

COMPULSORY SUBJECTS

GENERAL KNOWLEDGE - 100 MARKS

General Knowledge including knowledge of current events and of such matters of every day observation and experience in their scientific aspects as may be expected of an educated person who has not made a special study of any scientific subject. The paper will also include questions on Indian Polity including the political system and the Constitution of India, History of India and Geography of a nature which the candidate should be able to answer without special study.

GENERAL ENGLISH - 100 MARKS

General English Candidates will be required to write an essay in English. Other questions will be designed to test their understanding of English and workmanlike use of words. Passages will usually be set for summary or precis.

OPTIONAL SUBJECTS

AGRICULTURAL ENGINEERING - 100 MARKS

Section A

1. Soil and Water Conservation :

Scope of soil and water conservation. Mechanics and types of erosion, their causes. Rainfall, runoff and sedimentation relationships and their measurement. Soil erosion control measures - biological and engineering including stream bank protection-vegetative barriers, contour bunds, contour trenches, contour stone walls, contour ditches, terraces, outlets and grassed waterways. Gully control structures - temporary and permanent - design of permanent soil conservation structures such as chute, drop and drop inlet spillways. Design of farm ponds and percolation ponds. Principles of flood control-flood routing. Watershed Management - investigation, planning and implementation - selection of priority areas and water shed work plan, water harvesting and moisture conservation. Land development - levelling, estimation of earth volumes and costing. Wind Erosion process - design for shelter belts and wind brakes and their management. Forest (Conservation) Act.

2. Aerial Photography and Remote Sensing :

Basic characteristics of photographic images, interpretation keys, equipment for interpretation, imagery interpretation for land use, geology, soil and forestry.

Remote sensing - merits and demerits of conventional and remote sensing approaches. Types of satellite images, fundamentals of satellite image interpretation, techniques of visual and digital interpretations for soil, water and land use management. Use of GIS in planning and development of watersheds, forests including forest cover, water resources etc.

3. Irrigation and Drainage :

Sources of water for irrigation. Planning and design of minor irrigation projects. Techniques of measuring soil moisture - laboratory and in situ, Soil-water plant relationships. Water requirement of crops. Planning conjunctive use of surface and ground water. Measurement of irrigation water, measuring devices - orifices, weirs and flumes. Methods of irrigation - surface, sprinkler and drip, fertigation. Irrigation efficiencies and their estimation. Design and construction of canals, field channels, underground pipelines, head-gates, diversion boxes and structures for road crossing. Occurrence of ground water, hydraulics of wells, types of wells (tube wells and open wells) and their construction. Well development and testing. Pumps-types, selection and installation. Rehabilitation of sick and failed wells.

Drainage causes of waterlogging and salt problem. Methods of drainage— drainage of irrigated and unirrigated lands, design of surface, sub-surface and vertical drainage systems. Improvement and utilization of poor quality water. Reclamation of saline and alkali soils. Economics of irrigation and drainage systems. Use of waste water for irrigation — standards of waste water for sustained irrigation, feasibility and economics.

4. Agricultural Structures :

Site selection, design and construction of farmstead - farm house, cattle shed, dairy bam, poultry shed, hog housing, machinery and implement shed, storage structures for food grains, feed and forage. Design and construction of fences and farm roads. Structures for plant environment - green houses, poly houses and shade houses. Common building materials used in construction - timber, brick, stone, tiles, concrete etc and their properties. Water supply, drainage and sanitation system.

Section B

1. Farm Power and Machinery :

Agricultural mechanization and its scope. Sources of farm power - animate and electro-mechanical. Thermodynamics, construction and working of internal combustion engines. Fuel, ignition, lubrication, cooling and governing system of IC engines. Different types of tractors and power tillers. Power transmission, ground drive, power take off (p.t.o.) and control systems. Operation and maintenance of farm machinery for primary and secondary tillage. Traction theory. Sowing transplanting and interculture implements and tools. Plant protection equipment - spraying and dusting. Harvesting, threshing and combining equipment. Machinery for earth moving and land development - methods and cost estimation. Ergonomics of man-machine system. Machinery for horticulture and agro-forestry, feeds and forages. Haulage of agricultural and forest produce.

2. Agro-energy :

Energy requirements of agricultural operations and agro-processing. Selection, installation, safety and maintenance of electric motors for agricultural applications. Solar (thermal and photovoltaic), wind and bio-gas energy and their utilization in agriculture. Gasification of biomass for running IC engines and for electric power generation. Energy efficient cooking stoves and alternate cooking fuels. Distribution of electricity for agricultural and agro-industrial applications.

3. Agricultural Process Engineering :

Post harvest technology of crops and its scope. Engineering properties of agricultural produces and by-products. Unit operations - cleaning grading, size reduction, densification, concentration, drying/dehydration, evaporation, filtration, freezing and packaging of agricultural produces and by-products. Material handling equipment - belt and screw conveyors, bucket elevators, their capacity and power requirement. Processing of milk and dairy products - homogenization, cream separation, pasteurization, sterilization, spray and roller drying, butter making, ice cream, cheese and shrikhand manufacture. Waste and by-product utilization - rice husk, rice bran, sugarcane bagasse, plant residues and coir pith.

4. Instrumentation and computer applications in Agricultural Engineering :

Electronic devices and their characteristics - rectifiers, amplifiers, oscillators, multivibrators. Digital circuits — sequential and combinational system. Application of microprocessors in data acquisition and control of agricultural engineering processes- measurement systems for level, flow, strain, force, torque, power, pressure, vacuum and temperature. Computers — introduction, input/output devices, central processing unit, memory devices, operating systems, processors, keyboards and printers. Algorithms, flowchart specification, programme translation and problem analysis in Agricultural Engineering. Multimedia and Audio-Visual aids.

BOTANY - 100 MARKS**Section - A****1. Microbiology:**

Important plant diseases caused by viruses, bacteria, mycoplasma, fungi and nematodes. Mode of infection and dissemination. Molecular basis of infection and disease resistance/defence. Physiology of parasitism and control measures. Fungal toxins.

2. Cryptogams:

Algae, Fungi, Bryophytes, Pteridophytes-structure and reproduction from evolutionary viewpoint. Distribution of Cryptogams in India and their economic potential.

3. Phanerogams:

Gymnosperms: Concept of Progymnosperms. Classification and distribution of Gymnosperms. Salient features of Cycadales, Coniferales and Gnetales, their structures and reproduction. General account of Cycadofilicales, Bennettitales and Cordaitales.

Angiosperms: Systematics, anatomy, embryology, palynology and phylogeny. Comparative account of various systems of Angiosperm Classification. Study of angiospermic families—Magnoliaceae, Ranunculaceae, Brassicaceae (Cruciferae), Rosaceae, Leguminosae, Euphorbiaceae, Malvaceae, Dipterocarpaceae, Apiaceae (Umbelliferae), Asclepiadaceae, Verbenaceae, Solanaceae, Rubiaceae, Cucurbitaceae, Asteraceae (Composite), Poaceae (Gramineae), Arecaceae (Palmae), Liliaceae, Musaceae, Orchidaceae. Stomata and their types. Anomalous secondary growth, Anatomy of C₃ and C₄ plants. Development of male and female gametophytes, pollination, fertilization. Endosperm—its development and function. Patterns of embryo development. Polyembryony, apomixis, Applications of palynology.

4. Plant Utility and Exploitation:

Origin of cultivated plants, Vavilov's centres of origin. Plants as sources for food, fodder, fibres, spices, beverages, drugs, narcotics, insecticides, timber, gums, resins and dyes. Latex, cellulose Starch and their products. Perfumery. Importance of Ethnobotany in Indian context. Energy plantation. Botanical Gardens and Herbaria.

5. Morphogenesis:

Totipotency, polarity, symmetry and differentiation. Cell, tissue, organ and protoplast culture. Somatic hybrids and Cybrids.

Section -B**1. Cell Biology:**

Techniques of Cell Biology. Prokaryotic and eukaryotic cells -structural and ultrastructural details. Structure and function of extracellular matrix or ECM (cell wall) and membranes-cell adhesion, membrane

transport and vesicular transport. Structure and function of cell organelles (chloroplasts, mitochondria, ER, ribosomes, endosomes, lysosomes, peroxisomes, hydrogenosome). Nucleus, nucleolus, nuclear pore complex. Chromatin and nucleosome. Cell signalling and cell receptors. Signal transduction (G-1 proteins, etc.). Mitosis and meiosis; molecular basis of cell cycle. Numerical and structural variations in chromosomes and their significance. Study of polytene, lampbrush and B-chromosomes—structure, behaviour and significance.

2. Genetics, Molecular Biology and Evolution:

Development of genetics, and gene versus allele concepts (Pseudoalleles). Quantitative genetics and multiple factors. Linkage and crossing over—methods of gene mapping including molecular maps (idea of mapping function). Sex chromosomes and sexlinked inheritance, sex determination and molecular basis of sex differentiation. Mutation (biochemical and molecular basis). Cytoplasmic inheritance and cytoplasmic genes (including genetics of male sterility). Prions and prion hypothesis. Structure and synthesis of nucleic acids and proteins. Genetic code and regulation of gene expression. Multigene families.

Organic evolution-evidences, mechanism and theories. Role of RNA in origin and evolution.

3. Plant Breeding, Biotechnology and Biostatistics:

Methods of plant breeding — introduction, selection and hybridization (pedigree, backcross, mass selection, bulk method). Male sterility and heterosis breeding. Use of apomixis in plant breeding. Micropropagation and genetic engineering—methods of transfer of genes and transgenic crops; development and use of molecular markers in plant breeding.

Standard deviation and coefficient of variation (CV). Tests of significance (Z-test, t-test and chi-square tests). Probability and distributions (normal, binomial and Poisson distributions). Correlation and regression.

4. Physiology and Biochemistry:

Water relations, Mineral nutrition and ion transport, mineral deficiencies. Photosynthesis – photochemical reactions, photophosphorylation and carbon pathways including C₃ pathway (photorespiration), C₃, C₄ and CAM pathways. Respiration (anaerobic and aerobic, including fermentation-electron transport chain and oxidative phosphorylation. Chemiosmotic theory and ATP synthesis. Nitrogen fixation and nitrogen metabolism. Enzymes, coenzymes, energy transfer and energy conservation. Importance of secondary metabolites. Pigments as photoreceptors (plastidial pigments and phytochrome). Photoperiodism and flowering, vernalization, senescence. Growth substances-their chemical nature, role and applications in agri-horticulture, growth indices, growth movements. Stress physiology (heat, water, salinity, metal). Fruit and seed physiology. Dormancy, storage and germination of seed. Fruit ripening — its molecular basis and manipulation.

5. Ecology and Plant Geography:

Ecological factors. Concepts and dynamics of community. Plant succession. Concepts of biosphere. Ecosystems and their conservation. Pollution and its control (including phytoremediation).

Forest Types of India — afforestation, deforestation and social forestry. Endangered plants, endemism and Red Data Books. Biodiversity. Convention of Biological Diversity, Sovereign Rights and Intellectual Property Rights. Biogeochemical cycles. Global warming.

CHEMICAL ENGINEERING -100 MARKS**Section A****(a) Fluid and Particle Dynamics:**

Viscosity of fluids. Laminar and turbulent flows. Equation of continuity and Navier-Stokes equation-Bernoulli's theorem. Flow meters. Fluid drag and pressure drop due to friction, Reynold's Number and friction factor - effect of pipe roughness. Economic pipe diameter. Pumps, water, air/steam jet ejectors, compressors, blowers and fans. Agitation and mixing of liquids. Mixing of solids and pastes. Crushing and Grinding - principles and equipment. Rittinger's and Bond's laws. Filtration and filtration equipment. Fluid-particle mechanics - free and hindered settling. Fluidisation and minimum fluidization velocity, concepts of compressible and incompressible flow. Transport of Solids.

(b) Mass Transfer:

Molecular diffusion coefficients, First and second law and diffusion, mass transfer coefficients, film and penetration theories of mass transfer. Distillation, simple distillation, relative volatility, fractional distillation, plate and packed columns for distillation. Calculation of theoretical number of plates. Liquid-liquid equilibria. Extraction - theory and practice; Design of gas-absorption columns. Drying. Humidification, dehumidification. Crystallisation. Design of equipment.

