

**SCHEME AND SYLLABUS FOR THE RECRUITMENT TO THE POST OF  
FOREST RANGE OFFICERS**

**SCHEME**

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

<b><u>PART-A: COMPULSORY PAPERS:</u></b>			
i) General Studies	150 Marks	150 Questions	150 Minutes
ii) General English	100 Marks	100 Questions	100 Minutes
iii) Mathematics (SSC (High school) standard)	150 Marks	150 Questions	150 Minutes
<b><u>OPTIONAL SUBJECT:</u></b> (One optional subject only) Optional Subject (1 only)	200 Marks	200 Questions	180 Minutes
<b><u>PART-B:</u></b> Interview (Oral Test)	70 Marks		

**List of Optional Subjects:**

The candidates have to choose one optional subject from the following:

01. Agriculture	08. Geology
02. Agricultural Engineering	09. Horticulture
03. Botany	10. Mathematics
04. Chemistry	11. Mechanical Engineering
05. Chemical Engineering	12. Physics
06. Civil Engineering	13. Statistics
07. Forestry	14. Zoology

**Proviso:** Provided that the candidates will not be allowed to offer the following combination of subjects:

1. Agriculture and Agricultural Engineering
2. Chemistry and Chemical Engineering
3. Mathematics and Statistics
4. Not more than one Engineering subject among the Engineering subjects.
5. Agriculture and Horticulture

**N.B.:** 1. After written examination, eligible candidates will be called for interview (Oral test) at the ratio of 1:3 category-wise, duly following the special representation as laid down in General Rule 22 of State and Subordinate Service Rules.

2. A candidate will be required to undergo a walking test and also a Medical Examination (conducted by a Medical Board) before he/she is finally called for interview. Both the tests shall be arranged by the Forest Department, duly taking concurrence of A.P.P.S.C..

3. Appearance at all the above tests is compulsory for eligibility of candidature for Interview. Absence at any or all of the papers will render the candidature invalid..

4. The minimum qualifying Marks for Interview and selection are 40% for OCs; 35% for BCs and 30% for SC&ST.

5. The candidates belonging to SCs/STs/BCs may be called for interview by relaxing the minimum qualifying marks at the discretion of the Commission, if the Commission is of the opinion that sufficient number of candidates from these communities are not likely to come-up for Interview.

## SYLLABUS

### (i) GENERAL STUDIES

1. General Science – Contemporary developments in Science and Technology and their implications including matters of every day observation and experience, as may be expected of a well-educated person who has not made a special study of any scientific discipline.
2. Current events of national and international importance.
3. History of India – emphasis will be on broad general understanding of the subject in its social, economic, cultural and political aspects with a focus on AP Indian National Movement.
4. World Geography and Geography of India with a focus on AP.
5. Indian polity and Economy – including the country's political system- rural development – Planning and economic reforms in India.

### (ii) GENERAL ENGLISH

- a) Comprehension
- b) Usage and idiom
- c) Vocabulary and punctuation
- d) Logical re-arrangement of sentences

### (iii) MATHEMATICS (SSC (High School) Standard)

**ARITHMETIC:** Number System-Natural numbers, Integers, Rational and Real numbers, Fundamental operations, addition, subtraction, multiplication, division, Square roots, Decimal fractions.

Unitary method-time and distance, time and work, percentages, applications to simple and compound interest, profit and loss, ratio and proportion, variation.

Elementary Number Theory – Division algorithm. Prime and composite numbers. Tests of divisibility by 2,3,4,5,9 and 11. Multiples and factors. Factorisation Theorem. H.C.F. and L.C.M. Euclidean algorithm. Logarithms to base 10, laws of logarithms, use of logarithmic tables.

**ALGEBRA:** Basic Operations, simple factors, Remainder Theorem, H.C.F., L.C.M. Theory of polynomials, solutions of quadratic equations, relation between its roots and coefficients (Only real roots to be considered). Simultaneous linear equations in two unknowns – analytical and Graphical solutions. Simultaneous linear inequations in two variables and their solutions. Practical problems leading to two simultaneous linear equations or inequations in two variables or quadratic equations in one variable and their solutions. Set language and set notation, Rational expressions and conditional identities, laws of indices.

**TRIGONOMETRY:** Sine x, Cosine x, Tangent x when  $0^\circ \leq x \leq 90^\circ$  values of sin x, cos x and tan x, for  $x = 0^\circ, 30^\circ, 45^\circ, 60^\circ$  and  $90^\circ$ .

Simple trigonometric identities.

Use of trigonometric tables.

Simple cases of heights and distances.

**GEOMETRY:** Lines and angles, Plane and plane figures, Theorems on (i) Properties of angles at a point, (ii) Parallel lines, (iii) Sides and angles of a triangle, (iv) Congruency of triangles, (v) Similar triangles, (vi) Concurrence of medians and altitudes, (vii) Properties of angles, sides and diagonals of a parallelogram, rectangle and square, (viii) Circles and its properties including tangents and normals, (ix) Loci.

**MENSURATION:** Areas of squares, rectangles, parallelograms, triangle and circle. Areas of figures which can be split up into these figures (Field Book), Surface area and volume of cuboids, lateral surface and volume of right circular cones and cylinders, surface area and volume of spheres.

**STATISTICS:** Collection and tabulation of statistical data, Graphical representation frequency polygons, histograms, bar charts, pie charts etc. Measures of central tendency.

## **OPTIONAL SUBJECTS**

### **01. AGRICULTURE**

Agriculture, its importance in National economy. Factors determining agro-ecological zones and geographic distribution of crop plants. Importance of crop plants, cultural practices for cereal, pulses, oilseed, fibre, sugar, tuber and fodder crops and scientific basis for these crop-rotations, multiple and relay cropping, intercropping and mixed cropping.

Soil as medium of plant growth and its composition, mineral and organic constituents of the soil and their role in crop production; chemical, physical and microbiological properties of soils. Essential plant nutrients (macro and micro) their functions, occurrence, cycling in soils. Principles of soil fertility and its evaluation for judicious fertilizer use. Organic manures and bio-fertilizers, inorganic fertilizers, integrated nutrient management.

Principles of plant physiology with reference to plant nutrition, absorption, translocation and metabolism of nutrients.

Diagnosis of nutrient deficiencies and their amelioration photosynthesis and respiration, growth and development, auxins and hormones in plant growth.

Cell and cell organelles. Cell division. Reproductive cycle, Principles of genetics, gene-interaction, sex determination, linkage and re-combination, mutation, extra chromosomal inheritance, polyploidy. Origin and domestication of crop plants. Genetic resources-conservation and utilization. Floralbiology in relation to selfing and crossing.

Genetic basis of plant breeding pureline selection, mass selection, male sterility and incompatibility and their use in plant breeding. Pedigree selection, back-cross method of selection. Heterosis and its exploitation. Development of hybrids, composites and synthetic, important varieties, hybrids, composites and synthetic of major crops. Seeds and seed production techniques.

Important fruit and vegetable crops of India, method of propagation-Sexual and asexual. Package and practices and their scientific basis. Crop rotation, intercropping, companion crops, role of fruits and vegetables in human nutrition, post-harvest handling and processing of fruits and vegetables. Landscaping and ornamental horticulture, commercial floriculture. Medicinal and aromatic plants. Serious pests and diseases affecting major crops. Principles of control of crop pests and diseases, integrated management. Proper use and maintenance of plant protection equipment.

Principles of economics as applied to agriculture. Farm planning and optimum resource-use efficiency and maximizing income and employment. Farm systems and their spatial distribution, their significant roles in regional economic development.

