

St.Xavier's College (Autonomous), Kolkata

**Advertisement for Admissions to Ph.D. Programs 2021 in
(Physics/Microbiology/Biotechnology/Commerce/Computer Science)**

Applications are invited for admissions to the **Ph.D. Programs** in the Departments of **(Physics/ Microbiology/ Biotechnology/ Commerce/ Computer Science)**, St. Xavier's College (Autonomous), Kolkata, affiliated to the University of Calcutta, in the prescribed proforma to be filled in online from the College website at [//www.sxccal.edu](http://www.sxccal.edu).

Essential qualification:

(M.Sc/M.Com) in (Physics/Microbiology/Biotechnology/Commerce/Computer Science)

Eligibility:

- Candidates with at least 55% marks in (Physics/Microbiology/Biotechnology/Commerce /ComputerScience) at the (M.Sc./M.Com) level from the College or from any other UGC recognized university are eligible to take the examination in the related stream.
- The candidate has to have either NET/ SET/ INSPIRE/ MPhil (from any recognized university with 2-semester/ 1-year course work) or has to qualify in the research entrance test (RET) conducted by the department.
- Those who are expected to obtain MPhil in (Physics/Microbiology/Biotechnology/Commerce/Computer Science) from any UGC recognized university would also be exempted from RET and be eligible to appear directly in the interview.
- Those who have qualified in NET/SET/INSPIRE or already obtained M.Phil. degree would be exempted from the RET examination. They may directly submit a statement of purpose (SOP) indicating the area of research interest (not exceeding 1000 words) and appear in the interview.

Procedure:

- Online Application Forms are available at college website, www.sxccal.edu
- Filled in Application forms will be submitted online
- Payment of Rs1000 will be made online

- All **scanned** photocopies and self-attested copies of mark sheets and certificates to be submitted along with the application. Incomplete applications are liable to be cancelled.

- The Research Eligibility Test (RET) of 100 marks for the suitable candidates will be held once a year and the qualifying marks will be fixed at 50%.

Vacancy List of Scholars - Subject-Wise

Department	Number of Vacancies of Scholars
Biotechnology	2
Commerce	5
Microbiology	5
Physics	4
Computer Science	4

Information :

- The details of the syllabus is available in the College Website under the corresponding Department's RET Syllabus

- The eligible candidates identified through RET/ NET/ SET/ MPhil/INSPIRE, will have to submit statement of purpose (SoP) indicating the area of research interest (not exceeding 1000 words) on which a final interview will be conducted.

- The SoP has to be submitted along with the online application.**

□ **Structure of Statement of Purpose (SoP) :**

Times New Roman ; Font : 12; Spacing : 1.5 ; Word Limit : 1000 words.

Name of Applicant:

Department:

Title :

Introduction:

Literature Review:

Purpose of Study:

Proposed Research Area:

Previous Research Experience (if any):

- Those who are expected to obtain M.Sc./M.Com in *(Physics/Microbiology/Biotechnology/Commerce/Computer Science)* from any UGC recognized university will also be eligible to apply for RET.
- However, the final selection of these candidates would be contingent on their obtaining at least 55% of marks in aggregate in their M.Sc./M.Com. examinations from the College, or any other UGC recognized university.
- The list of finally selected candidates would be posted in the on the College website;

Important Dates:

- **Application for Ph.D Programs with Statement of Purpose (SOP) to be submitted online latest by : 25^h OCTOBER 2021**
- **List of Eligible Candidates for RET/Direct Interview on College Website : 27th OCTOBER 2021**
- **Dates and Details of RET Examination and Interview will be**

notified later on College Website.

RET SYLLABI 2021

PHYSICS

Mathematical Methods

Vector Calculus : Gradient, Divergence & Curl, Divergence & Stokes theorem. *Differential Equations*: Second order ordinary differential equations with non-constant coefficients. Inhomogeneous Differential Equations and Green's Function. Integral transforms. Complex variables theory: Cauchy-Riemann equations, Application of Residue Theorem. *Tensor Analysis*: Index notation, Transformation laws, Quotient theorem.

