. Cleaning and separation – principles, equipment, effectiveness of separation, selection of separating machines. Grading – principles equipment. Rice processing – parboiling of paddy, traditional and modern methods of parboiling, drying equipment, methods of rice milling, rice husk and bran utilisation, layout of modern rice mill, manufacturing process for puffed, flaked and extruded products. Cereal processing – wheat milling, maize shelling, Milling, Degerming. Milling of pulses, Red gram, black gram and green gram. Oil seed processing. Sugarcane crushers. Seed technology – terminology, storage of seeds and treatment. Principles of grain storage – parameters affecting storage, changes occurring during storage, moisture migration, storage insects, pests and their control. Fumigation – principles, properties of fumigants and applications, rodent control. Grain storage structures – bag and bulk storage of grains. Grain handling equipment – bucket elevator, belt, screw and pneumatic conveyors. Quality control – Agmark and BI Standards.

**III. Process Engineering for Horticultural produce:** Engineering properties of horticultural crops – introduction, harvesting indices, methods and equipment. Handling and transportation. Cleaning and grading equipment, Preservation of fruits and vegetables – drying and dehydration, freeze drying, canning, concentration and reverse osmosis techniques, modified atmospheric and control atmospheric storage. Processing and processing machinery of important horticultural produce. Spices and condiments – oleoresins and essential oil extractions from aromatic plants, flowers and spices. Processing of important vegetables. Principles of packaging and packaging materials.

**IV. Vegetable oil technology:** Oils and fats – occurrence and distribution in nature, enzymatic and chemical spoilage, rancidification and its control, emulsions and emulsification. Processing of Oilseeds and other oil bearing materials – pretreatment and equipments, extraction methods, mechanical expression, solvent extraction, supercritical extraction, oil cake utilisation, refining of oils, hydrogenation, quality factors.

**V. Dairy and Food Engineering:** Milk – composition, characteristics, nutritive value, physico – chemical properties of milk, standardization, pasteurization, low temperature long time (LTLT), high temperature short time (HTST), ultra high temperature (UHT), plate heat exchanger, sterilization, homogenization, Manufacture of milk products – milk powder, cream, butter and ice cream. Milk and milk products packaging.

Material and energy balances in food engineering. Reaction kinetics – general principles, effect of time and temperature, Food preservation – principles and methods, causes of food spoilage, radiation preservation of food, properties of ionizing radiation, effects of irradiation on living organisms, technology aspects of irradiation preservation. Freezing of foods – freezing point of foods, freezing point depression, calculation of freezing time.

**VI. Agro Industries and by-product utilisation:** Agro industries – definition, classification, factors responsible for establishment.

Byproducts utilisation – rice husk, rice bran, coconut coir and shell utilisation, mango stone, cashewnut shell, banana pseudo stem, sugarcane bagasse, paper making from agricultural wastes, feed processing plants, layout of feed mills for commercial production. Planning waste management – properties of agricultural waste, waste collection, industrial waste treatment, storage and handling, waste for reuse, briquetting. Establishment of agroprocessing industries in rural areas. Cost benefit ratio for agroprocessing industries. Estimation of BOD, COD, Biological treatment of effluents, trickling filters.

**VII. Biomass energy conversion:** Energy sources – introduction, classification. Biomass – biomass characteristics, utilisation, biodegradation, microbial species, biogas production,

parameters affecting gas production, stirring and dilution, types of biogas plants, comparison, merits and demerits, community biogas plants, constructional details, operation and maintenance, safety measures, slurry utilisation, alternate feed stocks. Biogas appliances – biogas lights, biogas run engines. Agricultural wastes – characteristics, principles of combustion, pyrolysis, incineration, thermodynamic concepts, gasification. Gasifiers – principles, types, stability of operation, design. Charcoal making – principle, methods.

**VIII. Solar and Wind Energy:** Solar energy and its importance – heat transfer from solar energy by conduction, convection, radiation, reflectivity, transmissivity. Solar radiation analysis – solar constant, terminology connected with solar radiation, solar time, solar radiation measurement and estimation. Solar collectors – flat plate collectors, principle of conversion of solar radiation into heat, thermal losses, energy balance equation. Solar air heaters – performance and application. Focusing type solar collectors – thermal performance, optical losses. Solar energy storage – solar pond principles, types and applications of solar pond. Solar energy applications – solar furnace, distillation, cooking, grain drying. Photovoltaics – semi conductor principles, cell characteristics, application of photovoltaic systems in pumping.

Nature of wind power – seasonal influence, diurnal variation, characteristics of suitable sites, velocity and direction measuring instruments, anemometer, wind monitor, rotor classification, air foils, comparison of different types, lift and drag characteristics, wind mill components, power transmission, performance of wind mill, application of wind mills.

