Part A: Research Methodology & Reasoning (50 Marks)

(Same for all Ph.D. disciplines, common pattern across university)

---

1. Foundation of Research
- Meaning, objectives, motivation, and utility.
- Concepts: theory, empiricism, deductive & inductive theory.
- Characteristics of the scientific method.
- Research process: concept, construct, definition, variables.

2. Problem Identification & Formulation
- Defining research problems.
- Importance of literature review.
- Hypothesis – types, qualities, testing, null vs alternative.

3. Research Design
- Features of good design.
- Exploratory, descriptive & experimental designs.
- Independent & dependent variables.

4. Qualitative & Quantitative Research
- Concepts of measurement, causality, generalization, replication.
- Integrating qualitative and quantitative approaches.

5. Data Collection & Analysis
- Observation, surveys, experiments.
- Hypothesis testing, interpretation, generalization.

6. Measurement
- Validity, reliability, levels (nominal, ordinal, interval, ratio).

7. Sampling
- Population, sample, sampling frame, sample size.
- Probability & non-probability sampling.

8. Data Analysis
- Univariate & bivariate analysis.
- Chi-square test, cross-tabulation, hypothesis testing.

9. Interpretation & Paper Writing
- Structure of research paper & thesis.
- Plagiarism, self-plagiarism, ethics in publishing.
- Use of research databases, referencing tools.

10. Tools & Techniques
- Reference management software (Zotero, Mendeley).
- LaTeX, MS Office, plagiarism check tools.

11. Reporting & Thesis Writing
- Components of scientific reports.
- Presentations & communication skills.

12. Ethics & Application of Results
- IPR, copyright, patents, commercialization.
- Environmental & social ethics.

13. Reasoning & Mental Ability
- Analogy, classification, coding-decoding, series.
- Mathematical reasoning, number & ranking tests.
- Statement & assumption, conclusions, actions.

Part B: Subject Specific (50 Marks)

AGRICULTURAL TECHNOLOGY

Unit I – Farm Machinery & Power Engineering

A. **Farm Power Sources :** Covers human, animal, mechanical, electrical, and renewable energy sources used in agricultural operations. Focuses on the selection and utilization of appropriate power sources based on farm size, crop type, and operational requirements. Includes energy conversion efficiency, cost analysis, environmental impacts, and adaptation of renewable energy like solar, wind, and biomass for farm mechanization.

B. **Tractors & Power Tillers :** Study of tractor and power tiller components, working principles, design parameters, and performance evaluation. Includes transmission systems, hydraulics, steering, braking, and engine systems. Covers selection criteria for various farm conditions, testing procedures based on BIS/ICAR standards, preventive maintenance, troubleshooting, and ergonomics for enhanced operator comfort and safety during prolonged operations.

C. **Tillage & Seeding Equipment :** Principles, types, and operational aspects of primary and secondary tillage implements such as ploughs, harrows, and rotavators. Detailed study of seed drills, planters, and precision seeding devices, including calibration methods, seed metering mechanisms, and depth control. Emphasis on design optimization for energy efficiency, uniform seed placement, and minimal soil disturbance.

D. **Plant Protection Equipment :** Explores sprayers, dusters, and modern application technologies for pesticides, herbicides, and bio-agents. Covers hydraulic, air-assisted, and electrostatic spraying systems, nozzle selection, spray pattern analysis, and droplet size optimization for effective coverage with minimal drift. Includes safety measures, calibration techniques, and advances in drone-based pesticide application and precision spraying.

E. **Harvesting & Threshing Machinery :** Study of mechanical harvesters, combines, reapers, and threshers for different crops. Focus on cutting mechanisms, grain separation processes, cleaning systems, and power requirements. Includes design considerations for reducing grain loss, improving throughput, and adapting machinery for multi-crop use. Addresses ergonomic design and operator safety during harvesting operations.

F. **Farm Mechanization & Ergonomics :** Concepts of farm mechanization planning, mechanization index, and economic feasibility analysis. Study of ergonomic principles for reducing operator fatigue and improving efficiency. Includes anthropometric data usage, machine control design, vibration and noise reduction, and farm safety standards to minimize accidents and injuries during agricultural operations.

G. **Power Transmission & Utilization :** Covers different power transmission systems including mechanical (belt, chain, gear), hydraulic, and PTO (Power Take-Off) systems. Focuses on their design, efficiency, and application in agricultural machinery. Includes maintenance practices, load transmission efficiency analysis, and modern trends such as electro-hydraulic and servo-assisted control systems in farm equipment.

Unit II – Soil & Water Engineering

A. **Soil Mechanics for Agricultural Engineering :** Study of soil physical and engineering properties such as texture, structure, permeability, and water-holding capacity. Covers soil compaction, infiltration, and stress-strain behavior relevant to tillage and construction of farm structures. Includes laboratory and field methods for determining soil parameters and their application in irrigation, drainage, and foundation engineering.

B. **Irrigation Engineering :** Covers irrigation methods—surface, sprinkler, and drip—along with their design, layout, and operational management. Includes water application efficiency, scheduling based on crop water requirements, and automation in irrigation systems. Discusses modern technologies such as

sensor-based irrigation control, fertigation, and precision water application for maximizing crop yield and conserving water.

C. **Drainage Engineering :** Principles and design of surface and subsurface drainage systems to remove excess water from agricultural fields. Includes tile drains, mole drains, open ditches, and pumped drainage systems. Focus on prevention of waterlogging and salinity. Covers hydraulic design, material selection, maintenance, and integration with irrigation systems for sustainable land management.
D. **Water Resources Development & Management :** Study of hydrological cycle, watershed management, and water harvesting techniques for agricultural sustainability. Includes planning and design of water storage structures such as ponds, tanks, and check dams. Emphasizes integrated water resources management (IWRM) approaches for balancing irrigation, domestic, and industrial needs with environmental conservation.
E. **Soil & Water Conservation :** Covers erosion types (sheet, rill, gully, wind), their causes, and control measures. Includes design and construction of contour bunds, terraces, grassed waterways, and windbreaks. Discusses conservation tillage, mulching, and vegetative measures for reducing runoff and enhancing soil moisture retention. Integrates conservation planning with crop and land use systems.
F. **Groundwater Hydrology :** Study of aquifer properties, groundwater occurrence, and flow characteristics. Includes well design, construction, and development techniques. Covers pumping systems, energy efficiency in water lifting, and groundwater recharge methods. Focuses on sustainable groundwater management through monitoring, regulation, and conjunctive use with surface water.
G. **Environmental Control in Agriculture :** Examines microclimate modification techniques such as windbreaks, shading, and greenhouses. Covers heating, cooling, humidification, and ventilation systems for protected cultivation. Includes environmental monitoring for temperature, humidity, and CO_2 levels to optimize plant growth and protect crops from extreme weather conditions.

