



## **Syllabus for the Entrance Examination for Admission to Ph.D., 2018**

**(SUN Ph.D. Entrance Test -SUNPET)**

### **1. Research Methodology (common to all discipline)**

#### **1. Introduction to Research**

Basics of Research and Methods, importance of scientific research, classifications of research, essential qualities of a researcher, Types of research – Quantitative vs. Qualitative, Descriptive vs. Analytical, use of tools/techniques for research

#### **2. Experimental Research and Data Collection methods**

Data classification, Data Processing, Hypothesis-formulation, sampling techniques, Survey methods, Aspects of Experimental Research including purpose of the report, abstracts, introduction and results and discussion. Structure and components of scientific reports, types of report, developing successful research proposals.

#### **3. Research Design**

Problem Identification & Formulation – Questions for investigation – Data, Measurements, Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.

#### **4. Research ethics, IPR and scholarly publishing**

Environmental impacts, Ethical issues, ethical committees, Commercialization – Copy right, royalty - Intellectual property rights and patent law, Reproduction of published material, Plagiarism - Citation and acknowledgement, Reproducibility and accountability. Use of Internet in Research – E Journal, E Library, INFLIBNET.

## **2. COSMETIC SCIENCE**

### **1. SKINCARE COSMETICS**

Introduction, raw material, preformulation aspect, formulations ,properties, stability and evaluation of Moisturizers, Sunscreens, Men's cosmetics, Colored make up preparations, Powders

### **2. HAIRCARE COSMETICS**

Introduction, raw material, preformulation aspect, formulations, properties, stability and evaluation of Hair oils, Hair tonics, Shampoo, Hair conditioners, hair dyes and hair colorants.

### **3. NATURAL COSMETICS AND NUTRACEUTICALS**

Introduction, Source, Chemical constituents, cosmetic uses, formulation and evaluation of *Curcuma longa*, *Bacopa monnieri*, *Gymnema sylvestre*, *Asparagus racemosus*, *Boswellia serrata*, Green coffee, Rose essential oil, Ylang Ylang essential Oil

### **4. STABILITY STUDIES OF COSMETICS**

Introduction, Freeze thaw cyclical test, Photostability test, Centrifugal separation method, vibration test, Drop test, Load test, Friction test .Stability problems related to Scale up processes.

### **5. GREEN CHEMISTRY**

Principles of green chemistry and its application in cosmetics. Silicone alternatives in haircare, Parabens alternative in Skincare.

### **6. NANOTECHNOLOGY**

Types of microencapsulation, Review of recent nanotechnologies used in cosmetic Science.

### **7. SKIN SENSITIZATION AND SENSITIVITY TESTING**

Patch test, Repeated insult patch test, Photopatch test, Draize eye irritation test

