SYLLABUS - MATH 4/5794: Optimization Modeling
Spring Semester - 2011

January 18, 2011
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Supplemental Text: Model Building in Mathematical Programming – 4th Edition by H. Paul Williams,
John Wiley & Sons Ltd, 1999.
Office Hours: Tuesdays 10:45 – 11:45am* 643 CU Bldg
Wednesdays 4:00 – 5:00pm 643 CU Bldg
Thursdays 2:15 – 3:15pm 643 CU Bldg
Other times by arrangement, * Except on optimization seminar
Tuesdays, in which case 2:15pm-3:15pm will be the office hours. I
will announce when these days are as soon as they are known.

Students with Disabilities: If you have a disability that requires accommodation in this course, please
see me as soon as possible. I am happy to make appropriate accommodations, provided timely notice is
received.
Cell Phones: Please turn off your cell phones prior to entering the classroom. This is especially
important when coming in for exams.

PROPOSED (Tentative) COURSE OUTLINE
The proposed outline is the initial guess of the topics that will be fruitful to investigate. We will not have
time to finish all topics. Some of the items you will read for yourself.

1. Introduction (Chapters 1 and 3 of Schrage and notes)
   a. Preliminaries
   b. Introductory Examples
2. General Mathematic Modeling Issues (Notes and Chapters 1-2 of Williams)
3. Software (Read Chapter 2 of Schrage and your text’s disk as well as various manuals)
   a. MATLAB Optimization Toolbox
   b. Excel – LP/NLP
   c. LINGO/LINDO
   d. C-Plex
4. Optimization Modeling Issues (Chapters 4-5 of Schrage, Chapters 3-11 of Williams)
   a. Model Formulation
   b. Validation
   c. Model Understanding
   d. Redundancy and Infeasibility
   e. Algorithms
   f. Modeling Languages (GAMS, TOMLABS, AMPL, MODLER)
   g. Model Equivalence
5. Linear Programming Model Template Types (Our text and notes)
   a. Product Mix (Chapter 6 of Schrage)
   b. Covering, Staffing, Cutting Stock (Chapter 7 of Schrage)
   c. Network, Distribution and PERT/CPM (Chapter 8 of Schrage)
   d. Multi-period Planning Problems (Chapter 9 of Schrage)
   e. Blending of Input Materials (Chapter 10 of Schrage)
6. Optimization Model Types (Our text and notes)
a. Static
   i. Linear
   ii. Non-linear
   iii. Integer, mixed-integer (Chapter 11 of Schrage)
   iv. Uncertainty (Chapter 12 of Schrage and Notes)
      - Stochastic
      - Flexible
      - Generalized uncertainty
b. Dynamic (Notes)
   i. Dynamic Programming
   ii. Calculus of Variation
   iii. Optimal Control

7. Topics (If we have time)
   a. Portfolio Optimization (Chapter 13 of Schrage)
   b. Heuristics (Notes)
      i. Genetic Algorithms
      ii. Simulated Annealing
      iii. Tabu Search
   c. Multi-Criteria Optimization (Chapter 14 of Schrage)

MY APPROACH TO TEACHING
I believe that teaching is a process that involves an active partnership. My role is that of a guide to your learning. We will endeavor to discover how we mathematically know within the structure of this course. If we have a mathematical problem, it is because we don’t know its solution. If we knew the solution, we would not have a problem. Thus, when we “solve” the problem, how do we know the answer we obtain is the solution to our problem? Thus to know mathematically (mathematical epistemology) is a central component of my teaching approach. This means that I believe it is important to know how one obtains the solution to a mathematical problem. Thus, it is imperative that you demonstrate the process by which you arrive at a solution, that is, you are to demonstrate knowledge of mathematics by articulating how you obtained the correct solution. Mathematical modeling in general and optimization modeling in particular is a process of discovery. So, this semester will be a process of discovery.

OUTCOMES
By the end of the semester you should be able to read, understand and apply appropriate methods associated with aspects of optimization modeling we’ve studied this semester to correctly solve associated problems. Secondly, given a problem in optimization modeling, you should be able to: (i) translate the description of the problem into a (useful) mathematical model, (ii) choose and apply the appropriate software method(s), (iii) obtain the correct solution(s), and (iv) (correctly) interpret and display results. Lastly, by the end of the semester you should be able to judge, for yourself, the veracity of statements made in the areas of our study.