Unit III – Processing & Food Engineering

A. **Post-Harvest Technology :** Principles of safe and efficient handling, threshing, and storage of agricultural produce to minimize losses. Includes mechanical and physiological changes during storage, pre-cleaning, grading, and packaging. Covers handling systems for grains, fruits, and vegetables and integration of post-harvest operations with mechanized processing units.
B. **Drying & Dehydration :** Covers psychrometrics, drying principles, and classification of dryers (sun, tray, tunnel, fluidized bed, and freeze dryers). Includes design parameters, drying kinetics, and energy efficiency measures. Discusses quality retention during drying, moisture content measurement, and modern techniques like microwave and infrared-assisted drying.
C. **Milling & Processing Equipment :** Study of milling systems for cereals, pulses, and oilseeds including rice mills, flour mills, and oil expellers. Covers equipment design, operational parameters, and performance evaluation. Includes process flow optimization, energy analysis, and maintenance practices for high efficiency and product quality.
D. **Thermal Processing :** Principles and applications of thermal treatments such as blanching, pasteurization, and sterilization in food preservation. Discusses heat penetration, microbial inactivation kinetics, and equipment design for continuous and batch processes. Includes energy efficiency, process automation, and quality retention in thermally processed foods.
E. **Refrigeration & Cold Storage :** Covers refrigeration principles, refrigerants, cooling load calculations, and design of cold storage facilities for perishable commodities. Discusses temperature and humidity control, insulation materials, and cold chain logistics. Includes energy conservation measures and the role of controlled and modified atmosphere storage in extending shelf life.
F. **Food Packaging & Preservation :** Study of packaging materials, properties, and their interaction with food products. Covers packaging techniques like vacuum, modified atmosphere, and active packaging. Includes preservation methods such as chemical additives, irradiation, and natural preservatives. Discusses regulations, labeling requirements, and sustainability in food packaging.
G. **By-Product Utilization :** Covers recovery and value addition of agricultural and food processing by-products such as husk, bran, pulp, shells, and press cakes. Discusses technologies for converting waste

into useful products like biofuels, compost, animal feed, and functional food ingredients. Emphasizes waste minimization and circular economy principles in agro-industries.

BIOTECHNOLOGY

Unit I – Molecular Biology

- Structure and function of nucleic acids and proteins; DNA replication, transcription, and translation in prokaryotes and eukaryotes.
- Regulation of gene expression, operon models, epigenetics, and post-transcriptional modifications.
- Recombinant DNA technology, cloning vectors, genome editing (CRISPR-Cas), and molecular markers.

Unit II – Cell Biology

- Structure and functions of prokaryotic and eukaryotic cells; cell organelles and their roles.
- Membrane structure, transport mechanisms, and cell signaling pathways.
- Cell cycle regulation, apoptosis, and cancer biology.
- Techniques in microscopy and cell culture.

Unit III – Biochemistry

- Structure, classification, and function of carbohydrates, proteins, lipids, and nucleic acids.
- Enzymes: classification, kinetics, regulation, and applications in biotechnology.
- Bioenergetics, metabolic pathways (glycolysis, TCA cycle, oxidative phosphorylation), and regulation.
- Vitamins, hormones, and secondary metabolites.

Unit IV – Microbiology

- Classification, morphology, and physiology of microorganisms.
- Microbial growth, nutrition, and control methods.
- Industrial microbiology – fermentation technology, production of antibiotics, enzymes, and biofuels.
- Microbial genetics, mutation, transformation, transduction, and conjugation.

Unit V – Immunology

- Components and organization of the immune system.
- Antigens, antibodies, and antigen-antibody interactions.
- Major Histocompatibility Complex (MHC), immune responses, vaccines, and immunological techniques.
- Immunodeficiency disorders and autoimmunity.

Unit VI – Plant & Animal Biotechnology

- Plant tissue culture techniques, somatic embryogenesis, protoplast culture, and transgenic plants.
- Animal cell culture, stem cell technology, and transgenic animals.
- Applications in agriculture, pharmaceuticals, and conservation.

Unit VII – Genetic Engineering & Genomics

- Cloning strategies, expression systems, and protein purification.
- Genomic and cDNA library construction, PCR, DNA sequencing methods.
- Genomics, transcriptomics, and proteomics; bioinformatics tools for sequence analysis.
- Applications in diagnostics, therapeutics, and crop improvement.

Unit VIII – Environmental & Industrial Biotechnology

- Wastewater treatment, bioremediation, biofertilizers, and biopesticides.
- Bioenergy – production of bioethanol, biogas, and biodiesel.
- Industrial enzymes, fermentation processes, and downstream processing.

Unit IX – Bioinformatics

- Biological databases, sequence alignment, phylogenetic analysis.
- Protein structure prediction and molecular docking.
- Applications of computational biology in drug discovery and genome analysis.

BIOMEDICAL SCIENCES

UNIT I - Anatomy and Human Physiology

A. Structural organization of the human body: cells, tissues, organs, and systems.
B. Detailed anatomy and physiology of musculoskeletal, respiratory, cardiovascular, nervous, endocrine, renal, and digestive systems.
C. Neurophysiology, sensory organs, and homeostatic mechanisms.
D. Clinical correlations and functional assessments in health and disease.

UNIT II - Biomedical Instrumentation

A. Principles, design, and applications of medical diagnostic and therapeutic devices.
B. Biosensors, bioelectrodes, and transducers.
C. ECG, EEG, EMG, blood pressure monitors, ventilators, infusion pumps, dialysis machines, and surgical instruments.
D. Safety standards, calibration, and performance evaluation of biomedical equipment.

UNIT III - Biomaterials

A. Classification and properties of biomaterials: metals, ceramics, polymers, and composites.
B. Biocompatibility, biodegradation, and biofunctionality.
C. Materials for orthopedic, dental, cardiovascular, and soft tissue implants.
D. Advances in smart biomaterials, drug delivery systems, and tissue-engineered scaffolds.

UNIT IV -Biomechanics

A. Mechanical properties of biological tissues: stress-strain relationships, viscoelasticity.
B. Kinematics and kinetics of human movement.
C. Biomechanics of the musculoskeletal system and prosthetic/orthotic design.
D. Modeling and simulation of physiological systems and rehabilitation biomechanics.

UNIT V - Medical Imaging

A. Physics and instrumentation of X-ray, CT, MRI, ultrasound, PET, and SPECT.
B. Image acquisition, reconstruction, and enhancement techniques.
C. Contrast agents and their applications.
D. Advances in molecular imaging, image-guided interventions, and AI in medical image analysis.

UNIT VI -Signals and Systems

A. Fundamentals of continuous and discrete-time signals and systems.
B. Laplace and Fourier transforms, Z-transform, convolution, and system response analysis.
C. Digital signal processing applications in biomedical engineering.
D. Noise reduction, filtering, and feature extraction from physiological signals.

UNIT VII - Physiology

A. Normal functions of living organisms at the cellular, tissue, and systemic levels.
B. Neurophysiology, endocrinology, cardiovascular, respiratory, renal, and reproductive physiology.
C. Adaptation and regulation mechanisms under stress, exercise, and environmental changes.
D. Pathophysiological deviations from normal function.

BUSINESS MANAGEMENT

Unit I – Principles and Functions of Management

Definition, scope, and significance of management as a discipline. Evolution of management thought from classical to modern approaches. Planning, organizing, staffing, directing, and controlling as core managerial functions. Roles, skills, and competencies required of managers in contemporary organizations. Social responsibility, corporate governance, and ethics in managerial decision-making.

