COMP36111: Advanced Algorithms I
Lecture 11: How to Pass the Examination

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2017–18
• Basic graph algorithms
  • directed and undirected graphs
  • DFS (depth-first search)
  • reachability
  • connectedness
• Strongly connected components of directed graphs
  • finding a topological sort of a dag
  • Tarjan’s algorithm
• Connected components of undirected graphs
  • union-find
  • optimizations
  • running time
• Matching and flow optimization
  • Flow networks
  • The Min-cut-max-flow theorem
  • How to compute optimal flows
  • Application to the marriage problem
• Stable marriage problem
  • Gale-Shapley algorithm
  • running-time
  • correctness
  • optimality (for boys!)

• String matching
  • Rabin-Karp
  • Knuth-Morris-Pratt

• Linear programming
  • Problem definition
  • Geometrical analysis
  • The simplex method (bounded cases, feasible)
  • The integer-case (ILP)
• Turing machines and complexity
  • Definition of Turing machines
  • Definitions of recursive, recursively enumerable (r.e.)
  • The existence of a universal TM and simulations
  • Undecidability of the halting problem
  • Time and space complexity (deterministic, non-deterministic)
  • Complement classes
  • The time-bounded halting problem and $\text{P} \neq \text{ExpTime}$

• Propositional satisfiability
  • Basic propositional logic
  • The problem SAT
  • The Davis-Putnam algorithm
  • The problem $k$-SAT
  • The problem Horn-SAT
  • Phase-transition phenomena (high-level description only)
• Reductions, completeness and hardness
  • Many-one polynomial-time/log-space reductions
  • Transitivity of many-one log-space reductions
  • Cook’s Theorem (Cook-Levin Theorem)
  • 3-SAT is NP-hard
  • 2-SAT (KROM-SAT) is (co-) NLogSpace-hard.

• Hard graph-theoretic problems
  • 3-colourability is $\text{NPTIME}$-hard
  • Hamiltonian and Eulerian circuits
  • The travelling salesman problem
• Two important theorems
  • Savitch’s Theorem (both forms)
  • The Immerman-Szelepcsényi Theorem (both forms)
  • Configuration graphs for Turing machines

• The standard complexity hierarchy
• Reading:
  http://studentnet.cs.manchester.ac.uk/ugt/2017/COMP36111/syllabus/

• Past exam papers:

Note that the syllabus may vary slightly from year to year.