(c) Heat Transfer :

Conduction, thermal conductivity, extended surface heat transfer. Convection - free and forced. Heat transfer coefficients - Nusselt Number. LMTD and effectiveness. NTU methods for the design of Double Pipe and Shell & Tube Heat Exchangers. Analogy between heat and momentum transfer. Boiling and condensation heat transfer. Single and multiple-effect evaporators. Radiation - Stefan-Boltzman Law, emissivity and absorptivity. Calculation of heat load of a furnace. Solar heaters.

(d) Noval Separation Processes :

Equilibrium separation processes - ion-exchange, osmosis, electro-dialysis, reverse osmosis, ultra-filtration and other membrane processes. Molecular distillation. super critical fluid extraction.

(e) Process Equipment Design:

Factors affecting vessel design criteria - Cost considerations. Design of storage vessels-vertical, horizontal spherical, underground tanks for atmospheric and higher pressure. Design of closures flat and elliptical head. Design of supports. Materials of construction-characteristics and selection.

(f) Process Dynamics and Control:

Measuring instruments for process variables like level, pressure, flow, temperature pH and concentration with indication in visual/pneumatic/analog/digital signal forms. Control variable, manipulative variable and load variables. Linear control theory-Laplace, transforms. PID controllers. Block diagram representation transient and frequency response, stability of closed loop system. Advanced control strategies. Computer based process control.

Section B**(a) Material and Energy Balances:**

Material and energy balance calculations in processes with recycle/bypass/purge. Combustion of solid/liquid/gaseous fuels, stoichiometric relationships and excess air requirements. Adiabatic flame temperature.

(b) Chemical Engineering Thermodynamics:

Laws of thermodynamics. PVT relationships for pure components and mixtures. Energy functions and inter-relationships - Maxwell's relations. Fugacity, activity and chemical potential. Vapour-liquid equilibria, for ideal/non-ideal, single and multi component systems. criteria for chemical reaction equilibrium, equilibrium constant and equilibrium conversions. Thermodynamic cycles - refrigeration and power.

(c) Chemical Reaction Engineering :

Batch reactors - kinetics of homogeneous reactions and interpretation of kinetic data. Ideal flow reactors - CSTR, plug flow reactors and their performance equations. Temperature effects and run-away reactions. Heterogeneous reactions - catalytic and non-catalytic and gas-solid and gas-liquid reactions. Intrinsic kinetics and global rate concept. Importance of interphase and intraparticle mass transfer on performance. Effectiveness factor. Isothermal and non-isothermal reactors and reactor stability.

(d) Chemical Technology :

Natural organic products - Wood and wood-based chemicals, pulp and paper, Agro industries - sugar, Edible oils extraction (including tree based seeds), Soaps and detergents. Essential oils - Biomass gasification (including biogas). Coal and coal chemical. Petroleum and Natural gas-Petroleum refining (Atmospheric distillation/cracking/reforming) - Petrochemical industries - Polyethylenes (LDPE/HDPE/LLDPE), Polyvinyl Chloride, Polystyrene. Ammonia manufacture. Cement and lime industries. Paints and varnishes. Glass and ceramics. Fermentation - alcohol and antibiotics.

(e) Environmental Engineering and Safety :

Ecology and Environment. Sources of pollutants in air and water. Green house effect, ozone layer depletion, acid rain. Micrometeorology and dispersion of pollutants in environment. Measurement techniques of pollutant levels and their control strategies. Solid wastes, their hazards and their disposal techniques. Design and performance analysis of pollution control equipment. Fire and explosion hazards rating - HAZOP and HAZAN. Emergency planning, disaster management. Environmental legislations - water, air environment protection Acts. Forest (Conservation) Act.

(f) Process Engineering Economics :

Fixed and working capital requirement for a process industry and estimation methods. Cost estimation and comparison of alternatives. Net present value by discounted cash flow. Pay back analysis. IRR, Depreciation, taxes and insurance. Break-even point analysis. Project scheduling - PERT and CPM. Profit and loss account, balance sheet and financial statement. Plant location and plant layout including piping.

CHEMISTRY - 100 MARKS**Section -A****1. Atomic structure**

Quantum theory, Heisenberg's uncertainty principle, Schroedinger wave equation (time independent). Interpretation of wave function, particle in one-dimensional box, quantum numbers, hydrogen atom wave functions. Shapes of s, p and d orbitals.

2. Chemical bonding

Ionic bond, characteristics of ionic compounds, factors affecting stability of ionic compounds, lattice energy, Born-Haber cycle; covalent bond and its general characteristics, polarities of bonds in molecules and their dipole moments. Valence bond theory, concept of resonance and resonance energy. Molecular orbital theory (LCAO method); bonding in homonuclear molecules: H₂, H₂ to Ne₂, NO, CO, HF, CN, CN⁻, BeH₂ and CO₂. Comparison of valence bond and molecular orbital theories, bond order, bond strength and bond length.

3. Solid State

Forms of solids, law of constancy of interfacial angles, crystal systems and crystal classes (crystallographic groups). Designation of crystal faces, lattice structures and unit cell. Laws of rational indices. Bragg's law. X-ray diffraction by crystals. Close packing, radius ratio rules, calculation of some limiting radius ratio values. Structures of NaCl, ZnS, CsCl, CaF₂, CdI₂ and rutile. Imperfections in crystals, stoichiometric and nonstoichiometric defects, impurity defects, semi-conductors. Elementary study of liquid crystals.

4. The gaseous state

Equation of state for real gases, intermolecular interactions, liquification of gases and critical phenomena, Maxwell's distribution of speeds, intermolecular collisions, collisions on the wall and effusion.

5. Thermodynamics and statistical thermodynamics

Thermodynamic systems, states and processes, work, heat and internal energy; first law of thermodynamics, work done on the systems and heat absorbed in different types of processes; calorimetry, energy and enthalpy changes in various processes and their temperature dependence. Second law of thermodynamics; entropy as a state function, entropy changes in various process, entropy–reversibility and irreversibility, Free energy functions; criteria for equilibrium, relation between equilibrium constant and thermodynamic quantities; Nernst heat theorem and third law of thermodynamics. Micro and macro states; canonical ensemble and canonical partition function; electronic, rotational and vibrational partition functions and thermodynamic quantities; chemical equilibrium in ideal gas reactions.

6. Phase equilibria and solutions:

Phase equilibria in pure substances; Clausius-Clapeyron equation; phase diagram for a pure substance; phase equilibria in binary systems, partially miscible liquids—upper and lower critical solution temperatures; partial molar quantities, their significance and determination; excess thermodynamic functions and their determination.

7. Electrochemistry

Debye-Huckel theory of strong electrolytes and Debye-Huckel limiting Law for various equilibrium and transport properties. Galvanic cells, concentration cells; electrochemical series, measurement of e.m.f. of cells and its applications, fuel cells and batteries. Processes at electrodes; double layer at the interface; rate of charge transfer, current density; overpotential; electroanalytical techniques—voltametry, polarography, amperometry, cyclic-voltametry, ion selective electrodes and their use.

8. Chemical kinetics

Concentration dependence of rate of reaction; differential and integral rate equations for zeroth, first, second and fractional order reactions. Rate equations involving reverse, parallel, consecutive and chain reactions; effect of temperature and pressure on rate constant. Study of fast reactions by stop-flow and relaxation methods. Collisions and transition state theories.

9. Photochemistry

Absorption of light; decay of excited state by different routes; photochemical reactions between hydrogen and halogens and their quantum yields.

10. Surface phenomena and catalysis

Adsorption from gases and solutions on solid adsorbents, adsorption isotherms—Langmuir and B.E.T. isotherms; determination of surface area, characteristics and mechanism of reaction on heterogeneous catalysts.

11. Bio-inorganic chemistry

Metal ions in biological systems and their role in ion-transport across the membranes (molecular mechanism), ionophores, photosynthesis—PSI, PSII; nitrogen fixation, oxygen-uptake proteins, cytochromes and ferredoxins.

12. Coordination chemistry

(a) Electronic configurations; introduction to theories of bonding in transition metal complexes. Valence bond theory, crystal field theory and its modifications; applications of theories in the explanation of magnetism and electronic spectra of metal complexes.

(b) Isomerism in coordination compounds. IUPAC nomenclature of coordination compounds; stereochemistry of complexes with 4 and 6 coordination numbers; chelate effect and polynuclear complexes; trans effect and its theories; kinetics of substitution reactions in square-planar complexes; thermodynamic and kinetic stability of complexes.

(c) Synthesis and structures of metal carbonyls; carboxylate anions, carbonyl hydrides and metal nitrosyl compounds.

(d) Complexes with aromatic systems, synthesis, structure and bonding in metal olefin complexes, alkyne complexes and cyclopentadienyl complexes; coordinative unsaturation, oxidative addition reactions, insertion reactions, fluxional molecules and their characterization. Compounds with metal-metal bonds and metal atom clusters.

13. General chemistry of 'f' block elements

Lanthanides and actinides; separation, oxidation states, magnetic and spectral properties; lanthanide contraction.

14. Non-Aqueous Solvents

Reactions in liquid NH₃, HF, SO₂ and H₂SO₄. Failure of solvent system concept, coordination model of non-aqueous solvents. Some highly acidic media, fluorosulphuric acid and super acids.

Section B**1. Delocalised covalent bonding :**

Aromaticity, anti-aromaticity; annulenes, azulenes, tropolones, kekulene, fulvenes, sydnones.

2. (a) Reaction mechanisms: General methods (both kinetic and non-kinetic) of study of mechanism or organic reactions illustrated by examples—use of isotopes, cross-over experiment, intermediate trapping, stereochemistry; energy diagrams of simple organic reactions—transition states and intermediates; energy of activation; thermodynamic control and kinetic control of reactions.

(b) Reactive intermediates: Generation, geometry, stability and reactions of carbonium and carbanium ions, carbanions, free radicals, carbenes, benzyne and nitrenes.

(c) Substitution reactions: S_N1, S_N2, S_Ni, S_N1', S_N2', S_Ni' and S_{RN}1 mechanisms; neighbouring group participation; electrophilic and nucleophilic reactions of aromatic compound including simple heterocyclic compounds—pyrrole, thiophene, indole.

(d) Elimination reactions: E₁, E₂ and E_{1c}b mechanisms; orientation in E₂ reactions—Saytzeff and Hoffmann; pyrolytic syn elimination—acetate pyrolysis, Chugaev and Cope eliminations.

(e) Addition reactions: Electrophilic addition to C=C and C≡C; nucleophilic addition to C=O, C=N, conjugated olefins and carbonyls.

(f) Rearrangements: Pinacol-pinacolone, Hoffmann, Beckmann, Baeyer–Villiger, Favorskii, Fries, Claisen, Cope, Stevens and Wagner–Meerwein rearrangements.

3. Pericyclic reactions :

Classification and examples; Woodward-Hoffmann rules—electrocyclic reactions, cycloaddition reactions [2+2 and 4+2] and sigmatropic shifts [1, 3; 3, 3 and 1, 5] FMO approach.

4. Chemistry and mechanism of reactions :

Aldol condensation (including directed aldol condensation), Claisen condensation, Dieckmann, Perkin, Knoevenagel, Wittig, Clemmensen, Wolff-Kishner, Cannizzaro and von Richter reactions; Stobbe, benzoin and acyloin condensations; Fischer indole synthesis, Skraup synthesis, Bischler-Napieralski, Sandmeyer, Reimer-Tiemann and Reformatsky reactions.

5. Polymeric Systems

(a) Physical chemistry of polymers: Polymer solutions and their thermodynamic properties; number and weight average molecular weights of polymers. Determination of molecular weights by sedimentation, light scattering, osmotic pressure, viscosity, end group analysis methods.

(b) Preparation and properties of polymers: Organic polymers—polyethylene, polystyrene, polyvinyl chloride, Teflon, nylon, terylene, synthetic and natural rubber. Inorganic polymers—phosphonitrilic halides, borazines, silicones and silicates.

(c) Biopolymers: Basic bonding in proteins, DNA and RNA.