### **02. AGRICULTURAL ENGINEERING**

01. Soil Science +soil physics +soil mechanics
02. Agronomy +Agricultural Extension + Agricultural Economics
03. Heat and mass transfer +Refrigeration and Air conditioning
04. Unit operations in Agricultural process Engineering
05. Process Engineering for Agricultural produce starting from crop threshing and upto storage of crops
06. Process Engineering for horticulture produce + dairy Engineering
07. Strength of materials and theory of structures
08. Electrical Engineering and farm electrification
09. Alternate energy sources
10. Thermodynamics-heat engines and farm power
11. Farm machinery and equipment
12. Instrumentation-design of Agricultural machines-Industrial Engineering
13. Land development machinery
14. Surveying and levelling
15. Open channels-wells and pumps
16. Irrigation + drainage + sprinkler and drip systems
17. Soil and water conservation + soil conservation structures.

### **03. BOTANY**

1. **Cell Biology:** Structure and function of cell wall (extracellular matrix or ECM), cell membrane and cell organelles, Nucleus, nucleolus, nuclear pore complex (NPC), chromosome and nucleosome, Mitosis, meiosis, molecular control involving check-points in cell division cycle. Differentiation, cellular senescence.

2. **Genetics, Molecular Biology and Biotechnology:** Laws of inheritance. Concept of gene and allelomorph. Linkage crossing over and gene mapping. Structural and numerical changes in chromosomes and gene mutations. Sex determination and differentiation. Structure and synthesis of nucleic acids and proteins. Genetic code. Regulation of gene expression. Genetic engineering and crop improvement. Protoplast, cell, tissue and organ cultures. Somatic hybridization. Biofertilizers and biopesticides. Biotechnology in agri-horticulture, medicine and industry.

3. **Tissue Systems:** Origin, development, structure and function of primary and secondary tissue.

4. **Plant Diversity and Systematics:** Structure and function of plant forms from evolutionary aspects (viruses to Angiosperms including fossils). Principles of nomenclature, classification and identification of plants. Modern approaches in plant Taxonomy. Recent classification of living organism into three groups (bacteria, archaea and eukarya).

5. **Plant Physiology:** Water relations. Mineral nutrition. Photosynthesis. Respiration. Nitrogen metabolism. Enzymes and coenzymes. Dynamics of growth, growth movements, growth substances, photomorphogenesis. Secondary metabolites. Isotopes in biological studies. Physiology of flowering.

6. **Methods of Reproduction and Seed Biology:** Vegetative, asexual and sexual methods of reproduction. Pollination and fertilization. Sexual incompatibility. Development, structure, dormancy and germination of seed.

7. **Plant Pathology:** Diseases of rice, wheat, sugarcane, potato, mustard, groundnut and cotton crops. Factors affecting infection (host factors, pathogen factors, biotic factors like rhizosphere and phyllosphere organisms). Chemical, biological and genetic methods of disease control (including transgenic plants).

8. **Plant and Environment:** Biotic and abiotic components. Ecological adaptation. Types of vegetational zones and forests of India. Deforestation, afforestation, social forestry and plant introduction. Soil erosion, wasteland, reclamation. Environmental pollution and its control (including phytoremediation). Bio-indicators. Global warming.

9. **Biodiversity, plant Genetic Resources:** Methods of conservation of plant genetic resources and its importance. Convention of Biological Diversity (CBD). Endangered, threatened and endemic taxa. Role of cell/tissue culture in propagation and enrichment of genetic diversity. Plants as sources of food, fodder, forage, fibres, oils, drugs, wood and timber, paper, rubber, beverages, spices, essential oils and resins, gums, dyes, insecticides, pesticides and ornamentation. Biomass as a source of energy.

10. **Origin of Life and Evolution:** Basic concept of origin of earth and origin of life. Theories of organic evolution, molecular basis of evolution.

## 04. CHEMISTRY

### SECTION-A: (INORGANIC CHEMISTRY):

**1.1 Atomic structure:** Schrodinger wave equation, significance of  $\Psi$  and  $\Psi^2$  quantum numbers and their significance, radial and angular probability, shapes of orbitals, relative energies of atomic orbitals as a function of atomic number. Electronic configurations of elements; Aufbau principle, Hund's multiplicity rule, Pauli exclusion principle.

**1.2 Chemical periodicity:** Periodic classification of elements, salient characteristics of s,p,d and f block elements. Periodic trends of atomic radii, ionic radii, ionization potential, electron affinity and electronegativity in the periodic table.

**1.3 Chemical bonding:** Types of bonding, overlap of atomic orbitals, sigma and pi-bonds, hydrogen and metallic bonds. Shapes of molecules bond order, bond length, V.S.E.P.R. theory and bond angles. The concept of hybridization and shapes of molecules and ions.

**1.4 Oxidation states and oxidation number:** Oxidation and reduction, oxidation numbers, common redox reactions, ionic equations. Balancing of equations for oxidation and reduction reactions.

**1.5 Acids and bases:** Bronsted and Lewis theories of acids and bases. Hard and soft acids and bases. HSAB principle, relative strengths of acids and bases and the effect of substituents and solvents on their strength.

#### **1.6 Chemistry of elements:**

- i) **Hydrogen:** Its unique position in the periodic table, isotopes, ortho and para hydrogen, industrial production, heavy water.
- ii) **Chemistry of 's' and 'p' block elements:** Electronic configuration, general characteristics properties, inert pair effect, allotropy and catenation. Special emphasis on solutions of alkali and alkaline earth metals in liquid ammonia. Preparation, properties and structures of boric acid, borates, boron nitrides, borohydride (diborane), carboranes, oxides and oxyacids of nitrogen, phosphorous, sulphur and chlorine; interhalogen compounds, polyhalide ions, pseudohalogens, fluorocarbons and basic properties of halogens. Chemical reactivity of noble gases, preparation, structure and bonding of noble gas compounds.
- iii) **Chemistry of 'd' block elements:** Transition metals including lanthanides, general characteristic properties, oxidation states, magnetic behaviour, colour. First row transition metals and general properties of their compounds (oxides, halides and sulphides); lanthanide contraction.

**1.7 Extraction of metals:** Principles of extraction of metals as illustrated by sodium, magnesium, aluminum, iron, nickel, copper, silver and gold.

**1.8 Nuclear Chemistry:** Nuclear reactions; mass defect and binding energy, nuclear fission and fusion. Nuclear reactors; radioisotopes and their applications.

**1.9 Coordination compounds:** Nomenclature, isomerism and theories of coordination compounds and their role in nature and medicine.

**1.10 Pollution and its control:** Air pollution, types of air pollution, control of air and water pollution, radioactive pollution.

### SECTION-B: (ORGANIC CHEMISTRY):

**2.1 Bonding and shapes of organic molecules:** Electronegativity, electron displacements-inductive, mesomeric and hyperconjugative effects; bond polarity and bond polarizability, dipole moments of organic molecules; hydrogen bond; effects of solvent and structure on dissociation constants of acids and bases; bond formation, fission of covalent bonds; homolysis and heterolysis; reaction intermediates-carbocations, carbanions, free radicals and carbenes; generation geometry and stability; nucleophiles and electrophiles.

