TAKSHASHILA UNIVERSITY

(Established under Tamil Nadu Private Universities Act, 2019 &
Recognised by UGC u/s 2(f) of the UGC Act, 1956)
ONGUR, TINDIVANAM TK, VILLUPURAM DT

FACULTY OF SCIENCES

Ph.D. Entrance Examination Syllabus

Department of Mathematics

I. Algebra

Vector spaces, subspaces, linear dependence, basis and dimension. Linear transformation, range space, null space, rank and nullity. Matrix representation of a linear transformation. Change of basis. Eigenvalues and eigenvectors. Inner product, orthogonality, Gram-Schmidt process, orthogonal expansion. Quadratic forms, reduction to normal form. Definition of Groups, Subgroups and Factor Groups, Lagrange's Theorem, Homomorphism's, Normal Subgroups. Quotients of Groups. Basic Examples of Groups including Symmetric Groups, Matrix Groups.

II. Analysis

The real number system. Sequences, series and uniform convergence. Continuity and differentiability of functions of real variables. Riemann and Lebesgue integrals. Metric spaces. Cauchy sequences and convergence. Completeness. Normed space. Banach space. Inner product space, Hilbert space.

Analytic function, Mobious Transformation, Cauchy Riemann equations, Cauchy's theorem and integral formula, singularities, Taylor's and Laurant's series. Cauchy's residue theorem.

III. Differential Equations

ODE: General solution of homogeneous equations, non-homogeneous equations, Wronskian, method of variation of parameters.

PDE: Linear and quasilinear first order partial differential equations, method of characteristics; second order linear equations in two variables and their classification.

IV. Numerical Methods

Bisection method, fixed-point iteration, Newton's method. Error analysis for Iterative Methods. Computing roots of polynomials. Interpolation: Lagrange Polynomial. Divided Differences. Numerical differentiation; numerical integration: Trapezoidal and Simpson rules; numerical solution of systems of linear equations: direct methods (Gauss elimination, LU decomposition); iterative methods (Jacobi and Gauss-Seidel); numerical solution of ordinary differential equations: initial value problems: Euler's method, Runge-Kutta methods of order 2.

V. Probability and Statistics

Sample space, events and probability axioms. Random variable and probability distributions. Mean and Variance. Binomial, normal and Poisson distributions. Random sampling, confidence intervals, testing hypotheses, goodness of fit, Regression.

Reference Books

1. Grewal B.S.," Higher Engineering Mathematics", Khanna Publishers, New Delhi, 41st Edition, 2011.
2. I.N.Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. Tom M. Apostol: Mathematical Analysis, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, (1997).
4. Lars V. Ahlfors, *Complex Analysis*, 3rd Edition, McGraw-Hill Inc., New York, 1979.
5. George F Simmons, Differential equations with applications and historical notes,Tata McGraw Hill, New Delhi,1974.
6. K.Sankara Rao, Introduction to Partial differential equations (Third edition), Prentice-Hall of India Ltd., New Delhi, 2016.
7. Grewal, B.S., and Grewal, J.S., "Numerical Methods in Engineering and Science", Khanna Publishers, 10th Edition, New Delhi, 2015.
8. M. Fisz, Probability Theory and Mathematical Statistics, 3rd Edition, John Wiley and Sons Inc., New York, 1963.

Department of Physics

I. Mathematical Methods of Physics & Quantum Mechanics

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.

Quantum Mechanics

Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation

II. Classical Mechanics & Electromagnetic Theory

Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory.

Electromagnetic Theory

Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation- from moving charges and dipoles and retarded potentials.

III. Electronics and Experimental Methods

Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lock-in detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

IV. Atomic & Molecular Physics

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

V. Condensed Matter Physics & Nuclear and Particle Physics

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: Meisner effect, type-I and type-II

superconductors. Josephson junctions. Super fluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

Nuclear and Particle Physics

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semiempirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra.

Reference Books

1. SatyaPrakash, Mathematical Physics, Sultan Chand & Sons, 6thEdition 2014.
2. H. Goldstein, Classical Mechanics, Pearson Education, Asia, New Delhi, 3rd Edition, 2002.
3. SathyaPrakash, Electromagnetic Theory and Electrodynamics, KedarnathRamnath and Co, 1st Edition, 2019.
4. Satnam P.Mathur, Electronic Devices - Applications and Integrated Circuits, Umesh Publications,New Delhi, 4th Edition, 2001.
5. Charles Kittle, Introduction to solid state physics, Wiley India Pvt. Ltd., New Delhi, 7th Edition, 2004.
6. G. Aruldhas, PHI, Molecular structure and Spectroscopy by.
7. Gupta Kumar and Sharma, Jaiprakashnath & co , Quantum Mechanics, Merrut, 1972.
8. David Jeffery Griffiths, Introduction to elementary particles, 2nd Edition John Wiley and Sons, [2011].

Department of Chemistry

I. Physical chemistry

Basic principles of quantum mechanics: Postulates; operator algebra; exactly solvable systems: particle-in-a-box, including shapes of atomic orbitals; orbital and spin angular momenta. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle. Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems. Polymer chemistry: Molar masses; kinetics of polymerization.

II. Organic chemistry

IUPAC nomenclature of organic molecules including regio- and stereoisomers. Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction. Aromaticity: Benzenoid and non-benzenoid compounds – generation and reactions. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways. Synthesis and reactivity of common heterocyclic compounds containing one heteroatom (O, N, S).

