Term 1, 2019/2020: Sept 2019 -- Dec 2019

Math 340:101 Introduction to Linear Programming

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Class: MonWedFri   14:00 -15:00 at Buchanan   A104
Office hours : TueThur 14:00--15:20 at my office MATH 216.
First class: Wednesday, Sept 04, 2019   **Last class:** Friday, Nov. 29, 2019

About the Course

- This course would be more properly called Linear Optimization, optimizing a linear objective function subject to linear constraints. The word `programming' is not used in the sense of computer programming. The word `programming' refers to the program of activities given by a solution.
- Prerequisites: One of MATH 152, MATH 221, MATH 223.
- **It is highly recommended that students have taken a multi-variable calculus course (e.g. Math 200, 253, etc.). Also, basic knowledge of mathematical proofs (e.g. Math 220) is highly recommended for taking this course.**

Main Texts:

- Linear Programming by Vaˇsek Chva ´tal. This book is short of examples and is rather dense for novices but it has made the excellent choice of the dictionary format. Additional examples will be given in the lectures or in the supplementary material to be provided throughout the course. The book is on reserve in the main library.

- Another good reference we will be using is Linear Programming by Robert Vanderbei (electronic copy available to download through the UBC library!).

- Nearly any book on linear programming will cover the main topics in this course, but the *notation* used for the simplex method may be quite different (and take some effort to translate to the notation we'll use).

Course Outline (subject to change):

- Simplex Method and related geometry (e.g. Chvatal chapters 1-4, 7 (first section)). 3 - 4 weeks.
- Duality Theory (e.g. Chvatal chapters 5,9). 2 -3 weeks.
- Revised Simplex Method (e.g. Chvatal chapters 7, 8). 1 - 2 weeks.
- Sensitivity Analysis (e.g. Chvatal chapter 10). 1- 2 weeks.
- Optional topics as time permits: Matrix games (e.g. Chvatal chapter 15), Geometry of convex sets (e,g. Chvatal chapter 17), etc．   1-3 weeks.

Learning Goals include the following:

- To be able to translate practical (high dimensional) optimization problems into linear programming
- To understand (and to be able to visualize) the basic geometry of convex sets and its relation to linear programming
- To be able to compute solutions of linear programming by the simplex method and its variants

- To be able to manipulate matrix calculations to solve linear optimization problems
- To understand and utilize duality to solve linear optimization problems
- To be able to give mathematical proofs for simple mathematical statements about concepts covered throughout the course, including and not restricted to convex sets, optimization, simplex method, duality, etc..

Expectations:

- Students are expected to attend all lectures and complete all assignments, quizzes, and exams to their full extent. Students should expect to spend between 9 and 12 hours per week outside of lectures on this course in order to be able to pass. Students should take notes during lectures as presentation of material may deviate at times from what is offered in the assigned reading material (the textbook and references). In the case a class meeting has to be missed by a serious reason, **it is the student's responsibility to make up the missed material;** this means lecture notes, lesson notes, etc. will not be provided if a student misses any sessio
- Students are expected to respect other students' learning. Please be on time so as not to disrupt the class.
- **All electronic devices should be turned off during class meetings except for note taking and/or course material viewing purpose.** This policy is to ensure all students have optimal learning experiences. Studies show that electronic device usage prevents students from focusing on learning during the classes; not only the students who use the device but also the neighboring students are affected.

How to succeed in this course:

- It is very important to learn mathematics by "doing". For example, it is not enough to read a worked out example from a book or lecture notes. It is not enough to understand each step in the solution. You have to struggle to work out examples or problems by yourself, without looking at the solutions. This way, you have to build up mathematical intuition on the subject.
- **Very useful advice on how to solve problems are in [Polya](#).**

Grading

Your grade for the course will be computed roughly as follows:
Quizzes: 15%
Assignments: 10%
Midterm: 15%
Attendance and class participation: 10%: For this there will be pop quizzes (each with a very short iclicker question) during randomly chosen lectures; there will be many such quizzes. We will drop the bottom 10% of the scores.
Final Exam: 50%

- Minimum final exam score requirement: **A minimum mark of 40% on the final exam is required to pass the course, independent of all others marks in the course. A student who has a total term average of above 50%, but scores lower than 40% on the final exam, will receive a maximum final course grade of 45%.**
- **Missing midterms:** There are *no make-up midterms* in this course. Missing the midterm for a valid reason normally results in the weight of that midterm being transferred to the final exam. Examples of valid reasons include illness and travel to play a scheduled game for a varsity team. Examples of

reasons that are not valid include conflicts with personal travel schedules or conflicts with work schedules or with other classes. Any student who misses the midterm is to present to their instructor the Department of Mathematics self-declaration form for reporting a missed assessment to their instructor within 72 hours of the midterm date. This policy conforms with the UBC Vancouver Senate's and students are advised to read this policy carefully.