**2.2 Chemistry of aliphatic compounds:** Nomenclature alkanes-synthesis, reactions (free radical halogenation) – reactivity and selectivity, sulphonation-detergents; cycloalkanes-Baeyers' strain theory; alkanes and alkynes-synthesis, electrohilic addition; reactions, Markownikov's rule, peroxide effects, 1-3-dipolar addition; nucleophilic addition to electron-deficient alkenes; polymerization; relative acidity; synthesis and reactions of alkyl halides, alkanols, alkanals, alkanones, alkanolic acids, esters, amides, nitriles, amines, acid anhydrides,  $\alpha\beta$ -unsaturated ketones, ethers and nitro compounds.

**2.3 Stereochemistry of carbon compounds:** Elements of symmetry, chiral and achiral compounds. Fischer projection formulae; optical isomerism of lactic and tartaric acids, enantiomerism and diastereoisomerism; configuration (relative and absolute); conformations of alkanes upto four carbons, cyclohexane and dimethylcyclo-hexanes their potential energy **D,L** and **R,S** notations of compounds containing chiral centers; projection formulae-Fischer, Newman and sawhorse of compounds containing two adjacent chiral centers; meso and dl-isomers, erythro and threo isomers; racemization and resolution; examples of homotopic, enantiotopic and diastereotopic atoms and groups in organic compounds, geometrical isomers; **E** and **Z** notations. Stereo-chemistry of SN1, SN2, E1 and E2 reactions.

**2.4 Organometallic compounds:** Preparation and synthetic uses of Grignard reagents, alkyl lithium compounds.

**2.5 Active methylene compounds:** Diethyl malonate, ethyl acetoacetate. ethyl cyanoacetate-applications in organic synthesis; tautomerism (keto-enol).

**2.6 Chemistry of aromatic compounds:** Aromaticity; Huckel's rule; electrophilic aromatic substitution-nitration, sulphonation, halogenation (nuclear and side chain), Friedel-Crafts alkylation and acylation, substituents effect; chemistry and reactivity of aromatic halides, phenols, nitro, diazo, dia-zonium and sulphonic acid derivatives, benzyne reactions.

**2.7 Chemistry of biomolecules:** (i) **Carbohydrates:** Classification, reactions, structure of glucose, D,L-configuration, osazone formation; fructose and sucrose; step-up step-down of aldoses and ketoses; and their interconversion, (ii) **Amino acids:** Essential amino acids; zwitterions, isoelectric point, polypeptides; proteins; methods of synthesis of  $\alpha$ -amino acids. (iii) Elementary idea of oils, fats, soaps and detergents.

**2.8** Basic principles and applications of UV, visible, IR and NMR spectroscopy of simple organic molecules.

### **SECTION-C: (PHYSICAL CHEMISTRY):**

**3.1 Gaseous state:** Deviation of real gases from the equation of state for an ideal gas, Vander Waals and Virial equation of state, critical phenomena, principle of corresponding states, equation for reduced state. Liquification of gases, distribution of molecular speed, collisions between molecules in a gas; mean free path, specific heat of gases.

#### **3.2 Thermodynamics:**

- (i) **First Law and its applications:** Thermodynamic systems, states and processes work, heat and internal energy, zeroth law of thermodynamics, various types of work done on a system in reversible and irreversible processes. Calorimetry and thermo-chemistry, enthalpy and enthalpy changes in various physical and chemical processes, Joule-Thomson effect, inversion temperature. Heat capacities and temperature dependence of enthalpy and energy changes.
- (ii) **Second Law and its applications:** Spontaneity of a process, entropy and entropy changes in various processes, free energy functions, criteria for equilibrium, relation between equilibrium constant and thermodynamic quantities.

**3.3 Phase rule and its applications:** Equilibrium between liquid, solid and vapours of a pure substance, Clausius-Clapeyron equation and its applications. Number of components, phases and degrees of freedom; phase rule and its applications; simple systems with one (water and sulphur) and two components (lead-silver, salt hydrates). Distribution law, its modifications, limitations and applications.

**3.4 Solutions:** Solubility and its temperature dependence, partially miscible liquids, upper and lower critical solution temperatures, vapour pressures of liquids over their mixtures, Raoult's and Henry's law, fractional and steam distillations.

**3.5 Colligative Properties:** Dilute solutions and colligative properties, determination of molecular weights, using colligative properties.

**3.6 Electro-chemistry:** Ions in solutions, ionic equilibria, dissociation constants of acids and bases, hydrolysis, pH and buffers, theory of indicators and acid-base titrations. Conductivity of ionic solutions, its variation with concentration, Ostwald's dilution law, Kohrausch law and its application. Transport number and its determination. Faraday's laws of electrolysis, galvanic cells and measurements of their e.m.f., cell reactions, standard cell, standard reduction potential Nernst equation, relation between thermodynamic quantities and cell e.m.f., fuel cells, potentiometric titrations.

**3.7 Chemical kinetics:** Rate of chemical reaction and its dependence on concentrations of the reactants, rate constant and order of reaction and their experimental determination; differential and integral rate equations for first and second order reaction, half-life periods; temperature dependence of rate constant and Arrhenius parameters; elementary ideas regarding collision and transition state theory.

**3.8 Photochemistry:** Absorption of light, laws of photochemistry, quantum yield, the excited state and its decay by radiative, non-radiative and chemical pathways; simple photochemical reactions.

**3.9 Catalysis:** Homogeneous and heterogeneous catalysis and their characteristics, mechanism of heterogeneous catalysis; enzyme catalysed reactions (Michaelis-Menten mechanism)

**3.10 Colloids:** The colloidal state, preparation and purification of colloids and their characteristics properties; lyophilic and lyophobic colloids and coagulation; protection of colloids; gels, emulsions, surfactants and micelles.

## **05. CHEMICAL ENGINEERING**

**PROCESS CALCULATIONS AND THERMODYNAMICS:** Laws of conservation of mass and energy; use of tie components; recycle, bypass and purge calculations; degrees of freedom.

First & Second law of thermodynamics and their applications; equations of state and thermodynamic properties of real systems; phase equilibria; fugacity; excess properties and correlations of activity coefficients; chemical reaction equilibria.

**FLUID MECHANICS AND MECHANICAL OPERATIONS:** Fluid statics, Newtonian and non-Newtonian fluids, macroscopic energy balance, Bernoulli equation, dimensional analysis, continuity equation, flow through pipeline systems, flow meters, pumps and compressors, packed and fluidized beds, elementary boundary layer theory.

Size reduction, and size separation, free and hindered settling, centrifuges, and cyclones, thickening and classification, filtration, mixing and agitation, storage and handling of solids.

**HEAT TRANSFER:** Conduction, convection and radiation, heat transfer coefficients, study and unsteady heat conduction, boiling, condensation and evaporation, types of heat exchangers & evaporators and their design principles.

**MASS TRANSFER:** Flick's law, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass trans analogies; stage wise continuous contacting and stage efficiencies; design principles and operation of equipment for distillation absorption, leaching, liquid-liquid extraction, crystallization, drying, humidification, dehumidification and adsorption.

**CHEMICAL REACTION ENGINEERING:** Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors; non-isothermal reactors; basics of non-ideal flow, F& E curves, axial dispersion; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

**INSTRUMENTATION AND PROCESS CONTROL:** Measurement of process variables; dynamics of simple systems such as CSTRs, heat exchanges, transfer functions, response of systems, process reaction curve, controller modes (P, PI, and PID); control valves; analysis of closed loop systems including stability, frequency response (including Bode plots) and controller tuning.