III. Inorganic chemistry

Atomic Structure: de Broglie matter waves. Heisenberg uncertainty principle. Atomic orbitals. Quantum numbers. Aufbau and Paulis exclusion principles. Hund's multiplicity rule. Electronic configuration of elements, effective nuclear charge and shielding; radial and angular wave functions and distribution curves, shape of s,p,d orbitals and their characteristics. Chemical periodicity, Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules - VBT & MOT. Concepts of acids and bases. Chemistry of the main group elements and their compounds. Allotropy, synthesis, bonding and structure. Coordination complexes: Nomencleture, Isomerism, Transition metal carbonyls compounds.

IV. Interdisciplinary Chemistry

Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations. Electrochemical series, Formal Potential and its application: Effect of pH**,** complexation, solubility; Disproportionation and comproportionation reaction, Principles involved in the extraction of the elements. Solid state: Crystal structures; Bragg's law and

applications; band structure of solids. Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

V. Spectroscopy techniques

Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance. Structure determination of organic compounds by IR, UV-Vis, ^{1}H & ^{13}C NMR and Mass spectroscopic techniques.

Reference BookS

1. Puri B.R., Sharma L.R., Kalia K.K. Principles of Inorganic chemistry, (23rd edition), New Delhi, Shoban Lal Nagin Chand.Co (1993).
2. Morrison R.T. and Boyd R.N., Organic Chemistry (6th edition), Ny, Allyn & Beecon Ltd., (1976).
3. Puri B.R., Sharma L.R. and Pathania M.S., Principles of Physical Chemistry, 47th ed., New Delhi, Vishal Publishing Co.,2016.
4. Huheey, J. E.; Keiter, E. A. Keiter, R. L. Inorganic Chemistry; 4th ed.; Harper and Row: NewYork,1983.
5. W. R. West, Solid State Chemistry and its Applications, John Wiley and Sons, New York,1984.
6. J. March and M. Smith, Advanced Organic Chemistry, 5th edn, John-Wiley and Sons.2001.

Department of Computer Science

I. Data Structures

Abstract Data Types (ADTs) – List ADT-Stack ADT – Operations – Applications-Tree ADT – Tree Traversals – Binary Tree ADT – Expression trees – Binary Search Tree ADT – AVL Trees-Graph Definition – Representation of Graphs – Types of graph – Breadth-first traversal – Depth-first traversal — Bi-connectivity – Euler circuits – Topological Sort – Dijkstra's algorithm – Minimum Spanning Tree – Prim's algorithm – Kruskal's Algorithm-Searching- Sorting-Hashing.

II. Design and Analysis of Algorithms

Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Fundamentals of the Analysis of Algorithmic Efficiency –Asymptotic Notations and their properties. – Mathematical analysis for Recursive and Non-Recursive Algorithms-Brute Force and Divide-And-Conquer-String Matching – Closest-Pair and Convex-Hull Problems - Exhaustive Search – Travelling Salesman Problem – Knapsack Problem – Assignment problem. Divide and Conquer Methodology – Binary Search – Merge sort – Quick sort – Heap Sort.

III. Operating Systems

Operating System Structures - Simple Batch – Multi-programmed - Parallel - Distributed Systems - Real-Time Systems - System components - Process and CPU Scheduling - Process concepts and scheduling - Memory Management and Virtual Memory - Logical versus Physical Address Space – Swapping - Contiguous Allocation – Paging – Segmentation - Segmentation with Paging - Demand Paging - Page Replacement - Page Replacement Algorithms - File System Interface and Operations - Access methods - Directory Structure – Protection - File System Structure - Allocation methods - Free-space.

IV. Software Engineering Concepts

Introduction to Software Engineering: Process models: Software Requirements: Functional and non-functional requirements - user requirements - system requirements - Requirements engineering process: Feasibility studies - requirements elicitation and analysis - requirements validation - requirements management. conceptual model of UML - basic structural modeling - class diagrams - sequence diagrams - collaboration diagrams - use case diagrams - component diagrams - Testing Strategies: Metrics for Process and Products: Software measurement - metrics for software Quality - Risk management.

V Database Design

Entity-Relationship model – E-R Diagrams – Enhanced - ER Model – ER-to-Relational Mapping – Functional Dependencies – Normal forms - ACID Properties -Concurrency Control - Deadlock Handling - RAID – File Organization - Distributed Databases - Database Security: Security issues – Access control based on privileges – Role Based access control.

Reference Books

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson. 2024.
2. Michael T. Goodrich, Roberto Tamassia & Michael H. Goldwasser, Data Structures and Algorithms in Java, 6th Edition, Wiley, 2021.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to Algorithms, 4th Edition, MIT Press, 2022.
4. Andrew S. Tanenbaum and Herbert Bos, Modern Operating Systems, 5th Edition, Pearson, 2023.
5. Roger S. Pressman and Bruce R. Maxim, Software Engineering: A Practitioner's Approach, 9th Edition, McGraw-Hill, 2023.
6. Ian Sommerville, Software Engineering, 10th Edition, Pearson, 2016.
7. Abraham Silberschatz, Henry F. Korth, and S. Sudarshan, Database System Concepts, 7th Edition, McGraw-Hill, 2020.
8. Ramez Elmasri & Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2017.