6. Synthetic uses of reagents :

OsO₄, HIO₄, CrO₃, Pb(OAc)₄, SeO₂, NBS, B₂H₆, Na-Liquid NH₃, LiAlH₄, NaBH₄ n-BuLi, MCPBA.

7. Photochemistry :

Photochemical reactions of simple organic compounds, excited and ground states, singlet and triplet states, Norrish-Type I and Type II reactions.

8. Principles of spectroscopy and applications in structure elucidation

(a) Rotational spectra—diatomic molecules; isotopic substitution and rotational constants.

(b) Vibrational spectra—diatomic molecules, linear triatomic molecules, specific frequencies of functional groups in polyatomic molecules.

(c) Electronic spectra : Singlet and triplet states. N→* and →* transitions; application to conjugated double bonds and conjugated carbonyls—Woodward-Fieser rules.

(d) Nuclear magnetic resonance : Isochronous and anisochronous protons; chemical shift and coupling constants; Application of ¹H NMR to simple organic molecules.

(e) Mass spectra : Parent peak, base peak, daughter peak, metastable peak, fragmentation of simple organic molecules;—cleavage, McLafferty rearrangement.

(f) Electron spin resonance : Inorganic complexes and free radicals.

FORESTRY -100 MARKS**Section - A****1. Agroforestry, Social Forestry, Joint Forest Management and Tribology :**

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 bio-diversity, 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. Tribology - tribal scene in India; tribes, concept of races, principles of social grouping, stages of tribal economy, education, cultural tradition, customs, ethos and participation in forestry programmes.

2. Forest Soils, Soil Conservation and Watershed management :

Forests 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 composting; Role of microorganisms in ameliorating soils; N and C cycles, VAM.

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, avalanche and landslide controls, 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.

3. 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.

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. Environmental policy and legislation in India. Environmental Impact Assessment. Economics assessment of watershed development vis-a-vis ecological and environmental protection.

4. Tree Improvement and Seed Technology :

General concept of tree improvement, methods and techniques, variation and its use, provenance, seed source, exotics; quantitative aspects of forest tree improvement, seed production and seed orchards, progeny tests, use of tree improvement in natural forest and stand improvement, genetic testing programming, selection and breeding for resistance to diseases, insects, and adverse environment; the genetic base, forest genetic resources and gene conservation in situ and ex-situ. Cost benefit ratio, economic evaluation.

Section B

1. 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 plantations, commercial forests, 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.

2. 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 and working schemes, their role in nature conservation, bio-diversity and other dimensions; preparation and control. Divisional Working Plans, Annual Plan of Operations.

3. 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 modelling.

4. Surveying and Forest Engineering :

Forest surveying - different methods of surveying, maps and map reading. Basic principles of forest engineering. Building materials and construction. Roads and Bridges; General principles, objects, types, simple design and construction of timber bridges.

5. 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 and arboreta. Conservation of forest ecosystems. 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. Factors affecting action and toxicity of drug plants and their chemical constituents.

6. Forest Resources and Utilization :

Environmentally sound forest harvesting practices; logging and extraction techniques and principles, transportation system, 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 of 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.

Anatomical structure of wood, defects and abnormalities of wood, timber identification - general principles.

7. Forest Protection & 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 CO₂. 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.

8. Forest Economics and Legislation :

Forest economics—fundamental principles, cost-benefit analysis; estimation of demand and supply; analysis of trends in the national and international market and changes in production and consumption patterns; assessment and projection of market structures; role of private sector and co-operatives; role of corporate financing. Socio-economic analysis of forest productivity and attitudes; valuation of forest goods and service.

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; institutional and structural changes. Decentralization and Forestry Public Administration. Forest laws, necessity; general principles, Indian Forest Act 1927; Forest Conservation Act, 1980; Wildlife Protection Act 1972 and their amendments; Application of Indian Penal Code to Forestry. Scope and objectives of Forest Inventory.

GEOLOGY - 100 MARKS**Section-A****(i) General Geology**

The Solar System, meteorities, origin and interior of the earth. Radioactivity and age of earth; Volcanoes- causes and products, volcanic belts. Earthquakes-causes, effects, earthquake belts, seismicity of India, intensity and magnitude, seismographs. Island arcs, deep sea trenches and mid-ocean ridges. Continental drift-evidences and mechanics; seafloor spreading, plate tectonics. Isostasy, orogeny and epeirogeny. Continents and oceans.

(ii) Geomorphology and Remote Sensing

Basic concepts of geomorphology. Weathering and mass wasting. Landforms, slopes and drainage. Geomorphic cycles and their interpretation. Morphology and its relation to structures and lithology. Applications of geomorphology in mineral prospecting, civil engineering, hydrology and environmental studies. Geomorphology of Indian subcontinent.

Aerial photographs and their interpretation-merits and limitations. The Electromagnetic Spectrum. Orbiting satellites and sensor systems. Indian Remote Sensing Satellites. Satellites data products. Applications of remote sensing in geology. The Geographic Information System and its applications. Global Positioning System.

(iii) Structural geology

Principles of geologic mapping and map reading, projection diagrams, stress and strain ellipsoid and stress-strain relationships of elastic, plastic and viscous materials. Strain markers in deformed rocks. Behaviour of minerals and rocks under deformation conditions. Folds and faults classification and mechanics. Structural analysis of folds, foliations, lineations, joints and faults, unconformities. Superposed deformation. Time-relationship between crystallization and deformation. Introduction to petrofabrics.

(iv) Paleontology

Species- definition and nomenclature. Megafossils and Microfossils. Modes of preservation of fossils. Different kinds of microfossils. Application of microfossils in correlation, petroleum exploration, paleoclimatic and paleoceanographic studies. Morphology, geological history and evolutionary trend in Cephalopoda, Trilobita, Brachiopoda, Echinoidea and Anthozoa. Stratigraphic utility of Ammonoidea, Trilobita and Graptoloidea. Evolutionary trend in Hominidae, Equidae and Proboscidae. Siwalik fauna. Gondwana flora and its importance.

(v) Stratigraphy and Geology of India

Classification of stratigraphic sequences: lithostratigraphic, biostratigraphic, chronostratigraphic and magnetostratigraphic and their interrelationships. Distribution and classification of Precambrian rocks of India. Study of stratigraphic distribution and lithology of Phanerozoic rocks of India with reference to fauna, flora and economic importance. Major boundary problems- Cambrian/Precambrian, Permian/Triassic, Cretaceous/Tertiary and Pliocene/Pleistocene. Study of climatic conditions, paleogeography and igneous activity in the Indian subcontinent in the geological past. Tectonic framework of India. Evolution of the Himalayas.

(vi) Hydrogeology and Engineering Geology :

Hydrologic cycle and genetic classification of water. Movement of subsurface water. Springs. Porosity, permeability, hydraulic conductivity, transmissivity and storage coefficient, classification of aquifers. Water-bearing characteristics of rocks. Groundwater chemistry. Salt water intrusion. Types of wells. Drainage basin morphometry. Exploration for groundwater. Groundwater recharge. Problems and management of groundwater. Rainwater harvesting. Engineering properties of rocks. Geological investigations for dams, tunnels and bridges. Rock as construction material. Alkali-aggregate reaction. Landslides-causes, prevention and rehabilitation. Earthquake-resistant structures.

Section-B**(i) Mineralogy**

Classification of crystals into systems and classes of symmetry. International system of crystallographic notation. Use of projection diagrams to represent crystal symmetry. Crystal defects. Elements of X-ray crystallography.

Petrological microscope and accessories. Optical properties of common rock forming minerals. Pleochroism, extinction angle, double refraction, birefringence, twinning and dispersion in minerals. Physical and chemical characters of rock forming silicate mineral groups. Structural classification of silicates. Common minerals of igneous and metamorphic rocks. Minerals of the carbonate, phosphate, sulphide and halide groups.

(ii) Igneous and Metamorphic Petrology

Generation and crystallisation of magma. Crystallisation of albite-anorthite, diopside-anorthite and diopside-wollastonite-silica systems. Reaction principle., Magmatic differentiation and assimilation. Petrogenetic significance of the textures and structures of igneous rocks. Petrography and petrogenesis of granite, syenite, diorite, basic and ultrabasic groups, charnockite, anorthosite and alkaline rocks. Carbonatites. Deccan volcanic province.

Types and agents of metamorphism. Metamorphic grades and zones. Phase rule. Facies of regional and contact metamorphism. ACF and AKF diagrams. Textures and structures of metamorphic rocks. Metamorphism of arenaceous, argillaceous and basic rocks. Minerals assemblages Retrograde metamorphism. Metasomatism and granitisation, migmatites, Granulite terrains of India.

(iii) Sedimentology

Sedimentary rocks: Processes of formation. diagenesis and lithification. Properties of sediments. Clastic and non-clastic rocks-their classification, petrography and depositional environment. Sedimentary facies and provenance. Sedimentary structures and their significance. Heavy minerals and their significance. Sedimentary basins of India.

(iv) Economic Geology

Ore, ore minerals and gangue, tenor of ore, classification of ore deposits. Process of formation of mineral deposits. Controls of ore localisation. Ore textures and structures. Metallogenic epochs and provinces. Geology of the important Indian deposits of aluminium, chromium, copper, gold, iron, lead zinc, manganese, titanium, uranium and thorium and industrial minerals. Deposits of coal and petroleum in India.

National Mineral Policy. Conservation and utilization of mineral resources. Marine mineral resources and Law of Sea.

(v) Mining Geology

Methods of prospecting-geological, geophysical, geochemical and geobotanical. Techniques of sampling. Estimation of reserves of ore. Methods of exploration and mining metallic ores, industrial minerals and marine mineral resources. Mineral beneficiation and ore dressing.

(vi) Geochemistry and Environmental Geology

Cosmic abundance of elements. Composition of the planets and meteorites. Structure and composition of earth and distribution of elements. Trace elements. Elements of crystal chemistry-types of chemical bonds, coordination number. Isomorphism and polymorphism. Elementary thermodynamics. Natural hazards-floods, landslides, coastal erosion, earthquakes and volcanic activity and mitigation. Environmental impact of urbanization, open cast mining, industrial and radioactive waste disposal, use of fertilizers, dumping of mine waste and fly-ash. Pollution of ground and surface water, marine pollution Environment protection-legislative measures in India.

MATHEMATICS - 100 MARKS

Section-A

Linear Algebra

Vector, space, linear dependence and independence, subspaces, bases, dimensions. Finite dimensional vector spaces.

Matrices, Cayley-Hamilton theorem, eigenvalues and eigenvectors, matrix of linear transformation, row and column reduction, Echelon form, equivalence, congruences and similarity, reduction to canonical form, rank, orthogonal, symmetrical, skew symmetrical, unitary, hermitian, skew-hermitian forms—their eigenvalues. Orthogonal and unitary reduction of quadratic and hermitian forms, positive definite quadratic forms.

Calculus

Real numbers, limits, continuity, differentiability, mean-value theorems, Taylor's theorem with remainders, indeterminate forms, maxima and minima, asymptotes. Functions of several variables: continuity, differentiability, partial derivatives, maxima and minima, Lagrange's method of multipliers, Jacobian. Riemann's definition of definite integrals, indefinite integrals, infinite and improper integrals, beta and gamma functions. Double and triple integrals (evaluation techniques only). Areas, surface and volumes, centre of gravity.

Analytic Geometry :

Cartesian and polar coordinates in two and three dimensions, second degree equations in two and three dimensions, reduction to canonical forms, straight lines, shortest distance between two skew lines, plane, sphere, cone, cylinder., paraboloid, ellipsoid, hyperboloid of one and two sheets and their properties. Section-B

Ordinary Differential Equations :

Formulation of differential equations, order and degree, equations of first order and first degree, integrating factor, equations of first order but not of first degree, Clairaut's equation, singular solution. Higher order linear equations, with constant coefficients, complementary function and particular integral, general solution, Euler-Cauchy equation.

Second order linear equations with variable coefficients, determination of complete solution when one solution is known, method of variation of parameters.