**PLANT DESIGN AND ECONOMICS:** Design of chemical process plants; principles of process economics and cost estimation.

**CHEMICAL TECHNOLOGY:** Inorganic chemical reactions; sulfuric acid, sodium hydroxide, fertilizers; ammonia, urea, di-ammonium phosphate super phosphate; natural product industries; pulp and paper, sugar, oil and fats; petroleum refining and petrochemicals; polymerization industries; poly ethylene, poly propylene, and synthetic fibres.

## **06. CIVIL ENGINEERING**

### **PART-A**

1. **Engineering Mechanics:** Units and Dimensions, SI Units, Vectors, Concept of Force, Concept of particle and rigid body. Concurrent, non-concurrent and parallel forces in a plane, moment of force and Varignon's theorem, free body diagram, conditions of equilibrium, Principle of virtual work, equivalent force system.

First and Second Moments of area, Mass moment of Inertia.

Static Friction Inclined plane and bearings.

Kinematics and Kinetics: Kinematics in Cartesian and polar co-ordinates, motion under uniform and non-uniform acceleration, motion under gravity. Kinetics of particle: Momentum and Energy principles, D'Alembert's Principle, Collision of elastic bodies, rotation of rigid bodies, simple harmonic motion.

2. **Strength of Materials:** Simple Stress and Strain, Elastic constants, axially loaded compression members, Shear force and bending moment, theory of simple bending moment, Shear Stress distribution across cross sections, Beams of uniform strength, Leaf spring, Strain Energy in direct stress, bending and shear.

**Deflection of beams:** Macaulay's method, Mohr's moment area method, Conjugate beam method, unit load method. Torsion of Shafts, Transmission of power, close coiled helical springs, Elastic stability of columns: Euler's, Rankine's and Secant formulae. Principal Stresses and Strains in two dimension, Mohr's Circle. Theories of Elastic failure, Thin and Thick cylinders: Stresses due to internal and external pressures-Lame's equation.

3. **Structural Analysis:** Analysis of pin jointed plane trusses, deflection in trusses. Three hinged and two hinged arches, rib shortening, temperature effects, influence lines in arches. Analysis of propped cantilevers, fixed beams, continuous beams and rigid frames. Slope deflection, moment distribution, Kani's method and Matrix method: Force and Displacement methods. Rolling loads and influence lines for determinate beams and pin jointed trusses.

### **PART-B**

**Geotechnical Engineering:** Types of soil, field identification and classification, phase relationships, consistency limits, particle size distribution, classification of soil, structure and clay mineralogy.

Capillary water and structural water, effective stress and pore water pressure, Darcy's Law, factors affecting permeability, determination of permeability, permeability of stratified soil deposits.

Seepage pressure, quick sand condition, compressibility and consolidation, Terzaghi's theory of one dimensional consolidation, consolidation test. Compaction of soil, optimum moisture content, Proctor Density.

Subsurface exploration, methods of boring, sampling, types of sampler, field tests.

Shear strength of soils, Mohr-Coulomb failure theory, shear tests Earth pressure at rest, active and passive pressures, Rankine's theory, Coulomb's wedge theory, earth pressure on retaining wall.

Bearing capacity, Terzaghi and other important theories, net and gross bearing pressure, immediate and consolidation settlement.

Load carrying capacity of pile groups.

Stability of slope-conventional method of slices, stability numbers.

**Transportation Engineering:** Highway alignment, choice of layout and capacity of highways, location survey, geometric design of highways-various elements, curves, grade separation and segregation of traffic, inter-section design, highway materials and testing subgrade and pavement components, type of pavements, road drainage, elements of airport engineering.

Railway engineering-elements of permanent track-rails, sleepers, ballast and rail fastenings, tractive resistance, elements of geometric design-gradients and grade compensation on curves, cant transition curves and vertical curves, stresses in railway tracks, points and crossing, signaling and inter-locking, maintenance of railway track. Culverts and small bridges.

### **PART-C**

**Fluid Mechanics:** fluid properties, fluid statics, forces on plane and curved surfaces, stability of floating and submerged bodies.

**Kinematics:** Velocity, streamlines, continuity equation, accelerations irrotational and rotational flow, velocity potential and stream functions, flownet, separation.

**Dynamics:** Euler's equation along streamline, control volume equation, continuity, momentum, energy and moment of momentum equation from control volume equation, applications to pipe flow, moving vanes, moment of momentum, Dimensional analysis.

Boundary layer on a flat plate, drag and lift on bodies. Laminar and Turbulent Flows. Laminar and turbulent flow through pipes, friction factor variation, pipe networks, water hammer and surge tanks.

**Open Channel Flow:** Energy and momentum correction factors, uniform and non-uniform flows, specific energy and specific force, critical depth, Friction factors and roughness co-efficients, flow in transitions, free overfall, weirs, hydraulic jump, surges, gradually varied flow equations, surface profiles, moving hydraulic jump.

## **PART-D**

### **Environmental Engineering:**

**Water Supply:** Estimation of surface and subsurface water resources, predicting demand for water, impurities of water and their significance, physical, chemical and bacteriological analysis, water borne diseases, standards for potable water.

**Intake of water:** Pumping and gravity schemes, water treatment; principles of coagulation, flocculation and sedimentation; slow-, rapid-, pressure-, filters; chlorination, softening, removal of taste, odour and salinity.

Water storage and distribution: storage and balancing reservoir types, location and capacity. Distribution systems: layout, hydraulics of pipe lines, pipe fittings, valves including check and pressure reducing valves, meters, analysis of distribution systems, leak detection, maintenance of distribution systems, pumping stations and their operations.

**Sewerage systems:** Domestic and industrial wastes, storm sewage-separate and combined systems, flow through sewers, design of sewers, sewer appurtenances, manholes, inlets, junctions, siphon. Plumbing in Public buildings.

**Sewerage characterization:** BOD, COD, solids, dissolved oxygen, nitrogen and TOC. Standards of disposal in normal water course and on land.

**Sewage treatment:** Working principles, units, chambers, sedimentation tank, trickling filters, oxidation ponds, activated sludge process, septic tank, disposal of sludge, recycling of waste water.

**Construction Management:** Elements and principles of Activity on Arrow (AOA) and Activity on Node (AON) networks and work breakdown structure. Interfaces. Ladder networks. Activity time. Time computations and works. ATC and PTC trade-off. Work study and sampling. Scheduling principles-material schedules. ABC and EOQ analysis of inventory. Budgeting with bar-charts. Working capital. PERT, probability of completion.

Elements of Engineering Economics, methods of appraisal, present worth, annual cost, benefit-cost, incremental analysis. Economy of scale and size. Choosing between alternatives including levels of investments. Project profitability.

## **07. FORESTRY**

### **1. SILVICULTURE – GENERAL:**

General Silvicultural Principles; ecological and physiological factors influencing vegetation, natural and artificial regeneration of forests, methods of propagation, grafting techniques; site factors; nursery and planting techniques – nursery beds, polybags and maintenance, water budgeting, grading and hardening of seedlings, special approaches, establishment and tending.

### **2. MANGROVE:**

Habitat and characteristics, mangrove, plantation-establishment and rehabilitation of degraded mangrove formations; protection of habitats against natural disasters.

### **3. SILVICULTURE OF TREES:**

Traditional and recent advances in tropical silvicultural research and practices. Silvi-culture of some of the economically important species in India such as Acacia Sundra, Acacia nilotica Acacia auriculiformis, Albizzia lebbeck, Albizzia procera, Anthocephalus Cadamba, Anogeissus latifolia, Azadirachta indica, Bamboo spp, Butea monosperma, Cassia siamea, Casuarina equisetifolia, Dalbergia sisoo, Dipterocarpus spp., Emblica officinalis, Eucalyptus spp, Gmelina arborea, Hardwickia binata, Lagerstoremia lanceolata, Pterocarpus marsupium, Prosepis juliflora, Santalum album, Semi-carpus anacardium, Salmalia malabaricum, Tectona grandis, Terminalia tomentosa, Tamarindus indica.