**8.** Review of recent patents in natural raw materials, Nanotechnology, Skincare, Haircare

**9.** Review of recent regulatory affairs in Cosmetics.

### 3. Botany

- 1. Biodiversity and Taxonomy:** Identification, Nomenclature and classification. Taxonomic literature, Evolutionary trends and variations, ICN, phylogenetic classifications, species concepts, speciation, Biosystematics, Paleobotany. DNA finger printing, numerical taxonomy, Biodiversity, Magnitude and distribution of biodiversity, economic value, conservation strategies.
- 2. Biochemistry:** Structures and Metabolism of Carbohydrates, Lipids, Proteins, Nucleic acid, Enzymes, Enzyme kinetics.
- 3. Cell and Molecular Biology:** Organization of plant cell and chloroplast, mitochondria, Golgi complex, Nucleus, Ribosome's, ER, Cell wall, Cell membrane, vacuoles, cytoskeleton, Totipotency differentiation and cell death, cell cycle, apoptosis, , signal transduction in cells. Chromosome organization, DNA replication and repair, Chromatin organization, protein synthesis, transcriptional and translational regulation, Protein targeting.
- 4. Inheritance Biology:** Mendelian genetics, concept of gene, Linkage and recombination, genetic mapping, extra chromosomal inheritance, chromosome banding, FISH and GISH, crossing over, recombination, 3 point test cross, tetrad analysis in Yeast and *Neurospora*.
- 5. Plant Breeding:** Selection – Mass and Pure line selection, hybridization – Backcross and Test cross, Heterosis breeding, Mutation breeding, role of polyploidy in plant breeding, genetically engineered plants.
- 6. Plant Physiology:** Water relations and membrane transport, photosynthesis and respiration, nitrogen metabolism, hormones, Stress physiology and tolerance mechanisms, strategies used for development of stress resistant / tolerant plants.
- 7. Development:** Vegetative and reproductive development in plants, organization of plant structures, Regulation of plant development by intrinsic and extrinsic factors.
- 8. Ecology:** Ecosystem- structure, types and functions, Ecological succession, habitat, biomes, Biomes, population ecology, plant interactions, phytogeography, endemism, RET species, IUCN categories, Ecological modelling Niche, evolution and co-evolution, Pollution ecology, Pollution indicator organisms, restoration ecology with reference to plants and microbes, Environmental Impact Assessment, Ecotoxicology, sewage treatment, carbon sequestration. National and International conventions and laws for protection and conservation of biological resources.
- 9. Plant Biotechnology:** Plant tissue culture techniques, Micro-propagation, cell, tissue and organ culture, Elicitation and secondary metabolites production. Genetic Engineering, Gene libraries, DNA sequencing.
- 10. Bioprospecting:** Ethno botany, types of Bioprospecting, Phytochemicals used in aroma, flavour and medicines, plant resources and natural products, Exploration of lower and higher plant for standardization of herbal medicines as per US-FDA.
- 11. Tools and Techniques:** Microscopy, Microtomy, Chromatography, Electrophoresis, Centrifugation, Radioactive techniques, Spectroscopy, SEM and TEM.
- 12. Biostatistics and Bioinformatics:** Experimental Design – Completely Randomized Block and Factorial Experimental Design. Analysis of variance, Populations and samples, Graphical representation of data, frequency distribution, central tendency and dispersion, Introduction to databases and retrieving information from databases, Molecular tools in protein and nucleotide sequence analysis.

## 4. Chemistry

### 1. Inorganic Chemistry

- a) Chemical periodicity
- b) Structure and bonding in homo- and heteronuclear molecules (VSEPR)
- c) Concepts of acids and bases,
- d) Main group elements and their compounds.
- e) Transition elements and coordination compounds.
- f) Organometallic compounds: synthesis, bonding and structure, and reactivity. applications.
- g) Analytical chemistry- Chromatography, Spectroscopic, Electro-analytical techniques
- h) Bioinorganic chemistry
- i) Nuclear chemistry

### 2. Physical Chemistry:

- a) Atomic Structure
- b) Basic principles of quantum mechanics: Postulates; operators
- c) Chemical bonding in diatomics;
- d) Chemical applications of group theory
- e) Molecular spectroscopy: IR and Raman and its application.
- f) Chemical thermodynamics
- g) Physical Photochemistry
- h) Electrochemistry
- i) Chemical kinetics
- j) Colloids and surfaces.
- k) Solid state: Crystal structures; Bragg's law and applications; band structure of solids.

### 3. Organic Chemistry

- a) IUPAC nomenclature of organic molecules.
- b) Stereochemistry: Nomenclature
- c) Aromaticity: Aromatic, Non-aromatic, Antiaromatic.
- d) Organic reactive intermediates.
- e) Organic reaction mechanisms: addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species.
- f) Common named reactions and rearrangements.
- g) Organic transformations and reagents: oxidizing and reducing agents.
- h) Pericyclic reactions and Photochemistry– electrocyclisation, cycloaddition, sigmatropic rearrangements.
- i) Chemistry of Biomacromolecules: Carbohydrates, proteins, fatty acids, nucleic acids,
- j) Organic Spectroscopy: IR, UV-Vis,  $^1\text{H}$  &  $^{13}\text{C}$  NMR and Mass spectroscopic techniques.

