PBM 778: Introduction to Linear Algebra

RTU Riga Business School

Spring 2023 semester
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Class meeting times: Mondays and Tuesdays, 14:00 - 15:40
Instructor: Dr Jānis Lazovskis, `janis.lazovskis@rbs.lv`
Grader: Dr Shraddha Christian, `shraddha.christian@rbs.lv`
Internal website: on ORTUS
External website: `jlazovskis.com/teaching/linearalgebra`
Drop-in hours: Thursdays 13:00 - 14:00 in 404 or on Zoom at `zoom.us/my/janis.lazovskis`
Consultations outside of drop-in hours are bookable at `calendly.com/jlazovskis`.

Welcome to "Introduction to Linear Algebra"!

This class is mostly based on the MIT course 18.06 Linear Algebra.

*One big difference is that the grading for this course uses **mastery-based grading**, in which outcomes are given in terms of specific topics (mastery of Topic A, Topic B, Topic C, ...) as opposed to specific assessment types (percentage on Homework, Midterm, Final, ...). The distinguishing features of this grading method are:*

- *Students show their mastery of each topic by multiple correct attempts*
- *Each correct attempt must satisfy **all** the specifications of the respective assessment type*
- *Every assessment can be reattempted without penalty*

The reason to use this approach is for the students (and instructors) to have a clearer understanding of what the students do and do not know, and that repeated attempts are allowed and encouraged, prompted by direct feedback from the instructors.

The words "topic," "objective," "skill," "standard" are used interchangeably in this course. These words all describe the things that you will learn.

About: Matrices and vectors will be reviewed in the first week. Then basic topics of linear algebra, including solving matrix equations, identifying and working in vector spaces, the rank-nullity theorem, projections, determinants. Matrix decompositions (including the LU-, QR-, and singular value decompositions) will be covered, as well as diagonalization for symmetric and non-symmetric matrices. Extensions to graphs will also be covered. A full list of topics is given in the following pages.

Textbook: There is no required texbook for this course (as all the material will be given in the lecture notes), but most comes from [1] as in the MIT course off which this course is based. Material will be taken in large part from the following two textbooks:

[1] (MIT) *Introduction to Linear Algebra*, Gilbert Strang (2016)

[2] (MIT) *Linear Algebra and Learning from Data*, Strang (2019)

Other textbooks that may be useful:

[3] *Linear Algebra for Dummies*, Mary Jane Sterling (2009). Conversational and easy to read

[4] *Linear Algebra Done Right*, Sheldon Axler (2015). Very abstract and theoretical

[5] *Linear Algebra Done Wrong*, Sergei Treil (2017). Very concrete and constructive

Sources [1] and [3] are available to you **in full** through links in ORTUS. Sources [4] and [5] are open access and available online.

Format: Every class of 1 hour and 40 minutes will be split into three parts.

- *45 min lecture:* Only key ideas from the lectures notes, not everything, will be presented during the lecture. You are expected to use the provided lecture notes as a primary resource.
- *10 min break*
- *45 min group work:* Students will follow learning prompts in the form of "Inquiries" in small groups, to formulate their understanding of concepts. You will have to submit your work at the end of every class.

Students attending in-person are expected to submit their class work on paper. Students attending online will have a link on ORTUS to submit their work, which will be active only for the duration of the lecture.

Standards and specifications: You will earn your grade based on *mastery-based grading*, which replaces a numerical score for assessments by qualitative feedback and evaluation related to skills, or "standards," that are assessed. You will still have a numerical score at the end of the semester. The aim is to give a clearer understanding to the student and instructor of skills that have been *mastered* by the students, and to remove the pressure of "one-shot" attempts at getting a good grade. Some ideas of *standards-based grading* are also used, in the sense of freuqently referring to the desired standards of successful students. More insight into these methods is at the following sources:

[6] *Simple specifications grading*, Sylvia Carlisle (2020), published in "PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies"

[7] *Assessing Proofs With Rubrics: the RVF Method*, David E. Brown and Shayla Michel (2010), published in "Proceedings of the 13th Annual Conference on Research in Undergraduate Mathematics Education"

Your progress will be evaluated on mastery of 60 standards, listed below and maintained on the course website (in case of conflict, the course website is to be taken as the true list). Every task on which you are assessed will indicate the standard(s) which you are mastering in completing the task.

Assessment release, deadline, reattempt: To give you a clearer understanding of how assessments work in this class, here I describe the life cycle of each thing you submit.

- *Release:*
  - Group work is released (at the latest) at the beginning of every lecture
  - Quizzes are released the Monday of the week they are due
  - Homework is released the Monday of the week before they are due
- *Deadline:*
  - Group work is due at the end of every lecture
  - In general, every Thursday one quiz and one homework will be due. Thursdays are chosen to discourage you from working during the weekend, and drop-in hours are on Thursdays to accomodate these deadlines.
- *Reattempt:*
  - Group work may be reattempted twice, up to three weeks after the lecture. Include your previous attempt with the reattempt.
  - Quizzes may be reattempted three times within the week when they are due.
  - Each individual homework task may be reattempted twice, up to two weeks after it has been returned the first time. Include your previous attempt with the reattempt.

