Theory Qualifying Exam Syllabus

Suggested Reading List:

Topics:
1. Basic Concepts
   A. Proof techniques: direct, mathematical induction, proof-by-contradiction
   B. Sets, functions, relations, equivalence relations and equivalence classes
   C. Strings and languages
   D. Countability and enumerability

2. Finite Automata (FA) and Regular Languages (RL)
   A. DFA, NFA, FA with epsilon transitions
   B. NFA to DFA conversion
   C. Regular expressions (RE)
   D. Relationship between DFA’s and RE’s
   E. Algebraic laws of RE’s
   F. Pumping lemma for and closure properties of RL’s
   G. Decision properties of RE’s
   H. Equivalence and minimization of automata
   Reading: HMU – Chapter 2, Chapter 3 and Chapter 4; SIPSER – Chapter 2

3. Context-Free Languages/Grammars (CFL/CFG) and Pushdown Automata (PDA)
   A. Parse trees and parsing
   B. The language and properties of a PDA
   C. Equivalence of PDA’s and CFG’s
   D. Deterministic PDA’s
   E. Normal forms for CFG’s
   F. The pumping lemma for and closure properties of CFL’s
   G. Decision properties of CFL’s
   Reading: HMU – Chapter 5, Chapter 6 and Chapter 7; SIPSER – Chapter 3
4 Turing Machines (TM’s)
   A. Definitions of and notions for various Turing machines
   B. Extensions of TM’s (e.g., multi-tape, equiv. of one-tape and multi-tape TM’s
   C. Non-deterministic TM’s (NTM’s) and running time of various simulations
   D. Restricted TM’s (e.g., multistack TM’s, counter machines, etc)
   E. Relations (and power) among DFA’s, PDA’s and TM’s
   Reading: HMU - Chapter 8; SIPSER – Chapter 3

5 Computability
   A. Church-Turing Thesis and its meaning
   B. Encoding of TM’s
   C. Diagonalization
   D. Undecidable languages (or problems)
   E. Recursive and recursively enumerable languages
   F. Universal machines
   G. Many-one reducibility
   H. Important theorems: the s-m-n theorem, recursion and fixed point theorems, various
      forms and extensions of Rice’s theorem, and the isomorphism theorem
   I. Other equivalent systems/models: the RAM model, Post systems, Thue systems
      and Lambda calculus.
   J. Oracles and Turing reducibility
   Reading: HMU – Chapter 9; SIPSER – Chapter 4, Chapter 5 and Chapter 6

6 Computational Complexity
   A. Classes P, NP and NP-complete
   B. Polynomial reduction of NP-complete problems
   C. NP-complete problems
   D. Classes co-NP and co-NP-complete
   E. Classes NSPACE, NTIME, PSPACE, NPSPACE, P-complete and
      PSPACE-complete
   F. Classes NL and NC
   G. Relations among the above mentioned classes
   Reading: HMU – Chapter 10, and Section 11.1, 11.2 and 11.3; SIPSER – Chapter 7 and
      Chapter 8