### 4. Interdisciplinary topics

- a) Chemistry in nanoscience
- b) Green chemistry and Environmental chemistry
- c) Medicinal chemistry.

## 5. Civil Engineering

### 1. Structural Engineering

**Engineering Mechanics:** System of forces, free-body diagrams, equilibrium equations; Internal forces in structures; Friction and its applications; Kinematics of point mass and rigid body; Centre of mass; Euler's equations of motion; Impulse-momentum; Energy methods; Principles of virtual work. **Solid Mechanics:** Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Theories of failures; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, buckling of column, combined and direct bending stresses. **Structural Analysis:** Statically determinate and indeterminate structures by force/ energy methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis. **Concrete Structures:** Working stress, Limit state and Ultimate load design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete; Analysis of beam sections at transfer and service loads. **Steel Structures:** Working stress and Limit state design concepts; Design of tension and compression members, beams and beam- columns, column bases; Connections - simple and eccentric, beam-column connections, plate girders and trusses; Plastic analysis of beams and frames.

### 2. Geotechnical Engineering

**Soil Mechanics:** Origin of soils, soil structure and fabric; Three-phase system and phase relationships, index properties; Soil classification system; Permeability – one and two dimensional flow; flow nets; Principle of effective stress, capillarity, seepage force and quicksand condition; Compaction in laboratory and field conditions; One dimensional consolidation, time rate of consolidation; Shear strength; Mohr's circle, effective and total shear strength parameters, Dynamic properties of soil and their measurement. **Foundation Engineering:** Sub-surface investigations; Earth pressure theories - Rankine and Coulomb; Stability of slopes - finite and infinite slopes; Stress distribution in soils - Boussinesq's and Westergaard's theories, pressure bulbs; Shallow foundations - Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Contact pressure; Settlement analysis in sands and clays; Deep foundations - types of piles, dynamic and static formulae, load capacity of piles in sands and clays, pile load test, negative skin friction.

### 3. Environmental Engineering

**Water and Waste Water:** Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, effluent discharge standards. Domestic wastewater treatment, quantity and characteristics of domestic wastewater, primary and secondary treatment. Unit operations and unit processes of domestic wastewater, sludge disposal. **Air Pollution:** Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits. **Municipal Solid Wastes:** Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal). **Noise Pollution:** Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

### 4. Transportation Engineering

**Transportation Infrastructure:** Highway alignment and engineering surveys; Geometric design of highways – cross-sectional elements, sight distances, horizontal and vertical alignments; Geometric design of railway track; Airport runway length, taxiway and exit taxiway design. **Highway Pavements:** Highway materials – desirable properties and quality control tests; Design of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible pavement using IRC: 37-2012; Design of rigid pavements using IRC: 58-2011; Distresses in concrete pavements. **Traffic Engineering:** Traffic studies on flow, speed, travel time – delay and O-D study, PCU, peak hour factor, parking study, accident study and analysis, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Control devices, signal design by Webster's method; Types of intersections and channelization; Highway capacity and level of service of rural highways and urban roads.

## 6. Computer Engineering

### 1. Discrete Mathematics: Propositional and first order logic

Sets, relations, functions, partial orders and lattices. Groups. **Graphs:** connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions. **Probability:** Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

### 2. Computer Organization and Architecture

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

### 3. Algorithms

Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer, Backtracking, Branch & Bound, Optimization Technique. Graph search, minimum spanning trees, shortest paths.

### 4. Software Engineering

Role of Software, Changing Nature of Software, Legacy Software, Software Myths. A Generic View of Process: Software Engineering -A Layered Technology, A Process Framework, The CMMI, Process Patterns, Process Assessment, Personal and Team Process Models, Process Technology, Product and Process. Test Strategies for Object Oriented Software, Art of Debugging.