Unit II – Organizational Behaviour and Human Resource Management

Fundamentals of organizational behaviour, including personality, perception, motivation, and leadership theories. Group dynamics, team building, and conflict resolution strategies. Strategic human resource management, workforce planning, job analysis and design. Recruitment, selection, training, performance appraisal, compensation, and employee welfare. Managing organizational change, development, and workplace diversity.

Unit III – Managerial Economics and Business Environment

Microeconomic principles including demand-supply analysis, elasticity, market structures, and pricing strategies. Macroeconomic concepts such as national income, inflation, monetary and fiscal policy. Analysis of the business environment – internal, external, and global perspectives. Industrial policy, economic reforms, and their impact on business. Tools for environmental scanning and strategic decision-making.

Unit IV – Financial Management and Accounting

Principles of financial management, capital budgeting, capital structure theories, cost of capital, and working capital management. Dividend policy decisions and risk-return analysis. Financial statement preparation and analysis, ratio analysis, cash flow and fund flow statements. Costing methods, budgeting, and budgetary control. Introduction to Indian financial systems, markets, and institutions.

Unit V – Marketing Management

Core marketing concepts, marketing mix strategies, and consumer behaviour models. Market segmentation, targeting, and positioning. Product development, branding, pricing, promotion, and distribution strategies. Services marketing and relationship marketing. Emerging trends in digital marketing and international marketing strategies in the global business environment.

Unit VI – Operations and Supply Chain Management

Concepts and scope of operations management in manufacturing and services. Facility location and layout planning, production planning and control, inventory management, and quality management. Lean production, Six Sigma, and total productive maintenance. Logistics, distribution, and integrated supply chain strategies for competitive advantage.

Unit VII – Strategic Management and Corporate Policy

Strategic planning process, environmental and organizational analysis, competitive advantage, and strategy formulation. Corporate, business, and functional level strategies. Strategic implementation, evaluation, and control. Models including Porter’s Five Forces, BCG Matrix, and Ansoff’s Growth Vector. Case-based analysis of corporate strategies and decision-making under uncertainty.

COMPUTER SCIENCE AND ENGINEERING

Unit I – Computer Organization and Architecture

A. **Basic Structure of Computers**: Overview of CPU, memory, input/output devices, and instruction cycles.
B. **Data Representation**: Number systems, binary arithmetic, floating-point representation, and error detection/correction codes.
C. **Processor Organization**: Control unit, ALU, register sets, and microprogramming.
D. **Memory Systems**: Cache memory, virtual memory, and memory hierarchy.
E. **I/O Organization**: Interrupts, DMA, I/O channels, and peripheral devices.
F. **Pipelining and Parallelism**: Concepts, hazards, superscalar architectures, and multiprocessors.

Unit II – Algorithms and Data Structures

A. **Complexity Analysis: Time and space complexity, Big-O, Big-Theta, and Big-Omega notations.**
B. **Searching and Sorting: Binary search, quicksort, mergesort, heapsort, radix sort, and complexity considerations.**
C. **Data Structures: Arrays, linked lists, stacks, queues, heaps, hash tables, and trees.**
D. **Graph Theory and Algorithms: BFS, DFS, shortest paths (Dijkstra, Bellman-Ford), minimum spanning tree (Kruskal, Prim).**
E. **Advanced Data Structures: B-trees, AVL trees**, red-black trees, and disjoint set union-find structures.

Unit III – Operating Systems

A. **Operating System Functions**: Process management, memory management, storage management, and file systems.
B. **Process Scheduling**: CPU scheduling algorithms, process synchronization, deadlock detection, and avoidance.
C. **Memory Management**: Paging, segmentation, virtual memory, and page replacement algorithms.
D. **File Systems**: Organization, allocation methods, and directory structures.
E. **Security and Protection**: User authentication, access control, and encryption methods in OS.

Unit IV – Databases and Information Systems

A. **Database Concepts**: Data models, ER modeling, relational databases, and normalization.
B. **SQL and Query Processing**: Basic to advanced queries, indexing, transactions, and concurrency control.
C. **Database Design**: Functional dependencies, schema refinement, and integrity constraints.
D. **Big Data and NoSQL**: Concepts of Hadoop, MongoDB, and distributed databases.
E. **Data Warehousing and Mining**: OLAP, data preprocessing, classification, clustering, and association rules.

Unit V – Computer Networks and Security

A. **Network Fundamentals**: OSI and TCP/IP models, data transmission, and switching techniques.
B. **Network Protocols**: IP addressing, routing protocols (RIP, OSPF, BGP), and congestion control.
C. **Wireless and Mobile Networks**: Cellular networks, Wi-Fi, Bluetooth, and MANETs.
D. **Network Security**: Cryptography, firewalls, VPNs, intrusion detection, and security protocols.
E. **Cloud Computing and IoT**: Architecture, applications, and security challenges.

Unit VI – Software Engineering and Programming

A. **Software Development Life Cycle (SDLC)**: Waterfall, Agile, Spiral models, and prototyping.
B. **Software Project Management**: Cost estimation, scheduling, and risk management.
C. **Testing and Maintenance**: Unit testing, integration testing, regression testing, and debugging.
D. **Programming Paradigms**: Procedural, object-oriented, functional, and scripting languages.
E. **Programming Concepts**: C, C++, Java, Python basics, and algorithm implementation.

LAW

UNIT I – Jurisprudence

- **Nature and sources of law:** Definition, characteristics, and sources such as legislation, precedent, and custom.
- **Schools of jurisprudence:** Natural law, positivism, historical, sociological, and realist schools.
- **Law and morality:** Interrelationship, legal enforcement of moral norms, Hart–Devlin debate.
- **Concept of rights and duties:** Classification, correlation, and theories.
- **Legal personality:** Natural and legal persons, rights and liabilities of corporations, unborn persons, and animals.
- **Property, ownership, possession:** Definitions, distinctions, modes of acquisition.
- **Concept of liability:** Civil, criminal, strict, and vicarious liability.
- **Law, poverty, and development:** Legal responses to poverty alleviation and sustainable development.
- **Global justice:** Concept, need, and challenges in the era of globalization.
- **Modernism and post-modernism:** Impact on legal theory and interpretation.

UNIT II – Constitutional and Administrative Law

- **Preamble, Fundamental Rights, Duties, and Directive Principles:** Interpretation and judicial trends.
- **Union and State executive:** Powers, functions, and interrelationship.
- **Union and State legislature:** Distribution of legislative powers, residuary powers.
- **Judiciary:** Structure, independence, powers of judicial review.
- **Emergency provisions:** Types, scope, and impact on fundamental rights.
- **Special provisions for certain states:** Temporary and transitional provisions.
- **Election Commission:** Composition, powers, and functions.
- **Administrative law:** Nature, scope, importance, delegated legislation.
- **Principles of natural justice:** Audi alteram partem and nemo judex in causa sua.
- **Judicial review of administrative actions:** Grounds and limits.

