Algorithm Design and Analysis

This is a one semester course

COURSE TITLE	Algorithm Design and Analysis
LECTURER(S)	Dominik Scheder
ASSISTANT	Liu Zhengyang
TEXTBOOKS	*Algorithms* by Sanjoy Dasgupta, Christos Papadimitriou, and Umesh Vazirani

AIMS & OBJECTIVES

Contents of this class are: Classical algorithms and algorithmic design paradigms (e.g. divide and conquer, greedy algorithms, dynamic programming); maximum flow and minimum cut; Linear programming (duality, simplex, applications). We will also discuss some important data structures and how to use them in algorithms. Depending on the time frame, we will teach more advanced topics like randomized, approximation, exponential, and streaming algorithms.

We will devote ample time to: (i) the path from a basic idea to the final algorithm; (ii) proofs of correctness; (iii) running time analysis.

Goals: Deep understanding of the mathematical strcuture underlying the algorithms we treat in class. Ability to apply learned methods and paradigms to new problems.

TEACHING METHOD Lectures and homework assignments.

RELATION TO OTHER COURSES

This course will extend the knowledge and abilities which the students have acquired in courses on data structures and programming.

PREREQUISITES

Basic calculus, linear algebra, programming.

COURSE OUTLINE

Fall Semester 2015

1. **Classical algorithmic paradigms**
   1.1 Divide and Conquer
   1.2 Greedy algorithms
   1.3 Dynamic programming
   1.4 Incremental algorithms: Prim's algorithm for Minimum Spanning Tree. Dijkstra's shortest path algorithm.
2. **Flow Algorithms**
   2.1 Networks with capadicites. Definition of network flows, cuts.
   2.2 Residual networks, augmenting paths.
   2.3 Duality: Max Flow Min Cut theorem
   2.4 A polynomial time algorithm for Max Flow..
   2.5 Algorithms for Min Cut
3. **Linear Programming**
   3.1 Definitions, examples. Modeling Max Flow as a linear program.
   3.2 The dual of a program. Weak duality.
   3.3 Strong duality, Farkas lemma.
   3.4 Simplex algorithm.
   3.5 Application to game theory: Zero-sum games and von Neumann's Minmax Theorem.

4. **Advanced Topics**
   4.1 Randomized algorithms.
   4.2 Approximation algorithms.
   4.3 Exact exponential algorithms.
   4.4 Streaming algorithms.