Grading specifications: Your final grade will be a result of your work on the following assessments. Please note that that these follow an "all-or-nothing" approach, in the sense that your submission must meet all the specifications to pass. You may try again if you do not meet all the specifications on your first attempt.

Group work: 25 total, graded Pass / No pass. Due at the end of lecture. *Graded by JL*

Pass: Meets all the following criteria:

- submitted on time
- all group members' names mentioned
- written up neatly
- clearly presented and organized
- any computer code written and explained what it is doing
- all questions should be attempted

No pass: Does not meet one or more of the above criteria

You may resubmit group work, to be regraded at most twice, up to three weeks after the lecture.

Quizzes: 13 total, each question graded Pass / No pass. Due every Thursday. *Graded automatically*

Pass: Correct answer

No pass: Incorrect answer

Timed quizzes with numerical answers. You have three attempts at each question in each quiz, each attempt will have different numbers.

Homework: 13 total, each task graded Pass / Progressing / No pass. Due every Thursday. *Graded by SC*

Pass: Meets all the following criteria:

- Your work is *readable*, in the sense that you use full sentences to explain mathematical operations, do not leave any mathematical expressions without a written reason for using them (even if just to say "This is the matrix given in the task")
- Your work is *valid*, in the sense that your work is correct, and reasons for doing operations are stated and justified. The given justifications are correct.
- Your work is *fluent*, in the sense that you use relevant and appropriate notation and terminology in your answers. Fluency means using formal language (such as "numerator" and "denominator", instead of 'top" and "bottom" for fractions) for specific terms. Informal language in explaining your thought process is perfectly fine (such as "I wasn't sure how to use this approach so I tried another").

Progressing: Fully meets two and mostly meets one of the above criteria

No pass: Does not fully or mostly meet each of the above cirteria

You will be given wirtten feedback on the homework by the grader, and are encouraged to come to drop-in hours for more feedback and suggestions on how to improve your answer. You may resubmit each individual task to be regraded, at most twice per task, up to two weeks after it has been returned.

Midterms: 3 total, **optional**, each task graded Pass / Progressing / Fail. *Graded by JL*

The specifications for each grade are the same as for the homework tasks. Each question on each midterm will correspond to a standard covered in the precious lectures. The questions will be chosen depending on which standards are yet to be mastered by students. The midterms will take place on the following dates:

- Midterm for standards 1.n from "Matrices and row reduction:" Tuesday, February 21
- Midterm for standards 2.n from "Vector spaces:" Tuesday-Wednesday, April 10-11
- Midterm for standards 3.n and 4.n from "Eigentheory" and "Extensions:" Thursday-Friday, April 20-21

On these dates, midterms are released at 7:00 and are due at 23:59. You may use any resource, but you may not communicate with oher students about the questions. You may attempt only the standards which you have not yet mastered. Attempting a standrad you have mastered and recieveing a lower grade on it will not affect your mastery of the standard.

Deadlines will not be changed. If you do not submit an assessment within the set deadline, you cannot reattempt it afterward. The last day of submission is the Friday of consultation week (April 14). If you cannot complete an assessment on time, please inform me and I will give you an extension.

Final grade determination: Your grade will be computed by the number of standards which you have mastered. If you pass every task (in group work, quizzes, and homework) assessing a given standard, you are considered to have mastered that standard. You will receive the highest grade under which you meet every benchmark. If you do not meet a benchmark for a grade of 5, you will recieve a grade of 3.

Grade	10	9	8	7	6	5
Standards mastered	all but 6	all but 8	all but 10	all but 12	all but 14	all but 18

Class schedule: The full schedule of planned lectures, associated standards, and dates of assessments is given on the course website. The lecture numbering follows the lecture notes, although most material is taken in some way from Strang [1] or Strang [2]. Two extra lectures are reserved to account for difficult topics and / or topics relevant to the students. Some earlier lectures may be split up into two parts, so the schedule may shift slightly.

Grade progress: Since mastery-based grading is difficult to implement in the ORTUS grading system, I will regularly update individual, private spreadsheets for each of you, indicating your current progress. Please disregard the grade the ORTUS displays for you.

Academic integrity: You are expected to work together for the group work, encouraged to work together on homework, and expected to do the quizzes alone. In case of homework, please always write up your own solutions. The work you submit must be your own and should reflect your own understanding of the problem. Part of the RBS official stance on academic integrity is indcluded below.

RTU Riga Business School values intellectual integrity and the highest standards of academic conduct. To be prepared to meet societal needs as leaders and role models, students must be educated in an ethical learning environment that promotes a high standard of honor in scholastic work. Academic dishonesty undermines institutional integrity and threatens the academic fame of RBS. Dishonesty is not an acceptable avenue to success. It diminishes the quality of RBS education, which is valued because of RBS high academic standards.

Fostering an appreciation for academic standards and values is a shared responsibility among students, faculty, and staff. RBS prohibits dishonesty in connection with any RBS activity. [..] A commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated.