AGRICULTURE PAPER-I

Ecology and its relevance to man, natural resources, their sustainable management and conservation. Physical and social environment as factors of crop distribution and production. Climatic elements as factors of crop growth, impact of changing environment on cropping pattern as indicators of environments. Environmental pollution and associated hazards to crops, animals, and humans.

Cropping pattern in different agro-climatic zones of the country. Impact of high-yielding and short-duration varieties on shifts in cropping pattern. Concepts of multiple cropping, multistorey, relay and intercropping, and their importance in relation to food production. Package of practices for production of important cereals, pulses, oil seeds, fibres, sugar, commercial and fodder crops grown during Kharif and Rabi seasons in different regions of the country. Important features, scope and propagation of various types of forestry plantations such as extension, social forestry, agro-forestry, and natural forests.


Farm management, scope, important and characteristics, farm planning. Optimum resources use and budgeting. Economics of different types of farming systems. Marketing and pricing of agricultural inputs and outputs, price fluctuations and their cost; role of co-operatives in agricultural economy; types and systems of farming and factors affecting them.

Agricultural extension, its importance and role, methods of evaluation of extension programmes, socio-economic survey and status of big, small, and marginal farmers and landless agricultural labourers; farm mechanization and its role in agricultural production and rural employment. Training programmes for extension workers; lab-to-land programmes.

PAPER-II

Cell Theory, cell structure, cell organelles and their function, cell division, nucleic acids-structure and function, gene structure and function. Laws of heredity, their significance in plant breeding. Chromosome structure, chromosomal aberrations, linkage and cross-over, and their significance in recombination breeding. Polyploidy, euploid and an euploids.
Mutation-micro and macro-and their role in crop improvement. Variation, components of variation. Heritability, sterility and incompatibility, classification and their application in crop improvement. Cytoplasmic inheritance, sex-linked, sex influenced and sex-limited characters.


Seed technology, its importance. Different kinds of seeds and their seed production and processing techniques. Role of public and private sectors in seed production, processing and marketing in India.

Physiology and its significance in agriculture. Imbibitions, surface tension, diffusion and osmosis. Absorption and translocation of water, transpiration and water economy. Enzymes and plant pigments; photosynthesis-modern concepts and factors affecting the process, aerobic and non-aerobic respiration; C, C and CAM mechanisms. Carbohydrate, protein and fat metabolism.

Growth and development; photo-periodism and vernalization. Auxins, hormones, and other plant regulators and their mechanism of action and importance in agriculture. Physiology of seed development and germination; dormancy.

Climatic requirements and cultivation of major fruits, plants, vegetable crops and flower plants; the package of practices and their scientific basis. Handling and marketing problems of fruit and vegetables. Principal methods of preservation of important fruits and vegetable products, processing techniques and equipment. Role of fruits and vegetables in human nutrition. Raising of ornamental plants, and design and layout of lawns and gardens.


Storage pests and diseases of cereals and pulses, and their control.

Food production and consumption trends in India. National and international food policies. Production, procurement, distribution and processing constraints. Relation of food production to national dietary pattern, major deficiencies of calorie and protein.

**AGRICULTURAL ENGINEERING PAPER - I SECTION A**

1. **Soil and Water Conservation**: Scope of soil and water conservation. Mechanics and types of erosion, their causes. 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,

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.

### Section B


   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.


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.

### PAPER-II Section A

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,


**Section B**


**ANIMAL HUSBANDRY AND VETERINARY SCIENCE PAPER-I**

1. **Animal Nutrition**: Energy sources, energy, metabolism and requirements for maintenance and production of milk, meat, eggs and wool. Evaluation of feeds as sources of energy.


1.2. Minerals in animal diet: Sources, functions, requirements and their relationship of the basic minerals nutrients including trace elements.

1.3. Vitamins, Hormones and Growth Stimulating, substances: Sources, functions, requirements and interrelationship with minerals.
1.5. Advances in Non-Ruminant Nutrition-Poultry-Nutrients and their metabolism with reference to poultry, meat and egg production, Nutrients requirements and feed formulation and broilers at different ages.

2. Animal Physiology:
2.3. Environmental Physiology: Physiological relations and their regulation; mechanisms of adaptation, environmental factors and regulatory mechanism involved in animal behaviour, methods of controlling climatic stress.

