Lahore University of Management Sciences

MATH 222
Linear Algebra II
Syllabus and Course
Policy-Tentative
Fall 2023-2024

Instructor	Haniya Azam
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Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 min
Recitation/Lab (per week)	Nbr of Lec(s) Per Week		Duration	
Tutorial (per week)	Nbr of Lec(s) Per Week		Duration	

Course Distribution				
Core	Math Majors			
Elective				
Open for Student Category	All students			
Close for Student Category	None			

This class will be held in-person. Please read this syllabus carefully as it contains extensive information about how the class will proceed. Ignorance of the policies and timelines of this course contained in this syllabus will not be considered a valid excuse at any time.
In case the university decides to switch completely online due to the COVID-19 pandemic, classes will be held virtually via Zoom.

At all times we should be empathetic towards the limitations of each other. I would request you to please reach out to me with any problems you are having regarding this course and I will try my best to help you. It's good to talk even if it doesn't result in an outcome we wished for, it makes us more human and more sensitive to our situations and circumstances.

COURSE DESCRIPTION

This is a second course on Linear Algebra. Linear Algebra is central to all subjects within mathematics. It is used in modelling natural phenomena that are of a linear nature. This course is designed for slightly mathematically mature students. The aim is to provide students with many useful concepts in Linear Algebra and rigorous proof techniques followed by solving problems. The course will emphasize on abstraction to a greater degree than what students have

experienced in their previous linear algebra course (MATH 120). It will prepare students for further courses in mathematics and/or related disciplines, like computer science, economics, Physics and Engineering. Functional Analysis for instance, is an application of linear algebra to the space of functions.

We will start by discussing vector spaces, linear independence, span, basis, and dimension. Then we will revisit linear maps, eigenvalues, and eigenvectors. Inner product spaces will be introduced next, leading to the finite-dimensional spectral theorem and its consequences such as the singular value decomposition.

COURSE PREREQUISITE(S)

Math 120-Linear algebra with differential equations.

COURSE OBJECTIVES

At the successful completion of the course students will be able to:

- Use and apply important basic notions of abstract vectorspaces such as linear independence basis and dimension.
- Analyze finite dimensional linear vector spaces, their classification, linear maps and isomorphisms.
- Explain concepts such as eigenvalues, eigenvectors and their applications to diagonalization.
- Build their ability to write mathematical proofs.
- Understand inner product spaces and apply their understanding to study operators on such spaces.
- Analyze in depth operators on Complex and real vectorspaces.

COURSE RULES AND POLICIES

Communication

i) **All emails** sent to the instructor or TAs must have a **subject line** of the following format (examples):
"MATH 222--URGENT—content related question"
"MATH 222--NOT URGENT—question about the average score in quiz 02"

ii) **All emails** must be signed with name and **roll-number**.

iii) I will communicate with students by email. If you send me a Whatsapp message or text message, I will not respond unless it relates to a connectivity issue (in case of online) in accessing email or any other emergency.

iv) If you email me asking me a question that is already answered in the syllabus, I will not respond to your email.

v) Also do not flood my inbox to ensure that I have received your submission in your LMSDropbox. I will not respond to such emails. If it is successfully uploaded, you should be able to see in your LMS Dropbox folder.

vi) You are advised not to use informal mediums such as Whatsapp to communicate with the TAs. Please use email.

Email response policy

I will try my best to respond to emails as soon as possible. However, in some situations it might take up to 24 hours for me to respond.
I will not usually respond to emails over the weekend. I will also not send out emails to the class on Saturday or Sunday unless absolutely necessary.

Announcements

All announcements will be posted on LMS. **It is your responsibility** to regularly check the LMS site for the course.

Lecture format

- All lectures will be held in-person using chalk-board.
- **If online:**
  lectures will be conducted live via zoom and will last one hour 15 minutes. **Zoom details:** TBA
  You are encouraged to use the chat box to raise questions during the lecture.

  All lecture videos will be made available via a Youtube link on lecture day via LMS.
  Link to the lecture notes on OneNote will be shared, where you can follow lectures in real time.

  Please ask questions, your feedback is essential for teaching and learning in all mediums whether in-person or online.

Grading Breakup

Assignments: (7 best ones out of 8)	3.57% x 7 = 25%
Quizzes: (3 best ones out of 4)	5% x 3 = 15%
Midterm Examination:	30%
Final Examination:	30%

Note that this is tentative and subject to change within the first few weeks of the course.
Note that the number of quizzes and assignments is final and won't be increased, so you must take these seriously.