EVALUATION
The following are components that will be evaluated.
1. Literature Review - annotated bibliography (2%)
2. Assignments – four problem sets (32% - each of the four worth 8%)
3. Two in-class exams, one midterm (10%) and one comprehensive final (20%)
4. Project – optimization model (30%)
5. Attendance at two Optimization Seminar Series (6% – each of the two seminars is worth 3%)
   Optimization Seminar talks are held on alternate Tuesdays, 11:00am – 12 noon, Room 626 or Room 656 (I will try to announce the venue and topic but you can link to it from the Math Dept
web site to find the location and topic of the talk). If you cannot make the seminars because of conflict in schedule, please see me for an alternative.

I do give +/- unless your school does not recognize +/- grades in which case I grade without +/-.

A  = 94%-100%  B+ = 88%-90%  C+ = 78% - 80%  D+ = 68% - 70%
A  = 94%-100%  B  = 84%-87%  C  = 74% - 77%  D  = 64% - 67%
A- = 91%-93%  B- = 81%-83%  C- = 71% - 73%  D- = 60% - 63%
F  less than 60%

** Graduate students will have extended content, be expected to have a deeper understanding, and be held to higher standards. There will be also be two types of exams – one for undergrads and one for grads.

Note: If your school does not recognize plus/minus, then an A is 92.6% to 100%, B is 82.6% to 92.5%, C is 70% to 82.5%, D is 60% to 69.9% and an F is less than 60%.

IMPORTANT DATES

Note: Problem sets will be due one week after we finish the associated topics

** Project proposal – February 4th
** Project approval and assignment 1 due – February 11th
** Project division of labor – February 18th
** Literature review, annotated bibliography and Assignment 2 due – March 4th
** Progress report 1 – March 8th
** Midterm – March 17th
** Spring break – March 21-25
** Progress report 2 and assignment 3 due – April 8th
** Assignment 4 – April 29th
** Project Reports – May 6th
** Final Exam – May 10th or May 12th

** General advice: Keep all materials that I turn back in case you think I have not credited you with the points you earned. I can only correct your score if you have what I have turned back to you. It is a good idea to xerox anything that you turn in just in case I lose what you turn in. Please check to make sure that the points you earned are the points I have recorded. The statistics that I have read about correctness of professors in grading and recording grades state that there is a 6% error rate. Please make sure that I have correctly graded and recorded your points.

** Advice on exam taking: Some exams may be longer (or more demanding or both) to what you are accustomed. Thus, it is wise (imperative) for you take exams as follows. Do all the problems you can do first. Don't waste too much time on making sure that you have done your arithmetic correctly since arithmetic mistakes are usually discounted at half a point per mistake unless your arithmetic mistake totally trivializes the problem in which case the deduction will be severe. That is, you should work on generating the most number of points per unit of time.

** POLICIES

** Drops and incomplete grades: See Spring 2011 CLAS Academic Policies (see below) for the relevant dates with respect to dropping this course. The incomplete policy of the Mathematics Department and the College of Liberal Arts and Sciences is strictly enforced. Incomplete grades are given only in situations in which a student who has been in good standing all semester, is prevented from completing a course assignment (for example the final exam) due to circumstances beyond her/his control (for example, hospitalization, jury duty, revised job assignments, death in the family).

** Missing Examinations: If you miss a test for acceptable reasons and we have met before the test and
agreed that indeed this is the case you will be given a make-up exam. You are to take the final exam on the given date. If you have more than two final exams on date of our final, this will have to be resolved at least one week in advance of our final exam. There are cases where an exam is missed without your being able to notify me ahead of time. These will be exceptional cases and we can work these out as long as your reasons are legitimate.

**Legitimate Reasons:** Legitimate reasons for missing tests, assignments, projects, or due dates are for situations beyond your control. You may be required to produce official, signed documentation. If you are needed in a wedding, for example, you must talk to me prior to the (blessed) event. If you are legally arrested, then this is not a legitimate excuse. For matters that are within your control, the general rule is that it is not excused. However, talk to me prior to the event.