UNIT III – Public International Law & International Humanitarian Law (IHL)

- **Definition, nature, and basis of international law.**
- **Sources:** Treaties, custom, general principles of law.
- **Recognition:** States, governments, criteria, and legal consequences.
- **Nationality, immigrants, refugees, IDPs.**
- **Extradition and asylum:** Legal framework and notable cases.
- **United Nations:** Structure, organs, and functions.
- **Dispute settlement:** Peaceful means and ICJ role.
- **WTO framework and dispute resolution.**
- **IHL conventions and protocols:** Geneva Conventions, Additional Protocols.
- **Implementation challenges in armed conflicts.**

UNIT IV – Law of Crimes

- **General principles:** Actus reus, mens rea, group and constructive liability.
- **Stages of crime:** Preparation, attempt, conspiracy, abetment.
- **General exceptions:** IPC provisions.
- **Offences:** Against body, state, property, women, children.
- **Terrorism, drug trafficking, counterfeiting.**
- **Offences against public tranquility.**
- **Punishments:** Theories, types, victim compensation.

UNIT V – Law of Torts & Consumer Protection

- **Nature and scope of tort law.**

- **General principles:** Fault, strict and absolute liability.
- **Defenses:** Volenti non fit injuria, inevitable accident, act of God.
- **Specific torts:** Negligence, nuisance, trespass, defamation.
- **Remoteness of damages.**
- **Liability of State in tort.**
- **Consumer Protection Act:** Rights, remedies, forums.
- **Motor Vehicles Act:** No-fault liability, third-party insurance.
- **Competition Act:** Anti-competitive agreements, dominant position.

UNIT VI – Commercial Law

- **Contracts:** Essentials, breach, frustration, e-contracts.
- **Special contracts:** Bailment, pledge, indemnity, guarantee, agency.
- **Sale of Goods Act:** Formation, rights, and liabilities.
- **Partnership & LLP:** Formation, rights, and liabilities.
- **Negotiable Instruments Act:** Cheques, bills, promissory notes.
- **Company law:** Incorporation, management, corporate governance.
- **CSR obligations.**

UNIT VII – Family Law

- **Sources and schools.**
- **Marriage and divorce:** Remedies, theories, live-in relationships.
- **Recognition of foreign decrees.**
- **Maintenance, dower, stridhan.**
- **Adoption, guardianship.**
- **Succession, inheritance, wills, gifts, wakf.**
- **Uniform Civil Code.**

UNIT VIII – Environment & Human Rights Law

- **Environment:** Concept, pollution types.
- **International environmental law:** UN summits and treaties.
- **Indian legal framework:** Constitutional provisions, NGT.
- **EIA & hazardous waste control.**
- **Human rights:** Concept, universality, cultural relativism.
- **International Bill of Rights.**
- **Group rights:** Women, children, minorities, persons with disabilities.
- **Enforcement:** NHRC, NCW, NCM, SC/ST Commissions, NCBC.

UNIT IX – Intellectual Property Rights & IT Law

- **Concept and theories of IP.**
- **International conventions.**
- **Copyright, patent, trademark:** Rights, infringement, remedies.
- **Geographical Indications.**
- **Biodiversity & traditional knowledge.**
- **IT Act provisions:** Digital signatures, e-governance, cybercrimes, penalties.

UNIT X – Comparative Public Law & Governance

- **Comparative law:** Methodology, challenges.
- **Forms of government:** Presidential, parliamentary, unitary, federal.
- **Federal models:** USA, Canada, India.
- **Rule of law:** Formal & substantive.
- **Separation of powers:** India, UK, USA, France.
- **Judicial independence, activism, accountability.**

- **Constitutional review systems.**
- **Amendment procedures:** Comparative study.
- **Ombudsman models.**
- **Open government & RTI:** India, USA, UK.

MICROBIOLOGY

Unit I: General Microbiology

- Classification of microorganisms: Haeckel's three-kingdom concept, Whittaker's five-kingdom concept, three-domain concept of Carl Woese, classification based on Bergey's Manual of Determinative Bacteriology.
- Morphology and ultra-structure of bacteria: size, shape, arrangement; bacterial cell wall (eubacteria, archaebacteria); protoplast, spheroplast, and L-forms.
- Components external to cell wall: flagella, fimbriae, pili, capsules, slime layers, S-layers.
- Prokaryotic cell membrane and cytoplasmic matrix: structure and function in bacteria and archaea; mesosomes, ribosomes, inclusion bodies (PHB, polyphosphate, oil droplets, cyanophycin), nucleoid.

Unit II: Nutrition and Cultivation

- Nutritional requirements: growth factors, nutritional categories, physical conditions.
- Media: complex, synthetic, differential, enrichment, selective media and their applications.
- Cultivation: aerobic vs. anaerobic culture, pure culture techniques, shaker/still cultures, maintenance and preservation.
- Bacterial growth: kinetics, growth curve, batch/continuous/synchronous culture, growth measurement, environmental effects.

Unit III: Viruses

- General properties, morphology, ultrastructure of viruses; capsids, envelopes, measurement.
- Viral genome: types and structure; viroids and prions.
- Cultivation: embryonated eggs, experimental animals, cell lines (primary, secondary, diploid).
- Plant viruses: classification, TMV structure & pathogenicity.
- Transmission: vector (insect, nematode, fungi) and non-vector (contact, seed, pollen); biochemical changes in host.

Unit IV: Fungi and Other Eukaryotic Microorganisms

- Structure, reproduction, and classification of fungi: Zygomycetes, Ascomycetes, Basidiomycetes, Deuteromycetes.
- Cultivation and preservation; environmental effects on fungal growth.
- Dimorphic fungi, yeasts (morphology, reproduction).
- Symbiotic associations: lichens, mycorrhiza.
- Actinomycetes: general features and significance.

Unit V: Instrumentation and Techniques

- Microscopy: principles, magnification, resolution, numerical aperture.
- Types of microscopy: bright field, dark field, phase contrast, fluorescence; micrometry.
- Electron microscopy: TEM, SEM, fixation & staining methods.
- Chromatography: partition, paper, TLC, adsorption, gel filtration, affinity, ion-exchange, gas chromatography.
- Electrophoresis: paper, starch gel, agarose, PAGE (native & SDS-PAGE).

Unit VI: Microbial Genetics

- DNA structure: supercoiling, linking number, role of topoisomerases; DNA denaturation/renaturation.
- DNA damage & repair: deamination, oxidative damage, alkylation, pyrimidine dimers; mismatch, excision, recombination, SOS repair.
- DNA replication: principles, modes, strand synthesis, enzymes.
- RNA: structural features of rRNA, tRNA, mRNA; polycistronic vs. monocistronic.
- Transcription: initiation, elongation, termination; RNA polymerases; inhibitors of transcription.

Unit VII: Immunology

- Organization of immune system: primary and secondary lymphoid organs.
- Antigens: structure, properties, immunogenicity factors, epitopes, haptens, mitogens, superantigens, adjuvants.
- Antibodies: structure, types, functions, antigenic determinants (isotypes, allotypes, idiotypes); antibody diversity and class switching.
- Cell-mediated immunity: mechanisms and effectors.
- Major Histocompatibility Complex (MHC): gene organization, types, functions, antigen presentation, polymorphism, MHC-related diseases.
- Complement system: components, pathways, regulation, and role in immunity.