### **4. AGROFORESTRY, SOCIAL FORESTRY, JOINT FOREST MANAGEMENT:**

Agroforestry: scope and necessity; role in the life of people and domestic animals and in integrated land use, planning especially related to

- i) soil and water conservation;
  - ii) water recharge;
  - iii) nutrient availability to crops;
  - iv) nature and eco-system preservation including ecological balances through pest-predator relationships and
  - v) providing opportunities for enhancing biodiversity, medicinal and other flora and fauna.
- Agro forestry systems under different agro-ecological zones, selection of species and role of multipurpose trees and NTFPs, techniques, food, fodder and fuel security. Research and Extension needs.

Social/Urban Forestry: objectives, scope and necessity; peoples participation.

JFM – principles, objectives, methodology, scope, benefits and role of NGOs.

### **5. FOREST SOILS, SOIL CONSERVATION AND WATERSHED MANAGEMENT:**

Forest soils, classification, factors affecting soil formation; physical, chemical and biological properties.

Soil conservation – definition, causes for erosion, types – wind and water erosion; conservation and management of eroded soils/areas, wind breaks, shelter belts; sand dunes; reclamation of saline and alkaline soils, water logged and other waste lands. Role of forests in conserving soils. Maintenance and build up of soil organic matter, provision of loppings for green leaf manuring; forest leaf litter and composing; Role of microorganisms in ameliorating soils; N and C cycles, VAM.

### **6. WATERSHED MANAGEMENT:**

Concepts of watershed; role of mini-forests and forest trees in overall resource management, forest hydrology, watershed development in respect of torrent control, river channel stabilization, rehabilitation of degraded areas; hilly and mountain areas; watershed management and environmental functions of forests; water-harvesting and conservation; ground water recharge and watershed management; role of integrating forest trees, horticultural crops, field crops, grass and fodders.

### **7. ENVIRONMENTAL CONSERVATION AND BIODIVERSITY:**

Environment: Components and importance, principles of conservation, impact of deforestation; forest fires and various human activities like mining, construction and developmental projects, population growth on environment.

**8. Pollution** - Types, global warming, green house effects, ozone layer depletion, acid rain, impact and control measures, environmental monitoring; concept of sustainable development. Role of trees and forests in environmental conservation; control and prevention of air, water and noise pollution.

### **9. FOREST MANAGEMENT AND MANAGEMENT SYSTEMS:**

Objective and principles; techniques; stand structure and dynamics, sustained yield relation; rotation, normal forest, growing stock; regulation of yield; management of forest plantation, commercial forests, forest plantations, forest cover monitoring. Approaches viz., i) site-specific planning, ii) strategic

planning, iii) Approval, sanction and expenditure, iv) Monitoring, v) Reporting and governance. Details of steps involved such as formation of Village Forest Committees, Joint Forest Participatory Management.

#### **10. FOREST WORKING PLAN:**

Forest planning, evaluation and monitoring tools and approaches for integrated planning; multipurpose development of forest resources and forest industries development; working plans. Annual Plan of Operations.

#### **11. FOREST MENSURATION AND REMOTE SENSING:**

Methods of measuring – diameter, girth, height and volume of trees; form-factor; volume estimation of stand, current annual increment; mean annual increment. Sampling methods and sample plots. Yield calculation, yield and stand tables, forest cover monitoring through remote sensing; Geographic Information Systems for management and modeling.

#### **12. FOREST ECOLOGY AND ETHNOBOTANY:**

Forest ecology – Biotic and abiotic components, forest eco-systems; forest community concepts; vegetation concepts, ecological succession and climax, primary productivity, nutrient cycling and water relations; physiology in stress environments (drought, water logging salinity and alkalinity: Forest types in India, identification of species, composition and associations; dendrology, taxonomic classification, principles and establishment of herbaria. Clonal parks. Role of Ethnobotany in Indian Systems of Medicine; Ayurveda and Unani – Introduction, nomenclature, habitat, distribution and botanical features of medicinal and aromatic plants.

#### **13. FOREST RESOURCES AND UTILIZATION:**

Environmentally sound forest harvesting practices, logging and extraction techniques and principles, transportation systems, storage and sale; Non-Timber Forest Products (NTFPs) definition and scope; gums, resins, oleoresins, fibres, oil seeds nuts, rubber, canes, bamboos, medicinal plants, charcoal lac and shellac. Katha and Bidi leaves, collection, processing and disposal.

Need and importance of wood seasoning and preservation; general principles and seasoning, air and kiln seasoning, solar dehumidification, steam heated and electrical kilns. Composite wood; adhesives-manufacture, properties, uses plywood manufacture-properties, uses fibre boards-manufacture properties uses; particle-boards manufacture; properties uses. Present status of composite wood industry in India in future expansion plans. Pulp-paper and rayon; present position of supply of raw material to industry, wood substitution, utilization of plantation wood; problems and possibilities.

#### **14. FOREST PROTECTION AND WILDLIFE BIOLOGY:**

Injuries to forest – abiotic and biotic destructive agencies, insect – pests and disease, effects of air pollution on forests and forest die back. Susceptibility of forests to damage, nature of damage, cause, prevention, protective measures and benefits due to chemical and biological control. General forest protection against fire, equipment and methods, controlled use of fire, economic and environmental costs; timber salvage operations after natural disasters. Role of afforestation and forest regeneration in absorption of CO<sub>2</sub>. Rotational and controlled grazing, different methods of control against grazing and browsing animals; effect of wild animals on forest regeneration, human impacts; encroachment, poaching, grazing live fencing, theft, shifting cultivation and control.

#### **15. FOREST ECONOMICS AND LEGISLATION:**

Forest economics – fundamental principles, cost-benefit analysis; estimation of demand and supply; role of private sector and cooperatives; role of corporate financing.

16. Legislation-History of forest development Indian Forest Policy of 1894, 1952 and 1990. National Forest Policy 1988 of People's involvement, Joint Forest Management, involvement of women, Forestry Policies and issues related to land use, timber and non-timber products, sustainable forest management; industrialisation policies.

## 08. GEOLOGY

### Part - I

- a) **General Geology:** Solar System. The Earth: its origin, age and internal constitution. Volcano-types, distribution geological effects and products. Earth-quakes-intensity, magnitude, distribution, causes and effects. Elementary ideas about isostasy, geosynclines, mountain building, continental drift, sea floor spreading and plate tectonics.
- b) **Geomorphology:** Basic concepts. External and internal processes. Rock weathering. Cycle of erosion. Fluvial landforms and drainage patterns. Landforms of Aeolian, marine, glacial and 'Karst' landscapes. Elements of Remote Sensing.
- c) **Structural and field Geology:** Primary and secondary structures. Dip and strike of beds. Unconformities. Study of folds, joints, faults, foliation and lineations. Overthrusts and nappe structures. Stages of rock deformation. Construction of block diagrams, Stereographic and equal-area nets. Solutions of simple problems by stereographic net. Topographic maps and their interpretation. Use of clinometer compass in the field Measurements of bed, foliation, folds joints, faults and lineations in the field. Principles of geological mapping. Effects of topography on outcrops. Drawing of sections.

