COMP 221– Design and Analysis of Algorithms

Department of Mathematics and Computer Science
Macalester College

What?

This course serves as an in-depth introduction to the study of algorithms, with emphasis on principles of design, mathematical analysis (both for performance and correctness), abstract problem structure, and the match between problem structure and algorithm structure. Topics include the design and analysis of algorithms (including recursive and parallel algorithms), algorithmic paradigms (divide and conquer, greedy, backtracking, dynamic programming, branch and bound), methodology (induction, structural features, analysis methods, verification), problem classes (optimization, searching, sorting), combinatorial and graph algorithms, algebraic and geometric algorithms, and introduction to complexity classes.

Why?

This is not a course on programming techniques. We look at problems at a conceptual level, to help us understand how to match an algorithmic technique to a problem of interest, and to use knowledge to verify that our approach is correct. Further, we use analysis techniques to gain an understanding of how efficient our approach is for solving the problem of interest. Excellent programming skills are necessary to succeed in this endeavor, but beyond that, we need to apply conceptual knowledge beyond the level of simple statements in programming languages. Much of our problem solving involves learning from the solutions of other problems and applying that knowledge to the current problem of interest, and thus part of the theme of this course is to gain competence in the reading of the professional literature.

Projects/Examples

In recent years the project aspect of this course has involved the development of a portfolio of algorithms. Each student prepares a portfolio which contains a selection of algorithms, each of which is discussed from 3 or more of the following perspectives: discussion of its algorithmic principles and/or problem structure (paradigm), formal analysis, formal correctness, implementation, thorough testing, relationship to other algorithms, applications. The topics for the algorithms come from the problem domains of sorting, combinatorial optimization, graph search, graph algorithms, number theoretic algorithms (e.g. as arising in cryptography), Fast Fourier Transform for digital signal processing, and approximation algorithms for "hard problems.