Group Theory: Discrete groups, Basic notions of group representations and symmetries, Lie groups and Lie algebras : SU(2) as a case study.

Classical Physics

Classical Mechanics: Conservation Principles, Calculus of Variations, Lagrangian and Hamiltonian Dynamics, Poisson Brackets. Canonical Transformations, Action-angle variables, Small oscillations. Rigid bodies: Moment of Inertia Tensor, Euler equations of motion.

Electrodynamics: Maxwell's equations, Scalar and Vector potentials, Gauge transformations. Green's function for wave equation. Radiation from electric dipole and accelerated charges, Retarded potentials, Larmor formula.

Special Relativity: Lorentz-transformation, Four vectors and relativistic dynamics. Lagrangian for a point relativistic particle in an electromagnetic field.

Quantum Physics

Quantum Mechanics: Formalism: Vector Space, Operators, Time evolution (pictures), Angular momentum, Identical Particles. Bound State problems in 1D, Harmonic Oscillator, Hydrogen atom problem, Coulomb Potential. Scattering theory, Born Approximation. Approximate methods: Variational method, First order time independent perturbation theory. Time dependent perturbation and Fermi Golden rule. Relativistic theory: Klein Gordon and Dirac Equations, Elementary notions on Scalar fields and simple applications of Noether's theorem.

Solid State Physics: Crystallography: Crystallographic point group, Bragg-Laue formulation of X-Ray

Diffraction, Schottky defects. Lattice vibrations: Phonon heat capacity (Einstein's and Debye's theory), Band theory of solids: Bloch equation, effective mass of electrons and holes, Fermi surfaces. Dielectric and Magnetic properties of solids. NMR and ESR (essential ideas only). Superconductivity: BCS theory, High T_c Superconductors (qualitative).

Atomic and Molecular Physics: Hydrogenic wavefunctions, Interaction with Radiation: Induced absorption and emission, Transition rates and selection rules. Fine structure splitting. Zeeman, Paschen-Back and Stark effects. Molecular Structure: bond length and dissociation energy of diatomic molecules. Molecular Rotational, Vibrational and Raman spectra of diatomic molecules. LASER: Spontaneous & Stimulated emissions, Einstein's A & B coefficients.

Nuclear and Particle Physics: Basic Properties: Size, Shape, Charge distribution, Parity, Isospin, Binding. Properties of Deuteron. Meson theory of nuclear Interactions. Fermi theory of beta decay, Nuclear models and Nuclear reactions. Symmetries and Conservation laws of particle interactions, Classification of hadrons, SU(2) and SU(3), Strange particles, CP violation, CPT invariance, elementary ideas about electroweak interactions and QCD.

- Meaning and Elements of Business Environment
- Economic environment, Economic Policies, Economic Planning
- Legal environment of Business in India, Competition policy, Consumer protection, Environment protection
- Policy Environment: Liberalization, Privatization and Globalization, Second generation reforms, Industrial policy and implementation. Industrial growth and structural changes

Unit—2

Accounting

A: Financial Accounting

- Basic Accounting concepts, Capital and Revenue, Preparation of Financial Statements
- Partnership Accounts: Admission, Retirement, Death and Dissolution
- Advanced Company Accounts: Issue and forfeiture of shares, Valuation of shares, Amalgamation and Reconstruction of Companies, Holding Company Accounts
- Ratio Analysis
- Cash Flow Analysis,
- Accounting standards in India

B: Cost and Management Accounting

- Marginal costing and Break-even analysis
- Standard costing
- Costing for decision-making
- Budgetary control

Unit—3

Business Economics

- Nature and uses of Business Economics, Concept of Profit and Wealth maximization, Demand Analysis and Elasticity of Demand, Indifference Curve Analysis,
- Utility Analysis and Laws of Returns and Law of proportions Cost, Revenue,

- Price determination in different market situations: Perfect competition, Monopolistic competition, Monopoly, Price discrimination and Oligopoly, Pricing strategies
- National Income- Concepts of GDP, GNP, NNP, NI- Measurement of NI- CPI and GDP Deflator- Saving-Investment Identities in open and closed economies.