ENVIRONMENTAL SCIENCE

Unit I – Environmental Geo-Science and Atmosphere

- Definition, evolution, and history of environment and environmental sciences.
- Primary differentiation and formation of core, mantle, crust.
- Magma generation, dynamics of Earth, plate tectonics, Continental drift theory.
- Earth's magnetic field, seismic waves, rock cycle, folds and faults.
- Soil profile and classification, soils of India, weathering processes.
- Geochemical cycles.
- Structure and characteristics of atmosphere, meteorological aspects.
- Electromagnetic, solar and terrestrial radiation; heat budget, lapse rates.
- Clouds: types, stability; elements of weather and climate.
- Atmospheric circulation, precipitation, storms, Indian monsoon, El Niño, La Niña, western disturbances.
- Cyclones, geostrophic and gradient winds.
- Climate variability, climate change, weather forecasting models.

Unit II – Ecosystem Concepts, Population Dynamics and Natural Resources

- Principles and concepts of ecosystems, biomes, ecotones, niche, indicators.
- Biogeochemical cycles: Carbon, Nitrogen, Phosphorus, Sulphur.
- C3 and C4 pathways, ecological pyramids, food chains and webs.
- Ecosystem energetics, productivity, succession, stability, decomposition.
- Forest, grassland, desert, aquatic, wetland ecosystems.
- Population concepts: growth, carrying capacity, regulation, r & k species.
- Community dynamics: structure, stratification, diversity, interdependence.
- Natural resources: plants, wildlife, soil, fisheries, minerals, energy resources.
- Conservation strategies: in-situ & ex-situ, social forestry, agro-forestry, carbon sequestration.

Unit III – Disasters

- Definitions, characteristics and classification of disasters.
- Natural vs. man-made hazards, zonation, risk assessment, mitigation.
- Biological, chemical, radiological disasters.
- Earthquakes, volcanoes, landslides, avalanches, floods, cyclones, tsunamis, drought, heat/cold waves.
- Causes, impacts, prediction, warning, mitigation strategies.

Unit IV – Environmental Pollution, Global Warming, Greenhouse Effect and Acid Rain

- Sources, impacts and management of air, water, noise, soil, thermal and radiation pollution.
- Ionizing radiation: sources, types, dose units, biological impacts.
- Global warming potential, GHG emissions and inventories.
- Greenhouse effect, climate change, ozone depletion, acid rain.
- Impacts on ecosystems, health, agriculture, mitigation measures.

Unit V – Environmental Chemistry and Green Technology

- Scope and principles of environmental chemistry.
- Chemistry of hydrocarbons, stoichiometry, equilibrium, solubility, carbonate system.
- Pesticides and synthetic polymers: degradation, ecological effects.
- Atmospheric chemistry: oxygen, ozone, smog, NOx, hydrocarbons, PAN.
- Green chemistry and green nanotechnology.
- Biofuels: bioethanol, biodiesel.

Unit VI – Ecotoxicology and Environmental Health

- Scope of toxicology, classification of toxicants, natural and synthetic toxins.

- Dose-response relationships, LD50, LC50, acute and chronic toxicity.
- Heavy metal toxicity (As, Cd, Pb, Hg), gaseous toxicants (CO, NOx, SO2, O3, cyanide).
- Impacts of pesticides on health and ecosystems.
- Carcinogenic, mutagenic, teratogenic effects.
- Environmental health, occupational cancers, waterborne and vector-borne diseases.

Unit VII – Environmental Impact Assessment (EIA)

- Origin, objectives, and methodologies of EIA.
- Screening, scoping, baseline studies, checklists, matrices, GIS overlays.
- Public hearing, EIA report preparation.
- Impact prediction on air, water, noise, biological, socio-cultural environment.
- Strategic Environmental Assessment (SEA), Social Impact Assessment (SIA).
- Environmental Management Systems (EMS).

Unit VIII – Research Methodology and Statistics

- Characteristics and types of scientific research.
- Experimental design, sampling designs, data collection.
- Statistical data representation: diagrams, graphs.
- Central tendency: mean, median, mode.
- Dispersion, skewness, kurtosis.
- Probability distributions: binomial, Poisson, normal.
- Statistical tests: chi-square, correlation, regression, ANOVA.
- Computer applications in environmental system analysis.

Unit IX – Techniques in Environmental Monitoring

- Sampling methodologies: air, water, soil, noise, radioactivity.
- Analytical instruments: high volume sampler, gas analysers, UV-Vis, AAS, GC, HPLC, XRD.
- Radiation detectors and monitors.
- Remote sensing & GIS: principles, systems, applications.
- Aerial photographs, satellite imagery, digital image processing.
- Applications in natural resources, disaster management, hazard mapping.

Unit X – Environmental Law, Governance, Policy, Treaties and Conventions

- Indian Environmental Policy and legal framework.
- Key legislations: EPA 1986, Air Act 1981, Water Act 1974, Forest Act 1986, Wildlife Act 1972, Biodiversity Act 2002.
- Rules: Hazardous Waste Rules, Noise Rules, Public Liability Act.
- Judicial response, IPC & CrPC provisions on environment.
- International environmental law and agencies (UNEP, IPCC, UNFCCC, GEF).
- Treaties: Stockholm 1972, Basel, Kyoto Protocol, Montreal Protocol, Paris Agreement, Ramsar Convention, Rio Summits.
- Sustainable Development Goals, carbon trading, credits, sequestration, footprint.

PSYCHOLOGY

UNIT I – Foundational Psychology

- **History and Systems of Psychology:** Origins and development of psychology; experimental psychology; major schools of thought—structuralism, functionalism, behaviorism, Gestalt, psychoanalysis (Freudian & neo-Freudian), humanistic, cognitive, existential, and evolutionary psychology. Indian perspectives: Buddhism, Hinduism, Sufism, and Integral Yoga.
- **Biological Bases of Behavior:** Structure and function of neurons, central and peripheral nervous system, neurophysiology, brain–behavior relationships, visual and auditory systems, biological basis of emotion and motivation.
- **Sensation and Perception:** Sensory processes, perceptual organization, attention, illusions, and cognitive influences on perception.
- **Learning and Memory:** Classical and operant conditioning, observational learning, cognitive learning theories, models of memory, encoding–storage–retrieval, forgetting.
- **Thinking, Intelligence, and Creativity:** Concept formation, decision-making, problem-solving, theories of intelligence, creativity assessment.
- **Personality:** Trait and type theories, psychodynamic, humanistic, biological, socio-cultural determinants.
- **Motivation and Emotion:** Theories, physiological correlates, stress and coping.

UNIT II – Research Methodology and Statistics

- **Research Design:** Variables, hypothesis formulation, measurement and scaling, qualitative and quantitative methods, sampling techniques.
- **Research Methods:** Experimental, correlational, descriptive, longitudinal, and cross-sectional methods.
- **Statistical Methods:** Descriptive statistics, parametric and non-parametric tests, correlation and regression, ANOVA, reliability and validity.
- **Psychometry and Test Construction:** Item writing and analysis, standardization, reliability, validity, norming.
- **Ethical Issues in Research:** Informed consent, confidentiality, ethical principles in psychological research and practice.