**INSTRUCTIONS FOR LITERATURE REVIEW**

You are to review at least five sources that are relevant to your project. This material needs to be at the level of an upper-level undergraduate or graduate-level. That is, upper-level textbooks, on-line sites, mathematical journals, operations research journals, or other relevant journals are what is expected. If you are in doubt about the level, please see me. Each reference should be written (one page max/min) containing:

1. Synopsis of the content (two paragraphs max),
2. Evaluation as to the relevance and/or importance of the content toward your project (one paragraph),
3. How you are going to use the material in your project (one paragraph).

**PROGRESS REPORTS**

Use a maximum of 1 page to convey the following:

1. Where your project is with respect to your division of labor?
2. What problems you have encountered? How did you or how are you planning to resolve these problems?
3. How you have modified your project from your original proposal?

**INSTRUCTIONS FOR PROJECTS**

A project consists of:

1. **Proposal** – A formal written proposal is to be submitted for my approval. A proposal must contain:
   a. Title
   b. Team Membership
   c. The optimization problem – description of the problem
   d. Data – what data is needed, how are you going to obtain and process the data?
   e. The methods and software you will be using to solve the problem
   f. Tasks and subtasks associated with the problem assigned to team members

2. **Division of labor** – Once the project is approved, the tasks and subtasks you have identified in your project proposal need to be given associated due-dates with the person(s) responsible for carrying out the tasks identified. This needs to be written up and submitted to me.

3. **Software** – Each project will likely have associated software development. If the project does not have a software component, this section will be modified according to the project proposal. The components of the software development are:
   a. Code - the actual computer implementation of the project. Attention must be paid to efficiency, readability and portability.
   b. User interface – the way information is passed to the software must be compelling to the client.
   c. Data and inputs
d. Execution - the algorithm as run must correctly perform what it was designed to do.

e. Output - relevant, clear display of solution (tables, graphs, images).

f. Ease – ease of use.

g. Documentation – an in-line and hardcopy of the documentation on how to use the software needs to be written. Moreover, help files must be part of the software.

4. Testing – each project must have a test data set and the optimization model must run on the test data. Part of the test data is for debugging and verifying that the algorithm is working correctly. Other data is gathered to solve the specific project problem.

5. Written Report (see below)

FINAL PROJECT REPORT: Each person will need to submit a final report. This will be done in MS-Word or PDF. Note: If you submit your final report (or any report) in an email attachment, make sure the attachment is ONE file. Please zip as one attachment if what you submit contains multiple files. The final report will (subject to modifications we uncover) consist of:

1. Introduction
2. Project
   a. Theoretical foundations – theory, application, algorithms
   b. Software – description
   c. Results – solutions, limitations and improvements

3. Opportunities for further research
4. Conclusions
5. Bibliography
6. Appendices
   a. Source code
   b. Test problems and data
   c. Documentation

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Spring 2011 CLAS Academic Policies

The following policies pertain to all students and are strictly adhered to by the College of Liberal Arts and Sciences (CLAS).

- Every student MUST check and verify their schedule prior to the published drop/add deadlines in the student portal. Failure to verify a schedule is not sufficient reason to justify a late add or drop later in the semester. It is the student’s responsibility to make sure that their schedule is correct prior to the appropriate deadlines.

- CLAS students must use their email.ucdenver.edu email address. Email is the official method of communication for all University of Colorado Denver business. All email correspondence will take place using your UCDenver email address. Go to http://www.ucdenver.edu/student-services/resources/registrar/students/policies/Pages/EmailPolicy.aspx to activate your email address.

- Students are NOT automatically added to a course off a wait list after wait lists are dropped. If a student is told by a faculty member that they will be added off the wait list, it is the responsibility of the student to complete the proper paperwork to add a course.

- Students are not automatically notified if they are added to a class from a wait-list. Again, it is the responsibility of the student to verify their schedule prior to any official dates to drop or add courses.