Grading policy

- This course will be relatively graded via the grader app on Zambeel.

- Anyone scoring an aggregate below 40 % will fail this course.

  If you think you are having any difficulties, please reach out to me or the TA well in advance so that we can help you fare better in the course.
- I will be assigning marks for graded components at my own discretion. Please don't mail me or ask the TA's to mediate unless there is a calculation error.

- You are welcome to contest your exams at the announced time, but be mindful of the fact that this

may increase or decrease your marks.

- Please don't email me at the end of the semester to ask me to adjust the cut-offs or to change your grades (without any justification) in order to get a higher grade. I will not entertain any such requests for two reasons: it will be unfair to everyone who does not send such emails, and it will undermine the integrity of the course.

Dates for graded components

The date for assignments, quizzes and exams will be strictly adhered to and late submissions will not be entertained, unless faced with some unforeseen circumstances.
These are mentioned in the description of assessments.

If you have accessibility issues or any other emergency, please email the instructor regarding graded instruments ASAP.

Mode of submission of graded components (in the event of online instruction)

You will be given time to turn in your assignments, quizzes and exams in LMS dropbox.

Make sure you turn them in as a single PDF file. Please arrange for the possibility to make one PDF from photos of answer sheets, on your device beforehand. **Individual images of answer sheets will not be acceptable.**

Harassment Policy

Harassment of any kind is unacceptable, whether it be sexual harassment, online harassment, bullying, coercion, stalking, verbal or physical abuse of any kind. Harassment is a very broad term; it includes both direct and indirect behaviour, it may be physical or psychological in nature, it may be perpetrated online or offline, on campus and off campus. It may be one offense, or it may comprise of several incidents which together amount to sexual harassment. It may include overt requests for sexual favours but can also constitute verbal or written communication of a loaded nature. Further details of what may constitute harassment may be found in the LUMS Sexual Harassment Policy, which is available as part of the university code of conduct.

LUMS has a Sexual Harassment Policy and a Sexual Harassment Inquiry Committee (SHIC). Any member of the LUMS community can file a formal or informal complaint with the SHIC. If you are unsure about the process of filing a complaint, wish to discuss your options or have any questions, concerns, or complaints, please write to the Office of Accessibility and Inclusion (OAI, oai@lums.edu.pk) and SHIC (shic@lums.edu.pk) —both of them exist to help and support you and they will do their best to assist you in whatever way they can.

To file a complaint, please write to harassment@lums.edu.pk.

Help related to equity and Belonging at SSE

SSE's Council on Equity and Belonging is committed to devising ways to provide a safe, inclusive, and respectful learning, living, and working environment for its students, faculty, and staff.
To seek counsel related to any such issue, please feel free to write to any member of the school council for help or feedback.
You are also welcome to write to me, as I am also a member of the council.

Privacy Policy (in the event of online instruction)

- The video recording link is not to be shared with anyone outside of our class.
- The videos or notes are shared in order to be used exclusively by the students enrolled in this course. Please ask for permission before sharing these with anyone.
- The TA sessions/ office hours will not be recorded.
- Tutorials conducted, if any, will be recorded to be shared with students absent.
- If at any time you are uncomfortable with keeping your videos on while a lecture/ tutorial is being recorded, please switch your videos off.
- If you are uncomfortable with your voice being recorded while you ask a question, use the chat feature of zoom to raise a question.

Mental Health Support at LUMS

For matters relating to counselling, kindly email student.counselling@lums.edu.pk, or visit https://osa.lums.edu.pk/content/student-counselling-office for more information.

You are welcome to write to me or speak to me if you find that your mental health is impacting your ability to participate in the course. However, should you choose not to do so, please contact the Counselling Unit and speak to a counsellor or speak to the OSA team and ask them to write to me so that any necessary accommodations can be made.

Contents of the syllabus

Note that this is tentative and subject to change as the course progresses. **The first few weeks,** being a review of already taught content in MATH 120 **will be fast-paced** to allow more time to dwell on new concepts towards the end of the course.

Week	Content	Reading/ Reference
1	The Euclidean vectorspaces R^n and C^n Abstract vectorspaces and examples Subspaces	Chapter 1 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.

