Indian Institute of Information Technology, Vadodara

PhD Entrance Exam Syllabus

1. Engineering

1.1 Computer Science and Engineering

1.1.1 C programming: Datatypes, variables, loops, control statements, arrays, structures, functions, and pointers.
1.1.2 C++ and Java Programming: Access specifiers, class, object, inheritance, polymorphism, overloading, templates, abstract class, Interface, exceptional handling.
1.1.3 Data Structures: Lists, stacks, queues, priority queues, heaps, trees, graphs (breadth first search, depth first search, minimum spanning trees, shortest paths), hash tables.
1.1.4 Algorithms: Recurrence relations, time complexity of algorithms, sorting (bubble sort, quick sort, merge sort, heap sort), searching, algorithmic techniques (dynamic programming, divide and conquer, greedy).
1.1.5 Theory of Computation: Regular languages, non-deterministic and deterministic finite automata, regular expressions, pumping lemma, and properties of Regular languages; context free languages, pushdown automaton, pumping lemma, and properties of context free languages.
1.1.6 Database Management System: Basic Concepts of Database and DBMS, Data Abstraction, Data Independence, Database Modeling, E-R Model, Relational Model, Integrity Constraints, SQL Queries, Database Design, Functional Dependencies and Normalization, Data Storage and Indexing, Database Application Development
1.1.7 Computer Networks: ISO/OSI protocol stack. LAN technologies, Basic concepts of hubs, switches, gateways, and routers. Flow and error control techniques. MAC protocols. Routing algorithms. Congestion control. IP, TCP/UDP and ICMP protocols. Application layer protocols (dns, smtp, pop, ftp, http).
1.1.8 Operating systems: Process concept and management, scheduling, process synchronization, concurrency control, critical section problems, deadlocks, memory management, file systems.

1.3 Electronics and Communication Engineering

1.3.1 Signal and Information Processing

1.3.1.1 Analog Modulation and Digital Communication: AM, FM and PM, Sampling, quantization, PCM, companding and delta modulation, Basics of Digital Modulation Schemes like ASK, FSK, PSK, QAM.
1.3.1.2 Signals and Systems: Introduction of signals and systems (ranging from their types, properties and different examples). Linear time-invariant (LTI) systems and their representation with the help of convolution sum or integral (which can used to model many real physical systems). Fourier analysis ranging from Fourier series, Fourier transform, time and frequency characterization of signals and systems (e.g. Fourier transform phase and concept of group delay), Shannon's sampling theory, Laplace and Z-transform, basics of linear algebra (linear independence of vectors, eigen value decomposition, overdetermined and undetermined nature of linear system of equations).
1.3.1.3 Digital Signal Processing: Discrete-time LTI systems, convolution sum, Discrete-Time Fourier Transform (DTFT) and its properties, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Z-transform, Sampling and Quantization, Design of FIR filters (concept of linear phase, zero locations of FIR filters, etc) and design of IIR Filters (impulse invariant vs. bilinear transformation, Butterworth and Chebyshevfilters), Digital Filter Structures.
1.3.1.4 Statistics: Probability space, basics of random variables, characterization of random variables like PDF, CDF, moments and characteristic functions.

1.3.2 VLSI and Embedded Systems

1.3.2.1 Electronic Devices and Circuits: Energy bands in intrinsic and extrinsic silicon; carrier transport: diffusion current, drift current, mobility and resistivity; generation and recombination of carriers; Poisson and continuity equations; PN junction, Zener diode, Tunnel diode, MOSFET, solar cell, BJT and MOSFET (single stage, multistage, cascade) amplifiers, small signal, frequency response and noise analysis of BJT and MOSFET amplifiers, Operational Amplifiers, stability and frequency compensate, negative feedback circuits, active filters and oscillators, current mirrors circuits.
1.3.2.2 Digital Circuits: Logic gates, logic families (RTL, TTL, CMOS), combinatorial circuits, sequential circuits (flip-flops, counters, registers), A/D and D/A conversion, finite state machine.
1.3.2.3 VLSI Design: Fabrication of MOSFETS, MOS transistor, MOSFET device physics, modeling of MOS transistors using SPICE, MOS inverters: static, switching characteristics and interconnect effects, sequential and dynamic MOS logic circuits, static and dynamic power dissipation, semiconductor memories, low-power CMOS logic circuits, VLSI Design methodologies, Y-chart, floor planning, design rules modeling and synthesis, Basics of ASIC, FPGA, PLD and SOC design.