Unit—4

Business Statistics

- Data types, Data collection, Analysis and Interpretation of Data
- Correlation and Regression
- Normal distribution
- Correlation and Regression
- Sampling, need, errors and methods of sampling
- Hypothesis testing - small sample tests—t-test, F-test and chi-square test

Unit—5

Business Management

- Principles of Management
- Planning- Objectives, Strategies, Planning process, Decision-making
- Organising- Organizational structure, Formal and Informal organizations, Organizational culture
- Staffing
- Leading: Motivation, Leadership, Committees, Communication
- Controlling
- Corporate Governance
- Value and Ethics

Unit—6

Marketing Management

- The evolution of marketing, Concepts of marketing mix, Marketing environment
- Consumer behavior, Market segmentation
- Product decisions
- Pricing decisions
- Distribution decisions
- Promotion decisions
- Marketing Research
- On- line marketing
- Direct Marketing; Social ethical and legal aspects of marketing in India

Unit—7

Financial Management

- Financial management- Concept, Objectives and Functions
- Capital Structure, leverage
- Cost of capital, Capital budgeting
- Working capital management
- Dividend Policy
- Money and Capital market, working of stock exchanges in India, NSE, OTCEI, NASDAQ, Derivatives and Options

Unit—8

Human Resources Management

- Concepts, Role and Functions of Human Resource management
- Human Resource Planning, Job analysis, Job description and specifications, Use of Job analysis information, Recruitment and Selection
- Training and Development, Succession Planning
- Compensation: Wage and Salary administration, Incentives and Fringe benefits, Morale and Productivity
- Performance Appraisal
- Industrial Relations in India, Health, Safety, Welfare and Social Security, Workers participation in Management

Unit—9

Income-tax Law and Tax Planning

- Basic concepts, Residential status and tax incidence, exempted incomes, computation of taxable income under various heads
- Computation of taxable income of individuals and firms
- Deduction of tax, filing of returns, different types of assessment; Defaults and penalties
- Tax planning: Concept, Significance and problems of tax planning, Tax evasion and tax avoidance, methods of planning
- Goods and Service Tax: Applicability and Basic Provisions

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BIOTECHNOLOGY

1. **BIOLOGICAL MACROMOLECULES** A. Structure of atoms, molecules and chemical bonds. B. Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). C. Stabilizing interactions

(Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). D. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). E. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. F. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes. G. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). H. Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA).

2. CELL BIOLOGY & CELL SIGNALING

A. Membrane structure and function: (Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes). B. Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility). C. Organization of genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons). D. Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle). E. Cancer Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, metastasis, interaction of cancer cells with normal cells, therapeutic interventions of uncontrolled cell growth. F. Programmed cell death, aging and senescence. G. Cell signaling General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Hormones and their receptors, cell surface receptor, signaling through G- protein coupled receptors, signal

transduction pathways, second messengers, regulation of signaling pathways.

3. MOLECULAR BIOLOGY

A. DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination). B. RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport). C. Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins). D. Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

4. GENETICS

A. Mendelian principles : Dominance, segregation, independent assortment. B. Concept of gene : Allele, multiple alleles, pseudoallele, complementation tests C. Extensions of Mendelian principles : Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters. D. Gene mapping methods : Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. E. Extra chromosomal inheritance : Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. F. Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes

by interrupted mating, fine structure analysis of genes. G. Human genetics: Pedigree analysis, karyotypes, genetic disorders. H. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal versus somatic mutants, insertional mutagenesis. I. Structural and numerical alterations of chromosomes : Deletion, duplication, inversion, translocation, ploidy and their genetic implications. J. Recombination: Homologous and non-homologous recombination including transposition. K. Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift.

5. ECOLOGY AND EVOLUTION

A. Ecosystem and Environment: Physical environment; biotic environment; biotic and abiotic interactions. Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition. B. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. C. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. D. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax. E. Mechanisms of Evolution: Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution

F. Molecular Evolution:

Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of

new genes and proteins; Gene duplication and divergence.