### Part – II

- a) **Crystallography:** Elements of crystal structure. Laws of crystallography, Symmetry elements of normal classes of seven crystal systems. Properties and interaction of light and crystalline matter. Petrological microscope and accessories. Construction and use of Nicole prism. Pleochroism, double refraction, extinction angle, birefringence and twinning in crystals, Isotropic, uniaxial and biaxial minerals.
- b) **Mineralogy:** Physical, chemical and optical properties of the following common rock forming minerals: quartz, feldspar, mica, pyroxene, amphibole, olivine, garnet, chlorite, carbonates, aluminosilicates. Structure of silicates and crystal chemistry of minerals. Gemstones.
- c) **Economic Geology:** Ore, ore mineral and gangue. Classification of ore deposits. Important processes of their formation. Occurrence, origin and distribution in India of the ores of aluminium, chromium, copper, gold, lead, zinc, iron, manganese and radioactive elements. Deposits of minerals use as abrasives, refractories and in ceramics, deposits of coal and petroleum. Elements of prospective of mineral deposits.

### Part – III

- a) **Igneous Petrology:** Origin of magma and formation of igneous rocks. Bowen's reaction principle. Crystallisation of binary systems. Classification of igneous rocks. Textures and structures of igneous rocks. Composition, origin and mode of occurrence of granite, syenite diorite, mafic and ultramafic groups, anorthosites and alkaline rocks.
- b) **Sedimentary Petrology:** Sedimentary process and products. Classification of sedimentary rocks. Sedimentary structures. Residual deposits – their mode of formation, characteristics and types, Clastic deposits – their classification, mineral composition and texture. Elementary ideas about the origin and characteristics of quartz arenites, arkoses and greywackes. Siliceous and calcareous deposits of chemical and organic origin.
- c) **Metamorphic Petrology:** Types and factors of metamorphism. Zones, grades and facies of metamorphism. Regional and contact metamorphism. Textures and structures of metamorphic rocks. Metamorphism of argillaceous, arenaceous, calcareous and basic rocks. Metasomatism.

### Part – IV

- a) **Paleontology:** Habits and habitats of animals. Fossils and fossilization. Modes of preservation. Application of fossils, Study of morphology and geological history of Foraminiferida, Brachiopoda, Bivalvia, Gastropoda, Cephalopoda, Trilobita, Echinoidea and Anthozoa. Mammals of Siwalik Group. A brief study of Gondwana flora.
- b) **Stratigraphy and Geology of India:** Fundamental laws of stratigraphy. Stratigraphic classification lithostratigraphic, biostratigraphic and chronostratigraphic. Geological time scale. Physiographic divisions and outline of stratigraphy of India. Brief study of Dharwar, Vindhyan and Gondwana Supergroups and Siwalik Group with reference to their major subdivisions, lithology, fossils, aerial distribution and economic importance.

## **9. HORTICULTURE**

### **I.**

a) Importance of horticulture in terms of economy, production, employment generation, environmental protection and human resource development. Nutritional value of horticultural crops. Divisions of horticulture and their importance.

b) Temperature, light, humidity, rainfall and soil requirements for horticultural crops. Selection of site for establishing an orchard, orchard plan, systems of planting. Establishment of an orchard. Objectives of orchard management culture, different methods of orchard culture. Pruning and training – objectives, methods and effects.

c) Nutrition of horticultural crops – assessment of nutritional requirements, Identification of deficiency symptoms, methods of nutrient application. Assessment of irrigation requirements for different horticultural crops, irrigation methods.

d) Flower bud initiation and formation. Factors affecting them, environmental influences, chemical, nutritional management practices. Pollination and fruit set, problems and requirements, flower and fruit drop, stages, causes, remedial measures. Unfruitfulness, reasons and remedial measures. Harvesting, maturity indices for horticultural crops. Ripening, chemical, physical changes during ripening, and methods of ripening. Use of growth regulators in Horticulture – propagation sex expression, fruit set, fruit drop and extension of shelf life.

### **II.**

a) Principles and classification of plant propagation methods. Plant propagation structures, containers and media.

b) Sexual propagation and its importance. Factors affecting germination and pregermination treatments.

c) Sexual propagation and its importance. Propagation of plants by cuttage, factors affecting regeneration of plants from cuttings. Types of cuttings, propagation by layerage. Factors affecting regeneration of plants by layerage. Methods of layerage.

d) Propagation by grafting, importance of graftage. Factors for successful grafting., Selection of rootstock and scion. Methods of budding and grafting Rootstocks for commercial fruit plants. Stock scion relations and role of Rootstocks in fruit production.

### **III.**

Area, production, importance in national economy, nutritive values, origin and distribution botany, classification and identification of species and varieties, root stocks, role in high density planting climate, soils, planting methods training and pruning, nutrition, irrigation scheduling, intercrops, and management of practices of

a) fruit crops mango, banana, citrus, grape, pineapple, guava, papaya, sapota.

b) Plantation Crops: Coconut, cashew nut, oil palm, coffee, tea, cacao, areca nut and rubber.

**IV.** Origin, importance, export potential, varieties, climate, soil requirements, propagation and planting and after care, manuring, irrigation, training, pruning, harvesting and post harvest handling, curing and processing practices, storage methods, yield and distillation of essential oils of the following crops.

a) Medicinal plants: Dioscorea, Opium poppy, Rauwolfia, Solanum Khasianum, Catharanthus roseus, Pyrethrum, Isabgol Digitalis, Belladonna, Senna and Trichonas nuxvomica.

b) Aromatic crops: Citronella, lemon grass, palmarosa, vetiver, geranium, davana, mint, lavender, vanilla.

c) Spices and Condiments: Cardamom, pepper, cinnamon, Clove and nutmeg.

### **V.**

a) Importance and scope, production of horticultural crops in greenhouse. Status and development of greenhouse production of horticultural crops. Points to be considered before establishing a greenhouse. Greenhouse and related structures location, types, size and arrangement, types of greenhouse framework, types of greenhouse covering materials, ventilation and air circulation, greenhouse benches etc.,

b) Control of environmental factors influencing the growth i.e., light, temperature (greenhouse heating and cooling) moisture, and relative humidity. Role of growth regulators on the growth and development of greenhouse crops.

c) Preparation of growing media requirement and its management at different stages of crop growth. Management of nutrients through fertigation at various stages of crop growth in different crops.