3. Livestock Production and Management:
3.1. Commercial Dairy Farming: Comparison of dairy farming in India with advanced countries. Dairying under fixed farming and as a specialised farming, economic dairy farming, Starting of a dairy farm. Capital and land requirement, organisation of the dairy farm.

Procurement of goods; opportunities in dairy farming, factors determining the efficiency of dairy animal, Herd recording, budgeting, cost of milk production; pricing policy; Personnel Management. Developing Practical and Economic ration for dairy cattle; supply of greens throughout the year, field and fodder requirements of Dairy Farm, Feeding regimes for day and young stock and bulls, heifers and breeding animals, new trends in feeding young and adult stock; Feeding records.
3.3. Feeding and management of animals under drought, flood and other natural calamities.

4. **Genetics and Animal Breeding**: Mitosis and Meiosis; Mendelian inheritance; deviations to Mendelian genetics; Expression of genes; Linkage and crossing over; Sex determination, sex influenced and sex limited characters; Blood groups and polymorphism; Chromosome aberrations; Gene and its structure; DNA as a genetic material; Genetic code and protein synthesis; Recombinant DNA technology, Mutations, types of mutations, methods for detecting mutations and mutation rate.

4.1. **Population Genetics Applied to Animal Breeding**: Quantitative Vs. qualitative traits; Hardy Weinberg Law; Population Vs. individual; Gene and genotypic frequency; Forces changing gene frequency; Random drift and small populations; Theory of path coefficient; Inbreeding, methods of estimating inbreeding coefficient, systems of inbreeding; Effective population size; Breeding value, estimation of breeding value, dominance and epistatic deviation; partitioning of variation; Genotype X environment correlation and genotype X environment interaction; Role of multiple measurements; Resemblance between relatives.

4.2. **Breeding Systems**: Heritability, repeatability and genetic and phenotypic correlations, their methods of estimation and precision of estimates; Aids to selection and their relative merits; Individual, pedigree, family and within family selection; Progeny testing; Methods of selection; Construction of selection indices and their uses; Comparative evaluation of genetic gains through various selection methods; Indirect selection and Correlated response; Inbreeding, upgrading, cross-breeding and synthesis of breees; Crossing of inbred lines for commercial production; Selection for general and specific combining ability; Breeding for threshold character. **Paper II 1. Health and Hygiene**


1.3 **Bovine Anatomy-Regional Anatomy**: Paranasal sinuses of OX-surface anatomy of salivary glands. Regional anatomy of infraorbital, maxillary, mandibuloalveolar, mental & coronal nerve block-Regional anatomy of paravertebral nerves, pudental nerve, median, ulnar & radial nerves-tibial, fibular and digital nerves-Cranial nerves-structures involved in epidural anaesthesia-superficial lymph nodes-surface anatomy of visceral organs of
thoracic, abdominal and pelvic cavities-comparative features of locomotor apparatus &
their application in the biomechanics of mammalian body.

1.4 **Anatomy of Fowl**: Musculo-skeletal system-functional anatomy in relation to
respiration and flying, digestion and egg production.

1.5 **Physiology of blood and its circulation, respiration; excretion, Endocrine
glands in health and disease.**

1.5.1 **Blood constituents**: Properties and functions-blood cell formation-Haemoglobin
synthesis and chemistryplasma proteins production, classification and properties;
coagulation of blood; Haemorrhagic disorders-anticoagulants-blood groups-Blood volume-
Plasma expanders-Buffer systems in blood. Biochemical tests and their significance in
disease diagnosis.

1.5.2. **Circulation**: Physiology of heart, cardiac cycle-heart sounds, heartbeat, electro-
cardiograms, Work and efficiency of heart-effect of ions on heart function-metabolism of
cardiac muscle, nervous and chemical regulation of heart, effect of temperature and stress
on heart, blood pressure and hypertension, Osmotic regulation, arterial pulse, vasomotor
regulation of circulation, shock. Coronary & pulmonary circulation, Blood-Brain barrier-
Cerebrospinal fluid-circulation in birds.

1.5.3 **Respiration**: Mechanism of respiration, Transport and exchange of gases-neural
control of respiration-chemo receptors-hypoxia-respiration in birds.

1.5.4 **Excretion**: Structure and function of kidney-formation of urine methods of studying
renal function-renal regulation of acid-base balance; physiological constituents of urine-
renal failure-passive venous congestion-Urinary recreation in chicken-Sweat glands and
their function. Biochemical tests for urinary dysfunction.