**IX. Greenhouse Technology:** Greenhouse technology – introduction, importance of greenhouse, greenhouse effect. Factors responsible for plant growth – heat, light, moisture, carbon dioxide, nutrients, plant response to greenhouse environment. Solar energy in greenhouse – importance, types of radiation, effect on greenhouse environment, parameters. Design criteria of greenhouse for cooling and heating purposes. Greenhouse equipments – materials of construction for traditional and low cost greenhouse, cost estimation and economic analysis. Typical applications – passive solar greenhouse, hot air greenhouse heating systems, greenhouse drying. Natural ventilation, summer and winter cooling – shadenets, polytunnels.

**X. Design and Costing of Farm Structures:** Farmstead – layout, design and costing of farm structures, farm, house, godowns, threshing and drying yards. Farm roads – types and construction. Farm fencing – types and cost estimation. Dairy barns – types, site selection, design and costing. Types, design and costing of poultry and hog housing. Storage structures – grain pressure theories, design and costing of traditional structures, bag storage structures, grain bins, silos for fodder storage. Design and costing of farm workshop and machinery storage structures.

**XI. Rural water supply, Sanitation and Environmental Engineering:** Rural water supply – water demands, sources of water supply. Collection and distribution of water – storage systems, distribution mains, pipes, joints and fittings, pumps and pumping stations. Quality and treatment of water – sedimentation, filtration, types of filters.

Sanitation – septic tanks, preparation of sanitary projects. Sewage disposal – methods, sewage treatment, sludge disposal and treatment methods. Air-pollution – sources and control measures.

**XII. Wells and Pumps with Special reference to Lift Irrigation:** Water resources – introduction, status of ground water development in India. Types of water bearing formations – ground water replenishment and recharge methods. Ground water investigation methods. Hydraulics of wells – aquifer characteristics influencing yield of wells both under steady state and unsteady state conditions, procedure involved in estimation of aquifer characteristics through pumping tests. Wells - classification of wells, design of open wells in unconsolidated formations, methods for increasing the yield in open wells. Types of tube wells – selection of type of tube well, analysis of particle size distribution of the aquifer, design of tube wells, tube well construction procedures and development and testing of tube wells.

Classification of water lifting devices – manual and animal powered devices. Pumps – reciprocating pumps (single and double acting). Centrifugal pumps – components, principle, characteristic curves, power requirements. Deep well pumps – turbine and submersible pumps, their components, working, principle installation and maintenance. Hydraulic ram – installation,

working principle. Jet pumps – components, working principle. Selection of pumps and economic evaluation of pumping.

**XIII. Irrigation Engineering:** Irrigation – necessity, benefits, sources, soil – water – plant relationships kinds of soil water. Types of Irrigation projects. Infiltration – characteristics, measurement and analysis. Evapotranspiration and its measurement. Water requirements of crops – duty and delta of water. Irrigation requirement – depth, interval, and period, irrigation efficiencies. Water application methods – borders, furrows and check basins and their designs. Measurement of irrigation water – different methods, volumetric, area velocity, measuring devices, weirs, flumes, watermeter. Design of open channels and canals – Lacey's and Kennedy's theories. Design of underground pipeline systems.

**XIV. Soil and Water Engineering:** Importance and phases of soil and water conservation engineering. Soil conservation programmes in India. Erosion – main types of erosion, factors effecting erosion. Water erosion – types of water erosion, control measures. Wind erosion – phases, control measures. Land use capability classification. Measurement of soil loss – universal soil loss equation. Contour and graded bunds – design of bunds, spacing of bunds, determination of height of the contour bund, construction and alignment of bunds, surplus arrangements, contour ditching, area lost under contour bunding. Terracing – types of terraces, planning and design of a terrace system, constructional procedure, equipment needed. Bunch terracing – types, area lost under Bund terracing. Contour trenching – types, alignment and construction. Bed and furrow system. Vegetated waterways – functions, shape of water ways, design of vegetated waterways, maintenance. Gullies – planning for gully control, methods of gully control, temporary gully control structures, permanent gully control structures, phases.

**XV. Watershed Management:** Watershed management – concept and principles – watershed characteristics, watershed protection, analysis, and control measures. Effects of watershed management. Study of watershed management as a multi disciplinary approach – watershed identification, watershed delineation.

**XVI. Drainage Engineering:** Drainage – necessity, benefits, drainage requirements, drainage coefficient, hydraulic conductivity and its measurement, field and lab methods. Types of drainage – surface drainage systems for ponded, flat and slopy areas. Subsurface drainage methods, tile drainage, layout, depth and spacing of drains, steady and unsteady state condition, Hooghoudt's analysis, equivalent depth concept, size, grade and materials for tile drains, envelope materials and types of outlets. Drainage for salinity control – leaching requirements. Loads on conduits – ditch type and projecting type conditions, strength requirements of tile drains.

