SYLLABUS – Math 5593: Linear Programming

Fall 2007
Professor: Weldon A. Lodwick
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Class Time/Location: Tu/Th 2:30-3:45pm, Room 656 CU-Denver Building
E-Mail: weldon.lodwick@cudenver.edu
Web Site: http://www­math.cudenver.edu/~wlodwick
Text: Linear and Nonlinear Programming by Stephen G. Nash and Ariela Sofer, McGraw-Hill, 1996. If you are not able to buy the textbook, we have permission from Ariela Sofer to copy Chapters 1-9. Please see me or a classmate for a copy of the text.

NOTE: I have Faculty Council/Faculty Senate meetings Thursdays on August 30th, September 27th, October 25th, and December 6th from 10am – 3pm, so that I will usually be late on these dates. We can make-up the time I miss. Moreover, I will miss my office hour Thursday September 6th and I will have a guest lecturer on September 20th (and will miss office hours on this date).

Office Hours: TTh 4:00 - 5:00 PM CU-Denver Bldg 643
W 9:00 – 10:00 AM CU-Denver Bldg 643
Other times by appointment

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.

Prerequisites: Math 3191 and Math 4320

Below is the proposed outline. The weeks listed are tentative and indicate my best estimate as to the pace of the class.

PROPOSED COURSE OUTLINE

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Introduction</td>
<td>Sections 1.1-1.3, 2.1-2.3,3.1-3.3 from Chapters 1 - 3</td>
</tr>
<tr>
<td>4/5</td>
<td>Geometry of Linear Programming</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>6/7</td>
<td>The Simplex Method</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>8/9</td>
<td>Duality and Sensitivity</td>
<td>Chapter 6 (skip Chapter 7)</td>
</tr>
<tr>
<td>10-12</td>
<td>Computational Complexity and Interior Point Method</td>
<td>Chapter 9 and notes</td>
</tr>
</tbody>
</table>

Math 5593: Linear Programming
August 21, 2007
OUTCOMES
By the end of the semester you should be able to read, understand and apply linear programming theory associated with the topics covered in the semester to correctly solve associated problems at the level of our textbook. Secondly, given a problem for which linear programming can be used, you should be able to translate the description of the problem into a correct linear programming model, and obtain the correct solution(s). Lastly, by the end of the semester, you should be able to judge for yourself, the veracity of statements made in linear programming texts and articles that are at beginning graduate level.

EVALUATION
There are four evaluative criteria: (i) one in-class exams (30% of your grade) – on October 11th, (ii) one take-home comprehensive final (40% of your grade) – due December 14th (due at 5pm), (iii) project (20% of your grade) – due November 30th, and (iv) project in-class presentation (10% of your grade) – due December 11th and 13th. Evaluation is based on a point system so that it is very important that you turn in your projects, assignments and complete exams as thoroughly as possible rather than taking a zero score. Note: Exams (in-class and take-home) will include problems taken from the list below.

PROBLEM LIST: A selection from these problems will appear on each exam.
2.2/1, 2, 6, 7, 9
2.3/1-5, 9, 13, 14a, c, g, 15-17
3.2/1c, d, 2-5
3.3/1a, 2-6, 8-10, 13, 15, 18
4.1/1b, f, 2
4.2/1, 2, 4-7
4.3/1-6, 12, 14
4.4/1-4, 6-8
5.2/2b, 3, 4, 6
5.3/1, 2, 4
5.4/1, 3, 4
5.5/1, 2, 6c, 8
5.6/1-3, 6
6.1/3-7
6.2/2, 5, 11, 12
6.3/3, 4, 7
PROJECTS: A project may be (i) theoretical (complexity theory of linear programming, all the optimality conditions for linear programming), (ii) application (network models in water systems, inventory models, coca cola truck scheduling, Denver Convention Center scheduling, radio-surgery models), (iii) algorithms (interior point methods compared to simplex), (iv) software implementation (write up a problem in GAMS, AMPL, C-Plex and solve it), and (v) survey (the current state of the art of modeling languages, linear optimization under uncertainty).

