Syllabus
Applied Mathematics and Statistics 550.666
Combinatorial Optimization
Spring, 2017

Description The main goal of this course is to introduce students to combinatorial optimization techniques. The first part of the course will focus on combinatorial algorithms for classical problems. The next part of the course will show how polyehdral theory can be used to deal with combinatorial optimization problems in a unifying manner. The final part of the course will introduce the use of semidefinite optimization and matroid theory.

Prerequisites
No formal prerequisites. Familiarity with the basic notions of the following will be helpful.
Linear Algebra (EN.550.291 or AS.110.201 or AS.110.212)
Graph Theory (EN.550.472 or EN.550.672)
Probability (EN.550.420 or equivalent)

Instructor
Amitabh Basu, `basu.amitabh@jhu.edu`, `http://www.ams.jhu.edu/~abasu9/`
Office: Whitehead 202A, 410-516-4883
Office hours: Mondays 4–6 pm and by appointment. Email me to schedule an appointment outside the listed hours. Office hours will be in the instructor's office: Whitehead 202A.

Teaching Assistant
Gaoran Yu, `gyu9@jhu.edu`
Office hours: Gaoran's office hours are on ~~Thursdays, 2:30–4:30p~~ Wednesdays, 7–9 pm in Whitehead 212.

Meetings
Lectures: Tuesday, Thursday, 4:30–5:45 pm, Gilman 377.

Textbook
Required: Combinatorial Optimization by Cook, Cunningham, Pulleyblank, Schrijver; 1st edition; ISBN 978-0-471-55894-1.

Other useful textbooks (but not required):
Integer Programming by Conforti, Cornuejols, Zambelli; ISBN 978-3-319-11007-3. Online access from Springer from within campus.
Theory of Linear and Integer Programming by Alexander Schrijver; 1st edition; ISBN 978-0-471-98232-6.

Online Resources
Course webpage: `http://www.ams.jhu.edu/~abasu9/AMS_550-666_Spring17.html`
Blackboard will be used for posting grades.

Course Objectives
The main goal of this course is to introduce students to combinatorial optimization techniques.

Course Topics

PART I: Combinatorial algorithms for classic discrete optimization problems

(1) Quick Overview of flow problems : Maximum flow, Minimum Cut, Minimum cost flow, Multicommodity flows
(2) Matching theory:
    - Matchings and alternating paths
    - Tutte-Berge formula
    - Maximum cardinality matchings : Bipartite matching via flow, Edmond's blossom algorithm

PART II: Polyhedral Combinatorics : A unifying approach to combinatorial optimization

(1) Basic polyhedral theory
(2) Linear Programming :
    - Quick overview of duality, algorithms for LP
    - Equivalence of optimization and separation
(3) Integer Programming :
    - Totally unimodular matrices (TUM), Total Dual Integrality (TDI)
    - Cutting plane theory
    - Branch and bound, branch and cut algorithms
(4) Application of linear and integer programming theory to problems discussed in Part I

PART III: Other techniques for Combinatorial Optimization

(1) Semidefinite Optimization
(2) Matroid Theory

A detailed lecture-by-lecture schedule or topics can be found here: `http://www.ams.jhu.edu/~abasu9/AMS_550-666/schedule-2017.html`.

Course Expectations & Grading
There will one take home Midterm and an in-class 3 hour Final exam. In addition, there will be weekly GRADED homework assignments.

In addition, there will be regular (approx. weekly) homework assigments. You will be asked to hand in some of the HW problems which will be graded (approximately every two weeks). Seriously attempting ALL the homework problems is imperative for your success in the class, and they will give an indication of the kind of problems on the tests. The HW problems will appear here on the course webpage: `http://www.ams.jhu.edu/~abasu9/AMS_550-666_Spring17.html`.

Key Dates
The Midterm will be posted on the course webpage by Friday, March 10, 2017 by noon. It will be due back the following Tuesday, March 14, 2017 at the beginning of class.

Final Exam will be open book. It will be in class on Monday, May 15, 2017 from 2-5pm.

Assignments & Readings
See the course webpage: `http://www.ams.jhu.edu/~abasu9/AMS_550-666_Spring17.html` for HW assignments.

Ethics

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In addition, the specific ethics guidelines for this course are:

(1) You may discuss HW problems with your fellow classmates. However, you have to write your own final solutions without looking at anyone else's solutions.

(2) MIDTERM RULES:
- You are not allowed to discuss any problem with another human being (this includes your classmates, of course), except Dr. Basu.
- You can use a computer only as a word processor; in particular, you cannot consult the internet in regards to this midterm. You CAN use any other resource like the textbook, your notes, books from the library.
- You CAN cite any result we have mentioned <u>in class</u> or from the HWs without proof. If you cite a result (e.g., from a book) that was NOT mentioned in class, you should include a complete proof of this fact.

(3) FINAL RULES:
- You are not allowed to discuss any problem with another human being (this includes your classmates, of course), except Dr. Basu.
- You can use a computer only as a word processor; in particular, you are not allowed to access the internet during your final. You CAN use any other resource that you bring with you to the final like the textbook, your notes, HW solutions, books from the library.
- You CAN cite any result we have mentioned <u>in class</u> or from the HWs without proof. If you cite a result (e.g., from a book) that was NOT mentioned in class, you should include a complete proof of this fact.

Report any violations you witness to the instructor.

You can find more information about university misconduct policies on the web at these sites:

- Undergraduates: `e-catalog.jhu.edu/undergrad-students/student-life-policies/`
- Graduate students: `e-catalog.jhu.edu/grad-students/graduate-specific-policies/`

Students with Disabilities

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Student Disability Services, 385 Garland, (410) 516–4720, `studentdisabilityservices@jhu.edu`.

ABET Outcomes

- Ability to apply mathematics, science and engineering principles.
- Ability to identify, formulate and solve engineering problems.
- Understanding of professional and ethical responsibility.
- Ability to communicate effectively.