Syllabus for Ph.D. Entrance Test

COMPUTER SCIENCE ENGINEERING

Section 1: Discrete Mathematics

Set theory, Functions, Relations, Permutations and Combinations, Pigeon-hole principle.

Generating functions, Recurrence relations, Linear recurrence relations with constant coefficients, Homogenous solutions, Particular solutions, Total solutions, Solution by the method of generating functions.

Graph Theory: Basic terminology, Multigraphs and weighted graphs, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, Planar graphs, Trees and rooted trees, Minimal spanning trees, Cut sets, Directed graphs.

Mathematical Logic: Propositions, Connectives, Conditionals and biconditionals, Well formed formulas, Tautologies, Equivalence of formulas, Duality law, Normal forms, Inference theory for propositional calculus; Predicate calculus: predicates, free and bound variables, Inference theory of predicate calculus, Lattices and boolean algebra.

Section 2: Numerical Computing

Solution to Transcendental and Polynomial Equations: Iterative methods, Bisection method, Secant method, Newton-Raphson method, Fixed point iteration, methods for finding complex roots. Matrices and Linear System of Equations: LU decomposition method for solving systems of equations, Symmetric positive definite matrices and least square approximation, Iterative algorithms for linear equations.

Interpolation: Polynomial interpolation, Newton-Gregory, Stirling's, Bessel's and Lagrange's interpolation formula, Newton's divided differences interpolation formulae. Curve fitting: Fitting linear and non-linear curves, Least square approximation.

Numerical Differentiation and Integration: Numerical differentiation and errors in numerical differentiation, Newton-Cotes formulae, Trapezoidal rule, Simpson's rule, Gaussian integration.

Section 3: Modeling and Simulation

Probability: Basic concepts & definitions (Classical & Axiomatic definition), Random variable, Probability density function, Probability mass function, Distribution function and their properties. Systems and environment: Concept of model and model building, Model classification and representation, Use of simulation as a tool, Steps in simulation study.

Various discrete and continuous probability distributions: Uniform (continuous and discrete), Binomial, Negative Binomial, Poisson, Exponential, Erlang, Gamma, Normal, χ^2, t-distribution and F-distribution, Bivariate normal distribution (Marginal and Conditional distributions), Central Limit Theorem, Simple random sampling with and without replacement.

Random Numbers: Properties of random numbers, Generation of pseudo random numbers, Techniques of random number generation: Multiplicative congruential, Linear congruential generators, Tests for randomness, Random variate generation using inverse transformation, direct transformation, Convolution method, Acceptance-rejection technique. Queuing & Inventory Models: Characteristics of queuing systems, Notation, Transient and steady-state behavior, Simulation of queueing and inventory systems.

Section 4: Data Structures

Arrays, Stacks and Queues: Representation of Array (Single & Multi Dimensional Arrays), Representation of Stacks & Queues using Arrays and their Operations, Circular Queues, Conversion from Infix to Postfix and Evaluation of Postfix expressions using Stack.

Linked List: Singly linked list, Linked stacks and queue, Polynomial representation and manipulation using linked list, Circular Linked list and doubly linked list.

Basic Search and Traversal Techniques: Selection sort, Bubble sort, Insertion sort, Quick sort, Heap sort, Merge sort, Shell sort; Depth - First Search, Breadth – First Search.

Trees: BST traversal methods (Preorder, Postorder and Inorder), B- trees: Insertion and Deletion operations.

Section 5: Design and Analysis of Algorithms

Algorithms, Analysis of algorithms, Asymptotic notation, Complexity of algorithms. Divide and Conquer: Binary Search, Finding Maximum and Minimum; String Processing: KMP, Boyre-Moore, Robin Karp algorithms. Greedy Method: Knapsack Problem, Job Sequencing with Deadlines, Optimal Merge Patterns.

Backtracking: 8 - Queens Problem, Sum of Subsets, Hamiltonian Cycles, Knapsack Problem. Dynamic Programming: Multistage Graphs, Optimal Binary Search Trees, 0/1 Knapsack, Reliability Design, Traveling Salesperson Problem.

