Optimization Models and Applications

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1. Course Information

Meeting Times: Tuesdays and Thursdays, 9.20am-10.40am
Location: 413
Prerequisites: ISE 220 or equivalent

2. Scope of the course

Optimization problems arise very often in Industry, and the ability to solve them is a competitive advantage. However, modeling an Optimization problem requires special tools and skills. A problem that is not understood or modelled correctly can lead to the wrong solution or can be very difficult to solve.

The purpose of this course is to provide you with the tools and knowledge necessary to model practical Optimization problems and solve them efficiently. We will see how to properly formulate a problem, how to choose an adequate solver, and how to solve practical applications with state-of-the-art solvers.

3. Course Logistics

3.1 Textbook

There are several books on Modeling and Optimization, and I don't think there is an overall best. No book in particular is required, and any of the following will be sufficient for the course:

- Select chapters of *Introduction to Operations Research* by F.S. Hiller and G.J. Lieberman, McGraw-Hill: New York, NY, 1990;
- Select chapters of *Introduction to Mathematical Programming: Applications and Algorithms* by W.L. Winston and M. Venkataramanan;
- Select chapters of *Operations Research: Applications and Algorithms* by Wayne L. Winston, PWS-Kent Pub. Co., 1991.

The modeling language is described in "AMPL: A Modeling Language for Mathematical Programming" by Robert Fourer, David M. Gay, and Brian W. Kernighan.

3.2 Modeling Tools

During the course I will use **Excel Solver** and **AMPL**, but you are allowed to use whatever language you prefer. Two alternatives are GAMS and Mosel. The latter has a good manual that also serves as an introduction to modeling. Both AMPL and Mosel have student versions that can be downloaded for free. They are limited to a maximum of 300 constraints and variables, but this is more than enough for most of this course. Problems formulated in AMPL or GAMS can be solved by submitting the model at

`http://neos.mcs.anl.gov/neos/`

Many solvers can be used for free, and with no limits on the number of constraints and variables.

3.3 Homework

There will be several homework, and **all must be completed to receive a grade for the course**. These require modeling and solving simple problems. The problems are stated in informal language, and your task is to translate them into a model in any of the above language, solve them, and do some extra work involving other tools of the language. Homework will be penalized for each day they are late. After solutions are released, they will not be accepted. No exceptions. Also, no exception to the no-exception rule.

3.4 Case Studies

An essential part of this course is a hands-on experience on real Optimization problems. As for the homework, **it must be completed to receive a grade.**
Groups of three-four people study an Optimization problem, propose a model and solve it using a tool of their choice. The result is a short report on the whole experience.There will be an informal discussion after the beginning of the study and another after the report is due. Possible topics are:

- Network design;
- Obnoxious location;
- Portfolio Optimization;
- Signal processing;
- Chemical engineering;
- Mechanical engineering;
- Electric and Computer Engineering;
- Logistics and Scheduling.

3.5 Evaluation

Homework	25%
Quiz #1	20%
Quiz #2	25%
Case study	20%
Class participation	10%

4. Policies for the Course

- You are expected to arrive on time, turn your cell phone off, refrain from reading the newspaper, refrain from text-messaging the rest of the world, and stay in class for the duration of the lecture. Students who need to leave early should notify me ahead of time.
- Each homework in the course must be completed on its due date. Homework are due at the beginning of class. Late homework will be heavily penalized.
- Collaboration between students is allowed, but each student has to write up his or her own solutions to the problems. Students also have to write on their homework the name of the people they have collaborated with. Students can collaborate with at most two other students on their homework.
- Any kind of cheating in any part of the course will be severely sanctioned and might result in disciplinary action.
- Regular attendance is required for the lectures. You should let me know in advance if you are going to be absent for a job interview, an athletic event, a religious holiday, a field trip, or any other good reason. Being sick is a good reason too, but you need to email me.
- If you plan to miss the lecture on a day where an assignment is due, you should make arrangements ahead of time so that your assignment is turned in on or before the due date. You are very strongly discouraged to miss a quiz.
- The lectures will be a lot more enjoyable if you participate.
- You are expected to check the course webpage regularly.
- Taping lectures, and specifically audio recording, is illegal in Pennsylvania without the prior consent of **all parties** in attendance.

5. Topics Covered in the Course

1. Introduction: Optimization models: variables, constraints, objective functions. Convexity and convex relaxations.
2. Linear Programming: Linear Programming models, graphical solution, sensitivity analysis. Network models.
3. Integer Programming: Modeling with integer and binary variables. Logical constraints and binary variables.
4. Nonlinear Programming: Nonlinear models, KKT conditions.
5. Robust Optimization. Duality, uncertainty models.
6. Stochastic Programming: Two-stage optimization, multi-stage optimization.
7. Multi-criteria Programming: Optimizing with many objective functions, Pareto-optimal solutions.

6. Other

6.1 Accommodations for Students with Disabilities

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

6.2 The Principles of Our Equitable Community

Lehigh University endorses The Principles of Our Equitable Community (http://www4.lehigh.edu/diversity/principles). We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.