Dynamics, Statics and Hydrostatics :

Degree of freedom and constraints, rectilinear motion, simple harmonic motion, motion in a plane, projectiles, constrained motion, work and energy, conservation of energy, motion under impulsive forces, Kepler's laws, orbits under central forces, motion of varying mass, motion under resistance. Equilibrium of a system of particles, work and potential energy, friction, common catenary, principle of virtual work, stability of equilibrium, equilibrium of forces in three dimensions. Pressure of heavy fluids, equilibrium of fluids under given system of forces Bernoulli's equation, centre of pressure, thrust on curved surfaces, equilibrium of floating bodies, stability of equilibrium, metacentre, pressure of gases.

Vector Analysis :

Scalar and vector fields, triple products, differentiation of vector function of a scalar variable, Gradient, divergence and curl in cartesian, cylindrical and spherical coordinates and their physical interpretations. Higher order derivatives, vector identities and vector equations. Application to Geometry: Curves in space, curvature and torsion. Serret-Frenet's formulae, Gauss and Stokes' theorems, Green's identities.

Section-B**Algebra:**

Groups, subgroups, normal subgroups, homomorphism of groups quotient groups basic isomorphism theorems, Sylow's group, permutation groups, Cayley theorem. Rings and ideals, principal ideal domains, unique factorization domains and Euclidean domains. Field extensions, finite fields.

Real Analysis :

Real number system, ordered sets, bounds, ordered field, real number system as an ordered field with least upper bound property, cauchy sequence, completeness, Continuity and uniform continuity of functions, properties of continuous functions on compact sets. Riemann integral, improper integrals, absolute and conditional convergence of series of real and complex terms, rearrangement of series. Uniform convergence, continuity, differentiability and integrability for sequences and series of functions. Differentiation of functions of several variables, change in the order of partial derivatives, implicit function theorem, maxima

and minima. Multiple integrals. Complex Analysis : Analytic function, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's integral formula, power series, Taylor's series, Laurent's Series, Singularities, Cauchy's residue theorem, contour integration. Conformal mapping, bilinear transformations.

Linear Programming :

Linear programming problems, basic solution, basic feasible solution and optimal solution, graphical method and Simplex method of solutions. Duality.

Transportation and assignment problems. Travelling salesman problems.

Partial differential equations:

Curves and surfaces in three dimensions, formulation of partial differential equations, solutions of equations of type $dx/p=dy/q=dz/r$; orthogonal trajectories, Pfaffian differential equations; partial differential equations of the first order, solution by Cauchy's method of characteristics; Charpit's method of solutions, linear partial differential equations of the second order with constant coefficients, equations of vibrating string, heat equation, Laplace equation.

Numerical Analysis and Computer programming:

Numerical methods: Solution of algebraic and transcendental equations of one variable by bisection, Regula-Falsi and Newton-Raphson methods, solution of system of linear equations by Gaussian elimination and Gauss-Jordan (direct) methods, Gauss-Seidel (iterative) method. Newton's (Forward and backward) and Lagrange's method of interpolation.

Numerical integration: Simpson's one-third rule, trapezoidal rule, Gaussian quadrature formula. Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods. Computer Programming: Storage of numbers in Computers, bits, bytes and words, binary system. arithmetic and logical operations on numbers. Bitwise operations. AND, OR, XOR, NOT, and shift/rotate operators. Octal and Hexadecimal Systems. Conversion to and from decimal Systems. Representation of unsigned integers, signed integers and reals, double precision reals and long integers.

Algorithms and flow charts for solving numerical analysis problems:

Developing simple programs in Basic for problems involving techniques covered in the numerical analysis.

Mechanics and Fluid Dynamics :

Generalised coordinates, constraints, holonomic and non-holonomic, systems. D'Alembert's principle and Lagrange's equations, Hamilton equations, moment of inertia, motion of rigid bodies in two dimensions.

Equation of continuity, Euler's equation of motion for inviscid flow, stream-lines, path of a particle, potential flow, two-dimensional and axisymmetric motion, sources and sinks, vortex motion, flow past a cylinder and a sphere, method of images. Navier-Stokes equation for a viscous fluid.

MECHANICAL ENGINEERING -100 MARKS

Section - A

1. Theory of Machines :

Kinematic and dynamic analysis of planar mechanisms. Cams, Gears and gear trains, Flywheels, Governors, Balancing of rigid rotors, Balancing of single and multicylinder engines, Linear vibration analysis of mechanical systems (single degree and two degrees of freedom), Critical speeds and whirling of shafts, Automatic Controls, Belts and chain drives. Hydrodynamic bearings.

2. Mechanics of Solids :

Stress and strain in two dimensions. Principal stresses and strains, Mohr's construction, linear elastic materials, isotropy and an isotropy, Stress-strain relations, uniaxial loading, thermal stresses. Beams : Bending moment and shear force diagrams, bending stresses and deflection of beams, Shear stress distribution. Torsion of shafts, helical springs. Combined stresses, Thick and thin walled pressure vessels. Struts and columns, Strain energy concepts and theories of failure. Rotation discs. Shrink fits.

3. Engineering Materials :

Basic concepts on structure of solids, Crystalline materials, Defects in crystalline materials, Alloys and binary phase diagrams, structure and properties of common engineering materials. Heat treatment of steels. Plastics, Ceramics and composite Materials, common applications of various materials.

4. Manufacturing Science :

Merchant's force analysis, Taylor's tool life equation, machinability and machining economics, Rigid, small and flexible automation, NC, CNC. Recent machining methods- EDM, ECM and ultrasonics. Application of lasers and plasmas, analysis of forming processes. High energy rate forming. Jigs, fixtures, tools and gauges, Inspection of length, position, profile and surface finish.

5. Manufacturing management :

Production Planning and Control, Forecasting-Moving average, exponential smoothing, Operations scheduling; assembly line balancing. Product development. Breakeven analysis, Capacity planning. PERT and CPM.

Control Operations : Inventory control-ABC analysis. EOQ model. Materials requirement planning. Job design, Job standards, work measurement, Quality management-Quality control. Operations Research: Linear programming-Graphical and Simplex methods. Transportation and assignment models. Single server queuing model.

Value Engineering : Value analysis, for cost/value. Total quality management and forecasting techniques. Project management.

6. Elements of Computation:

Computer Organisation, Flow charting. Features of Common Computer Languages-FORTRAN d Base III, Lotus 1-2-3 C and elementary programming.

Section -B**1. Thermodynamics :**

Basic concept. Open and closed systems, Applications of Thermodynamic Laws, Gas equations, Clapeyron equation, Availability, Irreversibility and Tds relations.

2. I.C. Engines, Fuels and Combustion :

Spark Ignition and compression ignition engines, Four stroke engine and Two stroke engines, mechanical, thermal and volumetric efficiency, Heat balance.

Combustion process in S.I. and C.I. engines, preignition detonation in S.I. engine Diesel knock in C.I. engine. Choice of engine fuels, Octane and Cetane ratings. Alternate fuels Carburation and Fuel injection, Engine emissions and control. Solid, liquid and gaseous fuels, stoichiometric air requirements and excess air factor, fuel gas analysis, higher and lower calorific values and their measurements.

3. Heat Transfer, Refrigeration and Air-Conditioning :

One and two dimensional heat conduction. Heat transfer from extended surfaces, heat transfer by forced and free convection. Heat exchangers. Fundamentals for diffusive and convective mass transfer, Radiation laws, heat exchange between black and non black surfaces, Network Analysis. Heat pump refrigeration cycles and systems, Condensers, evaporators and expansion devices and controls. Properties and choice of refrigerant, Refrigeration Systems and components, psychometrics, comfort indices, cooling loading calculations, solar refrigeration.

4. Turbo-Machines and Power Plants:

Continuity, momentum and Energy Equations. Adiabatic and Isentropic flow, Fanno lines, Rayleigh lines. Theory and design of axial flow turbines and compressors, Flow through turbo-machine blades, cascades, centrifugal compressor. Dimensional analysis and modelling. Selection of site for steam, hydro, nuclear and stand-by power plants, selection base and peak load power plants Modern High pressure, High duty boilers, Draft and dust removal equipment, Fuel and cooling water systems, heat balance, station and plant heat rates, operation and maintenance of various power plants, preventive maintenance, economics of power generation.

PHYSICS -100 MARKS**Section-A****1. Classical Mechanics**

(a) Particle dynamics: Centre of mass and laboratory coordinates, conservation of linear and angular momentum. The rocket equation. Rutherford scattering, Galilean transformation, inertial and non-inertial frames, rotating frames, centrifugal and Coriolis forces, Foucault pendulum.

(b) System of particles: Constraints, degrees of freedom, generalised coordinates and momenta. Lagrange's equation and applications to linear harmonic oscillator, simple pendulum and central force problems. Cyclic coordinates, Hamiltonian Lagrange's equation from Hamilton's principle.

(c) Rigid body dynamics: Eulerian angles, inertia tensor, principal moments of inertia. Euler's equation of motion of a rigid body, force-free motion of a rigid body. Gyroscope.

2. Special Relativity, Waves & Geometrical Optics

(a) Special Relativity: Michelson-Morley experiment and its implications. Lorentz transformations-length contraction, time dilation, addition of velocities, aberration and Doppler effect, mass-energy relation, simple applications to a decay process. Minkowski diagram, four dimensional momentum vector. Covariance of equations of physics.

(b) Waves: Simple harmonic motion, damped oscillation, forced oscillation and resonance. Beats. Stationary waves in a string. Pulses and wave packets. Phase and group velocities. Reflection and Refraction from Huygens' principle.

(c) Geometrical Optics: Laws of reflection and refraction from Fermat's principle. Matrix method in paraxial optic-thin lens formula, nodal planes, system of two thin lenses, chromatic and spherical aberrations.

3. Physical Optics

(a) Interference: Interference of light-Young's experiment, Newton's rings, interference by thin films, Michelson interferometer. Multiple beam interference and Fabry-Perot interferometer. Holography and simple applications.

(b) Diffraction: Fraunhofer diffraction-single slit, double slit, diffraction grating, resolving power. Fresnel diffraction: - half-period zones and zones plates. Fresnel integrals. Application of Cornu's spiral to the analysis of diffraction at a straight edge and by a long narrow slit. Diffraction by a circular aperture and the Airy pattern.

(c) Polarisation and Modern Optics: Production and detection of linearly and circularly polarised light. Double refraction, quarter wave plate. Optical activity. Principles of fibre optics attenuation; pulse dispersion in step index and parabolic index fibres; material dispersion, single mode fibres. Lasers-Einstein A and B coefficients. Ruby and He-Ne lasers. Characteristics of laser light-spatial and temporal coherence. Focussing of laser beams. Three-level scheme for laser operation.

4. Electricity and Magnetism

- a) Electrostatics and Magnetostatics: Laplace and Poisson equations in electrostatics and their applications. Energy of a system of charges, multipole expansion of scalar potential. Method of images and its applications. Potential and field due to a dipole, force and torque on a dipole in an external field. Dielectrics, polarisation. Solutions to boundary-value problems-conducting and dielectric spheres in a uniform electric field. Magnetic shell, uniformly magnetised sphere. Ferromagnetic materials, hysteresis, energy loss.
- (b) Current Electricity: Kirchhoff's laws and their applications. Biot-Savart law, Ampere's law, Faraday's law, Lenz' law. Self- and mutual-inductances. Mean and rms values in AC circuits. LR CR and LCR circuits- series and parallel resonance. Quality factor. Principle of transformer.

5. Electromagnetic Theory & Black Body Radiation

- (a) Electromagnetic Theory: Displacement current and Maxwell's equations. Wave equations in vacuum, Poynting theorem. Vector and scalar potentials. Gauge invariance, Lorentz and Coulomb gauges. Electromagnetic field tensor, covariance of Maxwell's equations. Wave equations in isotropic dielectrics, reflection and refraction at the boundary of two dielectrics. Fresnel's relations. Normal and anomalous dispersion. Rayleigh scattering.
- (b) Blackbody radiation: Blackbody radiation and Planck radiation law- Stefan-Boltzmann law, Wien displacement law and Rayleigh-Jeans law. Planck mass, Planck length, Planck time, Planck temperature and Planck energy.