UNIT III – Cognitive and Developmental Psychology

- **Cognitive Psychology:** Attention, consciousness, memory, reasoning, problem-solving, language, and decision-making.
- **Developmental Psychology:** Theories and stages of development, prenatal development, childhood, adolescence, adulthood, and aging.

UNIT IV – Social Psychology

- **Nature and Scope:** History and theoretical perspectives.
- **Social Cognition and Perception:** Attitudes, stereotypes, attribution, impression formation.
- **Group Dynamics:** Conformity, compliance, obedience, group decision-making, leadership.
- **Social Influence and Behavior:** Aggression, prosocial behavior, altruism, prejudice, intergroup relations.
- **Applied Social Psychology:** Issues in education, health, environment, and organizational settings.

UNIT V – Psychopathology and Clinical Psychology

- **Approaches to Psychopathology:** Biological, psychological, and socio-cultural models.
- **Diagnostic Systems:** DSM, ICD, Mental Status Examination.
- **Types of Disorders:** Anxiety, mood, psychotic, substance-use, personality, and developmental disorders.
- **Psychotherapy and Counseling:** Psychoanalytic, behavioral, cognitive, humanistic, existential, eclectic approaches; individual and group counseling; process, skills, and techniques; multicultural counseling.

- **Ethical Issues in Clinical Practice.**

UNIT VI – Organizational and Applied Psychology

- **Organizational Behavior:** Nature, scope, challenges and opportunities, motivation, job satisfaction, leadership, and communication.
- **Industrial Psychology:** Personnel selection, training, performance appraisal, workplace stress.
- **Health Psychology:** Stress and coping, pain and illness, health-compromising and health-promoting behaviors.
- **Forensic Psychology:** Psychology and law, eyewitness testimony, criminal profiling.
- **Positive Psychology and Emerging Areas:** Well-being, resilience, mindfulness, AI and machine learning applications in psychology.

COMMERCE

UNIT I: Accounting

- Basic accounting standards and principles
- Journal & Ledger entries
- Final Accounts (Trading, Profit & Loss, Balance Sheet)
- Partnership Accounts
- Ratio Analysis
- Cash Flow Analysis

UNIT II: Cost & Management Accounting

- Concept of different costs
- Elements of Costs
- Break-even Point Analysis
- Marginal Costing
- Standard Costing
- Budgetary Control

UNIT III: Financial Management

- Basic concepts of Financial Management
- Time Value of Money
- Capital Structure
- Capital Budgeting
- Cost of Capital
- Working Capital Management

UNIT IV: Economics, Banking and International Business

- Demand and Supply, Indifference Curve Analysis
- Production Theory, Cost & Revenue
- Various Markets and Pricing Strategies
- National Income, Inflation, Business Cycle
- Foreign Trade, Business Environment and Policy Framework in India
- International Business, Balance of Payment, International Banking, Foreign Exchanges and Foreign Trade Policy
- Banking Structure, Types of Banks and their Functions
- Role of RBI, SEBI, NABARD & Rural Banking
- E-Banking, Financial Institutions, Financial Regulators, Banking Sector Reforms

UNIT V: Taxation

- Basic Concepts of Taxation
- Residential Status
- Incidence of Tax for different Taxpayers
- Exempted Incomes
- Heads of Income
- Deductions and Rebates

UNIT VI: General Management

A. Marketing & Consumer Behaviour

- Marketing Mix
- Product Decisions, Pricing Decisions, Promotion Decisions, Distribution Decisions
- Market Segmentation, Targeting & Positioning

- Product Life Cycle
- Consumer Behaviour

B. Organizational Behaviour & HRM

- Planning, Decision Making, Organization, Motivation, Leadership
- Organization Structure & Organizational Culture
- HR Planning, Recruitment, Selection
- Job Description, Job Analysis, Job Specification
- Training & Development, Performance Appraisal

C. Business & Corporate Laws

- Indian Contract Act, 1872
- Sale of Goods Act, 1930
- Right to Information Act (RTI)
- Negotiable Instruments Act, 1881
- Goods and Services Tax (GST)
- The Companies Act, 2013

ECONOMICS

UNIT I: Microeconomics

- Theory of Consumer Behaviour
- Theory of Production and Costs
- Decision Making under Uncertainty; Attitude towards Risk
- Market Structures
- General Equilibrium Analysis, Pareto-Optimality
- Kaldor–Hicks Compensation Principle & Wealth Maximization
- Welfare Economics: Fundamental Theorems, Social Welfare Function
- Asymmetric Information: Adverse Selection and Moral Hazard

UNIT II: Macroeconomics

- National Income: Concepts and Measurement
- Determination of Output and Employment: Classical & Keynesian Approach
- Consumption and Investment Functions
- Multiplier and Accelerator
- Demand for Money, Supply of Money
- IS–LM Model Approach
- Inflation and Phillips Curve Analysis
- Business Cycles
- Monetary and Fiscal Policy
- Rational Expectations Hypothesis
- Money and Banking

UNIT III: Quantitative Economics

- Differential Calculus and its Applications
- Static Optimization Problems and their Applications
- Input-Output Model
- Linear Programming
- Difference and Differential Equations with Applications
- Linear Regression Models and Properties (BLUE)
- Time Series Analysis
- Probability Theory
- Game Theory: Strategic Games, Nash Equilibrium, Mixed Strategy Games

UNIT IV: International Economics

- Theories of International Trade, Gains from Trade, Terms of Trade
- Trade Multiplier, Balance of Payments
- Exchange Rate: Concepts and Theories
- Foreign Exchange Market and Arbitrage
- Tariff and Non-Tariff Barriers to Trade
- Dumping, GATT, WTO, and Regional Trade Blocs
- Trade Policy Issues
- IMF & World Bank

UNIT V: Development Economics

- Economic Growth and Development
- Theories of Economic Development: Adam Smith, Ricardo, Marx, Schumpeter, Rostow
- Balanced & Unbalanced Growth, Big Push Approach
- Models of Economic Growth: Harrod-Domar, Solow, Robinson, Kaldor

- Technical Progress, Endogenous Growth
- Indicators of Economic Development: PQLI, HDI, MDPI, GII, SDGs
- Poverty and Inequality – Concepts and Measurement

UNIT VI: Public Economics

- Market Failure: Asymmetric Information, Public Goods, Externalities
- Regulation of Market and Consumers' Welfare
- Public Revenue: Tax & Non-Tax Revenue
- Direct & Indirect Taxes, Progressive & Non-Progressive Taxation
- Incidence and Effects of Taxation
- Public Expenditure
- Public Debt and its Management
- Public Budget and Budget Multiplier
- Fiscal Policy and its Implications
- Environment as a Public Good

MATHEMATICS

UNIT I: Algebra

Matrix Algebra

- Rank of a Matrix, Linear Dependence
- Solutions of Linear Systems: Existence & Uniqueness
- Eigenvalues and Eigenvectors; Properties
- Cayley-Hamilton Theorem
- Diagonalization of a Matrix, Powers of a Matrix
- Diagonalization by Orthogonal Transformation
- Quadratic Forms

Abstract Algebra

- Groups, Subgroups, Homomorphisms, Normal Subgroups
- Quotient Groups, Factor Groups, Lagrange's Theorem
- Symmetric Groups, Matrix Groups
- Rings, Ideals, Fields, Field Extensions
- Basics of Galois Theory