Non-Deterministic Algorithm: Non-Deterministic Programming Constructs, Simple Non-Deterministic Programs; NP-Hard and NP-Complete Problems.

Section 6: Object Oriented Paradigm

Object Oriented Concepts: Abstraction, Encapsulation, Objects, Classes, Methods, Constructors, Inheritance, Polymorphism, Static and dynamic binding, Overloading.

C++: Identifiers, Variables, Constants, Primitive data types, Expressions, Structured data types, Arrays, Compilers & interpreters, Assignment statement, if then else statements, Switch statement, Looping statements: while, do while, for, break, continue, Input/output statements, Functions/procedures.

Object oriented analysis, design, Unit testing & debugging, System testing & integration, Maintenance.

Section 7: Database Management Systems

Basic Concepts of Database systems: Data modeling for a database, Abstraction and data integration, Three level architecture of a DBMS, Overview of relational, network, hierarchical data models.

Database Design: Entity Relationship model, Extended Entity Relationship model. Relational Model & Relational Data Manipulations: Relation, Conversion of ER diagrams to relations, Integrity constraints, Relational algebra, Relational domain & tuple calculus.

Structured Query Language: DDL, DML, Views, Embedded SQL.

Relational Database Design Concepts: Functional dependencies, Determining keys, Normalization-1st, 2nd, 3rd, BCNF, 4th and 5th, Lossless join and dependency preserving

decomposition.

Section 8: Theory of Computation

Introduction to automata theory: Alphabets, Strings, and languages.

Finite Automata and Regular Languages: Deterministic and non-deterministic finite automata, Regular expressions, Regular languages and their relationship with finite automata, Pumping lemma and closure properties of regular languages; Kleen's Theorem; Finite Automata with output; Minimization of DFA.

Context Free Grammars and Pushdown Automata: Context free grammars (CFG), Parse trees, Ambiguities in grammars and languages, Normal forms: CNF & GNF; Pushdown automaton (PDA) and the language accepted by PDA, Deterministic PDA, Non-deterministic PDA, Properties of context free languages; Normal forms, Pumping lemma, Closure properties, Decision properties.

Turing Machines: Turing machine as a model of computation, Linear bounded automata; Variants of Turing machine and their equivalence. Undecidability: Recursively enumerable and recursive languages, Undecidable problems about Turing machines: Halting problem, Post Correspondence Problem, and undecidability problems about CFGs.

Section 9: Compiler Design

Lexical and Syntactic Analysis: Design of a lexical analyzer generator, Syntactic analysis - design of top down and bottom up parsers.

Syntax directed translation: Top down and bottom up approaches, Data types, Mixed mode expression; Subscripted variables, Sequencing statement, Subroutines and functions: parameters called by address, by name and by value, subroutines with side effects; Code generation, Machine dependent and machine independent optimization techniques.

Section 10: Operating Systems

Introduction to operating systems: Operating System as a resource manager, Operating system classification, System calls, Traps, Architectures for operating systems. Device Management: Goals of I/O software, Design of device drivers.

Processor Management: Process overview, Process states and state transition, Multiprogramming, Multi-tasking, Levels of schedulers and scheduling algorithms; Process Synchronization - Critical section and mutual exclusion problem, Classical synchronization problems, Deadlock prevention; Multithreading.

Memory Management: Classical memory management techniques, Paging, Segmentation, Virtual memory.

File Management: Overview of file management system, Disk space management, Directory structures; Protection domains, Access control lists, Protection models.

Section 11: Systems Programming

8086 Architecture & Assembly Language Programming: Data representation, Instruction formats, Addressing techniques, Segments – Data Segment, Code Segment, Stack Segment,

Memory Segment, Procedures, Input/ Output, Program development in 8086.

Assembler: Macro processor, Macros, Calls, Parameters, Expansion, Design of two-pass assembler. Loaders and Linkers: Loading schemes, Design of absolute and direct linking loaders.

