APMA 1210 – SYLLABUS

Welcome to APMA 1210, an awesome Operations Research adventure awaits you! This is the survival manual for this course, where you can find all the administrative info you need to know, such as office hours, grading, and other goodies. Feel free to e-mail me if you have any other questions.

Disclaimer: Any item on this syllabus is subject to change. Any in-class or online announcement, verbal or written, is considered official addendum to this syllabus.

1. At a glance

Course Name	Operations Research: Deterministic Models
Term	Fall 2022
Class Times and Location	TuTh 10:30-11:50 am in 85 Waterman St, Rm 130
Instructor Name	Peyam (π-m) Tabrizian
E-mail	drpeyam@brown.edu
Office	Room 316, 182 George Street
Office Hours	Tu 12:30-1:15 pm, W + Th + F 1:30-2:15 pm

Date: Thursday, September 8, 2022.

TA Name	E-mail
Teressa Chambers	Teressa
Qian Zhang	Qian
Nadeen Kablawi	Nadeen
Gavin Lee	Gavin
Daniel Chey	Daniel
Kabir Randhawa	Kabir

2. Logistics

Course Description: An introduction to the basic mathematical ideas and computational methods of optimizing allocation of effort or resources, with or without constraints. Linear programming, network models, dynamic programming, and integer programming.

Prerequisites: Calculus, Linear Algebra, and Basic Programming, so the equivalent of Math 0100, Math 520, and APMA 0160/CSCI 0111

Topics Covered:

- **Linear Programming (LP):** Introduction and formulation of the LP problem, The graphical and simplex methods for solving the LP problem, Variant of simplex method: M-method, Two-phase method, Duality and sensitivity analysis.

- **Dynamic Programming (DP):** Examples of DP, Shortest Path Problems, Resource Allocation.

- **Integer Programming (IP):** Formulating IP, Budgeting Problems, Knapsack Problems, Fixed Charge Problems, either-or-constraints; Solving IP.

- **Nonlinear Programming (NP):** Global/local optimum, necessary condition, sufficient condition, Lagrange multiplier, KKT conditions, Unconstrained optimization algorithm: gradient descent methods (1st order, 2nd order), Newton method, Conjugate gradient method. Constrained optimization algorithm: penalty/barrier/augmented Lagrangian method.

Calculator Policy: Calculators are **NOT** allowed on the exams. That said, you **ARE** allowed to use them on the Homework.

What this course is really about: I highly doubt that you'll forget the techniques you'll learn in this course because they are essential to human survival. That said, as Steve Krantz puts it in his book How to teach Mathematics, there is another goal of teaching this course. Namely, real purpose of this course is to teach you about mathematical discourse and critical thought. Just like in rhetoric, philosophy or politics, mathematics has its own language and way of thinking. How do mathematicians deal with an unknown problem? What methods do they use? What do they do when a given method doesn't work? Getting acquainted with all those different types of discourses is what your college education is really about.

Textbook: *Introduction to Linear Optimization* by Berstimas (Athena Scientific/Dynamic Ideas)

Note: Strictly speaking, the textbook is not required, in the sense that the homework is self-contained. That said, I strongly recommend reading the book along with the course material in order to solidify

your understanding.

Recommended: Books that cover similar material include:

- *Applied Mathematical Programming* by Bradley, Hay, and Magnanti (Addison-Wesley, 1977). Available free online here.
- *Inroduction to Operations Research* by Hillier and Lieberman, McGraw-Hill Education

Online resources you can use:

- Course Website: This is the main course website, where you can find the lecture notes, homework, and study material
- Canvas: Here is where I'll post announcements and you can check your grades
- Gradescope: Here is where you upload your homework
- Ed Discussion: A forum-like tool like Canvas Discussions or Piazza, where you can post questions and your classmates or me can answer them
- Dr Peyam: My YouTube channel, where you'll find useful videos related to this course or not

3. Grading

	Date	Percent
Homework	Weekly on Wednesdays	30 %
Midterm 1	Thursday, October 13	15 %
Midterm 2	Tuesday, November 15	20 %
Final Exam	Wednesday, December 14, 2–5 pm	35 %

Range	Grade
$[90, 100]$	A
$[80, 90)$	B
$[65, 80)$	C
$[0, 65)$	NC

Note: The scales above are a guarantee. For example, if you get 80, you are guaranteed at least a B. The final grade calculation is up to my discretion. For students taking this course S/NC, a min grade of 65% is required to guarantee a grade of S.

Exams: There will be 2 midterm exams and a final exam, the dates are above. Bring your student ID and a pencil to all exams. They will be administered at the usual lecture time room. The exams are closed book, closed notes, and no calculators are allowed. The final exam is cumulative. **The final replaces your lowest midterm score if that's in your favor**

Graded Homework: Homework will be mostly due on Wednesdays by 11:59 pm (except for exam weeks and holidays) and covers the material from the previous week. It will be posted on the course website.