6. Thermal and Statistical Physics

- (a) Thermodynamics: Laws of thermodynamics, reversible and irreversible processes, entropy. Isothermal, adiabatic, isobaric, isochoric processes and entropy change. Otto and Diesel engines, Gibbs' phase rule and chemical potential. Van der Waals equation of state of a real gas, critical constants. Maxwell-Boltzmann distribution of molecular velocities, transport phenomena, equipartition and virial theorems. Dulong-Petit, Einstein, and Debye's theories of specific heat of solids. Maxwell relations and applications. Clausius- Clapeyron equation. Adiabatic demagnetisation, Joule-Kelvin effect and liquefaction of gases.
- (b) Statistical Physics: Saha ionization formula. Bose-Einstein condensation. Thermodynamic behaviour of an ideal Fermi gas, Chandrasekhar limit, elementary ideas about neutron stars and pulsars. Brownian motion as a random walk, diffusion process. Concept of negative temperatures.

Section-B**1. Quantum Mechanics I**

Wave-particle duality. Schrodinger equation and expectation values. Uncertainty principle. Solutions of the one-dimensional Schrodinger equation free particle (Gaussian wave-packet), particle in a box, particle in a finite well, linear harmonic oscillator. Reflection and transmission by a potential step and by a rectangular barrier. Use of WKB formula for the life-time calculation in the alpha-decay problem.

2. Quantum Mechanics II & Atomic Physics

(a) Quantum Mechanics II: Particle in a three dimensional box, density of states, free electron theory of metals. The angular momentum problem. The hydrogen atom. The spin half problem and properties of Pauli spin matrices.

(b) Atomic Physics: Stern-Gerlach experiment, electron spin, fine structure of hydrogen atom. L-S coupling, J-J coupling. Spectroscopic notation of atomic states. Zeeman effect. Frank-Condon principle and applications.

3. Molecular Physics

Elementary theory of rotational, vibrational and electronic spectra of diatomic molecules. Raman effect and molecular structure. Laser Raman spectroscopy Importance of neutral hydrogen atom, molecular hydrogen and molecular hydrogen ion in astronomy Fluorescence and Phosphorescence. Elementary theory and applications of NMR. Elementary ideas about Lamb shift and its significance.

4. Nuclear Physics

Basic nuclear properties-size, binding energy, angular momentum, parity, magnetic moment. Semi-empirical mass formula and applications. Mass parabolas. Ground state of a deuteron magnetic moment and non-central forces. Meson theory of nuclear forces. Salient features of nuclear forces. Shell model of the nucleus-success and limitations. Violation of parity in beta decay. Gamma decay and internal conversion. Elementary ideas about Mossbauer spectroscopy. Q-value of nuclear reactions. Nuclear fission and fusion, energy production in stars. Nuclear reactors.

5. Particle Physics & Solid State Physics

(a) Particle Physics: Classification of elementary particles and their interactions. Conservation laws. Quark structure of hadrons. Field quanta of electroweak and strong interactions. Elementary ideas about Unification of Forces. Physics of neutrinos.

(b) Solid State Physics: Cubic crystal structure. Band theory of solids- conductors, insulators and semiconductors. Elements of superconductivity, Meissner effect, Josephson junctions and applications. Elementary ideas about high temperature superconductivity.

6. Electronics

Intrinsic and extrinsic semiconductors-p-n-p and n-p-n transistors. Amplifiers and oscillators. Op-amps. FET, JFET and MOSFET. Digital electronics-Boolean identities, De Morgan's laws, Logic gates and truth tables., Simple logic circuits. Thermistors, solar cells. Fundamentals of microprocessors and digital computers.

STATISTICS 100 MARKS**Section - A****Probability :**

Sample space and events, probability measure and probability space, random variable as a measurable function, distribution function of a random variable, discrete and continuous-type random variable probability mass function, probability density function, vector-valued random variable, marginal and conditional distributions, stochastic independence of events and of random variables, expectation and moments of a random variable, conditional expectation, convergence of a sequence of random variable in distribution, in probability, in p -th mean and almost everywhere, their criteria and inter-relations, Borel-Cantelli lemma, Chebyshev's and Khinchine's weak laws of large numbers, strong law of large numbers and Kolmogorov's theorems, Glivenko-Cantelli theorem, probability generating function, characteristic function, inversion theorem, Laplace transform, related uniqueness and continuity theorems, determination of distribution by its moments. Linderberg and Levy forms of central limit theorem, standard discrete and continuous probability distributions, their inter-relations and limiting cases, simple properties of finite Markov chains.

Statistical Inference

Consistency, unbiasedness, efficiency, sufficiency, minimal sufficiency, completeness, ancillary statistic, factorization theorem, exponential family of distribution and its properties, uniformly minimum variance unbiased (UMVU) estimation, Rao-Blackwell and Lehmann-Scheffe theorems, Cramer-Rao inequality for single and several-parameter family of distributions, minimum variance bound estimator and its properties, modifications and extensions of Cramer-Rao inequality, Chapman-Robbins inequality, Bhattacharyya's bounds, estimation by methods of moments, maximum likelihood, least squares, minimum chi-square and modified minimum chi-square, properties of maximum likelihood and other estimators, idea of asymptotic efficiency, idea of prior and posterior distributions, Bayes estimators.

Non-randomised and randomised tests, critical function, MP tests, Neyman-Pearson lemma, UMP tests, monotone likelihood ratio, generalised Neyman-Pearson lemma, similar and unbiased tests, UMPU tests for single and several-parameter families of distributions, likelihood ratios and its large sample properties, chi-square goodness of fit test and its asymptotic distribution. Confidence bounds and its relation with tests, uniformly most accurate (UMA) and UMA unbiased confidence bounds.

Kolmogorov's test for goodness of fit and its consistency, sign test and its optimality. Wilcoxon signed-ranks test and its consistency, Kolmogorov-Smirnov two-sample test, run test, Wilcoxon-Mann-Whitney test and median test, their consistency and asymptotic normality. Wald's SPRT and its properties, OC and ASN functions, Wald's fundamental identity, sequential estimation.

Linear Inference and Multivariate Analysis

Linear statistical models, theory of least squares and analysis of variance, Gauss-Markoff theory, normal equations, least squares estimates and their precision, test of significance and interval estimates based on least squares theory in one-way, two-way and three-way classified data, regression analysis, linear regression, curvilinear regression and orthogonal polynomials, multiple regression, multiple and partial correlations, regression diagnostics and sensitivity analysis, calibration problems, estimation of variance and covariance components, MINQUE theory, multivariate normal distribution, Mahalanobis' D^2 and Hotelling's T^2 statistics and their applications and properties, discriminant analysis, canonical correlations, one-way MANOVA, principal component analysis, elements of factor analysis.

Sampling Theory and Design of Experiments

An outline of fixed-population and super-population approaches, distinctive features of finite population sampling, probability sampling designs, simple random sampling with and without replacement, stratified random sampling, systematic sampling and its efficacy for structural populations, cluster sampling, two-stage and multi-stage sampling, ratio and regression, methods of estimation involving one or more auxiliary variables, two-phase sampling, probability proportional to size sampling with and without replacement, the Hansen-Hurwitz and the Horvitz-Thompson estimators, non-negative variance estimation with reference to the Horvitz-Thompson estimator, non-sampling errors, Warner's randomised response technique for sensitive characteristics.

Fixed effects model (two-way classification) random and mixed effects models (two-way classification per cell), CRD, RBD, LSD and their analyses, incomplete block designs, concepts of orthogonality and balance, BIBD, missing plot technique, factorial designs : 2^n , 3^2 and 3^3 , confounding in factorial experiments, split-plot and simple lattice designs.

Section -B

Industrial Statistics

Process and product control, general theory of control charts, different types of control charts for variables and attributes, \bar{X} , R , s , p , np and c charts, cumulative sum chart, V-mask, single, double, multiple and sequential sampling plans for attributes, OC, ASN, AOQ and ATI curves, concepts of producer's and consumer's risks, AQL, LTPD and AOQL, sampling plans for variables, use of Dodge-Romig and Military Standard tables.

Concepts of reliability, maintainability and availability, reliability of series and parallel systems and other simple configurations, renewal density and renewal function, survival models (exponential), Weibull, lognormal, Rayleigh, and bath-tub), different types of redundancy and use of redundancy in reliability improvement, problems in life-testing, censored and truncated experiments for exponential models.

Optimization Techniques

Different, types of models in Operational Research, their construction and general methods of solution, simulation and Monte-Carlo methods, the structure and formulation of linear programming (LP) problem, simple LP model and its graphical solution, the simplex procedure, the two-phase method and the M-technique with artificial variables, the duality theory of LP and its economic interpretation, sensitivity analysis, transportation and assignment problems, rectangular games, two-person zero-sum games, methods of solution (graphical and algebraic).

Replacement of failing or deteriorating items, group and individual replacement policies, concept of scientific inventory management and analytical structure of inventory problems, simple models with deterministic and stochastic demand with and without lead time, storage models with particular reference to dam type.

Homogeneous discrete-time Markov chains, transition probability matrix, classification of states and ergodic theorems, homogeneous continuous-time Markov chains, Poisson process, elements of queueing theory, M/M/1, M/M/K, G/M/1 and M/G/1 queues.

Solution of statistical problems on computers using well known statistical software packages like SPSS.

Quantitative Economics and Official Statistics

Determination of trend, seasonal and cyclical components, Box-Jenkins method, tests for stationery of series, ARIMA models and determination of orders of autoregressive and moving average components, forecasting.

Commonly used index numbers-Laspeyre's, Paashe's and Fisher's ideal index numbers, chain-base index number uses and limitations of index numbers, index number of wholesale prices, consumer price index number, index numbers of agricultural and industrial production, tests, for index numbers I've proportionality test, time-reversal test, factor-reversal test, circular test and dimensional invariance test.

General linear model, ordinary least squares and generalised least squares methods of estimation, problem of multicollinearity, consequences and solutions of multicollinearity, autocorrelation and its consequences, heteroscedasticity of disturbances and its testing, test for independence of disturbances, Zellner's seemingly unrelated regression equation model and its estimation, concept of structure and model for simultaneous equations, problem of identification-rank and order conditions of identifiability, two-stage least squares method of estimation.

Present official statistical system in India relating to population, agriculture, industrial production, trade and prices, methods of collection of official statistics, their reliability and limitation and the principal publications containing such statistics, various official agencies responsible for data collection and their main functions.

Demography and Psychometry

Demographic data from census, registration, NSS and other surveys, and their limitation and uses, definition, construction and uses of vital rates and ratios, measures of fertility, reproduction rates, morbidity rate, standardized death rate, complete and abridged life tables, construction of life tables from vital statistics and census returns, uses of life tables, logistic and other population growth curves, fitting a logistic curve, population projection, stable population theory, uses of stable population and quasi-stable population techniques in estimation of demographic parameters, morbidity and its measurement, standard classification by cause of death, health surveys and use of hospital statistics.

Methods of standardisation of scales and tests, Z-scores, standard scores, T-scores, percentile scores, intelligence quotient and its measurement and uses, validity of test scores and its determination, use of factor analysis and path analysis in psychometry.

ZOOLOGY- 100 MARKS**Section-A****1. Non-chordata and chordata :**

(a) Classification and relationship of various phyla upto sub-classes; Acoelomata and Coelomata; Protostomes and Deuterostomes, Bilateria and Radiata; Status of Protista, Parazoa, Onychophora and Hemichordata; Symmetry.

(b) Protozoa : Locomotion, nutrition, reproduction; evolution of sex; General features and life history of Paramecium, Monocystis, Plasmodium, and Leishmania. (c) Porifera : Skeleton, canal system and reproduction.

(d) Coelenterata : Polymorphism, defensive structures and their mechanism; coral reefs and their formation; metagenesis; general features and life history of Obelia and Aurelia.

(e) Platyhelminthes : Parasitic adaptation; general features and life history of Fasciola and Taenia and their relation to man.

(f) Nematelminthes : General features, life history and parasitic adaptation of Ascaris; nematelminths in relation to man.

(g) Annelida : Coelom and metamerism; modes of life in polychaetes; general features and life history of Nereis (Nereis), earthworm (Pheretima) and leech (Hirudinaria).