1.5.5 **Endocrine glands**: Functional disorders, their symptoms and diagnosis. Synthesis
of hormones, mechanism and control of secretion-hormonal receptors classification and
function.

1.6. **General knowledge of pharmacology and therapeutics of drugs**: Cellular level
of pharmaco-dynamics and pharmaco-kinetics-Drugs acting on fluids and electrolyte
balance-drugs acting on Autonomic nervous system-Modern concepts of anaesthesia and
dissociative Anaesthetics-Autocoids-Antimicrobials and principles of chemotherapy in
microbial infections-use of hormones in therapeutics-chemotherapy of parasitic
infections-Drug and economic persons in the Edible tissues of animals-chemotherapy of
Neoplastic diseases.

1.7. **Veterinary Hygiene with reference to water, air and habitation**: Assessment of
pollution of water, air and soil-Importance of climate in animal health-effect of
environment on animal function and performance-relationship between industrialization
and animal agriculture-animal housing requirements for specific categories of domestic
animals viz. pregnant cows & sows, milking cows, broiler birds-stress, strain &
productivity in relation to animal habitation.

2. **Animal Diseases**:

2.1 Pathogenesis, symptoms, postmortem lesions, diagnosis, and control of infection
diseases of cattle, pigs and poultry, horses, sheep and goats.

2.2 Etiology, symptoms, diagnosis, treatment of production diseases of cattle, pig and
poultry.
2.3 Deficiency diseases of domestic animals and birds.
2.4 Diagnosis and treatment of nonspecific condition like impaction, Bloat, Diarrhoea, Indigestion, dehydration, stroke, poisoning.
2.5 Diagnosis and treatment of neurological disorders.
2.6 Principles and methods of immunization of animals against specific diseases-hard immunity-disease free zones 'zero' disease concept-chemoprophylaxis.
2.7 Anesthesia-local, regional and general-pre-anesthetic medication, Symptoms and surgical interference in fractures and dislocation, Hernia, choking, abdomassal displacement-Caesarian operations, Rumenotomy-Castrations.
2.8 Disease investigation techniques-Materials for laboratory investigation-Establishment Animal Health Centres Disease free zone.

3. Veterinary Public Health
3.1 Zoonoses : Classification, definition; role of animals and birds in prevalence and transmission of zoonotic diseases occupational zoonotic diseases.
3.2 Epidemiology : Principles, definition of epidemiological terms, application of epidemiological measures in the study of diseases and disease control, Epidemiological features of air, water and food borne infections.

4. Milk and Milk Products Technology :
4.2 Milk Products Technology : Selection of raw materials, assembling, production, processing, storing, distributing and marketing milk products such as Butter, Ghee, Khoa, Channa, Cheese; Condensed, evaporated, dried milk and baby food; Ice cream and Kulfi; by products; whey products, butter milk, lactose and casein. Testing Grading, judging milk products-BIS and Agmark specifications, legal standards, quality control nutritive properties. Packaging, processing and operational control Costs.

5. Meat Hygiene and Technology :
5.1 Meat Hygiene :
5.1.1 Ante mortem care and management of food animals, stunning, slaughter and dressing operations; abattoir requirements and designs; Meat inspection procedures and judgement of carcass meat cuts-drading of carcass meat cuts-duties and functions of Veterinarians in Wholesome meat production.
5.1.2 Hygienic methods of handling production of meat-spoilage of meat and control measures-Post slaughter physicochemical changes in meat and factors that influence them-quality improvement methods-Adulteration of meat and defection-Regulatory provisions in Meat trade and Industry.

5.2 Meat Technology
5.2.1 Physical and chemical characteristics of meat-meat emulsions-methods of preservation of meat-curing, canning, irradiation, packaging of meat and meat products; meat products and formulations.

5.3 Byproducts: Slaughter house by products and their utilisation-Edible and inedible byproducts-social and economic implications of proper utilisation of slaughter house byproducts-Organ products for food and pharmaceuticals.


5.5 Rabbit/Fur Animal farming: Care and management of rabbit meat production. Disposal and utilization of fur and wool and recycling of waste byproducts. Grading of wool.


BOTANY PAPER-I


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.