- **Please note that a student who misses the midterm and has otherwise not completed a substantial portion of the term work normally shall not be admitted to the final examination.**
- **Missing the Final Exam:** You will need to present your situation to the Dean's Office of your Faculty to be considered for a deferred exam. See the Calendar for **detailed regulations**. Your performance in a course up to the exam is taken into consideration in granting a deferred exam status (e.g. failing badly generally means you will not be granted a deferred exam). In Mathematics, generally students sit the next available exam for the course they are taking, which could be several months after the original exam was scheduled. *Note that your personal travel schedule is NOT a valid reason for missing a final exam and students who miss the MATH 340 exam for this reason will receive a grade of 0 on the exam and fail the course.*
- Passing the MATH 340 final exam may not be sufficient to ensure a student passes MATH 340 if they have failed the term work.
- IT IS ESPECIALLY IMPORTANT that students know that IF THEY DO NOT FULFILL THE COURSE REQUIREMENTS DURING THE TERM (including not writing the midterm test(s) even if you agree to transfer the weight to the final) AND THEN MISS THE FINAL EXAMINATION, THEY MAY BE DEEMED INELIGIBLE FOR A DEFERRED FINAL.
- **All marks are subject to scaling.**

Exams:

- **Midterm**: **Oct 18 (Friday) in class. 50 min.**
- **Final Exam: TBA.**

Quizzes/Midterm/Assignments schedule:

There will be a total of five quizzes and five assignments throughout the term**:**

- **Sept. 13 (Friday): Quiz 1**
- **Sept 20 (Friday): Quiz 2**
- **Sept 27 (Friday): HW 1 due**
- **Oct 4 (Friday): Quiz 3**
- **Oct 11 (Friday): HW 2 due**
- **Oct 18 (Friday): Midterm**
- **Oct 25 (Friday): Quiz 4 due**
- **Nov 1 (Friday): HW 3 due**
- **Nov 8 (Friday): Quiz 5**
- **Nov 15 (Friday): HW 4 due**
- **Nov 22 (Friday): HW 5 due.**

At the end of the semester, among the 5 quizzes and 5 HW assignments, your **lowest quiz grade** and **lowest homework grade** will be dropped. This policy is intended to cover situations where

you may miss a quiz or assignment for whatever reason, without you needing to ask for a concession.

Rules for tests (quizzes/midterm/final):

- **No calculators or other notes will be allowed!**
- There are **no make-up** tests but if you miss a test for a legitimate reason (e.g. illness), allowances can be made. **To claim legitimate emergency: Instructor must be notified within 72 hrs of missed test.**
- Students will be required to bring Photo ID to all tests and exams.

Homework Assignments Policy: Careful work on the assignments is the best way to prepare for the midterms and the final exam.

- There will be 5 assignments. Students may work together on assignments but must write up their solutions **independently**. Copying is forbidden. Any 2 (or more) assignments with some virtually identical answers deemed the result of copying will be given 0 total credit, and there will be further consequences for such dishonest actions. The students are reminded of the plagiarism policies of UBC.
- We will be using an online system for collecting the HWs. More details will be provided later.
- **Late homework is not accepted.**
- Unreadable homework will get a zero mark.
- Work must be shown.
- Missed homework will count as a zero mark.
- The number of each homework problem should be clearly printed.
- It is probable that only a subset of those problems turned in would be graded, and you will not be informed (in advance) which ones these are. For example, if your homework does not contain any of the problems to be graded (which will be known only after the due date), you will get zero mark. So, it would be better for you to do all the problems to be handed in.
- For the selected problems, only some important steps and the final answer will be checked.

How to ask for change of marking:

- If you feel that a returned assessment is incorrectly marked, you can appeal that mark by filling out a regrade request form, attaching it to a printout of the assignment, and submitting it to the instructor within one week of the return of the marked assignment. The form should include a summary of what you feel was incorrectly evaluated with some justification of the claim. Your work will be re-evaluated in accordance with the established grading procedures, and re-marked if necessary. Note in unusual circumstances, if you mistakenly received a higher grade than earned, your final grade might decrease upon re-marking.

Computing: There will be no computer programming in this course although for certain assignments you may possibly be asked to use LINDO, a fairly user friendly software package for Linear Programming.

- You can download and install a trial version of LINDO from their website. We recommend "Classic LINDO" at the bottom.
- UBC has computer labs located in the Leonard S. Klinck building (room 310). More info to be announced regarding the lab access, if necessity arises.

Vanderbei has an online pivoting tool that lets you choose entering and exiting variables and performs the pivot automatically. This is a good way to get an idea of how the simplex method will work on larger

problems without having to do all of the algebra by hand!

Academic Misconduct:

- UBC takes cheating incidents very seriously. After due investigation, students found guilty of cheating on tests and examinations are usually given a final grade of 0 in the course and suspended from UBC for one year. More information.
- While students are encouraged to study together, they should be aware that blatant copying of another student's work is a serious breach of academic integrity. Please discuss with your instructors their expectations for acceptable collaboration on any assigned coursework. Cases of suspected cheating will be investigated thoroughly.
- Note that academic misconduct includes misrepresenting a medical excuse or other personal situation for the purposes of postponing an examination or quiz or otherwise obtaining an academic concession.

The UBC Vancouver Senate's Academic Concession Policy V-135 applies to all assignments in this course, and students are advised to read this policy carefully.

Statement on UBC's Policies and Resources to Support Student Success:

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious and cultural observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available here.