2. Sciences

2.1 Physics/Material Science/Engineering Physics/Nanoscience & Nanotechnology/Electronics

2.1.1 Solid State Physics & Electronics: Elements of crystallography; diffraction methods for structure determination; bonding in solids; lattice vibrations and thermal properties of solids; free electron theory; band theory of solids: nearly free electron and tight binding models; metals, semiconductors and insulators; conductivity, mobility and effective mass; optical, dielectric and magnetic properties of solids.
Semiconductor devices: Diodes, Bipolar Junction Transistors, Field Effect Transistors; Operational Amplifiers: negative feedback circuits, active filters and oscillators; regulated power supplies; basic digital logic circuits, sequential circuits, flip-flops, counters, registers, A/D and D/A conversion, SRAM, DRAM.
2.1.2 Quantum Mechanics: Postulates of quantum mechanics; Uncertainty Principle; Schrodinger equation; one-, two- and three-dimensional potential problems; particle in a box, transmission through one dimensional potential barriers, harmonic oscillator, and hydrogen atom. Angular Momentum, L-S coupling, J-J coupling, Pauli Matrices, commutation relations, Stark effect, anomalous Zeeman effect.
2.1.3 Electromagnetic Theory: Electrostatics; Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector; Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth.
2.1.4 Experimental Techniques: X-ray diffraction, spectroscopic techniques like UV-vis, IR, Raman. Optical and Electron microscopy.
2.1.5 Statistical Mechanics: Microcanonical, Canonical and Grand Canonical ensembles, Partition function and its applications, ideal quantum gas, Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics, Bose-Einstein condensation, applications such as Doppler broadening, Einstein coefficients, specific heat of solid, black-body radiations. Transport phenomena: Diffusion, random walk, Einstein relations, Boltzmann transport equation, and electrical properties.
2.1.6 Mathematical Physics: Linear transformations, Similarity transformations, orthonormal sets, eigen values and eigen vectors; Partial differential equations and special functions (Legendre, Hermite and Lauguerre polynomials, Bessel functions, Neumann functions etc.) Separation of variables in cartesian, spherical and cylindrical coordinates, properties of special functions; Numerical differentiation formulae, Simpson's rule and Gauss-Legendre integration, Solutions of ODE and PDE: Runge-Kutta and finite difference methods.
2.1.7 Optics: Coherence and light sources, Theory of diffraction, Fresnel and Fraunhofer diffraction, Theory of interference: two beam interference, division of wave-front and division of amplitude, multiple-beam interference. Dispersion, Dissipation.
2.1.8 Nanoscience & Nanotechnology: Flow of electrons, ballistic (B) conductance, diffusive (D)

conductance, E(p) or E(k) relation, counting states, Density of states, number of modes, electron density (n), quantum capacitance, nano-transistor, quasi-Fermi levels (QFL's), current from QFL's, Landauer formulas, electrostatic potential, Boltzmann equation, spin voltages, heat current, law of equilibrium, quantum transport.