6. METHODS IN BIOLOGY

A. Molecular Biology and Recombinant DNA methods: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences. Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques. Isolation, separation and analysis of carbohydrate and lipid molecules. RFLP, RAPD and AFLP techniques. B. Microscopic techniques: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM, image processing methods in microscopy. C. Biophysical Methods: Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy. Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods. D. Statistical Methods: Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution Levels of significance; Regression and Correlation; t-test; Analysis of variance; X² test.

7. APPLIED BIOLOGY:

A. Microbial fermentation. B. Tissue and cell culture methods for animals. Transgenic animals. C. Tissue and cell culture methods for plants. Transgenic plants, gene transfer methods. D. Gene therapy. E. Breeding in plants and animals, including marker – assisted selection F. Bioremediation and phytoremediation, Biosensors.

8. IMMUNOLOGY

Innate and adaptive immune system Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. generation of antibody diversity, monoclonal antibodies, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell- mediated immune responses, inflammation, hypersensitivity and autoimmunity, vaccines.

Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy.

9. DEVELOPMENTAL BIOLOGY

A. Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development B. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in gamete recognition; zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers. C. Morphogenesis and organogenesis in animals: Axes and pattern formation in Drosophila, amphibia and chick; eye lens induction, limb development and regeneration in vertebrates; post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex

determination. D. Morphogenesis and organogenesis in plants: Shoot and root development; leaf development and phyllotaxy; flowering and floral development.

E. Programmed cell death, aging and senescence. .

COMPUTER SCIENCE

Unit - 1 : Discrete Structures and Optimization

Mathematical Logic: Propositional and Predicate Logic, Propositional Equivalences, Normal Forms, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference.

Sets and Relations: Set Operations, Representation and Properties of Relations, Equivalence Relations, Partially Ordering.

Counting, Mathematical Induction and Discrete Probability: Basics of Counting, Pigeonhole Principle, Permutations and Combinations, Inclusion-Exclusion Principle, Mathematical Induction, Probability, Bayes' Theorem.

Group Theory: Groups, Subgroups, Semi Groups, Product and Quotients of Algebraic Structures, Isomorphism, Homomorphism, Automorphism, Rings, Integral Domains, Fields, Applications of Group Theory.

Graph Theory: Simple Graph, Multigraph, Weighted Graph, Paths and Circuits, Shortest Paths in Weighted Graphs, Eulerian Paths and Circuits, Hamiltonian Paths and Circuits, Planner graph, Graph Coloring, Bipartite Graphs, Trees and Rooted Trees, Prefix Codes, Tree Traversals, Spanning Trees and Cut-Sets.

Boolean Algebra: Boolean Functions and its Representation, Simplifications of Boolean Functions.

Optimization: Linear Programming - Mathematical Model, Graphical Solution, Simplex and Dual Simplex Method, Sensitive Analysis; Integer Programming, Transportation and Assignment Models, PERT-CPM: Diagram Representation, Critical Path Calculations, Resource Levelling, Cost Consideration in Project Scheduling.

Unit - 2 : Computer System Architecture

Digital Logic Circuits and Components: Digital Computers, Logic Gates, Boolean Algebra, Map Simplifications, Combinational Circuits, Flip-Flops, Sequential Circuits, Integrated Circuits, Decoders, Multiplexers, Registers and Counters, Memory Unit.

Data Representation: Data Types, Number Systems and Conversion, Complements, Fixed Point Representation, Floating Point Representation, Error Detection Codes, Computer Arithmetic - Addition, Subtraction, Multiplication and Division Algorithms.

Register Transfer and Microoperations: Register Transfer Language, Bus and Memory Transfers, Arithmetic, Logic and Shift Microoperations.

Basic Computer Organization and Design: Stored Program Organization and Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Memory-Reference Instructions, Input-Output, Interrupt.

Programming the Basic Computer: Machine Language, Assembly Language, Assembler, Program Loops, Subroutines, Input-Output Programming.

Microprogrammed Control: Control Memory, Address Sequencing, Design of Control Unit.

