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

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

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.
Good Texts in this Area:

[CLR90] Introduction to Algorithms, Cormen, Leiserson, and Rivest, MGH, (1990)


[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)


The course will cover most of these material.

A. **ADVANCED DATA STRUCTURES**
   - **Heaps** and Graph Algorithms: Shortest Path and M ST
     (Ch. 6 of [Weiss92]; Ch. ?? of [CLR], Ch. 3 of [Tar83])
   - **Leftist Heaps** and $O(m \log \log n)$ M ST Alg.
     (Ch. 3 & 6 of [Tar83]; pp. 149-153, 159 of [Knu73])
   - **Amortized Analysis** and **Binomial Heaps**
     (Ch. 18 & 20 of [CLR])
     (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.
Background Knowledge
(Assumed or to be acquired "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)