Section 12: Software Engineering

Software Life Cycle Models: SDLC Models, Selection of a Life Cycle Model. Software Requirements Analysis and Specifications: Requirements Engineering, Requirements Elicitation, Requirements Analysis, Requirements Documentation.

Software Project Planning: Size Estimation, Cost Estimation, Models, Constructive Cost Model, Software Risk Management. Software Design: Design Definition, Modularity, Strategy of Design, Function Oriented Design, IEEE Recommended Practice for Software Design Description, Object Oriented Design.

Software Metrics: Software Metrics, Token Count, Data Structure Metrics, Information Flow Metrics, Metrics Analysis. Software Reliability: Basic Concepts, Software Quality, Software Reliability Models, Capability Maturity Model.

Software Testing: Testing Process, Functional Testing, Structural Testing, Levels of Testing, Debugging, Testing Tools. Software Maintenance: Maintenance Process, Maintenance Models, Estimation of Maintenance Costs, Regression Testing, Reverse Engineering, Software Re-engineering, Configuration Management.

Section 13: Computer System Architecture

Basic Building Blocks: Boolean logic and Boolean algebra, Tri-state logic; Flip-flops, Counters, Shift registers, Adders, Substractor, Encoders, Decoders, Multiplexors, Demultiplexors.

Register Transfer and Micro Operations: Bus and memory transfers, Arithmetic, Logic shift micro operations; Basic computer organization: common bus system, instruction formats, instruction cycle, CPU organization, register organization, stack organization, micro programmed control unit RISC architecture; Microprocessor architecture.

Memory Unit: Primary memory, Secondary memory, Associative memory, Sequential access, Direct access storage devices, Virtual & Cache memory.

Input-Output Organisation: Input/Output devices; Data transfer schemes - programmed I/O, interrupt I/O and DMA transfer; Data transfer schemes for microprocessors.

Section 14: Data Communication and Networks

Data Communication Systems: Concept of Data Communication Systems.

Network Reference Models: Local Area Networks, Wide Area network, Layered architectures, Protocol hierarchies, Interface and services: ISO-OSI reference model, TCP/IP reference model, Wireless network, Internetworking. Error Detection & Correction: Framing, Error-control, Flow-control; Sliding window protocol; HDLC; Data link layer of internet.

Switching Techniques: Circuit switching, Message switching, Packet switching, Routing and congestion control. Application Layer: File transfer protocol, Electronic mail, World Wide

Web, SNMP, STTP.

Routing Concepts: Distance Vector Routing-Link State Routing-Inter Domain Routing, Classless Inter-domain Routing, Interior Gateway Routing Protocols, Exterior Gateway Routing Protocol, Border Gateway Protocol. ATM Networks: Routing in ATM Networks, ATM Address Structure, ATM Routing.

Section 15: Distributed Computing

Distributed Operating System: Distributed computing system models, Issues in design of distributed operating system, message passing, Remote procedure calls, synchronization, process management, resource management, distributed file systems.

Distributed algorithms: Synchronous and partial synchronous models, Algorithms in general synchronous leader election, Breadth first search, shortest path randomized algorithms; Asynchronous shared memory model, mutual exclusion, resource allocation, consensus, Asynchronous network model, basic asynchronous network algorithms.

Section 16: Computer Graphics

Development of computer Graphics: Raster Scan and Random Scan graphics storages, Displays processors and character generators, Colour display techniques, Interactive input/output devices.

Points, lines and curves: Scan conversion, Line-drawing algorithms, Circle and ellipse generation, Conic-section generation, Polygon filling anti aliasing.

Two-dimensional viewing: Co-ordinate systems, Windows and Viewport, Linear transformations, Line and polygon clipping algorithms.

Three-dimensional concepts: 3-D representations, Transformations, Perspective and parallel projections, Spline curves and surfaces, Quadtree and Octree data structures; Hidden Surface and hidden - line removal algorithms, Shading modelsand colour models for solid objects.

Section 17: Artificial Intelligence

A.I. Techniques and its characteristics, Problems and problem spaces, Problems as state space search, Production systems, Control Strategies, Heuristic search, Problem characteristics, Production system characteristics.