Central Processing Unit: General Register Organization, Stack Organization, Instruction Formats, Addressing Modes, RISC Computer, CISC Computer.

Pipeline and Vector Processing: Parallel Processing, Pipelining, Arithmetic Pipeline, Instruction Pipeline, Vector Processing Array Processors.

Input-Output Organization: Peripheral Devices, Input-Output Interface, Asynchronous Data Transfer, Modes of Transfer, Priority Interrupt, DMA, Serial Communication.

Memory Hierarchy: Main Memory, Auxillary Memory, Associative Memory, Cache Memory, Virtual Memory, Memory Management Hardware.

Multiprocessors: Characteristics of Multiprocessors, Interconnection Structures, Interprocessor Arbitration, Interprocessor Communication and Synchronization, Cache Coherence, Multicore Processors.

Unit - 3 : Programming Languages and Computer Graphics

Language Design and Translation Issues: Programming Language Concepts, Paradigms and Models, Programming Environments, Virtual Computers and Binding Times, Programming Language Syntax, Stages in Translation, Formal Transition Models.

Elementary Data Types: Properties of Types and Objects; Scalar and Composite Data Types.

Programming in C: Tokens, Identifiers, Data Types, Sequence Control, Subprogram Control, Arrays, Structures, Union, String, Pointers, Functions, File Handling, Command Line Arguments, Preprocessors.

Object Oriented Programming: Class, Object, Instantiation, Inheritance, Encapsulation, Abstract Class, Polymorphism.

Programming in C++: Tokens, Identifiers, Variables and Constants; Data types, Operators, Control statements, Functions Parameter Passing, Virtual Functions, Class and Objects; Constructors and Destructors; Overloading, Inheritance, Templates, Exception and Event Handling; Streams and Files; Multifile Programs.

Web Programming: HTML, DHTML, XML, Scripting, Java, Servlets, Applets.

Computer Graphics: Video-Display Devices, Raster-Scan and Random-Scan Systems; Graphics Monitors, Input Devices, Points and Lines; Line Drawing Algorithms, Mid-Point Circle and Ellipse Algorithms; Scan Line Polygon Fill Algorithm, Boundary-Fill and Flood-Fill.

2-D Geometrical Transforms and Viewing: Translation, Scaling, Rotation, Reflection and Shear Transformations; Matrix Representations and Homogeneous Coordinates; Composite Transforms, Transformations Between Coordinate Systems, Viewing Pipeline, Viewing Coordinate Reference Frame, Window to View-Port Coordinate Transformation, Viewing Functions, Line and Polygon Clipping Algorithms.

3-D Object Representation, Geometric Transformations and Viewing: Polygon Surfaces, Quadric Surfaces, Spline Representation, Bezier and B-Spline Curves; Bezier and B-Spline Surfaces; Illumination Models, Polygon Rendering Methods, Viewing Pipeline and Coordinates; General Projection Transforms and Clipping.

Unit – 4 : Database Management Systems

Database System Concepts and Architecture: Data Models, Schemas, and Instances; Three-Schema Architecture and Data Independence; Database Languages and Interfaces; Centralized and Client/Server Architectures for DBMS.

Data Modeling: Entity-Relationship Diagram, Relational Model - Constraints, Languages, Design, and Programming, Relational Database Schemas, Update Operations and Dealing with Constraint Violations; Relational Algebra and Relational Calculus; Codd Rules.

SQL: Data Definition and Data Types; Constraints, Queries, Insert, Delete, and Update Statements; Views, Stored Procedures and Functions; Database Triggers, SQL Injection.

Normalization for Relational Databases: Functional Dependencies and Normalization; Algorithms for Query Processing and Optimization; Transaction Processing, Concurrency Control Techniques, Database Recovery Techniques, Object and Object-Relational Databases; Database Security and Authorization.

Enhanced Data Models: Temporal Database Concepts, Multimedia Databases, Deductive Databases, XML and Internet Databases; Mobile Databases, Geographic Information Systems, Genome Data Management, Distributed Databases and Client-Server Architectures.