4. **Plant Utility and Exploitation:**

5. **Morphogenesis:** Totipotency, polarity, symmetry and differentiation. Cell, tissue, organ and protoplast culture. Somatic hybrids and Cybrids.

**PAPER-II**


2. **Genetics, Molecular Biology and Evolution:** Development of genetics, and gene versus allele concepts (Pseudo alleles). Quantitative genetics and multiple factors. Linkage and crossing over-methods of gene mapping including molecular maps (idea of mapping function). Sex chromosomes and sex linked 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.


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


4. **Physiology and Biochemistry:** Water relations, Mineral nutrition and ion transport, mineral deficiencies. Photosynthesis-photochemical reactions, photophosphorylation and carbon pathways including C pathway (photorespiration), C, C


**CHEMISTRY PAPER-I**

1. **Atomic structure**
Quantum theory, Heisenberg's uncertainty principle, Schrödinger 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, BornHaber 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**

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 gages 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-planer 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, fluoro-sulphuric acid and super acids. PAPER II

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, benzynes and nitrarnes.

(c) Substitution reactions: SN1, SN2, SNi, SN1’, SN2’, SNi’ and SRN1 mechanisms; neighbouring group participation; electrophilic and nucleophilic reactions of aromatic compound including simple heterocyclic compounds-pyrrole, thiophene, indole.

(d) Elimination reactions: E1, E2 and E1cb 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=O; nucleophilic addition to C=O, C=N, conjugated olefins and carbonyls.


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.


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, LiA1H₄, NaBH₄ nBuLi, 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-π* and π-π* 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 H1 NMR to simple organic molecules.
   (e) **Mass spectra**: Parent peak, base peak, daughter peak, metastable peak, fragmentation of simple organic molecules; $	ext{E}$-cleavage, McLafferty rearrangement.
   (f) **Electron spin resonance**: Inorganic complexes and free radicals.

**CHEMICAL ENGINEERING PAPER-I Section A**

(a) **Fluid and Particle Dynamics**

(b) **Mass Transfer**

(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

Section B

(d) Noval Separation Processes
Equilibrium separation processes – ion-exchange, osmosis, electro-dialysis, reverse osmosis, ultra-filtration and other membrane processes. Molecular distillation. supercritical fluid extraction.

(e) Process Equipment Design

(f) Process Dynamics and Control

Section A

(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

(c) Chemical Reaction Engineering:

Section B

(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.

(e) **Environmental Engineering and Safety**

(f) **Process Engineering Economics**:  

**CIVIL ENGINEERING PAPER-1**  
**Part-A : ENGINEERING MECHANICS,**

**ENGINEERING MECHANICS :**
Units and Dimensions, SI Units, Vectors, Concept of Force, Concept of particle and rigid body. Concurrent, Non Concurrent and parallel forces in a plane, moment of force and Varignon's theorem, free body diagram, conditions of equilibrium, Principle of virtual work, equivalent force system.  
First and Second Moment of area, Mass moment of Inertia. Static Friction, Inclined Plane and bearings.  
Kinematics and Kinetics :  

**STRENGTH OF MATERIALS :**

**STRUCTURAL ANALYSIS :**
Castiglianio’s theorems I and II, unit load method, method of consistent deformation applied to beams and pin jointed trusses. Slope-deflection, moment distribution, Kani’s method of analysis and column Analogy method applied to indeterminate beams and rigid frames.

Rolling loads and Influences lines: Influences lines for Shear Force and Bending moment at a section of a beam. Criteria for maximum shear force and bending Moment in beams traversed by a system of moving loads. Influences lines for simply supported plane pin jointed trusses.

Arches: Three hinged, two hinged and fixed arches, rib shortening and temperature effects, influence lines in arches. Matrix methods of analysis: Force method and displacement method of analysis of indeterminate beams and rigid frames.

Plastic Analysis of beams and frames: Theory of plastic bending, plastic analysis, statical method, Mechanism method.

Unsymmetrical bending: Moment of inertia, product of inertia, position of Neutral Axis and Principle axes, calculation of bending stresses.

**Part-B**

**DESIGN OF STRUCTURES: STEEL, CONCRETE AND MASONRY STRUCTURES.**

**STRUCTURAL STEEL DESIGN:**

Structural Steel: Factors of safety and load factors. Rivetted, bolted and welded joints and connections. Design of tension and compression members, beams of built up section, rivetted and welded plate girders, gantry girders, stancheons with battens and lacings, slab and gusseted column bases.