### 5. Theory of Computation

Regular expressions and finite automata. Context free grammars and push down automata. Regular and context free languages, pumping lemma. Turing machines and undecidability.

### 6. Operating System

Processes, threads, interprocess communication, concurrency and synchronization. Deadlock. CPU scheduling. Memory management and virtual memory. File systems.

### 7. Databases Management System

ER model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

### 8. Computer Network

Reference models, Physical Layer, Multiple access protocols, Ethernet, Routing algorithms, Congestion control algorithms, Quality of service, Internet working, Network layer in the Internet, Transport service, Elements of transport protocols, Internet transport protocols: TCP & UDP, Domain Name System Section 10: Web Technology.

### 9. WEB Technologies

World Wide Web, markup language like HTML, XHTML and XML, dynamic content generated languages like ASP, JSP and SERVLETS

## 7. COMPUTER SCIENCE & APPLICATIONS

1. **Discrete Structures:** Sets, Relations, Functions, Pigeonhole Principle, Inclusion-Exclusion Principle, Equivalence and Partial Orderings, Counting Techniques. Probability, Measure(s) for information and Mutual information. *Computability:* Finite Automata, NFA, DPDA and PDAs and Languages accepted by these structures, Grammars. *Graph Theory:* Tree and rooted tree. Hamiltonian and Eulerian graphs, Planar graphs. Groups: Finite fields and Error correcting/detecting codes.
2. **Computer Arithmetic:** Propositional (Boolean) Logic, Predicate Logic, Well-formed-formulae (WFF), Satisfiability and Tautology. Logic Families : TTL, ECL and C-MOS gates. Boolean Algebra, Flip-flops-types, race condition and comparison, Design of combinational and sequential circuits. Representation of Integers
3. **Programming in C and C++ :** *Programming in C:* Data types in C. Control structures in C. Sequence, selection and iteration(s), Structured data types in C arrays, struct, union, string and pointers. *O-O Programming Concepts:* Class, object, instantiation, Inheritance, polymorphism and overloading. Constructors and destructors, Overloading, Inheritance, Templates, Exception handling.
4. **Relational Database Design and SQL:** E R diagrams and their transformation to relational design, normalization and its forms. SQL : Data Definition language (DDL), Data Manipulation Language (DML), Data Control language (DCL) commands. Database objects like-Views, indexes, sequences, synonyms, data dictionary.
5. **Data and File structures** Data, Information, Definition of data structure, Arrays, stacks, queues, linked lists, trees, graphs, priority queues and heaps. File Structures: Fields, records and files, Sequential, direct, index-sequential and relative files, Hashing, inverted lists and multi-lists B trees and B+ trees.
6. **Computer Networks** Network fundamentals: LAN, WAN, MAN. The OSI model, TCP/IP model, Data Communication, Internetworking, Routing, Network Security, Cryptography, Electronic Mail and Worldwide Web (WWW), E-mail architecture and Services.
7. **System Software and Compilers:** Assembly language fundamentals (8085 based assembly language programming). Loading, linking, relocation, Compilation and Interpretation, Phases of compilation process, Lexical analysis, Context free grammars, Intermediate code generation, Code generation, Code optimization.
8. **Operating Systems (with Case Study of Unix):** Main functions of operating systems, Types of Operating Systems, Memory Management, Concurrent Processing, Scheduling.  
**The Unix System:** Introduction. Working on various commands, Shell Scripting.
9. **Software Engineering:** System Development Life Cycle (SDLC), Software Metrics, Software Design Coding and testing.
10. **Current Trends and Technologies:**
  - a) *Parallel Computing,*
  - b) *Mobile Computing*
  - c) *E-Technologies:* Electronic Commerce, Digital Libraries and Data Warehousing, Software Agents, Broadband Telecommunications, Main concepts in Geographical Information System (GIS), E-cash, E-Business, ERP packages. Data Mining
  - d) *Windows Programming,*
  - e) *Advanced Windows Programming*