Data Warehousing and Data Mining: Data Modeling for Data Warehouses, Concept Hierarchy, OLAP and OLTP; Association Rules, Classification, Clustering, Regression,

Support Vector Machine, K-Nearest Neighbour, Hidden Markov Model, Summarization, Dependency Modeling, Link Analysis, Sequencing Analysis, Social Network Analysis.

Big Data Systems: Big Data Characteristics, Types of Big Data, Big Data Architecture, Introduction to Map-Reduce and Hadoop; Distributed File System, HDFS.

NOSQL: NOSQL and Query Optimization; Different NOSQL Products, Querying and Managing NOSQL; Indexing and Ordering Data Sets; NOSQL in Cloud.

Unit – 5 : System Software and Operating System

System Software: Machine, Assembly and High-Level Languages; Compilers and Interpreters; Loading, Linking and Relocation; Macros, Debuggers.

Basics of Operating Systems: Operating System Structure, Operations and Services; System Calls, Operating-System Design and Implementation; System Boot.

Process Management: Process Scheduling and Operations; Interprocess Communication, Communication in Client–Server Systems, Process Synchronization, Critical-Section Problem, Peterson’s Solution, Semaphores, Synchronization.

Threads: Multicore Programming, Multithreading Models, Thread Libraries, Implicit Threading, Threading Issues.

CPU Scheduling: Scheduling Criteria and Algorithms; Thread Scheduling, Multiple-Processor Scheduling, Real-Time CPU Scheduling.

Deadlocks: Deadlock Characterization, Methods for Handling Deadlocks, Deadlock Prevention, Avoidance and Detection; Recovery from Deadlock.

Memory Management: Contiguous Memory Allocation, Swapping, Paging, Segmentation, Demand Paging, Page Replacement, Allocation of Frames, Thrashing, Memory-Mapped Files.

Storage Management: Mass-Storage Structure, Disk Structure, Scheduling and Management, RAID Structure.

File and Input/Output Systems: Access Methods, Directory and Disk Structure; File-System Mounting, File Sharing, File-System Structure and Implementation; Directory Implementation, Allocation Methods, Free-Space Management, Efficiency and Performance; Recovery, I/O Hardware, Application I/O Interface, Kernel I/O Subsystem, Transforming I/O Requests to Hardware Operations.

Security: Protection, Access Matrix, Access Control, Revocation of Access Rights, Program Threats, System and Network Threats; Cryptography as a Security Tool, User Authentication, Implementing Security Defenses.

Virtual Machines: Types of Virtual Machines and Implementations; Virtualization.

Linux Operating Systems: Design Principles, Kernel Modules, Process

Management, Scheduling, Memory Management, File Systems, Input and Output;

Interprocess Communication, Network Structure.

Windows Operating Systems: Design Principles, System Components, Terminal Services and Fast User Switching; File System, Networking.

Distributed Systems: Types of Network based Operating Systems, Network Structure, Communication Structure and Protocols; Robustness, Design Issues, Distributed File Systems.

Unit – 6 : Software Engineering

Software Process Models: Software Process, Generic Process Model – Framework Activity, Task Set and Process Patterns; Process Lifecycle, Prescriptive Process Models, Project Management, Component Based Development, Aspect-Oriented Software Development, Formal Methods, Agile Process Models – Extreme Programming (XP), Adaptive Software Development, Scrum, Dynamic System Development Model, Feature Driven Development, Crystal, Web Engineering.

Software Requirements: Functional and Non-Functional Requirements; Eliciting Requirements, Developing Use Cases, Requirement Analysis and Modelling; Requirements Review, Software Requirement and Specification (SRS) Document.

Software Design: Abstraction, Architecture, Patterns, Separation of Concerns, Modularity, Information Hiding, Functional Independence, Cohesion and Coupling; Object-Oriented Design, Data Design, Architectural Design, User Interface Design, Component Level Design.

Software Quality: McCall's Quality Factors, ISO 9126 Quality Factors, Quality Control, Quality Assurance, Risk Management, Risk Mitigation, Monitoring and Management (RMMM); Software Reliability.