A project consists of:

1. **Proposal (10%)** – A formal written proposal due September 13, 2007 is to be submitted for my approval. A proposal must contain:
   a. **Title**
   b. **A linear programming problem**
   c. **The description of the problem and the data**
   d. **The methods (software, library search, your head) you will be using to solve the problem**
   e. **Tasks and subtasks with timelines associated with the problem**

2. **Software (90%)** – If the project does not have a software component, this section will be modified according to the project proposal. If your project is a software implementation, the components of the software development are:
   a. **Code (10%)** - the actual computer implementation of the project. Attention must be paid to efficiency, readability and portability.
   b. **User interface (10%)** – the way information is passed to the software must be compelling to the client.
   c. **Data and inputs (10%)**
   d. **Execution (10%)** - the algorithm as run must correctly perform what it was designed to do.
   e. **Output (10%)** - relevant, clear display of solution (tables, graphs, images).
   f. **Ease (10%)** – ease of use.
g. **Documentation (10%)** – 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.

h. **Report (30%)** – The report contents is listed below

3. **Report (90%)** – If your report is not software, then the report is the focus of your project. Each person will need to submit a final report. This will be done in MS-Word or Latex. The final report will (subject to modifications we uncover) consist of at least the following:
   a. **Introduction**
   b. **Project**
      i. **Theoretical foundations** – theory, application, algorithms
      ii. **Software** – description if you use software
      iii. **Survey or articulation of your research**
      iv. **Results** – solutions, limitations and improvements
   c. **Opportunities for further research**
   d. **Conclusions**
   e. **Bibliography**
   f. **Appendices (if relevant)**

The evaluative criteria for a report will be my judgment of:

1. **Depth (40%)** – The depth should be at least that of a masters-level class, that is, more than upper level undergraduate projects.
2. **Thoroughness (40%)** – The thoroughness will depend on the scope of the project that is agreed up in your project proposal and the relative importance of the project in light of the other demands of the class. That is, it’s 20% of your grade so I would expect you to put in at least the equivalent time as would be spent on the four assignments. Your report should have at least the items listed above.
3. **Correctness (20%)**

**Project Presentation**

1. Electronic presentation (30%)
2. Clarity (70%)

**POLICIES**

**Adds, drops and incomplete grades:** See *Schedule of Courses* for the relevant dates with respect to adding and dropping this course. **You must be registered by the dated specified or you will not get credit.** 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 part of the work
(for example the final report) due to circumstances beyond her/his control (for example, hospitalization, jury duty, revised job assignments, death in the family).

**Legitimate Excuses:** Legitimate excuses are for reasons that are beyond your control. You may be required to produce an official, signed excuse. 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.

The following distribution of grades is guaranteed. However, the university does not recognize pluses and minuses for graduate students.

- A+ 97-100%, A 93-96.9%, A- 90-92.9%
- B+ 87-89.9%, B 83-86.9%, B- 80-82.9%
- C+ 77-79.9%, C 73-76.9%, C- 70-72.9%
- D+ 67-69.9%, D 63-66.9%, D- 60-62.9%

**Point Distribution:**

- In-class exam 300
- Take-home final 400
- Project – written report 300
- Project – presentation 100
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  TOTAL  1,000

**Important Dates:**

- September 13\textsuperscript{th} Project proposal
- October 11\textsuperscript{th} In-class exam
- November 27\textsuperscript{th} Take-home exam given out
- November 30\textsuperscript{th} Written project report
- December 11\textsuperscript{th}, 13\textsuperscript{th} Project presentation
- December 14\textsuperscript{th} Take-home exam due by 5pm

**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 copy 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. Note: The statistics that I have read about correctness of professors in recording grades state that there is a 6\% error rate in our recording of your grades. Please make sure that I have correctly recorded your points.
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. Therefore, I am responsible to open the way, to encourage, and to nudge you toward your own learning. I will help guide you toward this learning by providing mathematics for you to experience. It is my aim to communicate mathematics in a way that is supportive and nurturing of your efforts. Your role is to find a way to experience and articulate the mathematics that is presented and that you encounter. I believe that it is your responsibility to let me know when you find yourself not understanding mathematical concepts that are presented in class. Once you make this known, it is our responsibility to work on trying to attain clarity. I will try to be as proactive as possible. I believe that results on examinations, project, and assignments give us the opportunity to clearly see where the areas of mathematical understanding are and what areas need more attention.
CLAS – Fall 2007 Key Policies, Deadlines, and Religious Holidays

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. 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.cudenver.edu email address. Email is the official method of communication for all University of Colorado at Denver and Health Sciences Center business. All email correspondence will take place using your UCDHSC email address. Go to http://www.cudenver.edu/registrar to activate your email.cudenver.edu 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 added to a course off the wait list after the 5th day of the semester when wait lists are dropped.