## 8. Electrical Engineering

- 1. Engineering Mathematics:** Linear Algebra, Calculus, Differential equations. Probability.
- 2. Electric Circuits:** Network graph, KCL, KVL, node and mesh analysis; AC and DC Theorems
- 3. Signals and Systems:** Representation of continuous and discrete-time signals; shifting and scaling operations; linear, time-invariant systems; Fourier series representation of continuous periodic signals; sampling theorem; Fourier, Laplace and Z transforms.
- 4. Electrical Machines:** Transformer, DC machines, single phase induction motors; synchronous machines; servo and stepper motors.
- 5. Power System Engineering:** Generation, transmission and distribution of electrical power; symmetrical component, circuit breakers; system stability concepts; HVDC transmission and Power System Protection, HVDC Systems, Power Quality, Operation and Control of Power System.
- 6. Control Systems:** Principles of feedback; transfer function; block diagrams; steady-state errors; Routh and Niquist techniques; Bode plots; root loci; state space model; state transition matrix, controllability and observability. Advanced Control Systems, Optimal Control System, Digital Control Techniques and Optimization Techniques.
- 7. Electrical and Electronic Measurements:** Bridges and potentiometers; PMMC, moving iron, dynamometer and induction type instruments; measurement of voltage, current, power, energy and power factor; instrument transformers; digital voltmeters and multimeters; phase, time and frequency measurement; Q-meters; oscilloscopes; potentiometric recorders; error analysis.
- 8. Analog and Digital Electronics:** Overview of power semiconductor devices: diodes, BJT, FET; amplifiers - biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers; VCOs and timers; multiplexer; Schmitt trigger; multi-vibrators; sample and hold circuits; A/D and D/A converters;
- 9. Power Electronics and Drives:** Semiconductor power diodes, transistors, thyristors, triacs, GTOs, MOSFETs and IGBTs Multi-Quadrant Chopper, Buck-Boost Converters, PWM Inverters, Multilevel Inverters, VSI/CSI Fed Induction Motor Drive.
- 10. Power System Deregulation and Automation:** Fundamentals of Restructured System, Models of Restructuring, Transmission Pricing & Open Access Issues, Power system automation, SCADA based automation.
- 11. Digital Circuits & Microprocessor:** Number systems; Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders and PLAs; Sequential circuits: latches, ADCs and DACs; Semiconductor memories: ROM, SRAM, DRAM; 8-bit microprocessor (8085): architecture, programming, memory and I/O interfacing.



