

CS6204 (Semester 1 (Fall) 1999)
Combinatorial and Graph Algorithms

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Course Web: www.comp.nus.edu.sg/~cs6204/Comb-Alg/

Objectives:

- presents ***advanced*** design and analysis of algorithms,
- emphasizes ***efficient*** algorithms and data structures,
- practical use of ds&alg in advanced software dev.

Target Students:

- those doing *advanced research in computer science*,
- those doing *research in algorithm design*,
- those doing *advanced appl/software development*.

Prereq: CS1102 Data Structures and Algorithms
CS3230 Analysis of Algorithms (preferred)
Or consent of instructor.

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Combinatorial and Graph Algorithms**Textbook and Materials:**

No one single text book. Materials comes from a few books ([CLR90], [Tarj83], [SKD83]) and some papers.

Grading:	40%	<i>Homework Assignments,</i>
	20%	<i>Programming Assignments/Project</i>
	40%	<i>Final Exam (Open Book)</i>

Homework: (40%)

About 4-5 homework sets altogether -- 1 every 2-3 weeks.

Programming Assignments/Project: (20%)

- About 3-4 assignments in all (from easy to interesting)
- Prog. assignments will use LEDA -- An advanced C++ Lib. of Data Structures and Algorithms.

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Combinatorial and Graph Algorithms****Good Texts in this Area :**

- [CLR90] *Introduction to Algorithms*,
Cormen, Leiserson, and Rivest, MGH, (1990)
- [Tar83] *Data Structures and Network Algorithms*,
Robert E. Tarjan, SIAM, 1983.
- [PS85] *Computational Geometry: An Introduction*,
Preparata & Shamos, SV, (1985)
- [Liu68] *Introduction to Combinatorial Mathematics*,
C. L. Liu, MGH, (1968)
- [RND77] *Combinatorial Algorithms: Theory & Practice*,
Reingold, Nievergelt & Deo, PH, (1977)
- [NiHi93] *Algorithms & Data Structures*
(with appl to graphics & geometry),
Nievergelt & Hinrichs, PH, (1993)
- [SKD83] *Discrete Optimization Algorithms with Pascal Programs*,
Syslo, Kowalik & Deo, PH, (1983)
- [PS82] *Combinatorial Optimization: Algorithms & Complexity*,
Papadimitriou & Steiglitz, PH, (1982)

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The course will cover most of these material.

A. ADVANCED DATA STRUCTURES

- ✧ **Heaps** and Graph Algorithms: *Shortest Path and MST*
(Ch. 6 of [Weiss92]; Ch. ?? of [CLR], Ch. 3 of [Tar83])
- ✧ **Leftist Heaps** and $O(m \lg \lg n)$ MST Alg.
(Ch. 3 & 6 of [Tar83]; pp. 149-153, 159 of [Knu73])
- ✧ Amortized Analysis and **Binomial Heaps**
(Ch. 18 & 20 of [CLR])
- ✧ Route Planning: F-Heaps & Fast Shortest Path Alg.
(Chapter 21 of [CLR], [FrTa87])

B. COMBINATORIAL ALGORITHMS

- ✧ Maximum Matching: Algorithms and Applications
(Ch. 11 of [PTW]; Ch. 10 of [PS82])
- ✧ Network Flow Problems: Algorithms and Applications
(Ch. ?? of [CLR], Ch. ?? of [??])

C. NP-COMPLETENESS

- ✧ NP-completeness: Cook's Theorem, Reduction
(Ch. 9 of [RND]; Ch. 1-3 of [GJ])
- ✧ Approximation Algorithms
(Ch. 4.3 of [RND], Part of Ch. 4&5 of [LLRS])

D. LOCAL SEARCH ALGORITHMS

- ✧ Exhaustive and Local Search Methods
(Ch. 4 of [RND])
- ✧ **CASE STUDIES:** Graph Partitioning, Port Berth Allocation, Rectangle Packing, Network Design.

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Background Knowledge

(Assumed or to be aquired "on-the-fly")

Data Structures:

Stacks, Queues, Lists,
Binary search trees, balanced trees,
Heaps and priority queues

Algorithm Design Paradigms

Standard sorting and searching algorithms
Graph algorithms: DFS, BFS,
Dijkstra's SP alg, MST Algorithms
Greedy Algorithms, Divide-and-Conquer

Analysis of Algorithms

Big-O notations,
Sample Analysis:
Quicksort, DFS, BFS, Divide-and-Conquer alg.

Alternatively, see that you have mastered the following Chapters from the text [CLR90] (including the analysis of their running times):

- Chapters 2-6 Mathematical Foundations
- Chapters 8-14 Basic Data Structures
- Chapters 23-25 Graph Algorithms

Otherwise:

Talk to instructor (case-by-case)