## **10. MATHEMATICS**

1. **Algebra:** Elements of Set Theory; Algebra of Real and Complex numbers including Demovire's between Coefficients and Roots, symmetric functions of roots; Elements of Group Theory; Sub-Group, Cyclic groups, Permutation, Groups and their elementary properties. Rings, Integral Domains and Fields and their elementary properties.
2. **Vector Spaces and Matrices:** Vector Space, Linear Dependence and Independence. Sub-spaces. Basis and Dimensions, Finite Dimensional Vector Spaces. Linear Transformation of a Finite dimensional vector Space, Matrix Representation. Singular and Nonsingular Transformations. Rank and nullity. **Matrices:** Addition, Multiplication, Determinants of a Matrix, Properties of Determinants of order  $n$ , Inverse of a Matrix, Cramer's rule.
3. **Geometry and Vectors:** Analytic Geometry of straight lines and conics in Cartesian and Polar coordinates; Three Dimensional geometry for planes, straight lines, sphere, cone and cylinder. Addition, Subtraction and Products of Vectors and Simple applications to Geometry.
4. **Calculus:** Functions, Sequences, Series, Limits, Continuity, Derivatives. Application of Derivatives: Rates of change, Tangents, Normals, Maxima, Minima, Rolle's Theorem, Mean value Theorems of Lagrange and Cauchy, Asymptotes, Curvature. Methods of finding indefinite integrals, Definite Integrals, Fundamental Theorem of integrals Calculus. Application of definite integrals to area, Length of a plane curve, Volume and Surfaces of revolution.
5. **Ordinary Differential Equations:** Order and Degree of a Differential Equation, First order differential Equations, Singular solution, Geometrical interpretation, Second order equations with constant coefficients.
6. **Mechanics:** Concepts of particles-Lamina; Rigid body; Displacement; force, Mass; Weight; Motion, Velocity; Speed; Acceleration; Parallelogram of forces; Parallelogram of velocity, acceleration; resultant; equilibrium of coplanar forces; Moments; Couples; Friction; Centre of mass, Gravity; Laws of motion; Motion of a particle in a straight line; simple Harmonic motion; Motion under conservative forces; Motion under gravity; Projectile; Escape velocity; Motion of artificial satellites.
7. **Elements of Computer Programming:** Binary system, Octal and Hexadecimal systems. Conversion to and from Decimal systems. Codes, Bits, Bytes and Words. Memory of a computer, Arithmetic and Logical operations on numbers. Precision. AND, OR, XOR, NOT and Shift/Rotate operators, Algorithms and Flow charts.

## **11. MECHANICAL ENGINEERING**

**STATICS:** Simple applications of equilibrium equations.

**DYNAMICS:** Simple applications of equations of motion, work, energy and power.

**THEORY OF MACHINES:** Simple examples of kinematic chains and their inversions.

Different types of gears, bearings, governors, flywheels and their functions.

Static and dynamic balancing of rigid rotors.

Simple vibration analysis of bars and shafts.

Linear automatic control systems.

**MECHANICS OF SOLIDS:** Stress, strain and Hookes Law. Shear and bending moments in beams.

Simple bending and torsion of beams, springs and thin walled cylinders. Elementary concepts of elastic stability, mechanical properties and material testing.

**MANUFACTURING SCIENCE:** Mechanics of metal cutting, tool life, economics of machining, cutting tool materials. Basic types of machine tool and their processes. Automatic machine tools, transfer lines.

Metal forming processes and machines-shearing, drawing, spinning, rolling, forging, extrusion. Types of casting and welding methods. Power metallurgy and processing of plastics.

**MANUFACTURING MANAGEMENT:** Methods and time study, motion economy and work space design, operation and flow process charts. Cost estimation, break-even analysis. Location and layout of plants, material handling. Capital budgeting, job shop and mass production, scheduling, dispatching, Routing, Inventory.

**THERMODYNAMICS:** Basic concepts, definitions and laws heat, work and temperature, Zeroth law, temperature scales, behaviour of pure substances, equations of state, first law and its corollaries, second law and its corollaries. Analysis of air standard power cycles, carnot, otto, diesel, brayton cycles. Vapour power cycles, Rankine reheat and regenerative cycles, Refrigeration cycles-Bell Coleman, Vapour absorption and Vapour compression cycle analysis, open and closed cycle gas turbine with inter-cooling, reheating.

**ENERGY CONVERSION:** Flow of steam through nozzles, critical pressure ratio, shock formation and its effect. Steam generators, mountings and accessories. Impulse and reaction turbines elements and layout of thermal power plants.

Hydraulic turbines and pumps, specific speed, layout of hydraulic power plants.

Introduction to nuclear reactors and power plants, handling of nuclear waste.

**REFRIGERATION AND AIR CONDITIONING:** Refrigeration equipment and operation and maintenance, refrigerants, principles of air conditioning, psychrometric chart, comfort zones, humidification and dehumidification.

**FLUID MECHANICS:** Hydrostatics, continuity equation, Bernoulli's theorem, flow through pipes, discharge measurement, laminar and turbulent flow, boundary layer concept.

## 12. PHYSICS

**1. Mechanics and Waves:** Dimensional analysis. Newton's laws of motion and applications, variable mass systems, projectiles. Rotational dynamics-kinetic energy, angular momentum, theorems of moment of inertia and calculations in simple cases. Conservative forces, frictional forces. Gravitational potential and intensity due to spherical objects. Central forces, Kepler's problem, escape velocity and artificial satellites (including GPS). Streamline motion, viscosity, Poiseuille's equation. Applications of Bernoulli's equation and Stokes' law.

Special relativity and Lorentz transformation-length contraction, time dilation, mass-energy relation. Simple harmonic motion, Lissajous figures. Damped oscillation, forced oscillation and resonance. Beats, Phase and group velocities. Stationary waves, vibration of strings and air columns, longitudinal waves in solids. Doppler effect. Ultrasonics and applications.

**2. Geometrical and Physical Optics:** Laws of reflection and refraction from Fermat's principle. Matrix method in paraxial optics- thin lens formula, nodal planes, system of two thin lenses. Chromatic and spherical aberrations. Simple optical instruments- magnifier, eyepieces, telescopes and microscopes.

Huygen's principle-reflection and refraction of waves. Interference of light – Young's experiment, Newton's rings, interference by thin films, Michelson interferometer. Fraunhofer diffraction-single slit, double slit, diffraction grating, resolving power. Fresnel diffraction- half-period zones and zone plate. Production and detection of linearly, circularly and elliptically polarized light. Double refraction, quarter-wave plates and half-wave plates. Polarizing sheets. Optical activity and applications. Raman & Rayleigh scattering and applications.

Elements of fibre optics-attenuation; pulse dispersion in step index and parabolic index fibres; material dispersion. Lasers, characteristics of laser light-spatial and temporal coherence. Focusing of laser beams and applications.

**3. Heat and Thermodynamics:** Thermal equilibrium and temperature. The zeroth law of thermodynamics. Heat and the first law of thermodynamics. Efficiency of Carnot engines. Entropy and the second law of thermodynamics. Kinetic theory and the equation of state of an ideal gas. Mean free path, distribution of molecular speeds and energies. Transport phenomena. Andrew's experiments-van der Waals equation and applications. Joule-Kelvin effect and applications. Brownian motion. Thermodynamic potentials-Maxwell relations. Phase transitions. Kirchhoff's laws. Black-body radiation – Stefan-Boltzmann law, spectral radiance, Wien displacement law, application to the cosmic microwave background radiation, Planck radiation law.

**4. Electricity and Magnetism:** Electric charge, Coulomb's law, electric field, Gauss' law. Electric potential, van de Graaff accelerator. Capacitors, dielectrics and polarization. Ohm's law, Kirchhoff's first and second rules, resistors in series and parallel, applications to two-loop circuits. Magnetic field-Gauss' law for magnetism, atomic and nuclear magnetism, magnetic susceptibility, classification of magnetic materials. Circulating charges, cyclotron, synchrotron. Hall effect. Biot-Savart law, Ampere's law, Faraday's law of induction – Lenz's law. Inductance. Alternating current circuits – RC, LR, single-loop LRC circuits, impedance, resonance, power in AC circuits. Displacement current, Maxwell's equations (MKS Units), electromagnetic waves, energy transport and Poynting vector.

**5. Atomic and Nuclear Physics:** Photoelectric effect, Einstein's photon theory. Bohr's theory of hydrogen atom. Stern Gerlach experiment, quantisation of angular momentum, electron spin. Pauli exclusion principle and applications. Zeeman effect. X-ray spectrum, Bragg's law, Bohr's theory of the Mosley plot. Compton effect, Compton wavelength. Wave nature of matter, de Broglie wavelength, wave-particle duality. Heisenberg's uncertainty relationships. Schroedinger's equation-eigenvalues and eigenfunctions of (i) particle in a box, (ii) simple harmonic oscillator and (iii) hydrogen atom. Potential step and barrier penetration. Natural and artificial radioactivity. Binding energy of nuclei, nuclear fission and fusion. Classification of elementary particles and their interactions.

