Test Code : CSB (Short Answer Type) 2021

Junior Research Fellowship (JRF) in Computer Science

The CSB test booklet will have two groups as follows:

GROUP A (30 marks)

A test of aptitude for Computer Science for all candidates in the basics of Computer Programming and Mathematics, as indicated in the syllabus.

GROUP B (70 marks)

A test divided into the following five sections:

- Computer Science,
- Electrical and Electronics Engineering,
- Mathematics,
- Physics, and
- Statistics.

A candidate has to answer questions from **only** one of these sections in GROUP B, according to his/her choice.

The syllabi for Group A and the five sections of Group B of the CSB test are given overleaf.

More details can be found at: `https://www.isical.ac.in/~deanweb/phdcs/`.

SYLLABI

GROUP A

Analytical reasoning.

Elements of computing: Basics of programming (using pseudo-code), procedure call and parameter passing, elementary data structures (array, stack and queue).

Elements of discrete mathematics: Basics of set theory, functions and relations, basic combinatorics (basic counting, inclusion-exclusion principle, pigeonhole principle), basic probability theory including conditional probability and Binomial distribution.

GROUP B

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

Computer Science

Discrete mathematics and graph theory: Order notation, permutation and combination, recurrence relations, generating functions, graph theory — paths and cycles, trees, digraphs, planar graphs, Eulerian graphs, Hamiltonian paths.

Programming languages: Fundamental concepts — abstract data types, procedure call and parameter passing, knowledge of any one of the following languages: C, C++, Java, Python.

Data structures and design and analysis of algorithms: Linked list, stack, queue, binary tree, heap, AVL tree, sorting, selection, searching, hashing, graph algorithms.

Digital circuits and systems: Gates and logic circuits, combinational and sequential circuits.

Computer organization and architecture: Number representation, computer arithmetic, memory organization, I/O organization, pipelining.

Operating systems: Process concept and management, scheduling, process synchronization, concurrency control, critical section problems, deadlocks, memory management, file systems.

Formal languages and automata theory: Finite automata and regular expressions, context-free grammars, Turing machines, undecidability.

Database management systems: Relational model, relational algebra, relational calculus, functional dependency, normalization (including multivalued dependencies), query processing and optimization.

Computer networks: Layered network structures, network security, LAN technology — bus/tree, ring, star; data communications — data encoding, flow control, error detection/correction.

Electrical and Electronics Engineering

Digital circuits and systems: Gates and logic circuits, combinational and sequential circuits.

Circuit theory: Kirchoff's laws, theorem of superposition, Thevenin's theorem, Norton's theorem, A.C. circuits, star-delta conversion.

Linear electronic devices and circuits: Diodes, transistors, amplifiers including feedback amplifiers, oscillators, operational amplifiers.

Digital communication: Information and coding theory, concept of entropy, elementary error-detecting and error-correcting codes, digital modulation techniques.

Digital signal processing: Sampling, linear time invariant systems, Z-transform, Fourier transform, Laplace transform.

Electrical machines: DC motors and generators, transformers, induction motors.

Mathematics

Abstract algebra: Groups, homomorphisms, normal subgroups and quotients, isomorphism theorems, finite groups, symmetric and alternating groups, direct product, structure of finite Abelian groups, Sylow theorems. Rings and ideals, quotients, homomorphism and isomorphism theorems, maximal ideals, prime ideals, integral domains, field of fractions, Euclidean rings, principal ideal domains, unique factorization domains, polynomial rings. Fields, characteristic of a field, algebraic extensions, roots of polynomials, separable and normal extensions, finite fields.

Linear algebra: Vector spaces, linear transformations, characteristic roots and characteristic vectors, systems of linear equations, inner product spaces, diagonalization of symmetric and Hermitian matrices, quadratic forms.

General topology: Topological spaces, continuous functions, connectedness, compactness, separation axioms, product spaces, complete metric spaces, uniform continuity, Baire category theorem.

Elementary number theory and combinatorics: Divisibility, congruences, standard arithmetic functions, permutations and combinations, combinatorial probability.

Physics

Classical Mechanics: Mechanics of a particle and system of particles, Scattering in a central field, Lagrange's equations and their applications, Hamilton's equations, Canonical transformations, Special theory of relativity, Small oscillations, Vibrations and acoustics.

Electromagnetic theory: Electrostatics, Magnetostatics, Maxwell's equations, Gauge transformations, Poynting's theorem, Wave equation and plane waves, Radiating system and scattering.

Statistical Physics and Condensed Matter Physics: Statistical basis of thermodynamics, Ensembles – microcanonical, canonical and grand canonical, Quantum statistics, Phase transitions, Statistical fluctuations, Free electron theory, Band theory of electrons, Semiconductor physics, Transport phenomena, Magnetism, Superconductivity.

Quantum Mechanics and Quantum Field Theory: Schrödinger wave equation, General formalism of wave mechanics, Exactly solvable eigenvalue problems for various potentials, Approximation methods, Scattering theory, Time dependent perturbation theory, Symmetries and conservation laws, Relativistic quantum mechanics, Quantum field theory – scalar and spinor fields, Quantum electrodynamics.

Elementary Particles: Elementary particles, Weak and strong interactions, Selection rules, CPT theorem, Symmetry principles in particle physics.

Statistics

Probability: Basic concepts, elementary set theory and sample space, conditional probability and Bayes theorem. Standard univariate and multivariate distributions. Transformations of variables. Moment generating functions, characteristic functions, convergence in probability, first and second Borel-Cantelli lemmas, almost sure convergence, weak and strong laws of large numbers, convergence in distribution and central limit theorem. Markov chains.

Inference: Sufficiency, minimum variance unbiased estimation, Bayes estimates, maximum likelihood and other common methods of estimation. Optimum tests for simple and composite hypotheses. Elements of sequential analysis and non-parametric inference.

Multivariate analysis: Standard sampling distributions. Basic properties of multivariate normal distribution, Wishart distribution, Hotelling's T^2 and related tests. Analysis of discrete data — contingency chi-square. Order statistics with applications.

Design of experiments: Inference in linear models. One and two-way ANOVA. Standard orthogonal and non-orthogonal designs. Analysis of general block designs. Factorial experiments.

Sample surveys: Simple random sampling, Systematic sampling, PPS sampling, Stratified sampling. Ratio and regression methods of estimation. Non-sampling errors, Non-response bias.

Regression: Regression, partial and multiple correlations. Linear regression analysis and and logistic regression.