Honors Algorithms
Alan Siegel

Main Text: An Insider’s Guide to the Design and Analysis of Algorithm by Siegel and Cole. We also cover the first 3.5 chapters from Intro. to Theory of Computation by Sipser.

Supplementary texts that you may wish to read:
Algorithms by Dasgupta, Papadimitriou, and Vazirani,
A Guide to the Theory of NP-Completeness by Garey and Johnson,
Intro. to Theory of Computation by Sipser,
and
Data Structures and Network Algorithms by Tarjan.

Topics

Recurrence equations
Recursion trees, plus pointers to the general theory of difference equations.

Sorting
Standard sorting algorithms with fairly detailed analyses. Includes Paige-Tarjan Lexicographic Sorting with applications.

Search and Advanced Data Structures
Heaps, Fibonacci heaps, Enhanced Dictionaries, Universal Hashing, Union-Find (limited analysis only), Prioritized Search Trees, Splay Trees (if time permits).

Adaptive BFS and Path Algorithms
Shortest Path (Floyd-Warshall, Dijkstra), path recovery, problem reductions and transformations.
Includes an advanced study of applications such as VLSI switch-level simulation, and methods to adapt these basic algorithms to a wide variety of different problems.
MST (Prim, Kruskal).

DFS (Connectivity, Biconnectivity, and Strong Connectivity)
Implicit combinatorial search.
Tarjan’s algorithms, Sharir’s Strong Connectivity Algorithm.
Includes a detailed analysis of the design decisions that went into these algorithms.

Lower Bounds
We present four basic lower bounds, but cover the issues by example as opposed to a systematic development of the subject.

Algorithmic paradigms and applications
Dynamic Programming, Greedy algorithms, Divide-and-Conquer, Backtracking (if time permits). Illustrative examples and applications.

Randomization
Hashing, polynomial identity testing, and additional applications (as time permits).

NP-Completeness
Cook’s Theorem and reductions.

Theory of computation
Finite automata and regular language (Sipser) (ch 1)
PDAs and CFLs (ch 2)
Decidability (ch 3-4).
Homework

Homework will be assigned every week. Over the course of the semester, about 150 problems will be assigned. More than half of the exercises will be quite challenging.