Linear Algebra

- Vector Spaces, Subspaces, Linear Independence, Basis & Dimension
- Linear Transformations & Matrices
- Eigenvalues, Eigenvectors, Diagonalization
- Quadratic Forms

UNIT II: Real Analysis

- Real Numbers: Completeness, Archimedean Property
- Sequences and Series: Convergence, Uniform Convergence
- Functions: Continuity, Differentiability, Mean Value Theorem
- Riemann and Improper Integrals
- Infinite Limits, Limit at Infinity
- Higher Order Derivatives, Taylor's Theorem, L'Hospital's Rule
- Monotonic Functions, Continuity & Compactness, Connectedness
- Metric Spaces: Compactness and Connectedness

UNIT III: Complex Analysis

- Analytic Functions, Cauchy-Riemann Equations
- Conformal Mappings, Bilinear Transformations
- Complex Integration: Cauchy's Integral Theorem & Formula
- Zeros and Singularities
- Taylor and Laurent Series
- Residue Theorem

UNIT IV: Vector Analysis

- Divergence and Curl of a Vector Function
- Solenoidal & Irrotational Fields
- Physical Interpretation of Divergence and Curl
- Line, Surface, and Volume Integrals
- Green's Theorem, Gauss Divergence Theorem, Stokes' Theorem

UNIT V: Differential Equations

Ordinary Differential Equations (ODEs)

- Homogeneous & Non-Homogeneous Equations
- Wronskian, Method of Variation of Parameters
- Existence and Uniqueness Theorems
- Systems of Equations, Singular Solutions
- Sturm-Liouville Problems

Partial Differential Equations (PDEs)

- First Order: Linear & Quasi-linear PDEs, Method of Characteristics
- Second Order Linear PDEs in Two Variables and their Classification
- Laplace, Heat, and Wave Equations

UNIT VI: Numerical Methods

- Root Finding: Bisection Method, Fixed Point Iteration, Newton's Method
- Error Analysis for Iterative Methods
- Interpolation: Lagrange Polynomials, Divided Differences
- Numerical Differentiation & Integration: Trapezoidal & Simpson's Rule
- Numerical Solution of Linear Systems:
    - Direct Methods (Gauss Elimination, LU Decomposition)
    - Iterative Methods (Jacobi, Gauss-Seidel)
- Numerical Solution of ODEs: Euler's Method, Runge-Kutta (Order 2)
- Computing Roots of Polynomials

UNIT VII: Probability and Statistics

- Probability, Conditional Probability, Independent Events
- Law of Total Probability, Bayes' Theorem
- Random Variables, Probability Density & Distribution Functions
- Mathematical Expectation & Variance
- Discrete Distributions: Binomial, Poisson
- Continuous Distribution: Normal Distribution

UNIT VIII: Advanced/Applied Areas ***(Optional Extension for Interview & Research Readiness)***

- Geometry & Topology: Differential Geometry, Manifolds, Tensors
- Applied Mathematics: Optimization, Mathematical Modeling

PHYSICS

UNIT I: Classical Mechanics

- Newton's Laws, Central Force Motion
- Two-Body Collisions: Laboratory & Center-of-Mass Frames
- Rigid Body Dynamics, Moment of Inertia Tensor
- Non-inertial Frames & Pseudo-forces
- Variational Principle, Generalized Coordinates
- Lagrangian & Hamiltonian Formalism, Equations of Motion
- Cyclic Coordinates & Conservation Laws
- Small Oscillations, Normal Modes, Periodic Motion
- Special Relativity: Lorentz Transformations, Relativistic Kinematics, Mass-Energy Equivalence
- Poisson Brackets & Canonical Transformations
- Symmetry, Invariance & Noether's Theorem
- Hamilton–Jacobi Theory, Phase Space Dynamics, Stability Analysis

UNIT II: Quantum Mechanics

- Wave–Particle Duality, Schrödinger Equation (T.D. & T.I.)
- Eigenvalue Problems: Particle in a Box, Harmonic Oscillator
- Tunneling through a Barrier
- Wavefunction Representations: Coordinate & Momentum
- Commutators & Uncertainty Principle
- Dirac Notation, Operator Formalism
- Angular Momentum: Orbital, Spin, Addition of Angular Momenta
- Hydrogen Atom, Stern-Gerlach Experiment
- Perturbation Theory (Time Independent & Time Dependent), Variational Method, WKB Approximation
- Fermi's Golden Rule, Selection Rules
- Identical Particles, Pauli Exclusion Principle, Spin-Statistics
- Spin-Orbit Coupling, Fine Structure
- Scattering Theory: Phase Shifts, Partial Waves, Born Approximation
- Relativistic Quantum Mechanics: Klein-Gordon & Dirac Equations
- Semi-classical Radiation Theory

UNIT III: Atomic & Molecular Physics

- Quantum States of Electrons in Atoms, Electron Spin
- Spectra: Helium, Alkali Atoms
- Relativistic Corrections, Hyperfine Structure, Isotopic Shifts
- Line Widths, LS & JJ Couplings
- Zeeman, Paschen–Back & Stark Effects
- Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR), Chemical Shift
- Born-Oppenheimer Approximation
- Molecular Spectra: Electronic, Rotational, Vibrational, Raman
- Selection Rules, Franck–Condon Principle
- Lasers: Spontaneous & Stimulated Emission, Einstein A & B Coefficients
- Optical Pumping, Population Inversion, Rate Equations, Resonator Modes, Coherence

UNIT IV: Condensed Matter Physics

- Crystal Structures: Bravais Lattices, Reciprocal Lattice, Structure Factor
- Bonding in Solids
- Elastic Properties, Phonons, Lattice Specific Heat
- Free Electron Theory, Electronic Specific Heat

- Drude Model of Electrical & Thermal Conductivity
- Hall Effect, Thermoelectric Power
- Electron Motion in Periodic Potential, Band Theory (Metals, Insulators, Semiconductors)
- Superconductivity: Type I & II, Josephson Junctions
- Superfluidity
- Defects, Dislocations
- Ordered Phases: Translational & Orientational Order, Liquid Crystals, Quasi-crystals

UNIT V: Nuclear & Particle Physics

- Nuclear Properties: Size, Shape, Charge Distribution, Spin, Parity
- Binding Energy, Semi-Empirical Mass Formula, Liquid Drop Model
- Nuclear Forces: Nucleon-Nucleon Potential, Charge Symmetry & Independence, Deuteron Problem
- Nuclear Models: Shell Model, Rotational Spectra, Validity & Limitations
- Nuclear Decays: α, β, γ – Selection Rules
- Fission & Fusion, Nuclear Reactions, Reaction Mechanisms, Compound Nucleus
- Classification of Fundamental Forces
- Elementary Particles: Quantum Numbers (Charge, Spin, Parity, Isospin, Strangeness, etc.)
- Gell-Mann–Nishijima Formula, Quark Model (Baryons & Mesons)
- Symmetry Arguments in Particle Reactions
- C, P, T Invariance, Parity Non-conservation in Weak Interaction
- Relativistic Kinematics