(h) Arthropoda : Larval forms and parasitism in Crustacea; vision and respiration in arthropods (prawn, cockroach and scorpion); modification of mouth parts in insects (cockroach, mosquito, housefly, honey bee and butterfly); metamorphosis in insects and its hormonal regulation; social organization in insects (termites and honey bees).

(i) Mollusca : Feeding, respiration, locomotion, shell diversity; general features and life history of Lamellidens, Pila and Sepia, torsion and detorsion in gastropods.

(j) Echinodermata : Feeding, respiration, locomotion larval forms; general features and life history of Asterias.

(k) Protochordata : Origin of chordates; general features and life history of Branchiostoma and Herdmania.

(l) Pisces : Scales, respiration, locomotion, migration.

(m) Amphibia : Origin of tetrapods; parental care, paedomorphosis.

(n) Reptilia : Origin of reptiles; skull types; status of Sphenodon and crocodiles.

(o) Aves : Origin of birds; flight adaptation, migration.

(p) Mammalia : Origin of mammals; definition; general features of egg-laying mammals, pouched-mammals, aquatic mammals and primates; endocrine glands and other hormone producing structures (pituitary, thyroid, parathyroid, adrenal, pancreas, glands) and their interrelationships.

(q) Comparative functional anatomy of various systems of vertebrates (integument and its derivatives, endoskeleton, locomotory organs, digestive system, respiratory system, circulatory system including heart and aortic arches; urino-genital system, brain and sense organs (eye and ear).

II. Ecology

- (a) Biosphere: Biogeochemical cycles, green-houses effect, ozone layer and its impact; ecological succession, biomes and ecotones.
- (b) Population, characteristics, population dynamics, population stabilization.
- (c) Conservation of natural resources- mineral mining, fisheries, aquaculture; forestry; grassland; wildlife (Project Tiger); sustainable production in agriculture-integrated pest management.
- (d) Environmental biodegradation; pollution and its impact on biosphere and its prevention.

III. Ethology :

- (a) Behaviour : Sensory filtering, responsiveness, sign stimuli, learning, instinct, habituation, conditioning, imprinting.
- (b) Role of hormones in drive; role of pheromones in alarm spreading; crypsis, predator detection, predator tactics, social behaviour in insects and primates; courtship (*Drosophila*, 3-spine stickleback and birds).
- (c) Orientation, navigation, homing; biological rhythms; biological clock, tidal, seasonal and circadian rhythms.
- (d) Methods of studying animal behaviour.

IV. Economic Zoology :

- (a) Apiculture, sericulture, lac culture, carp culture, pearl culture, prawn culture.
- (b) Major infectious and communicable diseases (small pox, plague, malaria, tuberculosis, cholera and AIDS) their vectors, pathogens and prevention.
- (c) Cattle and livestock diseases, their pathogens (helminths) and vectors (ticks, mites, *Tabanus*, *Stomoxys*)
- (d) Pests of sugar cane (*Pyrrilla perpusiella*), oil seed (*Achaea janata*) and rice (*Sitophilus oryzae*).

V. Biostatistics :

Designing of experiments; null hypothesis; correlation, regression, distribution and measure of central tendency, chi square, student t-test, F-test (one-way & two-way F-test).

VI. Instrumental methods :

- (a) Spectrophotometry, flame photometry, Geiger-Muller counter, scintillation counting.
- (b) Electron microscopy (TEM, SEM).

Section-B**I. Cell Biology:**

- (a) Structure and function of cell and its organelles(nucleus, plasma membrane, mitochondria, Golgi bodies, endoplasmic reticulum, ribosomes and lysosomes), cell division (mitosis and meiosis), mitotic spindle and mitotic apparatus, chromosome movement.

(b) Watson-Crick model of DNA, replication of DNA, protein synthesis, transcription and transcription factors.

II. Genetics

- a) Gene structure and functions; genetic code.
- (b) Sex chromosomes and sex determination in *Drosophilla*, nematodes and man.
- (c) Mendel's laws of inheritance, recombination, linkage, linkage-maps, multiple alleles, cistron concept; genetics of blood groups.
- (d) Mutations and mutagenesis : radiation and chemical.
- (e) Cloning technology, plasmids and cosmids as vectors, transgenics, transposons, DNA sequence cloning and whole animal cloning (Principles and methodology).
- (f) Regulation and gene expression in pro-and eu-karyotes.
- (g) Signal transduction; pedigree-analysis; congenital diseases in man.
- (h) Human genome mapping; DNA finger-printing.

III. Evolution

- (a) Origin of life
- (b) Natural selection, role of mutation in evolution, mimicry, variation, isolation, speciation.
- (c) Fossils and fossilization; evolution of horse, elephant and man.
- (d) Hardy-Weinberg Law, causes of change in gene frequency.
- (e) Continental drift and distribution of animals.

IV. Systematics

- (a) Zoological nomenclature; international code; cladistics.

V. Biochemistry

- (a) Structure and role of carbohydrates, fats, lipids, proteins, aminoacids, nucleic acids; saturated and unsaturated fattyacids, cholesterol.
- (b) Glycolysis and Krebs cycle, oxidation and reduction, oxidative phosphorylation; energy conservation and release, ATP, cyclic AMP-its structure and role.
- (c) Hormone classification (steroid and peptide hormones), biosynthesis and function.
- (d) Enzymes : types and mechanisms of action; immunoglobulin and immunity; vitamins and co-enzymes.
- (e) Bioenergetics.

VI Physiology (with special refernece to mammals)

- (a) Composition and constituents of blood; blood groups and Rh factor in man; coagulation, factors and mechanism of coagulation; acid-base balance, thermo regulation.
- (b) Oxygen and carbon dioxide transport; haemoglobin : constituents and role in regulation.

- (c) Nutritive requirements; role of salivary glands, liver, pancreas and intestinal glands in digestion and absorption.
- (d) Excretory products; nephron and regulation of urine formation; osmoregulation.
- (e) Types of muscles, mechanism of contraction of skeletal muscles.
- (f) Neuron, nerve impulse-its conduction and synaptic transmission; neurotransmitters.
- (g) Vision, hearing and olfaction in man.
- (h) Mechanism of hormone action.
- (i) Physiology of reproduction, role of hormones and pheromones.

VII. Developmental Biology

- (a) Differentiation from gamete to neurula stage; dedifferentiation; metaplasia, induction, morphogenesis and morphogen; fate maps of gastrulae in frog and chick; organogenesis of eye and heart, placentation in mammals.
- (b) Role of cytoplasm in and genetic control of development; cell lineage; causation of metamorphosis in frog and insects; paedogenesis and neoteny; growth, degrowth and cell death; ageing; blastogenesis; regeneration; teratogenesis; neoplasia.
- (c) Invasiveness of placenta; in vitro fertilization; embryo transfer, cloning.
- (d) Baer's law; evo-devo concept.

ELECTRICAL ENGINEERING -100 MARKS

Section - A

1. EM Theory

Electric and magnetic fields. Gauss's Law and Amperes Law. Fields in dielectrics, conductors and magnetic materials. Maxwell's equations. Time varying fields. Plane-Wave propagating in dielectric and conducting media. Transmission lines.

2. Electrical Materials

Band Theory, Conductors, Semi-conductors and Insulators. Super-conductivity. Insulators for electrical and electronic applications. Magnetic materials. Ferro and ferri magnetism. Ceramics, Properties and applications. Hall effect and its applications. Special semi conductors.

3. Electrical Circuits

Circuits elements. Kirchoff's Laws. Mesh and nodal analysis. Network Theorems and applications. Natural response and forced response. Transient response and steady state response for arbitrary inputs. Properties of networks in terms of poles and zeros. Transfer function. Resonant circuits. Three-phase circuits. Two-port networks. Elements of two-element network synthesis.

4. Measurements and Instrumentation

Units and Standards. Error analysis, measurement of current, Voltage, power, Power-factor and energy. Indicating instruments. Measurement of resistance, inductance, Capacitance and frequency. Bridge measurements. Electronic measuring instruments. Digital Voltmeter and frequency counter. Transducers and their applications to the measurement of non-electrical quantities like temperature, pressure, flow-rate displacement, acceleration, noise level etc. Data acquisition systems. A/D and D/A converters.

5. Control Systems.

Mathematical modelling of physical systems. Block diagrams and signal flow graphs and their reduction. Time domain and frequency domain analysis of linear dynamical system. Errors for different type of inputs and stability criteria for feedback systems. Stability analysis using Routh-Hurwitz array, Nyquist plot and Bode plot. Root locus and Nicols chart and the estimation of gain and phase margin. Basic concepts of compensator design. State variable matrix and its use in system modelling and design. Sampled data system and performance of such a system with the samples in the error channel. Stability of sampled data system. Elements of non-linear control analysis. Control system components, electromechanical, hydraulic, pneumatic components.

Section -B**1. Electrical Machines and Power Transformers**

Magnetic Circuits - Analysis and Design of Power transformers. Construction and testing. Equivalent circuits. Losses and efficiency. Regulation. Auto-transformer, 3-phase transformer. Parallel operation. Basic concepts in rotating machines. EMF, torque, basic machine types. Construction and operation, leakage losses and efficiency.

B.C. Machines. Construction, Excitation methods. Circuit models. Armature reaction and commutation. Characteristics and performance analysis. Generators and motors. Starting and speed control.

Testing, Losses and efficiency:

Synchronous Machines. Construction. Circuit model. Operating characteristics and performance analysis. Synchronous reactance. Efficiency. Voltage regulation. Salient-pole machine, Parallel operation.

Hunting. Short circuit transients.

Induction Machines. Construction. Principle of operation. Rotating fields. Characteristics and performance analysis. Determination of circuit model. Circle diagram. Starting and speed control. Fractional KW motors. Single-phase synchronous and induction motors.

2. Power systems

Types of Power Stations, Hydro, Thermal and Nuclear Stations. Pumped storage plants. Economics and operating factors.

Power transmission lines. Modeling and performance characteristics. Voltage control. Load flow studies. Optimal power system operation. Load frequency control. Symmetrical short circuit analysis. ZBus formulation. Symmetrical Components. Per Unit representation. Fault analysis. Transient and steady-state stability of power systems. Equal area criterion.

Power system Transients. Power system Protection Circuit breakers. Relays. HVDC transmission.

3. Analog and Digital Electronics and Circuits

Semiconductor device physics, PN junctions and transistors, circuit models and parameters, FET, Zener, tunnel, Schottky, photo diodes and their applications, rectifier circuits, voltage regulators and multipliers, switching behavior of diodes and transistors.

Small signal amplifiers, biasing circuits, frequency response and improvement, multistage amplifiers and feed-back amplifiers, D.C. amplifiers, Oscillators. Large signal amplifiers, coupling methods, push pull amplifiers, operational amplifiers, wave shaping circuits. Multivibrators and flip-flops and their applications. Digital logic gate families, universal gates-combination circuits for arithmetic and logic operational, sequential logic circuits. Counters, registers, RAM and ROMs.

4. Microprocessors

Microprocessor architecture-Instruction set and simple assembly language programming. Interfacing for memory and I/O. Applications of Micro-processors in power system.

5. Communication Systems

Types of modulation; AM, FM and PM. Demodulators. Noise and bandwidth considerations. Digital communication systems. Pulse code modulation and demodulation. Elements of sound and vision broadcasting. Carrier communication. Frequency division and time division multiplexing, Telemetry system in power engineering.

6. Power Electronics

Power Semiconductor devices. Thyristor. Power transistor, GTOs and MOSFETS. Characteristics and operation. AC to DC Converters; 1-phase and 3-phase DC to DC Converters; AC regulators. Thyristor controlled reactors; switched capacitor networks.

Inverters; single-phase and 3-phase. Pulse width modulation. Sinusoidal modulation with uniform sampling. Switched mode power supplies.

SILVICULTURE - 100 MARKS**SECTION - A****1. Principles of Silviculture**

Definition of silvics and silviculture, role of silviculture. Major forest types, distribution and composition in India.

Study of site factors like climatic, edaphic, physiographic and biotic in relation to forest.'

Classification of climatic factors, the role played by light, temperature, rainfall, snow, wind, humidity and evaporation in relation to forest vegetation.

