



St. Xavier's College (Autonomous), Kolkata

Advertisement for Admissions to Ph.D. Programs 2022

**In the Post- Graduate and Research Departments of
(Physics/Microbiology/Biotechnology/Computer
Science/English/Bengali)**

Applications are invited for admissions to the Ph.D. Programs in the Post- Graduate and Research Departments of **(Physics / Microbiology / Biotechnology / Computer Science /English /Bengali)** at St. Xavier's College (Autonomous), Kolkata, affiliated to the University of Calcutta, in the prescribed format to be filled in **ONLINE** from the College website at <https://www.sxccal.edu/>

Essential Qualification:

Physics: M.Sc. in Physics with at least 55% marks from a UGC recognized University.

Microbiology: M.Sc. in CSIR / UGC approved all branches of Life Sciences with at least 55% marks from a UGC recognized University.

Biotechnology: M.Sc. in CSIR/ UGC approved all branches of LifeSciences with at least 55% marks from a UGC recognized University.

Computer Science: M.Sc. in Computer Science or MCA or M.Tech. in Computer Science with at least 55% mark from a UGC recognized University.

English: M.A. in English with at least 55% marks from a UGC recognized University.

Bengali: M.A. in Bengali with at least 55% marks from a UGC recognized University.

OTHER RELEVANT INFORMATION

●The candidate has to have either NET/ SET/ INSPIRE or has to qualify in the Research Entrance Test (RET) conducted by the department. The RET syllabi is attached at the end of this document.

●Those who have qualified in NET/SET/INSPIRE would be exempted from the 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 will be available at college website, www.sxccal.edu

→**Filled in Application forms will be submitted online.**

→**Payment of Rs.1000 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 Entrance Test (RET) of 100 marks for the suitable candidates will be held and the qualifying marks will be fixed at 50%.

Vacancy List of Scholars– Subject Wise

SUBJECTS	SUPERVISOR (S)	SPECIALIZATION/ OTHER DETAILS	VACANCY
BIOTECHNOLOGY	Dr. Aryadeep Ray Chaudhuri	→ Plant Physiology, Molecular Biology, Biotechnology → Project to support	1
	Dr. Ronita Nag Chaudhuri	→ Molecular & Cellular Biology (Project to support)	2
BENGALI	Dr. Bodhisatwa Gupta	→ Tagore's Literature → Novels & Short Stories → (Ancient & Medieval Bengali Literature	3
	Dr. Madhumita Acharya	→ Modern Fictions / Novels → Short Stories → Novels and Short Stories of Rabindranath Tagore	3
	Dr. Debashis Bhattacharya	→ Life and Works of Rabindranath Tagore → Bengali Poetry of Twentieth Century	3
	Dr. Shruti Goswami	→ Fiction → Women's writings → Gender studies → Cultural Studies and Performance Studies	3
MICROBIOLOGY	Dr. Arup Kumar Mitra	→ Environmental Microbiology	1
	Dr. Jaydip Ghosh	→ Vector Gut Microbiology	1
PHYSICS	Dr. Sarbari Guha	→ Gravity and Relativistic Astrophysics	2
COMPUTER	Dr. Romit Beed	→ Optimization and Learning Techniques	3

SCIENCE			
ENGLISH	Dr. Argha Kumar Banerjee	→ Literature of the Two World Wars → British Romantic and Modern Literature → Eco – Criticism → Indian Writing in English → Literature and Spirituality → Literature and Mental Illness	3
	Dr. Chandrani Biswas	→ Postcolonial Literature → African – American and African Literature in English → Gender Studies → American Literature → British Romantic Woman-authored Fiction → Modern Literature	3

Information :

- The eligible candidates identified through RET/ NET/ SET/ GATE/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 (in **PDF form**) has to be submitted along with the online application.
- NAME OF **PDF FILE** : **FIRST NAME_SUBJECT**

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):

- **Candidates applying for Ph.D Programs in BENGALI may upload their SoPs in BENGALI VERSION within the word limit of 1000 words.**
- Those who are expected to obtain M.Sc./M.A. results in from any UGC recognized university by **31st October, 2022** 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.A. 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 : 30.09.2022**
- **List of Eligible Candidates for RET/Direct Interview to be published on College Website : 07.11.2022**
- **Dates and Details of RET Examination and Interview will be notified later on College Website.**

RET SYLLABI 2022

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 Tc 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.

