

COSC3101 Design and Analysis of Algorithms (Winter 2004)

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Syllabus and References Last updated: Feb 12, 2004

READINGS:

- **HTA:** Edmonds' notes - How to Think about Algorithms.
- **Sd:** Edmonds' class slides.
- **LN:** Mirzaian's on-line Lecture Notes. You are expected to read each of these.
- **CLRS:** Cormen, Leiserson, Rivest, and Stein. You are expected to read selected topics as needed. Chapter references are with respect to the new edition. In brackets are the same for the old edition. Some remaining parts of this book are studied in the sequel course COSC4101/5101/6121.
- **Strictly Optional Readings**, designed to provide breadth and application examples for interested students, are indicated by *italics* and curly braces {}.

I: RELEVANT MATHEMATICS (6 hours):

- General course description (LN0).
- Overview of algorithmic design (LN 1; CLRS1).
- Asymptotic notations and their properties (HTA 1.3; Sd; LN1; CLRS 3, [2])
- Time complexity analysis of algorithms (HTA 1.4; Sd; LN 1; CLRS 2, [1]).
- Summations: arithmetic, geometric, harmonic (HTA 1.5; Sd; CLRS A, [3]).
- Recurrence Relations (HTA 1.6; Sd; LN 2; CLRS 4, [4]).
- **References:** [CLRS01, PWZ96, GKP94, SeF96, GrK81, Ros00].

II: CENTRAL ALGORITHMIC TECHNIQUES (4 hours):

- Loop invariants for iterative algorithms (HTA 3, 4; Sd).
- Mathematical induction (HTA 3.7, 5.4; Sd).
- Recursive algorithms, the divide and conquer method (HTA 5, 6; Sd; CLRS 2.3, 33.4, [1, 33.4]).
- Examples:
 - Operations on integers (HTA 6.1.2, 6.1.3; CLRS 31.1,31.2, {*CLRS 28.2,30,31.3-31.7*}, [31.2, 32, 33]).
 - Algorithms for trees (HTA 6.2; Sd).
 - Recursive images (HTA 6.3; Sd).
- **References:** [CLRS01, Man89, AHU74].

III: SORTING and SELECTION (6 hours):

- Review basic sorting algorithms (HTA 3.3; Sd).
- Randomized QuickSort and Selection and their expected running times (HTA 6.1.1; Sd; LN 2; CLRS 7, [8]).
- Selecting the k-th smallest item (HTA 6.1.1; LN 4; CLRS 9, [10]).
- Heap sort and priority queues (HTA 7.1; CLRS6, [7]).
- Special sorting algorithms: CountingSort, BucketSort, RadixSort (HTA 7.2; CLRS 8, [9]).
- Lower bound on sorting (HTA 7.3; LN 3; CLRS 8.1, [9]).
- **References:** [CLRS01, BoG00, AHU74, AHU83, Koz92, Man89, Knu73, Meh84a].

IV: ALGORITHM DESIGN TECHNIQUES (8 hours)

- Greedy Methods (HTA 10; LN5; CLRS 16, [17]).
- Dynamic Programming (*{HTA 11, 12}*; LN6; CLRS 15, [16]).
- **References:**
[CLRS01, NeN98, BoG00, AHU74, HoS78, Koz92, Hu82, BrB88, BrB96, Man89, MoR95, Hoc97, Ski97, BK OS00, ORo94].

V: GRAPH ALGORITHMS (9 hours)

- Review definitions and graph terminology (HTA 2.2, 4.6.5; CLRS B, [5]).
- Breadth-First-Search (BFS) and shortest paths (HTA 8.1, 8.2; CLRS 22.2, [23.2]).
- Depth-First-Search (DFS) (HTA 8.4, 11.2.4; CLRS 22.3, [22.3]).
- Dags and topological sorting (HTA 8.5; CLRS22.4, [23.4]).
- Strongly connected components [Hopcroft-Tarjan, Kosaraju-Sharir] (LN 7; CLRS 22.5, [23.5]).
- Minimum Spanning Trees [greedy algorithms: Kruskal, Prim] (HTA 10.2.3; CLRS 23, [24]).
- Single Source Shortest Paths [Bellman-Ford, Dijkstra] (HTA 8.3; CLRS 24, [25]).
- All Pairs Shortest Paths [dynamic programming: Floyd-Warshall, Johnson] (HTA 12.2.7; CLRS 25, [26]).
- Network Flow and Matching [Ford-Fulkerson, Edmonds-Karp] (HTA 9; CLRS 26, [27]).
- **References:**[CLRS01, AHU74, Eve79, Hu82, Har72, Tar83, Meh84b, vanL90, Knu93, Koz92, HaR90, BeW78, Tut84, Ski97].

VI: SELECTED TOPICS (3 hours)

- NP-completeness (HTA 13.3.2; Sd; CLRS 34, [36]).
- **References:** [CLRS01, GaJ79, Hoc97, AHU74, Koz92, Man89, Meh84b, vanL90].