## 9. Law

- 1. Constitutional Law of India:** Essential Features of Indian Constitution, Distribution of Legislative Powers between Union and States, Fundamental Rights, Fundamental Duties , Directive Principles of State Policy, Judiciary, Emergency Provisions , Amendment to the Constitution, Writ Jurisdiction, Parliament and State Legislatures, Amending Process of the Constitution, Role of Election Commission in Democratic Process.
- 2. Jurisprudence and Legal Theory:** Nature and Sources of Law, Positivism, Natural Law Theory, Sociological Jurisprudence, Theories of Punishment, Judicial Process—Application of Doctrine of Precedent of India , Judicial Contribution in bringing Social Changes, Law and Morality, Legal Concepts—Right, Duty, Ownership, Possession and Person.
- 3. International Law:** Nature of International Law and its relationship with Municipal Law, Sources of International Law, Settlement of International Disputes, Global Trade Regime under International Law.
- 4. Administrative Law:** Nature, Scope and Importance of Administrative Law, Principles of Natural Justice, Administrative Discretion and its control, Judicial Review of Administrative Action, Lokpal and Lokayukta
- 5. Law of Contracts-General Principles:** Essentials of a valid contract, Offer, acceptance and consideration, Capacity to Contract-Minor's contract, Elements vitiating contract—mistake, fraud, misrepresentation, public policy, coercion, undue influence, frustration of contract, Remedies for breach of contract—Damages
- 6. Law of Crimes—General Principles:** General Principles of Criminal Law—meaning, nature, essentials and stages of offence, General Exceptions, Criminal Attempt, Conspiracy and Abetment, Offences against Women, Offences against Human Body, Offences against Property, Defamation
- 7. Family Law:** Sources of Family Law in India, Concepts in Family Law, Marriage and Dissolution of Marriage, Divorce, Maintenance, Matrimonial Remedies, Adoption and Guardianship, Uniform Civil Code
- 8. Company Law:** Incorporation of companies, basic documents, Doctrines of Indoor Management, constructive notice, Ultra Vires, Shares and Debentures, Directors, Meetings, Oppression and Mismanagement, Winding up, Mergers and Amalgamation
- 9. Environmental Law:** Environmental Pollution – Meaning of Environment and Environmental Pollution; Kinds of Pollution, Legislative Measures for Prevention and Control of Environmental Pollution in India – Air and Water Pollution and General Protection of Environment, International Development for Protection of Environmental Pollution, Remedies for Environmental Protection – Civil, Criminal and Constitutional, Impact of Forest and Wildlife in protecting environment, Environmental Impact Assessment and Control of Hazardous Wastes
- 10. Law of Torts:** Nature and Definition of Torts, Foundation of Tortious Liability, General Defences to an Action of Torts, Vicarious, Absolute and Strict Liability, Contributory Negligence, Damages, Specific Torts – Negligence, Nuisance and Defamation, Consumer Protection –Consumer Rights and Mechanism for Redressal of Consumer Grievances
- 11. Human Rights:** Concept and Development of Human Rights, Contribution of United Nations in the Development and Implementation of Human Rights, Implementation of Human Rights in India—Role of National Human Rights Commission, Protection of Marginalized Groups—Women, Children, Minorities and Refugees.

## **10. Management Studies**

### **1. Organisational behaviour**

The concept and significance of organisational behaviour – Skills and Roles in an organisation – Classical, Neo – Classical and Modern Theories of Organisational Structure – Organisational Design – Understanding and Managing individual behaviour personality – Perception – Values – Attitudes – Learning – Motivation.

### **2. Human Resource Management**

Concepts and perspectives in HRM; HRM in changing environment, Human Resource Planning – Objectives, Process and Techniques, Job analysis – Job Description, Selecting Human Resources. Induction, Training and Development. Exit policy and Implications. Performance Appraisal and Evaluation, Potential Assessment,

### **3. Financial Management**

Nature and Scope, Valuation Concepts and Valuation of Securities, Capital Budgeting Decisions – Risk Analysis, Capital Structure and Cost of Capital, Dividend Policy – Determinants, Long – Term and Short – Term Financing Instruments, Mergers and Acquisitions.

### **4. Marketing Management**

Marketing Environment and Environment Scanning; Marketing Information Systems and Marketing Research; Understanding Consumer and Industrial Markets; Demand Measurement and Forecasting; Market Segmentation – Targeting and Positioning; Product Decisions, Product mix, Product Life Cycle; New Product Development; Branding and Packaging; Pricing Methods and Strategies. Promotion Decisions – Promotion mix; Advertising; Personal Selling; Channel Management. Customer Relation Management; Uses of Internet as a Marketing Medium – Other related issues like branding, market development, Advertising and retailing on the net. New issues in Marketing.

### **5. Quantitative methods & Techniques**

Overview of Statistics, Classifying Data to convey meaning, Measures of Central Tendency – Mean, Median & Mode, Measures of Variation – Range, Average Deviation, Standard Deviation, Probability Theory; Probability distributions – Binomial, Poisson, Normal and Exponential; Correlation and Regression analysis; Sampling theory; Sampling distributions; Tests of Hypothesis; Large and small samples; t z, F, Chi – square tests.

## 11. Mathematics

**1. Real Analysis:** Sequences and series of functions, uniform convergence, power series, functions of several variables, maxima, minima; Riemann integration, multiple integrals, theorems of Green, Stokes and Gauss; metric spaces.