Edaphic factors of biological agencies parent rock topography etc. on the soil formation. Soil profiles-physical and chemical properties, mineral nutrients, nutrient cycling, soil moisture and their influences on forest production.

Tree growth photosynthesis biotic factor-influence of plants, insects, wild animals, man and domestic animals on vegetation.

Tree growth photosynthesis, respiration, translocation and transpiration. Cambial development, growth rings, effects on environment on cambial development. Shoot and crown development. Flowering, fruiting and seed production.

Root growth-distribution and biomass. Environmental effects on development silvicultural manipulation of root growth.

Stand dynamics- Plant succession, competition and tolerance stand development- basal area and yield table.

2. Practices of Silviculture

Classification of forests. Forest regeneration, natural, artificial (Plantation forests) and mixed regeneration. Natural forest types and their management. Plantation forests: planting survey, planting plan, plantation records, maps, ecological aspects for the choice of tree species, site preparation, planting tools and planting, direct seeding, gap filling, afforestation of dryland, wetland and adverse sites and taungya. Enrichment planting; fertilizer, application, nursery crops, cover crops. Tending; control of climbers and undesirable trees. Weed Management. Pruning and lopping. Thinning- thinning of irregular crops, increment felling, improvement felling. Fire prescribed burning. Conflicts between afforestation and cattle ranching.

SECTION - B**1. Silviculture of trees and shrubs (Soft wood)**

The origin, distribution, general description, economic value, Phenology, silviculture characters, regeneration methods, management of soft woods such as *Cedrus deodara*, *Cupressus torulosa*, *Pinus wallichiana*; *P. roxburghii*, *P. helpenensis*, *P. gerardiana*, *Abies Pindrow*, *Picea Smithiana* and Tropical Pines like *P. oocarpa*, *P. petula*, *P. kesiya* *Rhododendrons*, *Pyrus passia*, and *Indigofera* species, *Juniperus*, *Aqathis robusta*.

2. Silvicultural Systems

Silvicultural system:- definition, modern silviculture, classical silviculture, classification and detailed study of the following systems.

Clear felling system (Including clear strip and alternate strip system); shelter wood system; uniform system, the group system the Indian shelter wood system; the wedge system; the irregular shelter wood system; the coppice of two rotation system; the shelter wood coppice system; coppice selection system; coppice with standard system; coppice with reserve system; pollard system and culm selection system in bamboo

3. Silviculture of Indian trees:

General description, growth and silviculture characters and regeneration methods of following species:-

Quercus species, Alnus nitida, Acer Spp. Acacia nilotica, A catechu, Dalbergia Sissoo, Juglans regia. Toona Ciliata, Bauhimia Variegata, Fraxinus spp. Celtis australis, Grewia optiva, Morus species, Platinus Orientalis, Eucalyptus spp, populus species. salix species, Robinea pseudoacacia, Ulmus wallichiana, Catalpa bigninoides, Albizzia spp Dondonaea viscoso, parrotia spp. viburnum, olea cuspidate, Aesculus indica, Ailanthus excelsa; Tectona grandis, Shorea robusta, Berberis spp, Prosopis spp, Leucaena leucocephala, Hippophae rhamanoidls.

CIVIL ENGINEERING -100 MARKS

Section -A

1. Building Materials

Timber : Different types and species of structural timber, density-moisture relationship, strength in different directions, defects, influence of defects on permissible stress, preservation, dry and wet rots, codal provisions for design, 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, elasticity, non-destructive testing, mix design methods.

2. Solid Mechanics

Elastic constants, stress, plane stress, Mohr's circle of stress, strains, plane strain, Mohr's circle of strain, combined stress; Elastic theories of failure; Simple bending, shear; Torsion of circular and rectangular sections and simple members.

3. Structural Analysis

Analysis of determinate structures - different methods including graphical methods.

Analysis of indeterminate skeletal frames - moment distribution, slope-deflection, stiffness and force methods, energy methods, Muller-Breslau principle and application.

Plastic analysis of indeterminate beams and simple frames - shape factors.

4. Design of Steel Structures

Principles of working stress method. Design of connections, simple members, Built-up sections and frames, Design of Industrial roofs. Principles of ultimate load design. Design of simple members and frames.

5. Design of Concrete and Masonry Structures

Limit state design for bending, shear, axial compression and combined forces. Codal provisions for slabs, beams, walls and footings. Working stress method of design of R.C. members.

Principles of prestressed concrete design, materials, methods of prestressing, losses. Design of simple members and determinate structures. Introductions to prestressing of indeterminate structures.

Design of brick masonry as per I.S. Codes.

6. Construction Practice, Planning and Management

Concreting Equipment: Weight Batcher, Mixer, vibrator, batching plant, concrete pump. Cranes, hoists, lifting equipment.

Earthwork Equipment : Power shovel, hoe, dozer, dumper, trailers and tractor, rollers, sheep foot rollers, pumps.

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.

Section - B

1. (a) Fluid Mechanics, Open Channel Flow, Pipe Flow: Fluid Properties, Pressure, Thrust, Buoyancy; Flow Kinematics; Integration of flow equations; Flow measurement; Relative motion; Moment of momentum; Viscosity, Boundary layer and Control, Drag, Lift; dimensional Analysis, Modelling; Cavitation; Flow oscillations; Momentum and Energy principles in Open channel flow, Flow controls, Hydraulic jump, Flow sections and properties; Normal flow, Gradually varied flow; Surges; Flow development and losses in pipe flows, Measurements; Siphons; Surges and Water hammer; Delivery of Power Pipe networks.

(b) Hydraulic Machines and Hydropower: Centrifugal pumps, types, performance parameters, scaling, pumps in parallel; Reciprocating pumps, air vessels, performance parameters; Hydraulic ram; Hydraulic turbines, types, performance parameters, controls, choice; Power house, classification and layout, storage, pondage, control of supply.

2. (a) **Hydrology:** Hydrological cycle, precipitation and related data analyses, PMP, unit and synthetic hydrographs; Evaporation and transpiration; Floods and their management, PMF; Streams and their gauging; River morphology; Routing of floods; Capacity of Reservoirs.

(b) **Water Resources Engineering:** Water resources of the globe: Multipurpose uses of Water: Soil-Plant-Water relationships, irrigation systems, water demand assessment; Storages and their yields, ground water yield and well hydraulics; Waterlogging, drainage design; Irrigation revenue; 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 sections of gravity dams and their design, Energy dissipators and tailwater rating; Design of headworks, distribution works, falls, cross-drainage works, outlets; River training.

ENVIRONMENTAL ENGINEERING

3. (a) **Water Supply 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, detailing and maintenance of treatment units; Conveyance and distribution systems of treated water, leakages and control; Rural water supply; Institutional and industrial water supply.

(b) **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, streamflow rejuvenation Institutional and industrial sewage management; Plumbing Systems; Rural and semi-urban sanitation.

(c) **Solid Waste Management:** Sources, classification, collection and disposal; Design and Management of landfills.

(d) **Air and Noise Pollution and Ecology:** Sources and effects of air pollution, monitoring of air pollution; Noise pollution and standards; Ecological chain and balance, Environmental assessment.

4 (a) **Soil Mechanics:** Properties of soils, classification and interrelationship; Compaction behaviour, methods of compaction and their choice; Permeability and seepage, flow nets, Inverted filters; Compressibility and consolidation; Shearing resistance, stresses and failure; soil testing in laboratory and in-situ; Stress path and applications; Earth pressure theories, stress distribution in soil; soil exploration, samplers, load tests, penetration tests.

(b) **Foundation Engineering:** Types of foundations, Selection criteria, bearing capacity, settlement, laboratory and field tests; Types of piles and their design and layout, Foundations on expansive soils, swelling and its prevention, foundation on swelling soils.

5. (a) **Surveying:** 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 levelling; Relief representation; Contours; Digital elevation modelling concept; Establishment of control by triangulations and traversing - measurements 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.

(b) **Transportation Engineering:** Planning of highway systems, alignment and geometric design, horizontal and vertical curves, grade separation; Materials and construction methods for different surfaces and maintenance: Principles of pavement design; Drainage.

Traffic surveys, Intersections, signalling; Mass transit systems, accessibility, networking. Tunnelling, alignment, methods of construction, disposal of muck, drainage, lighting and ventilation, traffic control, emergency management.

Planning of railway systems, terminology and designs, relating to gauge, track, controls, transits, rolling stock, tractive power and track modernisation; Maintenance; Appurtenant works; Containerisation. Harbours - layouts, shipping lanes, anchoring, location identification; Littoral transport with erosion and deposition; sounding methods; Dry and Wet docks, components and operational Tidal data and analyses. Airports - layout and orientation; Runway and taxiway design and drainage management; Zoning laws; Visual aids and air traffic control; Helipads, hangers, service equipment.

ELECTRONICS ENGINEERING - 100 MARKS

Section - A

1. Materials and Components:

Structure and properties of Electrical Engineering materials; Conductors, Semiconductors and Insulators, magnetic, Ferroelectric, Piezoelectric, Ceramic, Optical and Super-conducting materials. Passive components and characteristics Resistors, Capacitors and Inductors; Ferrites, Quartz crystal Ceramic resonators, Electromagnetic and Electromechanical components.

2. Physical Electronics, Electron Devices and ICs:

Electrons and holes in semiconductors, Carrier Statistics, Mechanism of current flow in a semiconductor, Hall effect; Junction theory; Different types of diodes and their characteristics; Bipolar Junction transistor; Field effect transistors; Power switching devices like SCRs, GTOs, power MOSFETS; Basics of ICs - bipolar, MOS and CMOS types; basic of Opto Electronics.

3. Signals and Systems

Classification of signals and systems: System modelling in terms of differential and difference equations; State variable representation; Fourier series; Fourier transforms and their application to system analysis; Laplace transforms and their application to system analysis; Convolution and superposition integrals and their applications; Z-transforms and their applications to the analysis and characterisation of discrete time systems; Random signals and probability, Correlation functions; Spectral density; Response of linear system to random inputs.

4. Network theory

Network analysis techniques; Network theorems, transient response, steady state sinusoidal response; Network graphs and their applications in network analysis; Tellegen's theorem. Two port networks; Z, Y, h and transmission parameters. Combination of two ports, analysis of common two ports. Network functions : parts of network functions, obtaining a network function from a given part. Transmission criteria : delay and rise time, Elmore's and other definitions effect of cascading. Elements of network synthesis.

5. Electromagnetic Theory

Analysis of electrostatic and magnetostatic fields; Laplace's and Poisson's equations; Boundary value problems and their solutions; Maxwell's equations; application to wave propagation in bounded and unbounded media; Transmission lines : basic theory, standing waves, matching applications, microstrip lines; Basics of wave guides and resonators; Elements of antenna theory.

6. Electronic Measurements and instrumentation

Basic concepts, standards and error analysis; Measurements of basic electrical quantities and parameters; Electronic measuring instruments and their principles of working : analog and digital, comparison, characteristics, application. Transducers; Electronic measurements of non electrical quantities like temperature, pressure, humidity etc; basics of telemetry for industrial use.

Section - B

1. Analog Electronic Circuits :

Transistor biasing and stabilization. Small signal analysis. Power amplifiers. Frequency response. Wide banding techniques. Feedback amplifiers. Tuned amplifiers. Oscillators. Rectifiers and power supplies. Op Amp, PLL, other linear integrated circuits and applications. Pulse shaping circuits and waveform generators.

2. Digital Electronic Circuits :

Transistor as a switching element; Boolean algebra, simplification of Boolean functions, Karnaguh map and applications; IC Logic gates and their characteristics; IC logic families : DTL, TTL, ECL, NMOS, PMOS and CMOS gates and their comparison; Combinational logic Circuits; Half adder, Full adder; Digital comparator; Multiplexer Demulti-plexer; ROM an their applications. Flip flops. R-S, J-K, D and T flip-flops; Different types of counters and registers Waveform generators. A/D and D/A converters. Semiconductor memories.

3. Control Systems :

Transient and steady state response of control systems; Effect of feedback on stability and sensitivity; Root locus techniques; Frequency response analysis. Concepts of gain and phase margins: Constant-M and Constant-N Nichol's Chart; Approximation of transient response from Constant-N Nichol's Chart; Approximation of transient response from closed loop frequency response; Design of Control Systems, Compensators; Industrial controllers.

