Combinatorial Optimization

SUAMI 2015

Syllabus

Time and place: Monday through Friday, 1:30–3:00 p.m., in Wean Hall 7218.

Textbook: Christos H. Papadimitriou and Kenneth Steiglitz. *Combinatorial Optimization: Algorithms and Complexity.* Dover, 1998. ISBN 978-0-486-40258-1.

Recommended supplementary books (on reserve at the Sorrells Engineering and Science Library circulation desk, Wean Hall 4400):

- Bernhard Korte and Jens Vygen. *Combinatorial Optimization: Theory and Algorithms.* Springer, fifth edition, 2012. ISBN 978-3-642-24487-2. (Second edition is on reserve.)
- Dieter Jungnickel. *Graphs, Networks and Algorithms.* Springer, fourth edition, 2013. ISBN 978-3-642-32277-8. (Third edition is on reserve.)
- Paul E. Fishback. *Linear and Nonlinear Programming with Maple: An Interactive, Applications-Based Approach.* CRC Press, 2009. ISBN 978-1-420-09064-2.

Web page: `http://www.math.cmu.edu/~bkell/suami2015/`

Instructor: Brian Kell

E-mail: `bkell@cmu.edu`

Office: Wean Hall 6211

Office hours: Monday through Friday, 12:30–1:30 p.m. and 3:00–4:00 p.m., or by appointment. Feel free to stop by at other times; I'll be happy to meet with you if I'm in.

Teaching assistant: Michael Druggan, `michaeldruggan@gmail.com`

Objectives

This course is an introduction to the field of combinatorial optimization, which, in a nutshell, is the study of problems that involve a search for the "best" option among a (usually finite) set of choices. The meaning of "best" and the set of available choices depends on the problem to be solved. For example, the set of choices might be the possible production schedules of a factory, satisfying various constraints on resources, and the "best" choice might be the production schedule that yields the greatest profit. Or perhaps a salesperson has a list of cities to visit, so the set of choices consists of all possible routes among the cities that visit each city exactly once; the "best" choice may then be the route that minimizes total travel distance, or travel time, or cost.

Combinatorial optimization is therefore a very broad field. In this course we will focus on the following topics:

- linear programming and the simplex algorithm;
- integer programming;
- graphs and graph algorithms;
- "hard" problems, heuristics, and approximations; and
- computational complexity and the P vs. NP question.

We will discuss computational techniques and algorithms as well as theoretical foundations. Maple will be used as a platform for computation.

A student who successfully completes this course will be able to:

- recognize many types of combinatorial optimization problems;
- formulate linear and integer programs, and identify when a problem can be viewed in terms of various "standard" combinatorial optimization problems;
- understand the mathematical concepts underlying these problems and their solutions;
- solve combinatorial optimization problems using algorithms and mathematical software; and
- analyze the performance of simple algorithms, understand and interpret computational complexity, and reduce one problem to another.

Evaluation

This course is officially 21-470 section H, "Selected Topics in Analysis: Combinatorial Optimization," in the CMU course register.

Problem sets will be given on Thursdays and Mondays and will be due on the following Monday or Thursday (i.e., a problem set given on Thursday will be due the following Monday, and a problem set given on Monday will be due the following Thursday). There will be approximately 11 problem sets over the six weeks. Collectively these problem sets will count for 50% of your course grade.

Near the midpoint of the course (probably Thursday, June 18), a take-home midterm exam will be given instead of a problem set. This exam will count for 20% of your course grade. Even though it is a take-home exam, the midterm is an individual assessment; no collaboration with other students will be allowed.

At the end of the course, we will have an in-class written final exam. This exam will be comprehensive and will count for 30% of your course grade.

Your final course grade will be determined according to the following scale.

If you get at least this percentage:	90%	80%	70%	60%
Then you are guaranteed at least this grade:	A	B	C	D

Expectations

You are welcome and encouraged to collaborate with other students on the problem sets. It is often more fruitful and enjoyable to work with other people when trying to figure something out. They can give you a different perspective or fresh insight on the problem. Conversely, explaining one of your ideas to another person forces you to clarify your thoughts and can help to highlight flaws you may have previously overlooked. However, if you work with others to come up with a solution, afterward you should go away and write it up on your own, so that you are certain that you understand the solution. You should not see the solutions that another student will be handing in, and you should not show your final written solutions to other students. Remember:

Working with other students to figure out the problems is acceptable.

Working with other students to write the solutions is NOT acceptable.

When you do collaborate with other students, please acknowledge your partners in your submitted solutions. Also provide references to any sources other than the textbook (if any) that you used. Always give credit where credit is due; proper attribution of credit is one of the foundations of academic research.

Please familiarize yourself with the Carnegie Mellon Statement on Academic Integrity and the Policy on Academic Integrity:

- `http://www.cmu.edu/student-affairs/theword/acad_standards/integrity.html`
- `http://www.cmu.edu/policies/documents/Academic%20Integrity.htm`

I will be happy to answer any questions you may have about academic integrity.

Accommodations

Some students qualify for special accommodations due to various needs. If you are such a student, please let me know as soon as possible, and I will do my best to assist you. In addition, please contact the CMU Office of Disability Resources at `access@andrew.cmu.edu`.