**2. Functional Analysis:** Banach spaces, Hahn-Banach extension theorem, open mapping and closed graph theorems.

**3. Complex Analysis:** Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem, Calculus of residues. Conformal mappings, Mobius transformations.

**4. Algebra:** Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Sylow theorems.

**5. Linear Algebra:** Eigenvalues and eigenvectors, Cayley-Hamilton theorem. Matrix representation of linear transformations. Inner product spaces, orthonormal basis. Reduction and classification of quadratic forms.

**6. Ordinary Differential Equations (ODEs):** Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. ODEs of higher orders.

**7. Partial Differential Equations:** Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, General solution of higher order PDEs with constant coefficients.

**8. Numerical Analysis :** Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using modified Euler and Runge-Kutta methods.

**9. Calculus of Variations:** Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

**10. Linear Integral Equations:** Fredholm and Volterra integral equation, Solutions with separable kernels. Characteristic numbers and Eigenfunctions, resolvent kernel.

**11. Differential Geometry:** Space curves-their curvature and torsion; Serret-Frenet Formula; Fundamental theorem of space curves; Curves on surfaces; First and second fundamental form; Gaussian curvatures; Principal directions and principal curvatures.

**12. Fluid Mechanics:** Equation of continuity in fluid motion; Euler's equations of motion for perfect fluids; Two dimensional motion complex potential; vorticity.

**13. Linear programming:** Infeasible and unbounded LPP's, alternate optima; Dual problem and duality theorems, dual simplex method and its application in post optimality analysis; u -v method for solving transportation problems; Hungarian method for solving assignment problems.

## **12. Mechanical Engineering**

### **1. Materials Science & Metallurgy**

Classification of engineering materials, crystallography, solid solutions, eutectic, eutectoid, peritectic and peritectoid transformations, iron carbon diagrams, TTT diagrams, alloys and composite materials.

### **2. Manufacturing Processes and Machine Tools**

Manufacturing Processes: Casting, forging, sheet metal working, rolling, extrusion, metal joining processes (welding, soldering, and brazing).

Machine Tools: Lathe machine, drilling machine and grinding machine (basic elements, working and types of operations). Non-conventional machining methods, Introduction to NC, CNC, and DNC.

### **3. Introduction to Thermodynamics**

System, process, properties, specific properties, concept of mechanical work & heat, heat engine, heat pump and refrigerator, efficiency and COP terms, Laws of Thermodynamics (Zeroth, First and Second laws), various power cycles, refrigeration and air-conditioning.

### **4. Energy Producing Devices/Thermal Engineering Devices**

Boilers, working principle of two stroke and four stroke IC engines (diesel and petrol).

Power absorbing devices: pumps (reciprocating and centrifugal, rotary pumps), compressors (reciprocating and centrifugal compressors), fans, blowers.

### **5. Design of Machine Elements**

Design Fundamentals: Design concept, need, design considerations, design of machine elements.

Mechanisms: Kinematic link, kinematic pair, kinematic chain, mechanisms (four bar and slider crank). Machine Elements: Shaft, axle, keys, coupling (rigid & flexible), drives (belt, chain & gear), brakes.

### **6. Fluid Mechanics and Machinery**

Fluid statics, dynamics and kinematics, dimensional analysis and model testing, water turbines, pumps, and hydraulic couplings, computational fluid dynamics.

### **7. Industrial Engineering**

Productivity, method study and work measurements, types of production systems, plant layouts, aggregate planning, master production scheduling, materials requirement planning, facility layouts, sequencing and scheduling, CPM and PERT, inventory management and quality control.

## 13. PHYSICS

**1. Mathematical Physics and Numerical Analysis:** Curve fitting, data analysis, Probability theory. Vector algebra and vector calculus. Linear algebra, Matrices. Linear differential equations. Fourier series, Fourier transforms Elementary complex analysis.

**2. Classical Mechanics:** Newton's laws, Lagrangian and Hamiltonian formalisms. Symmetries and conservation laws, Motion in the central field of force. Collision and scattering, Mechanics of system of particles. Rigid body dynamics. Non-inertial frames and pseudo forces. Small oscillations and normal modes. Wave equation, phase velocity, group velocity, dispersion.