Design of highway and railway bridges: Through and deck type plate girder, Warren girder, Pratt truss.

**DESIGN OF CONCRETE AND MASONRY STRUCTURES:**


Water tanks: Design requirements for Rectangular and circular tanks resting on ground. Prestressed concrete: Methods and systems of prestressing, anchorages, Analysis and design of sections for flexure based on working stress, loss of prestress.

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

Design of masonry retaining walls.

**Part-C**

**FLUID MECHANICS, OPEN CHANNEL FLOW AND HYDRAULIC MACHINES**

**Fluid Mechanics:** Fluid properties and their role in fluid motion, fluid statics including forces acting on plane and curve surfaces.

Kinematics and Dynamics of Fluid flow: Velocity and accelerations, stream lines, equation of continuity, irrotational and rotational flow, velocity potential and stream functions, flownet, methods of drawing flownet, sources and sinks, flow separation, free and forced vortices.
Control volume equation, continuity, momentum, energy and moment of momentum equations from control volume equation, Navier-Stokes equation, Euler's equation of motion, application to fluid flow problems, pipe flow, plane, curved, stationary and moving vanes, sluice gates, weirs, orifice meters and Venturi meters.

**Dimensional Analysis and Similitude:** Buckingham's Pi-theorem, dimensionless parameters, similitude theory, model laws, undistorted and distorted models.

**Laminar Flow:** Laminar flow between parallel, stationary and moving plates, flow through tube.

**Boundary layer:** Laminar and turbulent boundary layer on a flat plate, laminar sub-layer, smooth and rough boundaries, drag and lift.

Turbulent flow through pipes: Characteristics of turbulent flow, velocity distribution and variation of pipe friction factor, hydraulic grade line and total energy line, siphons, expansion and contractions in pipes, pipe networks, water hammer in pipes and surge tanks.

**Open channel flow:** Uniform and non-uniform flows, momentum and energy correction factors, specific energy and specific force, critical depth, resistance equations and variation of roughness coefficient, rapidly varied flow, flow in contractions, flow at sudden drop, hydraulic jump and its applications surges and waves, gradually varied flow, classification of surface profiles, control section, step method of integration of varied flow equation, moving surges and hydraulic bore.

**HYDRAULIC MACHINES AND HYDROPOWER:**

**GEO TECHNICAL ENGINEERING**
Types of soil, phase relationships, consistency limits particles size distribution, classifications of soil, structure and clay mineralogy. Capillary water and structural water, effective stress and pore water pressure, Darcy's Law, factors affecting permeability, determination of permeability, permeability of stratified soil deposits. Seepage pressure, quick sand condition, compressibility and consolidation, Terzaghi’s theory of one dimensional consolidation, consolidation test. Compaction of soil, field control of compaction. Total stress and effective stress parameters, pore pressure coefficients. Shear strength of soils, Mohr Coulomb failure theory, Shear tests. Earth pressure at rest, acive and passive pressures, Rankine's theory, Coulomb's wedge theory, earth pressure on retaining wall, sheetpile walls, Braced excavation. Bearing capacity, Terzaghi and other important theories, net and gross bearing pressure.
Immediate and consolidation settlement.
Stability of slope, Total Stress and Effective Stress methods, Conventional methods of slices, stability number.
Subsurface exploration, methods of boring, sampling, penetration tests, pressure meter tests.
Essential features of foundation, types of foundation, design criteria, choice of type of foundation, stress distribution in soils, Boussinessq’s theory, Newmarks’s chart, pressure bulb, contact pressure, applicability of different bearing capacity theories, evaluation of bearing capacity from field tests, allowable bearing capacity, Settlement analysis, allowable settlement.
Proportioning of footing, isolated and combined footings, rafts, buoyancy rafts, Pile foundation, types of piles, pile capacity, static and dynamic analysis, design of pile groups, pile load test, settlement of piles, lateral capacity. Foundation for Bridges. Ground improvement techniques-preloading, sand drains, stone column, grouting, soil stabilisation.

PAPER-II Part-A

CONSTRUCTION TECHNOLOGY, EQUIPMENT, PLANNING AND MANAGEMENT

1. Construction Technology:

   Engineering Materials:

   Construction:
   Functional planning of building: Building orientation, circulation, grouping of areas, privacy concept and design of energy efficient building; provisions of National Building Code.
   Building estimates and specifications; Cost of works; valuation.

