CS 538 — Combinatorial Optimization
Syllabus version 2
Final except for unforseen circumstances and/or correcting typos

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1 Course Summary

Welcome to CS 538 Combinatorial Optimization. This is a theoretical computer science graduate course. CS 538 can be seen as a counter-part to CS 535 (Design and Analysis of Algorithms). While CS 535 is concerned with very fast algorithms (frequently via advanced data structures) for rather easy problem (such as Minimum Spanning Tree), CS 538 is concerned with harder problems (such as Graph Matching) for which we are satisfied to obtain polynomial-time algorithms. There will be rigorous analysis of the algorithms as well.

As for practical applications, most useful optimization problems fall in the "hard" category. We will cover modeling of problems as linear and integer programs and learn how to use existing tools to solve such problems. If linear programming is applicable, we can solve very large size instances; with integer programs we can frequently solve moderate-sized instances. For truly hard problem (so called *NP-Hard*, covered in CS 530) we study approximation algorithms, for which we prove that they are polynomial-time and produce near-optimal solutions.

2 Textbook

There is no required textbook. The lecture notes linked from the web of the class are closest to what will be covered in class.

Reference (optional) book are *Linear Programming* by Howard Karloff, *Data Structures and Algorithms* by R.E. Tarjan, *Combinatorial Optimization* by Korte and Vygen (the latter the edition the better; this has the best bang-for-buck ratio), *Network Flows* by Ahuja, Magnati, and Orlin, *Combinatorial Optimization* by Cook, Cunninghm, Pulleyblank, and Schrijver, and *Combinatorial Optimization* by A. Schrijver (the most comprehensive). These books, together with *Approximation Algorithms* by Vazirani, are the source of my knowledge and cover all the topics you'll see in the class.

3 Prerequisites

CS 430 and a linear algebra course are listed as prerequisite. Familiarity (or a desire and ability to learn) mathematical proofs is also necessary.

4 Lecture Format

I will use posted notes and prove the theorems, as well as provide examples. Best is if you follow and ask questions for clarifications during the class. Taking detailed notes does not help much.

5 Getting Help

Office hours are Monday and Wednesday 2-3 in room SB 228D, or by appointment. For an appointment send e-mail to `calinescu@iit.edu`. You can also call me at 312-567-5273. I will also be on Blackboard Collaborate during office hours. Please spend a little time trying to understand yourself a homework problem before asking for help.

Handouts (including this syllabus, homeworks, and the project) will be available at `http:// www.cs.iit.edu/~cs538`. Some solutions may be posted on blackboard.

Students are expected to check email every week day of the semester. Clarifications on assignments or other important announcements may be sent by email - and will also be posted on the web page.

6 Grading

The grading allocation is given below.

Homework	50%
Midterm	20%
Final exam	30%

The midterm exam will be on October 19. I plan for an in-class exams if possible. Those unable or unwilling to attend will log into Blackboard/Zoom/Google Meet and work on paper and scan their answer. The final exam will be in the Dec. 7-12 week, as scheduled by the registrar. Again, a "real-time" (in-class as much as possible) is planned. The exams will be closed books and closed notes - except for my handouts which you should print and bring. In-class exams may contain modified homework problems or ask for proofs from the class.

Five homeworks will be assigned to be solved individually and submitted via blackboard. Seek help from me if you are having difficulties with the homework. Except for extraordinary circumstances, homeworks will be accepted at latest one week late. The penalty for late submission is 10% for one lecture late and 20% for one week late.

The final grades will be assigned by comparison to the students who took this class in previous semesters. In a total of five semesters, there were 24 A's, 56 B's, five C's, an two E's of which one did no show up for the final exam. As a guideline, about 80% will be needed for an A, 60% for a B, and 40% for a C.

Standard departmental policy regarding academic (dis)honesty applies. This includes
`https://web.iit.edu/student-affairs/handbook/fine-print/code-academic-honesty`

In particular, homework solutions copied from the Internet are not allowed. If I have evidence that the work submitted is not your own, I will assign a score of zero on that particular assignment at the first occurence. This happened many times in my classes, including Spring 2020. The incident may also be reported to `academichonesty@iit.edu`. The second occurence will be reported and an appropiate sanction will be applied after consultation with the office of the Associate Provost for Academic Affairs.

Whenever in doubt, ask first if some action is allowed or not. Moreover, the students must submit the signed College of Science Academic Integrity Pledge together with the first homework.

Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources and make an appointment to speak with me [the instructor] as soon as possible. The Center for Disability Resources (CDR) is located in Life Sciences Room 218, telephone 312-567-5744 or `disabilities@iit.edu`.

7 Topics to be covered

1. Matching and weighted matching in bipartite and general graphs
2. Solving maximum flows, minimum-cost flows
3. Linear programming- geometry of LP's, Simplex Method, complementary slackness
4. Modeling and Integer Linear Programming
5. Polynomial-time algorithm for Linear Programming: the ellipsoid method
6. Matroids (time permitting)
7. Approximation Algorithms (occasionally, when easy to obtain from exact algorithms)