**6. Electronics:** Diodes in half-waves and full-wave rectification, qualitative ideas of semiconductors p type and n type semiconductors, junction diode, Zener diode, transistors, binary numbers, Logic gates and truth tables, Elements of microprocessors and computers.

## **13. STATISTICS**

**Probability:** Random experiment, sample space, event, algebra of events, probability on a discrete sample space, basic theorems of probability and simple examples based theorem, conditional, probability of an event, independent events, Bayer's theorem and its application, discrete and continuous random variables and their distributions, expectation, moments, moment generating function, joint distribution of two or more random variables, marginal and conditional distributions, independence of random variables, covariance, correlation, coefficient, distribution of a function of random variables. Bernouli, binomial, geometric, negative binomial, hypergeometric, poisson, multinomial, uniform, beta, exponential, gamma, cauchy, normal, longnormal and bivariate normal distributions, real-life situations where these distributions provide appropriate models, Chebyshev's inequality, weak law or large numbers and central limit theorem for independent and identically distributed random variables with finite variance and their simple applications.

**Statistical Methods:** Concept of a statistical population and a sample, types of data, presentation and summarization of data, measures of central tendency, dispersion, skewness and kurtosis, measures of association and contingency, correlation, rank correlation, intraclass correlation, correlation ratio, simple and multiple linear regression, multiple and partial correlations (involving three variables only), curve-fitting and principle of least squares, concepts of random sample, parameter and statistic, Z, X<sup>2</sup>, t and F statistics and their properties and applications, distributions of sample range and median (for continuous distributions only), censored sampling (concept and illustrations).

**Statistical Inference:** Unbiasedness, consistency, efficiency, sufficiency, completeness, minimum variance unbiased estimation, Rao-Blackwell theorem, Lehmann-Scheffe theorem, Cramer-Rao inequality and minimum variance bound estimator, moments maximum likelihood, least squares and minimum chisquare methods of estimation, properties of maximum likelihood and other estimators, idea of a random interval, confidence intervals for the parameters of standard distributions, shortest confidence intervals, large-sample confidence intervals. Simple and composite hypotheses, two kinds of errors, level of significance, size and power of a test, desirable properties of a good test, most powerful test, Neyman-Pearson lemma and its use in simple example, uniformly most powerful test, likelihood ratio test and its properties and applications.

Chi-square test, sign test, Wald-Wolfowitz runs test, run test for randomness, median test, Wilcoxon test and Wilcoxon-Mann-Whitney test.

Wal's sequential probability ratio test, OC and ASN functions, application to binomial and normal distributions.

Loss function, risk function, mini-max and Bayes rules.

**Sampling Theory and Design of Experiments:** Complete enumeration vs. sampling, need for sampling, basic concepts in sampling, designing large-scale sample surveys, sampling and non-sampling errors, simple random sampling, properties of a good estimator, estimation of sample size, stratified random sampling, systematic sampling cluster sampling, ratio and regression methods of estimation under simple and stratified random sampling, double sampling for ratio and regression methods of estimation, two-stage sampling with equal-size first-stage units.

Analysis of variance with equal number of observations per cell in one, two and three-way classifications, analysis of covariance in one and two-way classifications, completely randomized design, randomized block design, latin square design, missing plot technique, 2<sup>n</sup> factorial design, total and partial confounding, 3<sup>2</sup> factorial experiments, split-plot design and balanced incomplete block design.

## **14. ZOOLOGY**

### **1. Cell structure and function:**

- a) Prokaryote and eukaryote
- b) Structure of animal cell, structure and functions of cell organelles.
- c) Cell cycle-mitosis, meiosis.
- d) Structure and contents of nucleus including nuclear membrane, structure of chromosome and gene, chemistry of genetic components.
- e) Mendel's laws of inheritance, linkage and genetic recombination; cytoplasmic inheritance.
- f) Function of gene: replication, transcription and translation; mutations (spontaneous and artificial); Recombinant DNA; principle and application
- g) Sex determination in Drosophila and man; sex linkage in man

### **2 Systematics:**

- a) Classification of non-chordates (upto sub-classes) and chordates (up to orders) giving general features and evolutionary relationship of the following phyla: Protozoa, Porifera, Coelenterata, Platyhelminthes, Nematelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Minor Phyla (Bryozoa, Phoronida and Chaetognatha) and Hemichordata.
- b) Structure reproduction and life history of the following types: Amoeba, Monocystis, Plasmodium, Paramecium, Sycon, Hydra, Obelia, Fasiola, Taenia, Ascaris, Neanthes, Pheretima, Hirudina, Palaemon, Buthus, Periplaneta, Lamellidens, Pila, Asterias and Balanoglossus.
- c) Classification of chordates (up to orders), giving general features and evolutionary relationship of the following: Protochordata; Agnatha; Gnathostomata-Pisces, Amphibia, Reptilia, Aves and Mammalia.
- d) Comparative functional anatomy of the following based on type animals (Scoliodon, Rana, Calotes, Columba and Oryctolagus): integument and its derivatives, endoskeleton, digestive system, respiratory system, circulator system including heart and aortic arches, urinogenital system; brain and sense organs (eye and ear); endocrine glands and other hormone producing structures, (Pituitary, thyroid, parathyroid, adrenal, pancreas, gonads) their function.

### **3. Vertebrate Physiology and Biochemistry:**

- a) Chemical composition of protoplasm; nature and function of enzymes; vitamins, their sources and role; colloids and hydrogen ion concentration; biological oxidation, electron transport and role of ATP, enegetics, glycolysis, citric acid cycle; vertebrate hormones; their type, sources and function; pheromones and their role.
- b) Neuron and nerve impulse-conduction and transmission across synapses; nenurotrasmitters and their role, including acetyl cholinesterase activity.
- c) Homeostasis; osmoregulation; active transport and ion pump.
- d) Composition of carbohydrates, fats, lipids and proteins; steroids.

### **4. Embryology:**

- a) Gametogenesis, fertilization, cleavage; gastrulation in frog and chick
- b) Metamorphosis in frog and retrogressive metamorphosis in ascidian; extra-emhryonic membranes in chick and mammal; placentation in mammals; Bio-genetic law.

### **5. Evolution:**

- a) Origin of life; principles, theories and evidences of evolution; species concept.
- b) Zoogeographical realms, insular fauna; geological eras.
- c) Evolution of man; evolutionary status of man.

### **6. Ecology, Wildlife and Ethology:**

- a) Abiotic and biotic factors; concept of ecosystem, food chain and energy flow; adaptation of aquatic, terrestrial and aerial fauna; intra-and inter-specific animal relationships; environmental pollution; Types, sources, causes, control and prevention.
- b) Wildlife of India; endangered species of India; sancturaries and national parks of India.
- c) Biological rhythms.

### **7. Economic Zoology:**

- a) Beneficial and harmful insects including insect vectors of human diseases.
- b) Industrial fish, prawn and molluscs of India.
- c) Non-poisonous and poisonous snakes of India
- d) Venomous animals-centipede, wasp, honey bee
- e) Diseases caused by aberrant chromosomes/genes in man; genetic counselling; DNA as a tool for forensic investigation.