2. Construction Equipment:
   Standard and special types of equipment, Preventive maintenance and repair, factors affecting the selection of equipment, economical life, time and motion study, capital and maintenance cost.

   Concreting equipments: Weigh batcher, mixer, vibration, batching plant, Concrete pump.

   Earth-work equipment: Power shovel hoe, bulldozer, dumper, trailors, and tractors, rollers, sheep foot roller.
3. **Construction Planning and Management**: Construction activity, schedules, job layout, bar charts, organization of contracting firms, project control and supervision. Cost reduction measures.

**New-work analysis**: CPM and PERT analysis, Float Times, cashing of activities, contraction of network for cost optimization, updating, Cost analysis and resource allocation.

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

**Part-B**

**SURVEY AND TRANSPORTATION ENGINEERING**


**Railways**: Permanent way, sleepers, rail fastenings, ballast, points and crossings, design of turn outs, stations and yards, turntables, signals, and interlocking, level-crossing. Construction and maintenance of permanent ways: Superelevation, creep of rail, ruling gradient, track resistance, tractive effort, relaying of track.


**Traffic Engineering**: Forecasting techniques origin and destination survey, highway capacity. Channelised and unchannelised intersections, rotary design elements, markings, sign, signals, street lighting; Traffic surveys. Principle of highway financing.

**Part-c :**

**HYDROLOGY, WATER RESOURCES AND ENGINEERING**

Hydrology: Hydrological cycle, precipitation, evaporation, transpiration, depression storage, infiltration, overland flow, hydrograph, flood frequency analysis, flood estimation, flood routing through a reservoir, channel flow routing Muskingam method.

**Ground water flow**: Specific yield, storage coefficient, coefficient of permeability, confined and unconfined aquifers, aquitards, radial flow into a well under confined and unconfined conditions, tube wells, pumping and recuperation tests, ground water potential.

**WATER RESOURCES ENGINEERING**: Ground and surface water resource, single and multipurpose projects, storage capacity of reservoirs, reservoir losses, reservoir sedimentation, economics of water resources projects.

**IRRIGATION ENGINEERING**: Water requirements of crops: consumptive use, quality of water for irrigation, duty and delta, irrigation methods and their efficiencies. Canals: Distribution systems for canal irrigation, canal capacity, canal losses, alignment of main and distributory canals, most efficient section, lined canals, their design, regime
theory, critical shear stress, bed load, local and suspended load transport, cost analysis of lined and unlined canals, drainage behind lining.
Water logging: causes and control, drainage system design, salinity.
Canal structures: Design of cross regulators, head regulators, canal falls, aqueducts, metering flumes and canal outlets.
Diversion head work: Principles and design of weirs of permeable and impermeable foundation, Khosla's theory, energy dissipation, stilling basin, sediment excluders.
Storage works: Types of dams, design, principles of rigid gravity and earth dams, stability analysis, foundation treatment, joints and galleries, control of seepage.
Spillways: Spillway types, crest gates, energy dissipation.
River training: Objectives of river training, methods of river training.

ENVIRONMENTAL ENGINEERING
Water Supply: Estimation of surface and subsurface water resources, predicting demand for water, impurities, of water and their significance, physical, chemical and bacteriological analysis, waterborne diseases, standards for potable water.
Intake of water: pumping and gravity schemes. Water treatment: principles of coagulation, flocculation and sedimentation; slow-, rapid-, pressure-, filters; chlorination, softening, removal of taste, odour and salinity.
Sewage treatment: Working principles, units, chambers, sedimentation tanks, trickling filters, oxidation ponds, activated sludge process, septic tank, disposal of sludge, recycling of waste water.
Solid waste: collection and disposal in rural and urban contexts, management of long-term ill-effects.

FORESTRY PAPER-I Section A
1. Silviculture - General:
   General Silvicultural Principles: ecological and physiological factors influencing vegetation, natural and artificial regeneration of forests; methods of propagation, grafting techniques; site factors; nursery and planting techniques nursery beds, polybags and maintenance, water budgeting, grading and hardening of seedlings; special approaches; establishment and tending. 2. Silviculture - systems:
Clear felling, uniform shelter wood selection, coppice and conversion systems. Management of silviculture systems of temperate, subtropical, humid tropical, dry tropical and coastal tropical forests with special reference to plantation silviculture, choice of species, establishment and management of standards, enrichment methods, technical constraints, intensive mechanized methods, aerial seeding thinning.

