IEM 6053 Integer and Combinatorial Optimization

Syllabus for Spring 2020

Class Hours: TR 12:30–1:45pm
Classroom: 305 Engineering North

Instructor: Austin Buchanan
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Office Hours: TBD

Course Description: Theory, algorithms, and applications of discrete optimization. Binary, pure, and mixed-integer linear optimization formulations, relaxations; preprocessing, branch and bound, formulation strength, polynomial equivalence of separation and optimization; theory of polyhedra, convex hulls and facets, valid inequalities for pure and mixed-integer problems, lifting, perfect formulations, extended formulations. Previously offered as IEM 6023. Prerequisite(s): Concurrent prerequisites. IEM 5063, IEM 6033, or consent of instructor.

Texts: Conforti, Cornuéjols, and Zambelli, *Integer Programming*, Springer, 2014. (A modern take on IP)
Free PDF here: http://link.springer.com/book/10.1007%2F978-3-319-11008-0
Jeff Linderoth's slides: http://homepages.cae.wisc.edu/~linderot/classes/ie418/index.html

Other References: Wolsey, *Integer Programming*, Wiley, 1998. (Accessible)
Nemhauser and Wolsey, *Integer and Combinatorial Optimization*, Wiley, 1999. (Comprehensive)
Schrijver, *Theory of Linear and Integer Programming*, Wiley, 1998. (Highly mathematical)

Announcements: I will post many things on the course website, including homeworks, class notes, project descriptions, and links to interesting websites. Please check it and your okstate.edu e-mail address daily!

Evaluation Procedure:
◇ Homework 20%
◇ Projects 30% (10% for Project 1 and 20% for Project 2)
◇ Midterm 25%
◇ Final 25%
Final grades scale (tentative): 90-100% A, 80-90% B, 70-80% C, 60-70% D, $< 60\%$ F.

Class Policies:

1. *Final exam shall be held at the time listed in the official schedule.* It is your responsibility to make sure that you will be available to take the final exam at the said time. No exceptions will be made, and a make-up for the finals will be offered only under *extenuating circumstances* (such as medical reasons), and only if permitted by the university.

2. All tests will be comprehensive up to a specified topic although emphasis will be on newer material. No make-ups will given for the tests unless prior arrangements have been made with the instructor, and a written *authorized* excuse is provided. The validity of the excuse will be determined by the instructor. If a test is missed due to an emergency, inform the instructor as early as possible.

3. Homework assignments and projects are to be completed individually. You are allowed to discuss the class material pertinent to assignment questions with your class mates, but you *should not* share your solution with another person. When in doubt, avoid discussion and contact the instructor for help. Specific instructions will be provided with each assignment.

4. Homeworks will be collected at the *start of class* on the due date and will be considered *late after start of the class*. Late submissions *will not be accepted* for grading. Contact the instructor at least 2 days in advance if you are not able to meet the deadline, or within 2 days from the deadline if unforeseen circumstances forced the delay. Decision to give full/partial/no credit will be made by the instructor.
5. No disagreement on a score received on any graded material will be entertained 5 working days after the date it was returned.
6. Academic misconduct or dishonesty in any form will be dealt with severely in this course. The instructor will impose the maximum possible penalty permitted by the University system.
7. Please review the syllabus attachments for information on academic integrity, and resources made available by OSU student disability services. Information is also available online at: `http://academicintegrity.okstate.edu/` and `http://sds.okstate.edu/`.

Date		**Tentative topic**	**Chapter/Note**
Jan	14	What good is IP? What is an IP?	Bixby slides
	16	Formulating IPs	CCZ-2
	21	Formulating IPs	CCZ-2
	23	Formulating IPs	CCZ-2
	28	Branch-and-bound (bounding, valid disjunctions, pruning)	CCZ-1.2.1
	30	Branch-and-bound (bounding, valid disjunctions, pruning)	CCZ-1.2.1
Feb	4	Branch-and-bound (node selection)	Lind L4, L5
	6	Comparing alternative formulations	Wolsey-1.6
	11	Cutting plane method and the separation problem	CCZ-1.2.2, Dey slides
	13	Gomory Fractional Cuts	CCZ-1.2.2, Dey slides
	18	Ellipsoid method and "optimization=separation"	CCZ-7.5
	20	Branch-and-cut	CCZ-1.2.3, Rubin blog post
	25	Preprocessing (redundant constraints, coefficient tightening)	Savelsbergh paper
	27	Preprocessing (variable fixing)	Savelsbergh paper
Mar	3	Logical Inequalities and Conflict Graphs	Wolsey-8.1, 8.2, Atamtürk paper
	5	**MIDTERM**	One page of handwritten notes
	10	Convex hulls and Meyer's Theorem	CCZ-3.5,4.8
	12	*No class*	AMS conference
	17	*No class*	Spring Break
	19	*No class*	Spring Break
	24	Chvátal-Gomory (CG) cuts; CG rank; CG closure	Wolsey-8.3, CCZ-5.2
	26	Mixed Integer Rounding (MIR) cuts	Wolsey-8.7, CCZ-5.1.5
	31	Split/disjunctive cuts	CCZ-5.1
Apr	2	Gomory Mixed Integer (GMI) cuts	CCZ-5.3
	7	Minimal descriptions; facets; dimension; aff. independence	Wolsey-9.2, CCZ-3.7-9, Lind-L11
	9	Direct facet proofs (e.g., clique inequalities for ind. set)	Lind-L12
	14	Generating facets by lifting (e.g., knapsack covers)	Lind-L15, CCZ-7.1,7.2, Wolsey-9.3
	16	Perfect formulations and their characterizations	Wolsey-9.2.3, CCZ-4.1
	21	Total unimodularity and total dual integrality	Wolsey-3.2, CCZ-4.2,4.6
	23	Example perfect formulations (in original space)	CCZ-4.3,4.4, Lee-4.2
	28	Example perfect formulations (in extended space)	Kaibel survey, Wolsey-1.7
	30	More extended formulations and extension complexity	CCZ-4.9, Fiorini (JACM)
May	5	**FINAL EXAM** (10:00-11:50am, cumulative)	Two pages of handwritten notes