2	Span and Linear Independence	Chapter 2 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
3	Bases and Dimension The vectorspace of linear maps	Chapter 2 & 3 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
4	Null spaces and Range Matrices Isomorphism of vectorspaces	Chapter 3 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
5	Products of vectorspaces Quotients of vectorspaces Dual spaces	Chapter 3 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
6	Polynomials Eigenvalues and Eigenvectors	Chapter 4 &5 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
7	Diagonalization Inner product spaces	Chapter 5 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
8	Inner product spaces continued Operators on inner product spaces Polar decomposition and SVD	Chapter 6 &7 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
9	Operators on inner product spaces Polar decomposition and SVD	Chapter 7 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
10	Operators on complex vectorspaces	Chapter 8 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
11	Operators on complex vectorspaces	Chapter 8 Book: Linear Algebra Done Right, 3rd

		edition, by Sheldon Axler, Springer 2004.
12	Operators on real vectorspaces	Chapter 9 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.
13	Trace and determinants	Chapter 10 Book: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2004.

Textbook(s)/Supplementary Readings

Text: Linear Algebra Done Right, 3rd edition, by Sheldon Axler, Springer 2015.

References: Friedberg, S.H., Insel, A.J., & Spence, L.E. (2003) Linear Algebra (4th ed.). Upper Saddle River, Prentice-Hall/Pearson Education

Sheldon Axler. Linear Algebra Done Right videos, free videos to accompany the book, 2017. http://linear.axler.net/LADRvideos.html

Assessments

All the assessments are described in the following table including mode of submission (in case n online), dates and expectations from learners.

Note that these are subject to change at the discretion of the instructor.

		Weight (%)
Type 1	**Assignments** will be 10 in number subject to **N-2 policy**, each assignment considered will be carrying a weight of 3.57%, doled out roughly every other week throughout the semester. Meant for informal feedback on presentation of arguments and assessment of applications of concepts learnt until that point in the course. **Mode of assessment:** Take home. **Mode of submission (online):** written submission through LMS dropbox. Please **name** the file (example) **"Assignment_2_YourRollNumber"** and submit	

	within the time provided for submission. **Submit your work as a single PDf file and not as a collection of individual images or photographs of your answer sheets.** <mark>**Make sure you turn them in as a single PDF file.** Please arrange for the possibility to make one PDF from photos of answer sheets, on your device beforehand. Individual images of answer sheets</mark> **will not be acceptable.**	
Type 2	**Quizzes** meant to access retention of key concepts in announced quiz syllabus and their application to one or more problems. **Dates: TBA** **Duration:** 15-20 minutes **Mode of assessment: In-person/live** and in-class. **Mode of submission(online):** written submission through LMS dropbox. Please **name** the file (example) **"Quiz_2_YourRollNumber"** and submit within the time provided for submission (5 minutes after exam time finishes). **Submit your work as a single PDf file and not as a collection of individual images or photographs of your answer sheets.** <mark>**Make sure you turn them in as a single PDF file.** Please arrange for the possibility to make one PDF from photos of answer sheets, on your device beforehand. Individual images of answer sheets</mark> **will not be acceptable.**	
Type 3	**Midterm exam** will assess understanding of concepts, ability to reproduce/ improvise on small proofs of statements explained in class, as well as applications of concepts to some problems. **Date:** TBA **Duration:** 90 minutes **Mode of assessment: In-person/**Live **Mode of submission:** written submission through LMS dropbox. Please **name** the file **"Midterm_YourRollNumber"** and submit within the time provided for submission (5 minutes after exam time finishes).	

	Submit your work as a single PDf file and not as a collection of individual images or photographs of your answer sheets. <mark>Make sure you turn them in as a single PDF file.</mark> Please arrange for the possibility to make one PDF from photos of answer sheets, on your device beforehand. <mark>Individual images of answer sheets will not be acceptable.</mark>	
Type 4	**Final exam** will be comprehensive and will assess understanding of concepts, ability to reproduce/ improvise small proofs of statements learnt in class, as well as applications of concepts to some problems. The portion of midterm syllabus tested will be very small compared to post-mid syllabus. Date: as per schedule published on Zambeel. Duration: 120 minutes **Mode of assessment:** Live. **Mode of submission:** written submission through LMS dropbox. Please **name** the file **"Final_YourRollNumber"** and submit within the time provided for submission (5 minutes after exam time finishes). **Submit your work as a single PDf file and not as a collection of individual images or photographs of your answer sheets.** <mark>Make sure you turn them in as a single PDF file.</mark> Please arrange for the possibility to make one PDF from photos of answer sheets, on your device beforehand. <mark>Individual images of answer sheets will not be acceptable.</mark>	

If you have any issue or you are uncomfortable with the assessments framework or polices laid out in this syllabus/ outline please write to me as soon as possible, before you are in the thick of things and it is too late.