CISE Ph.D. Qualifying Exam Syllabus
Algorithms and Theory Area

Textbooks

1. Cormen, Leiserson and Rivest, Algorithms
2. Horowitz, Sahni and Rajeshekaran, Computer Algorithms
3. Sipser, Introduction to the Theory of Computing

Relevant Courses

COT 5405
COT 6315

A. Algorithms

1. Algorithm Analysis - Asymptotic Order of Growth notation, Complexity Classes, Amortized Analysis, Recurrence Relations

2. Algorithm Design Techniques - Greedy Algorithms, Divide and Conquer Dynamic Programming, Heuristic Search (Branch and Bound, A*), Randomized Algorithms

3. NP Completeness - Polynomial Time Verification, Reducibility, Approximation Algorithms

4. Selected Topics - Sorting and Order Statistics (Heapsort, Quicksort, Radix Sort, Bucket Sort, Selection), Graph Algorithms (BFS, DFS, Strong Connectivity, Minimum Spanning Tree, Single Source Shortest Paths, All Pair Shortest Paths, Maximum Flow), String Matching Algorithms (RK, KMP, BM algorithms), Computational Geometry (Line Segment Intersection, Convex Hull, Closest Pair of Points), Algebraic Algorithms (Strassen Matrix Multiplication, Boolean Matrix Multiplication, Matrix inverses, DFT, FFT)

B. Theory

1. Finite State Automata (deterministic and nondeterministic) and Regular Languages and their properties including closures and pumping lemma

2. Push Down Automata (deterministic and nondeterministic) and Context Free Languages and their properties including closures and pumping lemma

3. Decidable and Undecidable Sets, Recursively Enumerable Sets, co-R.E. sets, their properties and relationships including Rice's theorem, Closures, Diagonalization, many-one and Turing reductions and completeness.

4. Deterministic and Nondeterministic time bounded complexity classes, their properties and relationships including closures and hierarchy theorems. Specifically, the classes P, NP, and co-NP, many-one and Turing reductions Cook's theorem, completeness. Polynomial time approximability and inapproximability of NP-complete sets.

5. Randomized time bounded complexity classes of different types: Las Vegas vs. Monte Carlo; one-sided versus two-sided error, bounded vs. unbounded error etc. Specifically, the classes RP, co-RP, BPP, ZPP and PP, their relationships and basic properties including probability amplification, use of

pseudorandomness and derandomization.

6. Deterministic and Nondeterministic space bounded complexity classes, their properties and relationships including hierarchy theorems, Savitch's theorem and closure under complementation.

7. Basic knowledge of special topics including: Kolmogorov complexity, Goedel's incompleteness theorem, complexity lower bounds, parallel computation and corresponding complexity classes, circuit complexity, communication complexity, interactive protocol based complexity classes, alternative models of computation, their relationships and basic properties.