Estimation and Scheduling of Software Projects: Software Sizing, LOC and FP based Estimations; Estimating Cost and Effort; Estimation Models, Constructive Cost Model (COCOMO), Project Scheduling and Staffing; Time-line Charts.

Software Testing: Verification and Validation; Error, Fault, Bug and Failure; Unit and Integration Testing; White-box and Black-box Testing; Basis Path Testing, Control Structure Testing, Deriving Test Cases, Alpha and Beta Testing; Regression Testing, Performance Testing, Stress Testing.

Software Configuration Management: Change Control and Version Control; Software Reuse, Software Re-engineering, Reverse Engineering.

Unit – 7 : Data Structures and Algorithms

Data Structures: Arrays and their Applications; Sparse Matrix, Stacks, Queues, Priority Queues, Linked Lists, Trees, Forest, Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree, B Tree, B+ Tree, B* Tree, Data Structure for Sets, Graphs, Sorting and Searching Algorithms; Hashing.

Performance Analysis of Algorithms and Recurrences: Time and Space Complexities; Asymptotic Notation, Recurrence Relations.

Design Techniques: Divide and Conquer; Dynamic Programming, Greedy Algorithms, Backtracking, Branch and Bound.

Lower Bound Theory: Comparison Trees, Lower Bounds through Reductions.

Graph Algorithms: Breadth-First Search, Depth-First Search, Shortest Paths, Maximum Flow, Minimum Spanning Trees.

Complexity Theory: P and NP Class Problems; NP-completeness and Reducibility.

Selected Topics: Number Theoretic Algorithms, Polynomial Arithmetic, Fast Fourier Transform, String Matching Algorithms.

Advanced Algorithms: Parallel Algorithms for Sorting, Searching and Merging, Approximation Algorithms, Randomized Algorithms.

Unit – 8 : Theory of Computation and Compilers

Theory of Computation: Formal Language, Non-Computational Problems, Diagonal Argument, Russels's Paradox.

Regular Language Models: Deterministic Finite Automaton (DFA), Non-Deterministic Finite Automaton (NFA), Equivalence of DFA and NFA, Regular Languages, Regular Grammars, Regular Expressions, Properties of Regular Language, Pumping Lemma, Non-Regular Languages, Lexical Analysis.

Context Free Language: Pushdown Automaton (PDA), Non-Deterministic Pushdown Automaton (NPDA), Context Free Grammar, Chomsky Normal Form, Greibach Normal Form, Ambiguity, Parse Tree Representation of Derivation Trees, Equivalence of PDA's and Context Free Grammars; Properties of Context Free Language.

Turing Machines (TM): Standard Turing Machine and its Variations; Universal Turing Machines, Models of Computation and Church-Turing Thesis; Recursive and Recursively-Enumerable Languages; Context-Sensitive Languages, Unrestricted Grammars, Chomsky Hierarchy of Languages, Construction of TM for Simple Problems.

Unsolvable Problems and Computational Complexity: Unsolvable Problem, Halting Problem, Post Correspondence Problem, Unsolvable Problems for Context-Free Languages, Measuring and Classifying Complexity, Tractable and Intractable Problems.

Syntax Analysis: Associativity, Precedence, Grammar Transformations, Top Down Parsing, Recursive Descent Predictive Parsing, LL(1) Parsing, Bottom up Parsing, LR Parser, LALR(1) Parser.

Semantic Analysis: Attribute Grammar, Syntax Directed Definitions, Inherited and Synthesized Attributes; Dependency Graph, Evaluation Order, S-attributed and L-attributed Definitions; Type-Checking.

Run Time System: Storage Organization, Activation Tree, Activation Record, Stack Allocation of Activation Records, Parameter Passing Mechanisms, Symbol Table.

Intermediate Code Generation: Intermediate Representations, Translation of Declarations, Assignments, Control Flow, Boolean Expressions and Procedure Calls.

Code Generation and Code Optimization: Control-flow, Data-flow Analysis, Local Optimization, Global Optimization, Loop Optimization, Peep-Hole Optimization, Instruction Scheduling.