3. Silviculture - Mangrove and Cold desert:

- **Mangrove**: habitat and characteristics, mangrove, plantation-establishment and rehabilitation of degraded mangrove formations; silvicultural systems for mangrove; protection of habitats against natural disasters.
- **Cold desert**: Characteristics, identification and management of species.

4. Silviculture of trees:

Traditional and recent advances in tropical silvicultural research and practices. Silviculture of some of the economically important species in India such as *Acacia catechu*, *Acacia nilotica*, *Acacia auriculiformis*, *Albizia lebbeck*, *Albizia procera*, *Anogeissus latifolia*, *Azadirachta indica*, *Bamboo spp.*, *Butea monosperma*, *Cassia siamea*, *Casuarina equisetifolia*, *Cedrus deodara*, *Chukrasia tabularis*, *Dalbergia sissoo*, *Dipterocarpus spp.*, *Emblica officindils*, *Eucalyptus spp.*, *Gmelina Arborea*, *Hardwickia binata*, *Lagerstroemia Lanceolata*, *Pinus roxburghi*, *Populus spp.*, *Pterocarpus marsupium*, *Prosopis juliflora*, *Santalum album*, *Semecarpus anacardium*, *Shorea robusta*, *Salmalia malabaricum*, *Tectona grandis*, *Terminalis tomentosa*, *Tamarindus indica*.

Section B

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 ecosystem preservation including ecological balances through pest-predator relationships and (v) providing opportunities for enhancing bio-diversity, medicinal and other flora and fauna. Agroforestry 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.

PAPER II Section A

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 modeling.

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.

Section B

1. **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.

2. **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.

3. **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.

4. **Forest Economics and Legislation** :

   - **Forest economics**: fundamental principles, cost-benefit analyses; 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. Socioeconomic analyses of forest productivity and attitudes; valuation of forest goods and service.

**GEOLOGY PAPER I Section-A**

(i) General Geology

(ii) Geomorphology and Remote Sensing

(iii) Structural geology

Section-B

(iv) Paleontology

(v) Stratigraphy and Geology of India
Classification of stratigraphic sequences: litho-stratigraphic, 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
Geological investigations for dams, tunnels and bridges. Rock as construction material.
Alkaliaggregate reaction. Landslides-causes, prevention and rehabilitation. Earthquake-
resistant structures. Paper-II

Section-A

(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
of the carbonate, phosphate, sulphide and halide groups.

(ii) Igneous ad Metamorphic Petrology:
Generation and crystallisation of magma. Crystallisation of albite-anorthite, diopside-
anorthite and diopside-wollastonite-silica systems. Reaction principle. Magmatic
differentation 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 nonclastic 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**

(v) **Mining Geology**

(vi) **Geochemistry and Environmental Geology**

**Mathematics Paper-I Section-A**

**Linear Algebra**
Vector, space, linear dependence and independence, subspaces, bases, dimensions. Finite dimensional vector spaces. Matrices, Cayley-Hamilton theorem, Eigen values and Eigenvectors, matrix of linear transformation, row and column reduction, Echelon form, equivalence, congruence and similarity, reduction to canonical form, rank, orthogonal, symmetrical, skew symmetrical, unitary, hermitian, skew-hermitian forms their Eigen values. 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.

**Paper-II**

**Section-A 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.

Section-B Partial differential equations:
Curves and surfaces in three dimensions, formulation of partial differential equations, solutions of equations of type \( \frac{dx}{p} = \frac{dy}{q} = \frac{dz}{r} \); 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.


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’ equations, Hamilton equations, moment of intertia, 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, twodimensional and axisymetric 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 Paper I

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 anisotropy, 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:

4. Manufacturing Science:

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.