- Students must complete and submit a drop/add form to make any schedule changes. Students are not automatically dropped from a class if they never attended, stopped attending or do not make tuition payments.
- Late adds will be approved *only* when circumstances surrounding the late add are beyond the student’s control and can be documented independently. This will require a petition and documentation from the student. Please note that the signature of a faculty member on an add form does not guarantee that a late add petition will be approved. Petitions for undergraduates are available in NC 4002 and for graduate students in NC 5012.
- Late drops will be approved *only* when circumstances surrounding the late drop have arisen *after* the published drop deadlines, are beyond the student’s control, and can be documented independently. This will require a petition and documentation from the student. Pre-existing circumstances (circumstances that existed prior to the published drop deadlines) regarding illness, work, family, or other confounding issues will not be considered adequate reason to drop or withdraw from courses after the published University and/or College drop deadlines. Please note that the signature of a faculty member does not guarantee that a late drop petition will be approved. Petitions are available in NC 4002 for undergraduates and NC 5012 for graduate students.
- **Undergraduate students wishing to graduate in spring of 2011** must complete the online intent to graduate and meet with their academic advisor by census date to obtain a graduation application. This application must be completed and submitted by 5 PM on **February 2, 2011**. You can obtain an application ONLY after meeting with your academic advisor. **There are no exceptions to this policy or date.**
- **Graduate students wishing to graduate in spring semester 2011** must complete their Intent to Graduate form and have a Request for Admissions to Candidacy on file with the CLAS Dean’s office no later than 5 PM, **February 2, 2011**.
- Students are responsible for completing financial arrangements with financial aid, family, scholarships, etc. to pay their tuition. Students will be responsible for all tuition and fees for courses they do not officially drop using proper drop/add procedures and forms. Students who drop after the published drop/add period will not be eligible for a refund of the COF hours or tuition.

### Important Dates

- **January 18, 2011**: First day of Class
- **January 23, 2011**: Last day to add a class or be added to a wait list for a class using the UCDAccess student portal. After this date you must use a schedule adjustment form to change add or drop a course.
- **January 24, 2011**: LAST DAY TO DROP WITHOUT DROP CHARGE – THIS INCLUDES SECTION CHANGES.
- **January 24, 2011**: **Wait Lists are dropped.** Any student who was not added to a course automatically from the wait list by this date and time MUST complete a schedule adjustment form to be added to the class. Students are NOT automatically added to the class from the wait list after this date and time. If your name is not on the official student roster, you are not registered for the course.
- **January 25-February 2, 2011**: Students are responsible for verifying an accurate spring 2011 course schedule via the UCDAccess student portal. Students are NOT notified of their wait-list status by the university. All students must check their scheduled prior to February 2, 2011 for accuracy.
- **January 25, 2011**: First day instructor may approve request to add a student to a full course with a Schedule Adjustment Form.
- **February 2, 2011**: Census date.
- **February 2, 2011 at 5 PM**: Last day to add structured courses without a written petition
for a late add. *This is an absolute deadline and is treated as such.* This deadline does not apply to independent study, internships, project hours, thesis hours, dissertation hours, and late-starting modular courses.

- **February 2, 2011 at 5 PM:** Last day to drop a spring 2011 course or completely withdraw from all spring 2011 courses using a schedule adjustment form with a tuition adjustment minus the drop charge and no transcript notation – this includes section changes. Drops after this date will appear on your transcript. *This is an absolute deadline and is treated as such.*
- **February 2, 2011 at 5 PM:** Last day to request pass/fail or no credit option for a course.
- **February 2, 2011 at 5 PM:** Last day to for a graduate student to register for a Candidate for Degree.
- **February 2, 2011 at 5 PM:** Last day for a Ph.D. student to petition for a reduction in hours.
- **February 2, 2011 at 5 PM:** Last day to apply for spring 2011 graduation. You must make an appointment and see your academic advisor before this date to apply for graduation if you are an undergraduate; you must complete the intent to graduate and candidate for degree form if you are a graduate student.
- **February 14-23, 2011:** Faculty can use the early alert system.
- **March 21-27, 2011:** Spring break (no classes/campus open)
- **April 1, 2011 at 5 PM:** Last day for CLAS students to drop or withdraw from all classes without a petition and special approval from the student’s academic Dean. *After this date, a dean’s signature is needed.*
- **April 15, 2011 at 5 PM:** Last day for CLAS students to drop or withdraw from all classes with signatures from the faculty and Dean without a full petition. *This is treated as an absolute deadline.*
- After **April 15, 2011** all schedule changes require a full petition. Petitions are available in NC 4002 for undergraduates and NC 5012 for graduate students.
- **May 9-14, 2011:** Finals Week
- **No schedule changes will be granted once finals week has started. There are NO exceptions to this policy.**