2.2 Mathematics/Statistics

2.2.1 Linear Algebra: Vector spaces over fields, subspaces, bases and dimension. Systems of linear equations, matrices, rank, Gaussian elimination. Linear transformations, representation of linear transformations by matrices, rank-nullity theorem, duality and transpose. Determinants, Laplace expansions, cofactors, adjoint, Cramer's Rule. Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, Cayley-Hamilton theorem, triangulation, diagonalization, rational canonical form, Jordan canonical form. Inner product spaces, Gram-Schmidt ortho-normalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators, spectral Theorem for normal operators. Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.
2.2.2 Real Analysis: Archimedean property and completeness of real numbers. Metric spaces, compactness, connectedness (with emphasis on R^n). Continuity and uniform continuity. Monotonic functions, functions of bounded variation; absolutely continuous functions. Derivatives of functions and Taylor's theorem. Riemann integral and its properties, characterization of Riemann integrable functions. Improper integrals, Gamma functions. Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration. Fourier series, pointwise convergence, Fejer's theorem, Weierstrass approximation theorem.
2.2.3 Abstract Algebra (for Mathematics only): Group theory: Simple groups and solvable groups, nilpotent groups, simplicity of alternating groups, composition series, Jordan-Holder Theorem. Semidirect products. Free groups, free abelian groups. Rings theory: Examples (including polynomial rings, formal power series rings, matrix rings and group rings), ideals, prime and maximal ideals, rings of fractions, Chinese Remainder Theorem for pairwise comaximal ideals. Euclidean Domains, Principal Ideal Domains and Unique Factorizations Domains. Polynomial rings over UFD's. Fields theory: Characteristic and prime subfields, Field extensions, Finite, algebraic and finitely generated field extensions, Classical ruler and compass constructions, Splitting fields and normal extensions, algebraic closures. Finite fields, Cyclotomic fields, Separable and inseparable extensions. Galois groups, Fundamental Theorem of Galois Theory, Composite extensions, Examples (including cyclotomic extensions and extensions of finite fields). Norm, trace and discriminant. Solvability by radicals, Galois' Theorem on solvability. Cyclic extensions, Abelian extensions, Transcendental extensions. Module theory: Submodules, quotient modules and module homomorphisms. Generation of modules, direct sums and free modules. Tensor products of modules. Exact sequences, projective modules. Tensor algebras, symmetric and exterior algebras. Finitely generated modules over principal ideal domains, invariant factors, elementary divisors, rational canonical forms. Applications to finitely generated abelian groups and linear trans-formations.
2.2.4 Probability (for Statistics only): Axioms of probability, conditional probability and independence, random variables and distribution functions, random vectors and joint distributions, functions of random vectors. Expectation, moment generating functions and characteristic functions, conditional expectation and distribution. Modes of convergence, weak and strong laws of large numbers, central limit theorem.

3. Humanities & Social Sciences

3.1 Linguistics

3.1.1 Language and Communication: Human and non-human communication, Verbal and non-verbal communication, Language, mind and society, Language-independent and language-dependent semiotic system, Language structure and language system, Speech and writing.

3.1.2 Language Structure: The concept of linguistic sign, Syntagmatic and paradigmatic relation, Langue and parole, Competence and performance, Etic and emic, Form and substance.

3.1.3 Concepts and Forms

3.1.3.1 Basic concepts in phonetics and phonology: Phonetics vs. Phonology, Phoneme and archiphoneme.
3.1.3.2 Basic concepts in morphology: Morpheme and morphemic processes, Inflectional and derivational processes.
3.1.3.3 Basic concepts in syntax: IC analysis and construction types, Endocentric vs. exocentric constructions, Nominative vs. ergative construction, Phrase structure grammar and transformational grammar.
3.1.3.4 Basic concepts of semantics: Synonymy, Antonymy, Homonymy, Polysemy, Componential analysis.
3.1.4 Language Classification and Language Change: Language families, Genetic, typological and areal classification, Synchronic and diachronic approaches, Types of language change.
3.1.5 Sociolinguistics: the sociology of language, the ethnography of speaking, Language and Culture, Language Contacts, Language Standardization, Language Planning and Language Ideology, Language Politics, language and gender, discourse analysis.

3.2 English

3.2.1 English Language/Literature History
3.2.2 English as a world language
3.2.3 English as an Indian Language
3.2.4 English as a second Language
3.2.5 Indian English Literature
3.2.6 World Literature in English-Australian and Asian
3.2.7 English Science Fiction
3.2.8 Film and Literature-Theory and Adaptation
3.2.9 Diasporic Literature
3.2.10 Women's Literature in English
3.2.11 English Literature and Culture
3.2.12 Indian Literature in Translation
3.2.13 Children's Literature in English
3.2.14 English as a language of Advertisement
3.2.15 New Gender Studies