Syllabus and Question Paper Format
for
Junior Research Fellowship (JRF)
in
Computer Science (CS)

Test Codes: CSA and CSB (Short Answer Type)

2024

Candidates for Junior Research Fellowship in Computer Science will have to take two tests, each of 2 hours duration: **CSA** (forenoon session) and **CSB** (afternoon session).

Test code: CSA (60 marks)

- **CSA** is a test of aptitude on the basics of Computing and Mathematics, as indicated in the syllabus.
- A candidate should answer **ALL** the questions.

Test code: CSB (60 marks)

- **CSB** will have TWELVE questions from Computer Science and Mathematics.
- A candidate should answer **any** FIVE out of these TWELVE questions.

SYLLABI

CSA

Analytical Reasoning.

Elements of Computing: Basics of programming (using pseudo-code). Procedure call and parameter passing (using C).

Basics of Data Structures: Array, stack and queue.

Discrete Mathematics: Basics of Set Theory. Functions and relations. Boolean algebra. Fundamental Theorem of Arithmetic. Binary and decimal representation of integers. Linear congruences. Basic combinatorics: basic counting, permutations and combinations, Inclusion-Exclusion and Pigeonhole Principles, Binomial Theorem.

Discrete Probability Theory: Combinatorial probability. Conditional probability, Bayes Theorem and applications.

Algebra: Vector spaces. Matrices, determinant, rank and inverse. Properties of symmetric and idempotent matrices. Eigenvalues and eigenvectors. System of linear equations. Polynomials and Theory of Equations.

Calculus: Sequences and convergence. Limits, continuity and differentiability of functions of one variable. Rolle's Theorem and Mean Value Theorem. Maxima and minima. Integration and its applications.

CSB

The TWELVE questions in **CSB** will be organised into two groups as indicated below. A candidate needs to answer any FIVE out of these TWELVE questions.

NOTE: The topics below should be covered at the M.Sc./M.E./M.Tech. level.

Computer Science (SIX questions)

Data Structures and Design and Analysis of Algorithms: Linked list, stack, queue. Binary tree, heap, AVL tree. Sorting, selection, searching, hashing. Graph algorithms (traversals, spanning trees, shortest paths, maximum bipartite matching).

Digital Circuits and Systems: Gates and logic circuits. Combinational and sequential circuits.

Computer Organization and Architecture: Number representation, computer arithmetic. Instruction set design. Pipelining. Memory organization. I/O organization. Multiprocessor Systems.

Operating Systems: Process concept and management, scheduling, process synchronization, concurrency control, critical section problems, deadlocks. Memory management. File systems.

Database Management Systems: Relational model, relational algebra, relational calculus. Functional dependency, normalization (including multivalued dependencies). Query processing and optimization.

Computer Networks: Layered network structures. LAN topologies (bus/tree, ring, star). Data communications (data encoding, flow control, error detection/correction). Network security.

Mathematics for Computer Science (SIX questions)

Elementary Number Theory: Divisibility, congruences, Chinese Remainder Theorem. Wilson's Theorem, Fermat's Little Theorem, Euler's phi function, Euler's Theorem.

Discrete Mathematics: Order notation. Mathematical induction. Permutation and combination. Inclusion-Exclusion and Pigeonhole Principles. Recurrence relations. Generating functions.

Graph Theory: Paths, cycles, connectivity, trees, bipartite graphs, graph colouring, planar graphs, Eulerian graphs, Hamiltonian paths, digraphs.

Discrete Probability: Combinatorial probability. Conditional probability, Bayes Theorem and applications. Standard discrete distributions (uniform, binomial, Poisson, geometric, hypergeometric). Expectation, variance and moments. Concentration bounds (Markov, Chebyshev, Chernoff bounds).

Formal Languages and Automata Theory: Finite automata and regular languages. Pushdown automata and context-free languages. Turing machines and recursively enumerable languages. Undecidability.

Real Analysis: Sequence and series of real numbers and functions. Limit, continuity and differentiability of real valued functions of one variable and applications. Uniform convergence. Riemann integration, improper inte-

grals. First order ordinary linear differential equations.
Limits, continuity and differentiability of real valued functions of several variables, partial derivatives and mixed partial derivatives, total derivative. Double integrals and their applications. Vector calculus.

Linear Algebra: Vector spaces and linear transformations. Eigenvalues and eigenvectors. Systems of linear equations. Inner product spaces. Diagonalization of symmetric and Hermitian matrices. Quadratic forms.