4. Communication Systems :

Basic information theory; Modulation and detection in analogue and digital systems; Sampling and data reconstructions; Quantization & coding; Time division and frequency division multiplexing; Equalization; Optical Communication : in free space & fiber optic; Propagation of signals at HF, VHF, UHF and microwave frequency; Satellite Communication.

5. Microwave Engineering :

Microwave Tubes and solid state devices, Microwave generation and amplifiers, Waveguides and other Microwave Components and Circuits, Microstrip circuits, Microwave Antennas, Microwave Measurements, Masers, lasers; Microwave propagation. Microwave Communication Systems terrestrial and Satellite based.

6. Computer Engineering :

Number Systems. Data representation; Programming; Elements of a high level programming language PASCAL/C; Use of basic data structures; Fundamentals of computer architecture; Processor design; Control unit design; Memory organisation, I/o System Organisation. Microprocessors : Architecture and instruction set of Microprocessors 8085 and 8086, Assembly language Programming. Microprocessor Based system design : typical examples. Personal computers and their typical uses.

HORTICULTURE - 100 MARKS**Section - A****Basic Horticulture:**

Scope and importance of Horticulture and horticultural crops - Area and Production - Imports and Exports - Nutritive value of Horticultural crops - climatic zones of India and Tamil Nadu in relation to Horticultural crops - scope for horticultural development in Tamil Nadu - Factors limiting horticultural crop production - climate (Rainfall, temperature, Light, humidity, sunshine) - Soil(PH, EC, Soil depth) - Crops suitable for different soils - water (Quality and quantity) - Drainage.

Planning, Layout and Planting of orchards - fencing - wind breaks - spacing - systems of planting - cropping systems - Multitier cropping - cover crops - Intercrops - Mulching - weed control.

Manures and manuring - organic and inorganic manures - Bio fertilizers - Essential elements - functions - deficiency symptoms - fertilizer schedule - Time and method of application Irrigation - water requirement of different horticultural crops - various irrigation methods including drip, sprinkler, fog, mist, water stress on horticultural crops.

Training and pruning - principles and methods

Flowering - Pollination - fruit set - fruit drop - causes and prevention - unfruitfulness associated with external and internal factors. Maturity - harvesting - Post harvest handling - Processing and preservation.

Role of plant growth regulators in Horticulture

Seed and vegetative propagation - advantages and disadvantages - seed treatment - Important methods of vegetative propagation - cutting - layering - rootstock - scion - (stock - scion relationship) - Incompatibility - grafting - budding - specialized parts of propagation (bulbs, tubers, offsets, runners etc.) - Mist propagation - Micropropagation

Section - B

Tropical, subtropical, temperate and arid zone horticultural crops - climate and soil - propagation practices spacing and planting - varieties - nutrient, water and weed management - mulching - intercropping - use of growth regulators - yield - Economics - Integrated pest and disease management - pre and post - harvest practices - processing and preservation - Marketing.

Fruit Crops: Mango, banana, grapes, citrus, papaya, Sapota, guava, ber, Pomegranate, annonas, amla, tamarind, jack, pineapple, apple, plum, pear, peach.

Spice Crops: Pepper, Cardamom, nutmeg, cinnamon, clove, allspice, ginger, turmeric, coriander, cumin, fenugreek, fennel.

Plantation Crops: Coffee, Tea, Coconut, Cocoa, Arecanut, Oilpalm, Cashew, Palmyrah, rubber.

Vegetable Crops: Tomato, brinjal, bhendi, chilli, cucumber, melons, gourds, pumpkin, peas, beans, potato, cassava, sweet potato, minor tubers, carrot, radish, Beetroot, Turnip, cabbage, cauliflower, onion, garlic, Amaranthus, other greens, Moringa, chow chow, curry leaf.

Flower Crops: Jasmine, rose, chrysanthemum, Tube rose, crossandra - marigold, Gerbera, orchid, gladiolus, anthurium.

Medicinal plants: Catharanthus - Gloriosa, Senna, Pyrethrum - Digitalis.

Aromatic plants: Geranium - oil yielding grasses, patchouli, Mentha.

Ornamental gardening: Landscaping - design and principles - Types of gardens - Layout - garden components - flowering, foliage and Avenue trees - Arboretum - shrubs - creepers and climbers, cacti and succulents, hedge and edge plants, plants for rockery and water garden - Flowring annuals Indoor plants

AGRONOMY**Section - A****I. Introduction**

Agriculture and Agronomy; History of Agriculture; Agricultural Science; Relation of Agronomy to Other Sciences; Scope of Agronomy; Role of Agronomist; References.

II. Climate

Atmosphere - Structure of Atmosphere; Weather Elements - Solar Radiation, Temperature, Atmospheric Pressure, Wind, Humidity, Evaporation, Rainfall, Clouds; Hydrologic Cycle; Monsoon; Seasons; Abnormalities in Weather - Floods, Droughts, Other Abnormalities, Cyclones; Weather Forecasting - Weather Forecasting Organisations, Essentials of Weather Forecasting, Forecasting Information, Types of Weather Forecasting, Method of Forecasting; Weather Modifications - Artificial Rain Making, Reduction in Wind Velocity and its Losses, Protection Against Frost Damage, Heat Trapping; Agroclimatic Zones of India;

III. Influence of Climate on Crops

Solar Radiation - Photosynthetic Effect, Photoperiodic Effect, Other Effects, Utilization of Solar Energy; Temperature - Cardinal Temperatures, Cool Season Crops, Warm Season Crops, Influence of Temperature on Growth, Growing Degree-Days, Photothermal Units, Extreme Temperature; Rainfall - Rainfall Climatology; Relative humidity - Water Relations, Leaf Growth, Photosynthesis, Pollination, Pests, Grain Yield; Wind; References.

IV. Growth and Development of Crops.

Growth - Photosynthesis, Respiration, Net Photosynthesis, Translocation of Assimilates, Growth of Plant; Development - Developmental Stages; Physiological Growth Components; Factors Influencing Growth and Development; Plant Growth Substances; Growth Expressions; Analysis of Growth, Development and Yield - Growth Analysis, Developmental Analysis, Yield Analysis;

V. Soil Environment and its Modification

Soil Fertility and Productivity; Fertility Losses and Maintenance; Physical Environment - Soil Texture, Soil Structure, Soil Water, Soil Temperature, Soil Air, Pore Space, Other Properties; Chemical Environment - Soil pH, Clay Minerals, Cation Exchange Capacity, Anion Exchange Capacity, Soil Solution, Nutrients; Soil Biological Environment - Classification of Soil Organisms, Influence of Soil Environment, Transformation of Nutrients, Degradation of Toxic Chemicals, Modification of Biological Environment; Environment of Submerged Soils - Physical Environment, Chemical Environment, Biological Environment; References.

VI. Tillage

Characteristics of Good Tillage; Objectives of Tillage; Influence of Tillage on Soil Physical Properties; Types of Tillage - Preparatory Cultivation, After Cultivation; Tillage Implements - Primary Tillage Implements, Secondary Tillage Implements, Implements for Layout of Seedbed, Implements for Sowing, Implements for Intercultivation; Modern Concepts of Tillage - Minimum Tillage, Zero Tillage, Stubble Mulch Tillage; Puddling;

VII. Seeds and Sowing

Methods of Propagation; Seeds - Selection of Seed, Cultivar, Categories of Cultivars, Seed Production, Quality of Seed; Vegetative Propagation; Micropropagation - Types of Regeneration, Techniques of Micropropagation; Sowing - Time of Sowing, Depth of Sowing, Method of Establishing Crops, Types of Sowing Seed Treatment;

VIII. Plant Population

Yield of Individual Plants and Community; Plant Population and Growth; Plant Population and Yield; Biological and Economic Yield, Optimum Plant Population; Optimum Plant Population and Environment; Planting Pattern; Gap Filling and Resowing; Seed Rate;

Section - B

I. Mineral Nutrition, Manures and Fertilisers

Mineral Nutrition - Essential Elements, Criteria of Essentiality, Classification of Essential Elements, Nutrient Availability, Absorption of Nutrients, Translocation, Assimilation, Functions of Nutrients in the Plant, Deficiency Symptoms, toxicity Symptoms; Manures - Bulky Organic Manures, Concentrated Organic Manures, Amendments; Fertilisers - Classification of Fertilisers, Nitrogenous Fertilisers, Phosphatic Fertilisers, Potassic Fertilisers, Calcium, Magnesium and Sulphur Fertilisers, Micronutrients; Fertiliser Dose - Calculation of Fertiliser Dose; Method of Fertiliser Application - Factors Influencing Method of Fertiliser Application, Different Methods; Time of Application - Crop Uptake, Soil Properties and Nature of Fertilisers, Utilization of Carbohydrates, Basal Application, Split Application; Biofertilisers - Saprophytes, Symbiotic Bacteria, Free Living Organisms; Integrated Nutrient Management;

II. Irrigation

Water Resources of the world - Water Resources of India; Water in the Soil-Plant-Atmosphere System - Water Movement in the Soil, Water Uptake, Translocation, Evapotranspiration, Soil Water, Water Requirement of Crops - Factors Influencing ET, ET and Crop Yield, Estimation of ET, Irrigation Requirement; Scheduling Irrigation - Soil Moisture Depletion Approach, Climatological Approach, Combination Approach, Critical State Approach, Simple Techniques for Irrigation Scheduling; Measurement of Irrigation Water; Methods of Irrigation, Sub-surface Irrigation, Sprinkler Irrigation, Microirrigation; Irrigation Water Control Devices; Irrigation Efficiency; Water-use Efficiency - Factors affecting WUE; Suitability of Water for Irrigation - Quality of Irrigation Water, Quality of Water of Different Sources, Irrigation with Poor Quality Water; Drainage - Excess Moisture, Agricultural Drainage;

III. Soil Conservation

Soil Erosion - Water Erosion, Factors influencing Water Erosion, Soil Loss Equation, Losses due to Erosion, Extent of Erosion; Soil Conservation - Erosion Preventing Measures; Wind Erosion - Mechanisms of Wind Erosion, Factors Influencing Wind Erosion, Losses due to Wind Erosion, Estimating Soil Loss due to Wind Erosion, Wind Erosion Control; Wave Erosion - Watershed Management, Wasteland Management;

IV. Dryland Agriculture

Classification of Climate; Problems of Crops Production in Dry Farming; Moisture Stress - Development of Moisture Stress, Effects of Moisture Stress, Crop Adaptations, Drought Evaluation; Resources Development and Utilisation - Water Harvesting, Methods of Water Harvesting, Supplemental Irrigation, Soil Resources and their Utilization; Reducing ET Losses - Mulches, Antitranspirants; Wind-brakes and Shelter belts; Weed Control; Soil and Moisture Conservation Measures; Integrated Watershed Management, Fifty Years of Dryland Agricultural Research in India - Future Research Priorities;

V. Weed Management

Concept of Weed; Weed Problems; Classification of Weeds; Weed Growth Stages; Crop-Weed Competition; Critical Period of Weed Competition; Establishment of Weeds; Weed Control Methods - Cultural Methods of Weed Control, Physical Methods of Weed Control, Biological Weed Control; Chemical Weed Control - Classification of Herbicides, Herbicides Formulations, Mode of Action of Herbicides, Selectivity of Herbicides, Methods of Application, Dosage of Herbicides, Time of Application of Herbicides,

Effect of Herbicides on Crops, Fate of Herbicides in Soil, Herbicide Combinations, Interaction with other Agro-Chemicals; Integrated Weed Management;

VI. Cropping Systems

Systems Approach; Cropping System; Efficient Cropping Systems; Interactions between different Component Crops; Assessment of Yield Advantage; Assessment of Land-use; Economic Evaluation; Management of Cropping Systems;

VII. Harvesting and Storage

Harvesting; Threshing and Winnowing; Drying; Storage;

VIII. Sustainable Agriculture

Definitions; Differences between Modern and Sustainable Agriculture; Problems of Modern Agriculture; Management Practices; Advantages and Disadvantages; Integrated Intensive Farming Systems (IIFS) - Components of IIFS.