- 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. Late adds will only be approved if the student has not taken any exams, quizzes, or has not completed any other graded assignments. Independent verification of this from the professor of record will be required. 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 are available in NC 2024.

- Late drops will be approved only when circumstances surrounding the late drop 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 does not guarantee that a late drop petition will be approved. Petitions are available in NC 2024.

- Students wishing to graduate in fall of 2007 must meet with their academic advisor by the end of the drop/add period to obtain a graduation application. This application must be completed and submitted by 5 PM on September 5, 2007. You can obtain an application ONLY after meeting with your academic advisor. There are no exceptions to this policy or date.

- 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.

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• Students who drop after the published drop/add period will not be eligible for a refund of the COF hours or tuition.

Important Dates

• **August 20, 2007:** First day of Class

• **August 26, 2007:** Last day to be added to a wait list.

• **August 26, 2007:** Last day to add a course using the SMART system.

• **August 20-August 27, 2007:** Students are responsible for verifying an accurate fall 2007 course schedule via the SMART registration system. Students are NOT notified of their wait-list status by the university. All students must check their scheduled prior to August 27, 2007 for accuracy.

• **August 27, 2007:** LAST DAY TO DROP WITHOUT DROP CHARGE.

• **August 27, 2007:** 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 drop/add 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.

• **August 28, 2007:** First day instructor may approve request to add a student to a full course with a Schedule Adjustment Form.

• **August 31 – September 5, 2007:** Drops allowed using SMART system. **Drop charge applies.** Full term courses may be added using Schedule Adjustment Form.

• **September 5, 2007 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, and late-starting modular courses.

• **September 5, 2007 at 5 PM;** Last day to drop a fall 2007 course with a tuition refund minus the drop charge and no transcript notation. Drops after this date will appear on your transcript. This is an absolute deadline, and is treated as such.

• **September 5, 2007 at 5 PM;** Last day to completely withdraw from all fall 2007 courses with a tuition refund and no transcript notation. **Drop charge applies.** Drops after this date will appear on your transcript. This is an absolute deadline and is treated as such.

• **September 5, 2007 at 5 PM;** Last day to request pass/fail option for a course.

• **September 5, 2007 at 5 PM;** Last day to request a no credit option for a course.

• **September 5, 2007 at 5 PM;** Last day to register for a Candidate for Degree.

• **September 5, 2007 at 5 PM;** Last day to petition for a reduction in thesis or dissertation hours.
• **September 5, 2007 at 5 PM:** Last day to apply for fall 2007 graduation. You must make an appointment and see your academic advisor to apply for graduation.

• After September 5, 2007 all schedule changes require a petition. Petitions are available in NC 2024.

• **October 29, 2007 at 5 PM:** Last day for **non CLAS students** to drop or withdraw from all classes without a petition and special approval from the student’s academic Dean. **This is treated as an absolute deadline.**

• **November 9, 2007 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. **This is treated as an absolute deadline.**

• **No schedule changes will be granted once finals week has started. There are NO exceptions to this policy.**

**Major Religious Holidays Fall 2007**

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<tr>
<th>Date</th>
<th>Event Description</th>
<th>Religion</th>
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</thead>
<tbody>
<tr>
<td>Tues, Sept 4</td>
<td>Sri Krishna Jayanti (Janmashtami)</td>
<td>Hindu</td>
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<tr>
<td>Thurs-Fri, Sept 13-14</td>
<td>Rosh Hashanah (begins at sundown on the 12th)</td>
<td>Jewish</td>
</tr>
<tr>
<td>Thurs, Sept 13</td>
<td>Ramadan (begins at sundown on the 12th and continues through Oct 20th)</td>
<td>Islam</td>
</tr>
<tr>
<td>Sat, Sept 22</td>
<td>Yom Kippur (begins at sundown on the 21st)</td>
<td>Jewish</td>
</tr>
<tr>
<td>Thurs-Fri, Sept 27-28</td>
<td>Sukkot (begins at sundown on the 26th)</td>
<td>Jewish</td>
</tr>
<tr>
<td>Sat, Oct 13</td>
<td>Eid al Fitr (Ramadan ends)</td>
<td>Islam</td>
</tr>
<tr>
<td>Sun, Oct 21</td>
<td>Dasera</td>
<td>Hindu</td>
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<tr>
<td>Fri, Nov 9</td>
<td>Diwali (Deepavali)</td>
<td>Hindu</td>
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**College of Liberal Arts & Sciences, University of Colorado at Denver and Health Sciences Center**

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