**XVII. Sprinkler and Drip Irrigation:** Sprinkler irrigation – adaptability, limitations, types, components of the sprinkler system including fertilizer applicator, precipitation profiles and recommended spacings, effect of wind speed on working of the system, design of sprinkler system, lay out, laterals and mains, selection of pump, operation and maintenance of system. Field evaluation of the system – distribution pattern and uniformity coefficient, cost analysis.

Drip irrigation – advantages and limitations, types, components of the system including fertilizer applicator and pressure regulators, distribution network, main lines, laterals, drippers. Planning and design of the drip system – collection of preliminary data, layout, crop water requirements, hydraulic design, selection of components, installation, operation and maintenance, testing and field evaluation of the system.

**XVIII. Land Development Machinery:** Land Clearing – rock blasting, stump pulling. Land development – terminology, methods, cost of material movement. Land development machinery – types, crawler tractors, track versus rubber tyres. Excavators – shovel, hoe, dragline, clamshell, proclaines, rippers. Combined excavation and hauling units – wagons, trucks and front end dumpers, hydraulic trippers. Compaction rollers. Scrapers – types, bulldozers, levelling blades.

**XIX. Farm power and Tractor Systems:** I.C. engines – introduction, principles of operation of I.C. engines, performance characteristics of diesel engine, different components of I.C. engines. Tractor systems – fuel, lubrication, cooling, electrical, transmission, governing, brakes, steering, hydraulic systems, principle and maintenance of storage battery. Chasis mechanism –

determination of center of gravity, maximum drawbar pull. Tractor and power tillers – classification, selection, operation, adjustments, common troubles and remedies, maintenance, comfort, safety, power and its measurement, traction theory, tyres.

**XX. Farm machinery and agricultural machine design:** Tillage – introduction, objectives, primary and secondary tillage, animal and tractor drawn implements. Mould board plough – constructional details, terminology, materials of construction, types of plough bottoms, shares, plough accessories, force analysis and design considerations, problems on M.B. Plough operations, victory plough, turn wrest plough. Disc ploughs – advantages, disadvantages, constructional details of various components, accessories, plough adjustments, disc angle and tilt angle, differences between M.B. plough and disc plough, Ploughing methods. Chisel and subsoiler. Secondary tillage implements – harrows, types, constructional details of single action, double action, tandem and offset disc harrows, spike tooth, spring tooth harrows, differences between vertical disc plough and standard disc plough. Cultivators – rigid, spring type cultivator, types of sweeps and shovels. Weeding, manual and power operated equipments. Other implements – bund former, ridger, APAU puddler, clod breaker, rototiller, green manure trampler. Cost of operation of farm implements. Sowing – methods, seed drill functions, calibration procedure, numerical problems, types of metering mechanisms, types of furrow opener, types of planter, construction and working principles of dibbler. Planting equipments – paddy transplanter, potato planter, sugarcane planter. Manure and fertilizer application – manure applicators spreaders, broadcasters, fertidrill.

Plant protection equipments – importance, types, Sprayers – classification, bucket, knapsack, boom sprayers, parts and accessories, atomizers, agitators, determination of particle size distribution, MMD and SMD/VMD, ultra low volume, low volume, high volume spraying, aerial spraying, orchard sprayers, factors affecting drift. Distlers – types, hand, rotary and power operated sprayers cum dusters. Care and maintenance of plant protection equipment. Crop harvesting machinery – mower, reaper, cutting and driving mechanism, adjustments of mower. Combines – working of combines. Harvesting equipment for cotton, maize, potato, groundnut, fruits and vegetables.

Design process – classification of design work. Working stresses – stress concentration, notch sensitivity. Theories of failure – maximum shear stress theory, maximum strain theory, maximum distortion theory. Limits, fits and tolerances. Design of knuckle joints, cotter joints. Design of hand lever, foot lever, crank lever. Design of springs – flat and leaf springs. Design of shafts – design of belts pullys – keys and key ways. Design of flywheels. Design of couplings – muff, flange couplings. Design of bearings – ball, roller bearing. Design of I.C. engine parts – cylinder, cylinder head, connecting rod.

**XXI. Design and Costing of Soil Conservation and Irrigation Structures:** Introduction to soil and water conservation structures. Design and costing of mechanical structures – contour bund, graded bund, broad based terraces, bench terraces, contour trenches and conservation ditches. Design and costing of gully control structures – drop spillways, drop inlet spillways, chute spillways, check dams. Design and costing of water harvesting structures – farm ponds, percolation tanks. Design and costing of energy dissipaters – stilling basins.

Irrigation engineering structures – design and costing of canal falls, cross drainage works, aqueducts, super passage, inverted syphon aqueduct. Irrigation outlets – non-modular, semi modular, rigid modular outlets, baffle sluice irrigation modules. Regulators – head regulator, cross regulator.