Unit – 9 : Data Communication and Computer Networks

Data Communication: Components of a Data Communication System, Simplex, Half-Duplex and Duplex Modes of Communication; Analog and Digital Signals; Noiseless and Noisy Channels; Bandwidth, Throughput and Latency; Digital and Analog Transmission; Data Encoding and Modulation Techniques; Broadband and Baseband Transmission; Multiplexing, Transmission Media, Transmission Errors, Error Handling Mechanisms.

Computer Networks: Network Topologies, Local Area Networks, Metropolitan Area Networks, Wide Area Network, Wireless Networks, Internet.

Network Models: Layered Architecture, OSI Reference Model and its Protocols; TCP/IP Protocol Suite, Physical, Logical, Port and Specific Addresses; Switching Techniques.

Functions of OSI and TCP/IP Layers: Framing, Error Detection and Correction; Flow and Error Control; Sliding Window Protocol, HDLC, Multiple Access – CSMA/CD, CSMA/CA, Reservation, Polling, Token Passing, FDMA, CDMA, TDMA, Network Devices, Backbone Networks, Virtual LANs.

IPv4 Structure and Address Space; Classful and Classless Addressing; Datagram, Fragmentation and Checksum; IPv6 Packet Format, Mapping Logical to Physical Address (ARP), Direct and Indirect Network Layer Delivery; Routing Algorithms, TCP, UDP and SCTP Protocols; Flow Control, Error Control and Congestion Control in TCP and SCTP.

World Wide Web (WWW): Uniform Resource Locator (URL), Domain Name Service (DNS), Resolution - Mapping Names to Addresses and Addresses to Names; Electronic Mail Architecture, SMTP, POP and IMAP; TELNET and FTP.

Network Security: Malwares, Cryptography and Steganography; Secret-Key Algorithms, Public-Key Algorithms, Digital Signature, Virtual Private Networks, Firewalls.

Mobile Technology: GSM and CDMA; Services and Architecture of GSM and Mobile Computing; Middleware and Gateway for Mobile Computing; Mobile IP and Mobile Communication Protocol; Communication Satellites, Wireless Networks and Topologies; Cellular Topology, Mobile Adhoc Networks, Wireless Transmission and Wireless LANs; Wireless Geolocation Systems, GPRS and SMS.

Cloud Computing and IoT: SaaS, PaaS, IaaS, Public and Private Cloud; Virtualization, Virtual Server, Cloud Storage, Database Storage, Resource Management, Service Level Agreement, Basics of IoT.

Unit – 10 : Artificial Intelligence (AI)

Approaches to AI: Turing Test and Rational Agent Approaches; State Space Representation of Problems, Heuristic Search Techniques, Game Playing, Min-Max Search, Alpha Beta Cutoff Procedures.

Knowledge Representation: Logic, Semantic Networks, Frames, Rules, Scripts, Conceptual Dependency and Ontologies; Expert Systems, Handling Uncertainty in Knowledge.

Planning: Components of a Planning System, Linear and Non Linear Planning; Goal Stack Planning, Hierarchical Planning, STRIPS, Partial Order Planning.

Natural Language Processing: Grammar and Language; Parsing Techniques, Semantic Analysis and Pragmatics.

Multi Agent Systems: Agents and Objects; Agents and Expert Systems; Generic Structure of Multiagent System, Semantic Web, Agent Communication, Knowledge Sharing using Ontologies, Agent Development Tools.

Fuzzy Sets: Notion of Fuzziness, Membership Functions, Fuzzification and Defuzzification; Operations on Fuzzy Sets, Fuzzy Functions and Linguistic Variables; Fuzzy Relations, Fuzzy Rules and Fuzzy Inference; Fuzzy Control System and Fuzzy Rule Based Systems.

Genetic Algorithms (GA): Encoding Strategies, Genetic Operators, Fitness Functions and GA Cycle; Problem Solving using GA.

Artificial Neural Networks (ANN): Supervised, Unsupervised and Reinforcement Learning; Single Perceptron, Multi Layer Perceptron, Self Organizing Maps, Hopfield Network.