Problem Solving Methods: Forward versus backward reasoning, Problem trees versus Problem graphs, Knowledge representation and the frame problem, Generate-and-test, Hill climbing, Breadth-First-Search, Problem Reduction, Constraint satisfaction, Means-End analysis.

Game Playing: Minimax search, Alpha-beta pruning, Secondary search.

Knowledge Representation using Predicate Logic: Representing simple facts using logic, Resolution, Conversion to clause form, Resolution in clause form, Unification algorithm.

Section 18: Soft Computing

Fundamentals of ANN: The Biological Neural Network, Artificial Neural Networks, Building Blocks of ANN. ANN Terminologies: Architecture, Setting of Weights, Activation Functions, Mcculloch- Pitts Neuron Model, Hebbian Learning Rule,

Perception Learning Rule, Delta Learning Rule.

Fuzzy System: Fuzzy Sets, Properties and Operations - Fuzzy Relations, Cardinality, Operations and Properties of Fuzzy Relations, Fuzzy Composition; Fuzzy Variables, Types of Membership Functions. Genetic Algorithm (GA): Biological Terminology, Elements of GA: Encoding, Types of Selection, Types of Crossover, Mutation, Reinsertion, Theoretical Foundation: Schema, Fundamental Theorems of GA.

Section 19: Data Warehouse & Data Mining

Data Warehouse: Data warehouses and data marts, metadata in the data warehouse; Defining the business requirement: Dimensional analysis, information packages, requirement-gathering methods; Architecture and Infrastructure: Data warehousing architecture, Architectural framework, Technical architecture, Collection of tools, Infrastructure supporting architecture.

Data Mining: The process of knowledge discovery in databases, Predictive and descriptive data mining techniques, Supervised and unsupervised learning techniques. Techniques of Data Mining: Link analysis, Predictive modeling, Database segmentation, Score functions for data mining algorithms, Bayesian techniques in data mining; Issues in Data Mining: Scalability and data management issues in data mining algorithms, Parallel and distributed data mining, Privacy, Social, Ethical issues in KDD and data mining, Pitfalls of KDD and data mining.

Section 20: Parallel Computing

Introduction to Parallel Computing, Advantages of Parallel Computing; Array Processors, Shared memory multi-processors, Message passing multi-processors, MMC systems; Elementary sorting algorithms; PRAM Algorithms.

Matrix algorithms: Matrix-Vector multiplication, Matrix multiplication, Matrix inversion; Graph algorithms: Mesh algorithm for transitive closure, Searching a Graph, Connected Components, All-paired Shortest Path, Single-source Shortest Path, Minimum- cost Spanning Tree.

Section 21: Information Security

Overview of Security: Protection versus security; Aspects of security–data integrity, data availability, privacy; Security problems, User authentication. Security Threats: Program threats, Worms, Viruses, Trojan horse, Trap door, Stack and buffer overflow; System threats- intruders; Communication threats- tapping and piracy, Intrusion detection.

Cryptography: Substitution, Transposition ciphers, Symmetric-key algorithms-Data Encryption Standard, Advanced encryption standards, Public key encryption - RSA; Diffie-Hellman key exchange.

Digital signatures: Symmetric key signatures, Public key signatures, Message digests, Public key infrastructures.

Section 22: Electronic Commerce

Building Blocks of Electronic Commerce: Introduction, internet and networking technologies, Internet and network protocols, web server scalability, software technologies

for building E-commerce applications, distributed objects, object request brokers, component technology, web services, web application architectures, BizTalk framework Compliant Server.

Security of E-commerce transactions: Review of cryptographic tools, authentication, signatures, observers, anonymity, privacy, traceability, key certification, management and escrow.

Payment protocols and standards: Smart card, e-cash, e-wallet technologies, electronic money and electronic payment systems, business models for electronic commerce, electronic marketplaces, auctions and other market mechanisms, design of auctions, optimization algorithms for marketplaces, multi-agent systems.