MATH 340 101 2020W Introduction to Linear Programming

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Term 1, 2020/2021: Sept 2020 -- Dec 2020

Math 340:101 Introduction to Linear Programming

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Class: MonWedFri 14:00 -15:00 (Vancouver time) via **Zoom** through **Canvas.**

IMPORTANT: Find Zoom in the left menu in the Canvas page (under Home).

Office hours: TBA
First class: Wednesday, Sept 09, 2020 **Last class: Wednesday**, Dec. 2, 2020

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 (https://courses.students.ubc.ca/cs/courseschedule?pname=subjarea&tname=subj-course&dept=MATH&course=152) , MATH 221 (https://courses.students.ubc.ca/cs/courseschedule?pname=subjarea&tname=subj-course&dept=MATH&course=221) , MATH 223 (https://courses.students.ubc.ca/cs/courseschedule?pname=subjarea&tname=subj-course&dept=MATH&course=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 Reference:

- ***Linear Programming by Robert Vanderbei*** ***(https://link.springer.com/book/10.1007/978-0-387-74388-2)*** (electronic copy available to download through the UBC library!).

Additional examples will be given in the lectures or in the supplementary material to be provided throughout the course.

- Another useful reference is **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.
- 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. 3 - 4 weeks.
- Duality Theory. 2 -3 weeks.
- Revised Simplex Method. 1 - 2 weeks.
- Sensitivity Analysis. 1- 2 weeks.
- Optional topics as time permits: Matrix games, Geometry of convex sets, 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.**

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 (http://www.math.utah.edu/%7Epa/math/polya.html) .**

Grading

Your grade for the course will be computed roughly as follows:

Assignments: 40%
Midterm: 20%
Final Exam: 40%

- **All marks are subject to scaling.**
- **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 **Academic Concession Policy V-135 (http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,329,0,0)** 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 (http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,41,94,0)** . 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.

Optional project for bonus points (up to 10%): This is optional and there will be no instructional support for this. Students should learn the related material, including necessary software packages by themselves.

- **Optional project:** Students can earn up to additional bonus 10% to their final course grade, by submitting an optional term project; for example, if your course grade after the final exam is 80 and you get a perfect project mark then your final course grade will be 80+10 =90. We will follow the following policy ***STRICTLY***.
- **Deadlines for projects**: these are **firm deadline**s and will not be flexible.
  - **October 15:** Submission of initial proposal.
    - The proposal to explain what problem will be considered in the project.
    - The background and aim of the project should be properly demonstrated.
    - It should be typed in 11pt and three pages long.
  - **October 30:** Submission of any changes of the proposal. In case the students want to change their intended project, they can submit a revised proposal by this time.
- Up to TWO people can work together as a team.
- The project should be **original,** be **application of linear programming to practical problems, and it** SHOULD be specifically targeted to solving problems **RELATED TO UBC and British**

Columbia; e.g. transportation in Vancouver, housing market in Vancouver, UBC students' scheduling problem, reducing carbon exhaustion in British Columbia, etc.

- The report should be ORIGINAL. Plagiarism will not be tolerated, and will result in academic discipline.
- The term project should be in the form of a typed written report. The expected length is 10-- 15 pages (or more if you have many pictures and datasets) in 11pt.
- The term project will be marked under the following rubrics:
  - Originality of the project and how it is formulated: 30%. Is the project interesting? Are the problems formulated in an original and property way?
  - Mathematical contents: 20%. How well are the contents of the course embedded in the project? Is the mathematics correctly applied?
  - Supporting data: 20%. Are the supporting data for the project provided sufficiently and properly?
  - Presentation of the material: 30%. This includes: whether the presentation is to the point, and logically well organized.

Exams:

- **Midterm**: **Oct 16 (Friday) in class. 50 min.**
- **Final Exam: TBA.**

Rules for tests (midterm/final):

- Students will be required to bring Photo ID to all tests.
- **A number of selected students will be contacted after the midterm and the final, for oral tests to confirm their knowledge. Your oral test results should be consistent with the exam results.**
- **For exams, students should submit all the scratch work.**
- **For each exam, students will need to sign up an `integrity contract' of pledging integrity for the exams.**
- **More details will be given for each test.**

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

Assignments schedule:

There will be a total of 10 assignments throughout the term**:**

- **Sept 18 (Friday): HW 1 due**
- **Sept 25 (Friday): HW 2 due**
- **Oct 2 (Friday): HW 3 due**
- **Oct 9 (Friday): HW 4 due**
- **Oct 16 (Friday): Midterm**
- **Oct 23 (Friday): HW 5 due**
- **Oct 30 (Friday): HW 6 due**
- **Nov 6 (Friday): HW 7 due**
- **Nov 13 (Friday): HW 8 due**
- **Nov 20 (Friday): HW 9 due.**
- **Nov 27 (Friday): HW 10 due.**

At the end of the semester, **your two 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. **Most academic concession requests for assignments will be addressed by this policy.**

- Students may work together on the HW 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 Canvas for collecting the HWs.
- **Late homework is not accepted.**
- Unreadable homework will get a zero mark. You should write neatly and organize your material for a third party can understand.
- 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 selected problems, only some important steps and/or 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 submitting a regrade request statement to the instructor within one week of the return of the marked assignment. The statement 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

For certain assignments and if you opt for the optional project, you will need to use software packages for computing linear programming problems.

- Many programming languages, including Mathlab, Python, R, etc, have linear programming packages.
- **Our default is Python language via Jupyter Notebook, which is available via UBC syzygy server.** You can use this using your UBC CWL. There is Python library for linear programming, called PuLp. More details will be given later in the class.
- Another simple tool is LINDO. You can download and install a trial version of LINDO from **their website (http://www.lindo.com/index.php/ls-downloads)** . We recommend "Classic LINDO" at the bottom.
- Vanderbei has an **online pivoting tool (http://www.princeton.edu/%7Ervdb/JAVA/pivot/simple.html)** 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!
- Excel has linear programming package in it.

Academic Misconduct:

- University is the time in your life when you're deciding what kind of person you want to be as an adult—commit to integrity.
- The biggest reason not to cheat is because you have integrity.
- 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 (http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,0) .**

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- 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** (http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,329,0,0) 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** (https://senate.ubc.ca/policies-resources-support-student-success) .

Course Summary:

Date	Details