UNIT VI: Electromagnetism

- Electrostatics, Magnetostatics
- Maxwell's Equations in Free Space & Matter
- Electromagnetic Waves & Radiation
- Fields in Dielectrics, Conductors, Plasmas

UNIT VII: Thermodynamics & Statistical Mechanics

- Laws of Thermodynamics, Thermodynamic Potentials
- Phase Transitions & Critical Phenomena
- Classical & Quantum Statistics: Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac
- Partition Function & Thermodynamic Relations
- Blackbody Radiation, Bose-Einstein Condensation

UNIT VIII: Mathematical Physics

- Vector Spaces, Linear Algebra Applications
- Complex Analysis: Cauchy-Riemann Equations, Cauchy's Theorem, Residue Theorem
- Differential Equations: ODEs & PDEs
- Fourier & Laplace Transforms
- Tensor Analysis

UNIT IX: Emerging/Applied Areas ***(Optional Extension for Research Readiness)***

- Research Methodology: Research Design, Data Collection & Analysis
- Electronics: Basics of Analog & Digital Circuits
- Computational Physics: Numerical Methods, Simulation Techniques

CHEMISTRY

UNIT I: Inorganic Chemistry

- **Chemical Periodicity**: Structure and bonding in homo- and heteronuclear molecules; VSEPR theory and shapes of molecules.
- **Main Group Elements**: Allotropy, synthesis, structure, bonding, and industrial importance of compounds.
- **Transition Elements & Coordination Compounds**: Structure, bonding theories (CFT, MOT, LFT), spectral and magnetic properties, reaction mechanisms.
- **Inner Transition Elements**: Spectral and magnetic properties, redox chemistry, analytical applications.
- **Organometallic Compounds**: Synthesis, bonding, structure, reactivity.
- **Bioinorganic Chemistry**: Photosystems, porphyrins, metalloenzymes, oxygen transport, electron-transfer reactions, nitrogen fixation, metal complexes in medicine.
- **Characterisation of Inorganic Compounds**: IR, Raman, NMR, EPR, Mössbauer, UV-Vis, NQR, Mass spectrometry, electron spectroscopy, and microscopic techniques.

UNIT II: Physical Chemistry

- **Quantum Mechanics**: Postulates, operator algebra, particle-in-a-box, harmonic oscillator, hydrogen atom, tunnelling.
- **Approximate Methods & Group Theory**: Variational, perturbation, symmetry elements, point groups, character tables, selection rules.
- **Molecular Spectroscopy**: Rotational, vibrational, and electronic spectra of diatomic molecules; IR & Raman activities and selection rules.
- **Chemical Thermodynamics**: Laws of thermodynamics, state and path functions, phase equilibria and phase rule, ideal & non-ideal gases and solutions.
- **Statistical Thermodynamics**: Concepts, partition functions, applications.
- **Electrochemistry**: Nernst equation, redox systems, electrochemical cells.
- **Chemical Kinetics**: Collision theory, transition state theory, unimolecular reactions, enzyme kinetics, salt effects, homogeneous catalysis, photochemical reactions.
- **Colloids & Surfaces**: Stability, properties, adsorption isotherms, surface area, heterogeneous catalysis.

UNIT III: Organic Chemistry

- **IUPAC Nomenclature**: Organic molecules, regio- and stereoisomers.
- **Stereochemistry**: Chirality, conformations, stereoisomerism.
- **Reaction Mechanisms**: Addition, elimination, substitution reactions with electrophilic, nucleophilic, radical species.
- **Named Reactions & Rearrangements**: Applications in organic synthesis.
- **Organic Transformations & Reagents**: Oxidations, reductions, interconversions; reagents (organic, inorganic, organometallic, enzymatic).
- **Concepts in Organic Synthesis**: Retrosynthesis, disconnections, synthons, asymmetric synthesis.
- **Pericyclic Reactions**: Electrocyclic, cycloaddition, sigmatropic rearrangements, concerted processes.
- **Photochemistry**: Principles and applications in organic transformations.
- **Spectroscopy & Structure Elucidation**: IR, UV-Vis, 1H NMR, 13C NMR, Mass Spectrometry.

UNIT IV: Analytical Chemistry

- **Errors in Analysis**: Accuracy, precision, significant figures, standard deviation.
- **Classical Methods**: Gravimetric analysis, volumetric titrations (neutralization, complexation, precipitation, redox).
- **Electroanalytical Methods**: Standard electrode potentials, potentiometry, coulometry, electrogravimetry, voltammetry.

- **Spectrochemical Methods**: Molecular absorption, fluorescence, atomic spectroscopy, mass spectrometry.
- **Analytical Separations**: Solvent extraction, chromatographic techniques (paper, thin-layer, gas, HPLC, ion-exchange).

INDIAN KNOWLEDGE SYSTEMS (IKS)

UNIT I: Foundational Texts and Concepts

- **Vedic Literature**:
  - The four Vedas (Rigveda, Yajurveda, Samaveda, Atharvaveda).
  - Divisions: *Samhita, Brahmana, Aranyaka, Upanishads*.
  - Vedangas: Shiksha (phonetics), Vyakarana (grammar), Nirukta (etymology), Chanda (prosody), Jyotisha (astronomy), Kalpa (rituals).
- **Indian Philosophical Systems**:
  - Hindu schools: Samkhya, Yoga, Nyaya, Vaisheshika, Purva Mimamsa, Vedanta.
  - Buddhist schools: Madhyamaka, Yogachara, Abhidharma, and others.
- **Wisdom Literature**:
  - Puranas (Mahapuranas, Upapuranas, Sthalapuranas).
  - Itihasa: *Ramayana, Mahabharata*.
  - Niti Shastras: Ethical and moral codes, including texts on statecraft and conduct.

UNIT II: Specific Disciplines in IKS

- **Mathematics**:
  - Concepts from *Sulbasutras*.
  - Ancient Indian number systems, units of measurement, and contributions to algebra and geometry.
- **Astronomy**:
  - Aryabhatiya and related texts.
  - Understanding celestial bodies, planetary motion, and time calculation.
- **Linguistics**:
  - Sanskrit grammar and phonetics (Panini's *Ashtadhyayi* and other texts).
  - Development of Indian languages and linguistic traditions.
- **Health and Wellness**:
  - Ayurveda (*Charaka Samhita*, *Sushruta Samhita*).
  - Yoga philosophy and practice (*Patanjali Yoga Sutras*).
  - Naturopathy and traditional healing practices.
- **Architecture**:
  - Principles of *Vastu Shastra*.
  - Ancient Indian temple architecture, sculpture, and design.
- **Governance and Polity**:
  - Raja Dharma: Duties of rulers and ethical governance.
  - Kautilya's *Arthashastra* and other treatises on polity and economics.

UNIT III: Interdisciplinary Aspects of IKS

- **Knowledge Frameworks**:
  - Indian system of classification of knowledge (*Chaturdasha Vidya Sthanas* and *Upavedas*).
  - Unique approaches to organizing information and wisdom.
- **Practical Applications**:
  - IKS contributions in management, agriculture, environment, education, and social sciences.
- **Ancient India and the World**:
  - Cross-cultural interactions, global exchanges of knowledge, and India's role in shaping world intellectual traditions.