You will upload your assignments on Gradescope. **Make sure to check your submission, we will NOT accept any incomplete or corrupt files.** You are encouraged to work together but all students must independently write up their own solutions. There is no 'make up' homework, but **the lowest assignment is dropped** Don't worry too much if you submit your homework 10-15 mins late, we'll still accept that.

Late Assignments: Late submissions of assignments can create unfair situations to others in the class and make it harder for the TAs to give timely feedback. Hence, I will generally not give credit for late work unless in the case of emergencies or illnesses. If you encounter circumstances that make it hard for you to complete assignments in time or keep up with the course material, please reach out to me as soon as possible, so that we can work on a plan together. **TAs cannot grant homework extensions**

Grading Policy: If there is a mistake in the grading of your assignment (points are added incorrectly, your score was mis-entered into the grade book) please let me know immediately. If you disagree with the grading of your assignment then you may write up an explanation of your disagreement and turn it back in to me. I will look at the concern at the end of the semester if it will possibly affect your overall grade. **Please note that small changes in homework points generally do not affect an overall grade.**

4. Miscellaneous Information

Statement on Inclusivity: I strive to foster an inclusive, collaborative, and supportive learning environment where everybody is welcome

and feels they belong. I also aim to create an atmosphere where everyone is comfortable to add their voices and opinions. I acknowledge that there are many disparities in representation in the mathematical sciences and that we, as a community, need to work much harder and more persistently to become more diverse.

Accessibility and Accommodations Statement: Brown University is committed to full inclusion of all students. Please inform me early in the term (by email, office hours, after class, or by appointment) if you may require accommodations or modification of any of course procedures. If you need accommodations around online learning or in-classroom accommodations, please reach out to Student Accessibility Services (SAS) for their assistance (sas@brown.edu, 401-863-9588). Undergraduate students in need of short-term academic advice or support can contact an academic dean in the College by emailing college@brown.edu. Graduate students may contact one of the deans in the Graduate School by emailing graduate_school@brown.edu.

Books, Supplies, and Materials If your Brown undergraduate financial aid package includes the Book/Course Material Support Pilot Program (BCMS), concerns or questions about the cost of books and course materials for this or any other Brown course (including RISD courses via cross-registration) can be addressed to bcms@brown.edu. For all other concerns related to non-tuition course-related expenses, whether or not your Brown undergraduate financial aid package includes BCMS, please visit the Academic Emergency Fund in E-GAP (within the umbrella of "E-Gap Funds" in UFunds) to determine options for financing these costs, while ensuring your privacy.

Finally: Sit back, relax, and enjoy the show! On the next page, you can find *very tentative* schedule of the lectures.

#		Date	Section	Lecture Title
1	Th	Sep 8	1.8	Intro to Operations Research
2	Tu	Sep 13	1.1, 1.2	Intro to Mathematical Programming
3	Th	Sep 15	1.1, 1.4	Linear Programming
4	Tu	Sep 20	2.1, 2.2	Geometry of Feasible Regions, Convexity
	W	Sep 21		HW 1 due
5	Th	Sep 22	2.2, 2.5, 2.6 3.1, 3.2	Extreme Points of Feasible Regions Simplex Algorithm (I)
6	Tu	Sep 27	3.1, 3.2, 3.4 3.5, 3.7	Simplex Algorithm (II)
	W	Sep 28		HW 2 due
7	Th	Sep 29	3.1, 3.2, 3.4 3.5, 3.7	Simplex Algorithm (III)
8	Tu	Oct 4	4.1 – 4.3	LP Duality (I)
	W	Oct 5		HW 3 due
9	Th	Oct 6	4.1 – 4.3	LP Duality (II) Complementary Slackness
10	Tu	Oct 11	5.1	Sensitivity Analysis
11	**Th**	**Oct 13**		**Midterm 1**
12	Tu	Oct 18		Zero-Sum Games
13	Th	Oct 20	7.1, 7.2	Network Problems (I)
14	Tu	Oct 25	7.1, 7.2	Network Problems (II)
	W	Oct 26		HW 4 due
15	Th	Oct 27	7.3	Network Simplex Algorithm

#		Date	Section	Lecture Title
16	Tu	Nov 1	7.5	Max Flow (Min Cut)
	W	Nov 2		HW 5 due
17	Th	Nov 3	Notes, 11.3	Dynamic Programming
	Tu	**Nov 8**		**No Class (Election Day)**
	W	Nov 9		HW 6 due
18	Th	Nov 10	10.1, 10.2	Integer Programming (I)
19	**Tu**	**Nov 15**		**Midterm 2**
20	Th	Nov 17	10.1 – 10.3	Integer Programming (II)
21	Tu	Nov 22	Notes, 11.2	Integer Programming (III)
	Th	**Nov 24**		**No Class (Thanksgiving)**
22	Tu	Nov 29	Notes	Non-Linear Programming (I)
23	Th	Dec 1	Notes	Non-Linear Programming (II)
24	Tu	Dec 6	Notes	Gradient Descent
	W	Dec 7		HW 7 due
25	Th	Dec 8		Review
	W	**Dec 14**		**Final Exam**