6. ELEMENTS OF COMPUTATION:

PAPER-II

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:

3. HEAT TRANSFER, REFRIGERATION AND AIR CONDITIONING:

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 blade, 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 Paper I**

**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, generalized coordinates and moments. 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:**

   **(c) Geometrical Optics:**

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:

Section-B

4. Electricity and Magnetism:
(a) Electrostatics and Magnetostatics:
Laplace and Poisson equations in electrostatics and their applications. Energy of a system of charges, multiple 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 magnetized sphere. Ferromagnetic materials, hysteresis, energy loss. (b) Current Electricity:

5. Electromagnetic Theory & Black Body Radiation:
(a) Electromagnetic Theory:

(b) Blackbody radiation:
Planck mass, Planck length, Planck time., Planck temperature and Planck energy.

6. Thermal and Statistical Physics :
(a) Thremodynamics:
Laws of thermodynamics, reversible and irreversible processes, entropy. Isothermal, adiabatic, isobaric, isochoic 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-Boltzman 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: 

Paper-II
Section-A

1. Quantum Mechanics I:

2. Quantum Mechanics II & Atomic Physics:
(a) Quantum Mechanics II:
(b) Atomic Physics:

3. Molecular Physics:

Section-B

4. Nuclear Physics:

5. Particle Physics & Solid State Physics:
(a) Particle Physics:
(b) **Solid State Physics:**

**6. Electronics:**

**Paper-I**

**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, complete-ness, 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 rotates 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 D2 and Hotelling’s T2 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 randomized 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.

**PAPER-II**

1. **Industrial Statistics**
Process and product control, general theory of control charts, different types of control charts for variables and attributes, 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.

2. **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 queuing 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.

III. 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 like 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.

IV. 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, percentiles, intelligence quotient and its measurement and uses, validity of test scores and its determination, use of factor analysis and path analysis in psychometry.

**ZOOLOGY PAPER-1**

**Section-A**

1. Non-chordata and chordata:
   (a) Classification and relationship of various phyla up to sub-classes; Acoelomata and Coelomata; Protostomes and Deuterostomes, Bilateralia and Radiata; Status of Protista, Parazoa, Onychophora and Hemichordata; Symmetry.
   (b) Protozoa: Locomotion, nutrition, reproduction; evolution of sex; General features and life history of Paramaecium, 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) Nematathelmintes: General features, life history and parasitic adaptation of Ascaris; nemathelminths in relation to man.
   (g) Annelida: Coelom and metamerism; modes of life in polychaetes; general features and life history of nereis (Neanthes), earthworm (Pheretima) and leach (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; dentition; general features of egg laying mammals, pouched-mammals, aquatic mammals and primates; endocrine glands and other hormone producing structures (pituitary, thyroid, parathyroid, adrenal, pancreas, gonads) 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; urinogenital system, brain and sense organs (eye and ear).

**Section- B**

1. Ecology:
Biosphere: Biogeochemical cycles, green-houses effect, ozone layer and its impact; ecological succession, biomes and ecotones.

Population, characteristics, population dynamics, population stabilization.

Conservation of natural resources- mineral mining, fisheries, aquaculture; forestry; grassland; wildlife (Project Tiger); sustainable production in agriculture integrated pest management.

Environmental biodegradation; pollution and its impact on biosphere and its prevention.

II. 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.

III. 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 (helminthes) and vectors (ticks, mites, Tabanus, Stomoxys).
(d) Pests of sugar cane (Pyrilla perpusiella), oil seed (Achaea janata) and rice (Sitophilus oryzae).

IV. 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).

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

PAPER-II

Section-A I. Cell Biology:
(a) Structure and function of cell and its organelles (nucleus, plasma membrane, mitochondria, Golgi bodies, endoplasmic reticulum, ribosome’s 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 Drosophila, nematodes and man.
(c) Mendel’s laws of inheritance, recombination, linkage, linkage maps, multiple alleles, citron concept; genetics of blood groups.
(d) Mutations and mutagenesis: radiation and chemical.
(e) Cloning technology, plasmids and cosmids as vectors, transgenic, transposons, DNA sequence cloning and whole animal cloning (Principles and methodology).
(f) Regulation and gene expression in pro- and eukaryotes.
(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.

Section-B
I. Biochemistry
(a) Structure and role of carbohydrates, fats, lipids, proteins, amino acids, nucleic acids; saturated and unsaturated fatty acids, 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 coenzymes.
(e) Bioenergetics.

II Physiology (with special reference 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.

III. 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, placenta in mammals. (b) Role of cytoplasm in and genetic control of development; cell lineage; causation of metamorphosis in frog and insects; paedogenesia
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.