**3. Electromagnetics:** Laplace and Poisson equations, Ampere's theorem, Biot-Savart Law, electromagnetic induction. Maxwell's equation Scalar and vector potentials. Reflection and refraction, dispersion, Rectangular wave guides.

**4. Quantum Mechanics:** Wave-particle duality. Heisenberg's Uncertainty Principle. Schrodinger equation. Particle moving in a one-dimensional potential. Orbital angular momentum. Motion in a central potential symmetry conservation laws and degeneracy. Operator formalism of quantum mechanics. Angular momenta algebra, spin. Addition of angular momenta.

**5. Thermodynamics and Statistical Physics:** Chemical potential, phase equilibria. Phase space, Microstates and macrostates. Ensembles. Partition function, Free energy and connection with thermodynamic quantities. Classical and quantum statistics. Degenerate electron gas, Blackbody radiation and Planck's distribution law.

### **7. Electronics:**

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Optoelectronic devices (solar cells, photo-detectors, LEDs).

### **8. Atomic and Molecular Physics:**

Quantum states of an electron in an atom. Electron spin. Spectrum of hydrogen, helium and alkali atom. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

### **9. Condensed Matter Physics:**

Bravais lattices. Reciprocal lattice. Bonding of solids. Phonons, lattice specific heat. Drude model of electrical and thermal conductivity. Hall Effect. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors.

### **10. Nuclear and Particle Physics:**

Nuclear size, shape and charge distribution, spin and parity. Binding energy, Semiempirical mass formula, liquid drop model. Shell model. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism.

## 14. Zoology

- 1. Molecular Biology:** Structure of atoms, molecules and Stabilizing forces; Composition, structure and function of biomolecules; Bioenergetics, Glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers; Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes; Metabolism
- 2. Cell Biology:** Structure and function of Membrane; intracellular organelles, genes and chromosomes; Cell division and cell cycle; Microbial Physiology; DNA replication, repair and recombination; RNA synthesis and processing; Protein synthesis and processing; Control of gene expression at transcription and translation level; Cell communication and cell signaling; Cancer and Immune system
- 3. Development Biology:** Gametogenesis, fertilization and early development, Morphogenesis and organogenesis in animals, Programmed cell death, aging and senescence
- 4. Physiology:** Blood and circulation; Cardiovascular System; Respiratory system; Nervous system; Sense organs; Excretory system; Thermoregulation; Stress and adaptation; Digestive system; Endocrinology and reproduction
- 5. Genetics:** Mendelian principles; Concept of gene; Gene mapping methods; Extra chromosomal inheritance; Microbial genetics; Human genetics; Quantitative genetics; Mutation; Structural and numerical alterations of chromosomes
- 6. Biodiversity:** Principles & methods of taxonomy; Levels of structural organization; Outline classification of plants, animals & microorganisms; Natural history of Indian subcontinent; Organisms of health & agricultural importance; Organisms of conservation concern
- 7. Ecology and Evolution:** The Environment; Habitat and Niche; Population Ecology; Species Interactions; Community Ecology; Ecological Succession; Ecosystem Ecology; Biogeography; Applied Ecology; Conservation Biology; Emergence of evolutionary thoughts; Origin of cells and unicellular evolution; Paleontology and Evolutionary History; Molecular Evolution; The Mechanisms of evolution; Brain, Behavior and Evolution.
- 8. Applied Biology:** Microbial fermentation, principles, vaccines, diagnostics, Tissue and cell culture, GMO, Bioremediation and phytoremediation, Biosensors, Bioresource
- 9. Techniques:** Molecular Biology and Recombinant DNA methods; Histochemical and Immunotechniques; Biophysical Method; Statistical Methods; Radiolabeling techniques, Microscopic techniques, Electrophysiological methods; Methods in field biology