REFERENCES: [Books marked with a * contain selected exercise solutions.]

- [AHU74] A.V. Aho, J.E. Hopcroft, and J.D. Ullman, *The Design and Analysis of Computer Algorithms*, Addison-Wesley (1974).
- [AHU83] A.V. Aho, J.E. Hopcroft, and J.D. Ullman, *Data Structures and Algorithms*, Addison-Wesley (1983).
- [BeW78] L.W. Beineke and R.J. Wilson (editors), *Selected Topics in Graph Theory*, volume 1 (1978), volume 2 (1983), volume3(1988), AcademicPress.
- [BoG00] S. Baase, A. Van Gelder, *Computer Algorithms: Introduction to Design & Analysis*, 3rd edition, Addison Wesley (2000).
- [BrB88] G. Brassard and P. Bratley, *Algorithmics: Theory & Practice*, Prentice Hall (1988).
- [BrB96] G. Brassard and P. Bratley, *Fundamentals of Algorithmics*, Prentice Hall (1996).
- [BKOS00] M. de Berg, M. van Kreveld, M. Overmars, and O.Schwarzkopf, *Computational Geometry: Algorithms and Applications*, Springer-Verlag, second edition(2000).
- [CLRS01] T.H. Cormen, C.E. Leiserson, R.L. Rivest, and C. Stein, *Introduction to Algorithms*, second edition McGraw-Hill & MIT Press (2001).

- [Eve79] S. Even, *Graph Algorithms*, Computer Science Press (1979).
 - [GaJ79] M.R. Garey, and D.S. Johnson, *Computers and Intractability: A Guide to the Theory of NP Completeness*, W.H. Freeman and Company (1979).
 - [GKP94] R.L. Graham, D.E. Knuth, and O. Patashnik, *Concrete Mathematics*, Addison-Wesley (second edition) (1994). *
 - [GrK81] D.H. Greene, and D.E. Knuth, *Mathematics For The Analysis of Algorithms*, Birkhauser (1981). *
 - [HoS78] E. Horowitz, and S. Sahni, *Fundamentals of Computer Algorithms*, Computer Science Press (1978).
 - [HaR90] N. Hartsfield and G. Ringel, *Pearls in Graph Theory*, Academic press (1990).
 - [Har72] F. Harary, *Graph Theory*, Addison-Wesley (second edition) (1972).
 - [Hoc97] D.S. Hochbaum (Editor), *Approximation Algorithms for NP-Hard Problems*, PWS Publishing Company (1997).
 - [Hu82] T.C. Hu, *Combinatorial Algorithms*, Addison-Wesley (1982).
 - [Knu69] D.E. Knuth, *The Art of Computer Programming, VOL I: Fundamental Algorithms*, Addison-Wesley (1969). *
 - [Knu73] D.E. Knuth, *The Art of Computer Programming, VOL III: Sorting and Searching*, Addison-Wesley (1973). *
 - [Knu93] D.E. Knuth, *The Stanford GraphBase -- A Platform for Combinatorial Computing*, Addison-Wesley (1993).
 - [Koz92] D.C. Kozen, *The Design and Analysis of Algorithms*, Springer-Verlag (1992). *
 - [Man89] U. Manber, *Introduction to Algorithms: A Creative Approach*, Addison-Wesley (1989). *
 - [Meh84a] K. Mehlhorn, *Data Structures and Algorithms 1: Sorting and Searching*, Springer-Verlag (1984).
 - [Meh84b] K. Mehlhorn, *Data Structures and Algorithms 2: Graph Algorithms and NP-Completeness*, Springer-Verlag (1984).
 - [MoR95] R. Motwani, and P. Raghavan, *Randomized Algorithms*, Cambridge Univ. Press (1995).
 - [NeN98] R. Neapolitan, and K. Naimipour, *Foundations of Algorithms*, second edition, Jones and Bartlett Pub. Comp. (1998).
 - [ORo94] J. O'Rourke, *Computational Geometry in C*, Cambridge University Press (1994), (second edition, 1998).
 - [PWZ96] M. Petkovsek, H.S. Wilf, D. Zeilberger, *A=B*, A.K.Peters, Ltd., 1996.
 - [Ros00] K.H. Rosen (editor-in-chief), *Handbook of Discrete and Combinatorial Mathematics*, CRC Press, 2000.
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 - [Ski97] S. Skiena, *The Algorithms Design Manual*, Telos/Springer-Verlag, ISBN0-387-94860-0 (1997).
 - [Tar83] R.E. Tarjan, *Data Structures and Network Algorithms*, CBMS 44, SIAM monograph (1983).
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 - [vanL90] J. van Leeuwen (editor), *Handbook of Theoretical Computer Science, Volume A: Algorithms and Complexity*, The MIT Press (1990).
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