Thermal Physics

Kinetic theory : Maxwell's velocity distribution, mean free path & transport phenomena.

Thermodynamics : Laws of Thermodynamics, Entropy, Phase Transition.

Statistical Mechanics: Microcanonical, Canonical and Grand Canonical Ensembles, Quantum

Mechanical ensemble theory: Density matrix, Maxwell, Fermi-Dirac and Bose-Einstein Statistics.

He-3 and He-4 (introductory ideas).

Electronics

Semiconductor Physics: Current components & Transistor biasing , junction band diagrams, Amplifiers (Class A, AB, B), Oscillators (RC, Hartley, Colpitts, Wien Bridge), h-parameters.

Devices: BJT, FET and MOSFETs, Tunnel Diodes, UJT and SCR. Analog Circuits: OPAMPS, Comparators and Multivibrators. Digital Circuits: Basic gates and Boolean Algebra, K-map simplifications, A/D, D/A conversion, Counters and Multiplexers. Microprocessors.

Computation & Laboratory Techniques

Algorithms involving iteration and choice. Fortran / Python / C (any one) implementation of root finding techniques (iteration, bisection, Newton-Raphson) for non linear equations in one variable, integration (Simpson and Trapezoidal rules) and Solution of ordinary differential equations (Euler and modified Euler).

Estimation & propagation of errors in experiments.

MICROBIOLOGY

Syllabus

- Biological macromolecules
- Biophysical techniques, microscopy, spectroscopy, thermodynamics
- Cell biology and cell signaling, Cellular structure and function
- Enzymes, microbial metabolism, photosynthesis
- Molecular biology (DNA replication, transformation, conjugation transduction, mutation and repair)
- Environmental microbiology
- Recombinant DNA technology
- Immunology and cancer biology
- Industrial microbiology

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 verses 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.

ENGLISH

Unit I: Drama

Unit II: Poetry

Unit III: Fiction, Short Story

Unit IV: Non- Fictional Prose

Unit V: Language: Basic concepts, theories, pedagogies. English in use

Unit VI: English in India: History, evolution and futures

Unit VII: Cultural Studies

Unit VIII: Literary Theory and Criticism

Unit IX: Research Methods and Materials in English

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BENGALI

Module 1- Linguistics

1. Phonetics
2. Morphology
3. Syntax
4. Study on Bengali Dialects

Module 2- Medieval Bengali Literature

1. Mangalkavya (Manasamangal, Chandimangal, Dharmamangal)
2. Charita Sahitya [Biography & Hagiography] (Shreechaitanya and his associates)
3. Literature of Arakan or Rosang Court
4. Translated Literature (Ramayana, Mahabharata, Bhagavata)

Module 3- Bengali Folklore

1. Rhymes
2. Riddles
3. Folk Tales
4. Proverbs and Maxim

Module 4- Drama & Theatre

1. Theory of Drama
2. History of Bengali Drama (Initiation of Original Bengali Drama, Important ways of Playwritings in 19 th and 20 th Century Bengal)
3. History of Bengali Theatre (Swadeshi or Indian Theatre, Journey of Domestic Theatre to Group Theatre)

Module 5- 19th Century

1. Commencement of Printing Culture and First Phase of Bengali Literary Prose
2. Effect of Brahmadharma and Brahmasamaj Movement
3. Beginning of Bengali Naksha and Novel
4. Foundation of Bengali Lyrical Poetry

Module 6- Tagore's Literature

1. Poetry- 'Noibedyo' to 'Balaka'

2. Prose Play- 'Sharatotsav' to 'Rather Roshi'
3. Short Story- Sadhana-Bharati Phase
4. Letters and Epistolary Writings

Module 7- Bengali Literature in Between Two World Wars

1. Bengal Famine, Crisis of food and Clothes
2. Tebhaga and other Scio-political Movements
3. Partition and Communal Riot
4. Non-urbanization of Fiction, Inclusion and Expansion of 'Local' Setting and Culture

Module 8- Literary Movements of 20th century

1. Hungry Movement
2. Shruti Movement
3. Nimsahitya
4. Shastravirodhi Movement

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