CS 595 — Special Topic: LP-based Approximation Algorithms
Preliminary Syllabus Version 1.1

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1 Course Summary

Welcome to CS 595 Linear-Programming-based Approximation Algorithms, a theoretical computer science graduate course. Many optimization problems, both of practical and theoretical importance, are NP-hard. For NP-hard optimization problems, there is no hope of designing efficient (i.e., polynomial-time) algorithms giving the exact solution. One way of dealing with NP-Hard optimization problems is to find polynomial-time approximation algorithms. These algorithms are guaranteed to be fast and to return a near-optimal answer. Two very succesful methodologies for approximation algorithms use Linear Programming: LP-rounding and the Primal-Dual schema.

In this class we design and analyze such algorithms using these two methodologies. with most of the time spent on analysis (proving the *approximation ratio* of the algorithm). We define the *approximation ratio* (sometimes called *performance ratio* or *approximation guarantee*) of an algorithm A for a minimzation problem Π to be to be the infimum, over all inputs I of problem Π, of $A(I)/Opt(I)$. The closer to 1, the better the approximation ratio.

2 Textbook

The required textbook is *Introduction to Algorithms* (third edition) by Cormen, Leiserson, Rivest, and Stein, MIT Press, 2009. ISBN-10: 0262033844 — ISBN-13: 978-0262033848 It should be available at the bookstore, and the library has a copy on reserve (available only inside the building).

Our library has on-line access to the third edition of this book:
from `http://http://www.gl.iit.edu/database/database.htm` look for Books 24x7, login and search for "Cormen".

Reference (optional) books are *Computers and Intractability* by M. R. Garey and D. S. Johnson, and *Approximation Algorithms* by V. J. Vazirani. One can also google "williamson shmoys pdf" to get another (free) textbook.

3 Prerequisites

CS430 and either CS538 or MATH435 or MATH535 are the prerequisites, or consent of instructor. In particular, the following topics of the textbook are assumed and can appear on homeworks and

exams:

1. Mathematical Background (Appendices A, B, C.1, D)

2. Pseudocode and Notations (Chapters 1 and 2)

3. Greedy Algorithms (Chapter 16)

4. Dynamic Programming (Chapter 15)

5. Graph Algorithms: BFS, DFS (Chapter 22 except 22.5), Minimum Spanning Trees (Chapter 23), Shortest Paths - the Floyd-Warshall algorithm (Subchapter 25.2)

Familiarity with mathematical proofs is also necessary.

4   Getting Help

Office hours are TBD 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. Please spend a little time trying to understand yourself a homework problem before asking for help.

The handouts (including this syllabus and homeworks) will be available at www.cs.iit.edu/~calinesc/cs595.html.

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

5   Grading

The grading allocation is given below.

Homework	60%
Final exam	20%
Presentations	20%

There will be no midterm. The final exam will be take-home and individual, due in the week of Dec 5-10.

Four homeworks will be assigned (the questions will specify if team work is allowed). 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.

Each student, possibly in a team, will be asked to make a presentation of a (part of a) research paper. Proofs will be required.

Standard departmental policy regarding academic (dis)honesty applies. This includes https://www.iit.edu/student-affairs/student-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 report to `academichonesty@iit.edu` and make a decision in consultation with the Designated Dean for Academic Honesty. In the past, this likely meant zero points on the specific problem and a record in the Dean's database, for the first occurence, Whenever in doubt, ask first if some action is allowed or not.

6   Administrative Matters

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`.

Illinois Techs Sexual Harassment and Discrimination Information:
Illinois Tech prohibits all sexual harassment, sexual misconduct, and gender discrimination by any member of our community. This includes harassment among students, staff, or faculty. Sexual harassment of a student by a faculty member or sexual harassment of an employee by a supervisor is particularly serious. Such conduct may easily create an intimidating, hostile, or offensive environment.

Illinois Tech encourages anyone experiencing sexual harassment or sexual misconduct to speak with the Office of Title IX Compliance for information on support options and the resolution process.

You can report sexual harassment electronically at `iit.edu/incidentreport`, which may be completed anonymously. You may additionally report by contacting the Title IX Coordinator, Virginia Foster at `foster@iit.edu` or the Deputy Title IX Coordinator at `eespeland@iit.edu`.

For confidential support, you may reach Illinois Techs Confidential Advisor at (773) 907-1062. You can also contact a licensed practitioner in Illinois Techs Student Health and Wellness Center at verb+student.health@iit.edu+ or (312)567-7550

For a comprehensive list of resources regarding counseling services, medical assistance, legal assistance and visa and immigration services, you can visit the Office of Title IX Compliance website at `https://www.iit.edu/title-ix/resources`.

7   Topics to be covered

1. Introduction to LP and Duality

2. Set Cover (greedy methods via Dual Fitting, and via LP-rounding)

3. Vertex Cover via LP-rounding

4. Set Cover via Primal-Dual schema

5. Separating points by axis-parallel lines

6. Multicut and Integer Multicommodity Flows in Trees

7. Max-SAT via LP-rounding, and Pipage Rounding

8. Multiway Cut

9. Multicut in General Graphs

10. Zero-Extension

11. Sparsest Cut

12. Energy Optimal Task Scheduling

13. Register Loading

14. Steiner Forest via Primal-Dual schema