Faculty of Engineering Sciences (FES),
Ghulam Ishaq Khan Institute of Engineering Sciences and Technology

ES-205: Advanced Linear Algebra	**Spring 2025**

Pre-Requisite: MT-201
Courses for which this course is a Pre-requisite: n/a
Instructor: Dr. Asad Mahmood
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Consultation hours: During office hours, or by appointment for long consultation

Course Introduction

We are passing through the 'information age' in which information extraction and processing plays a vital role in many disciplines from engineering to computer science, economics, biology etc. Vectors and matrices provide a useful framework for the storage and processing of information. The *language* of vectors and matrices is known as Linear Algebra in mathematics. This course aims to delve deeper into the concepts related to vectors and matrices and the operations that are performed on them which allows them to be applied to real-world problems. Application examples will also be discussed to demonstrate the importance of linear algebra in different fields such as engineering, computer science and economics.

Course Contents

1. **Linear equations in Linear Algebra** – Review (Systems of Linear Equations, Row Reduction and Echelon Forms, Vector and Matrix Equations, Solution Sets of Linear Systems), Applications of Linear Systems, Linear Independence, Introduction to Linear Transformations
2. **Matrix Algebra** – Review (Matrix inverse), Characterization of invertible matrices, Partitioned matrices, and Matrix factorization
3. **Vector Spaces**- Vector spaces and subspaces, null space, linearly independent sets, Bases, and linear transformations
4. **Eigenvalues and Eigenvectors** – Review (Eigenvalues and eigenvectors), characteristic equation, diagonalization
5. **Orthogonality and least squares** – Inner product and orthogonality, Gram Schmidt process, Least-squares Problems
6. **Symmetric matrices and quadratic forms** (if time permits) – Diagonalization of symmetric matrices, quadratic forms, singular value decomposition

CLOs and PLOs			
Sr. No.	**Course Learning Outcomes**	**PLOs**	**Blooms Taxonomy**
CLO1	Be able to solve systems of linear equations, perform important matrix algebra operations and demonstrate associated understanding.	PLO1 (Engineering Knowledge)	C3 (Application)
CLO2	Be able to demonstrate understanding of vector spaces and solve problems related to vector spaces, including eigenspace and its associated parameters.	PLO1 (Engineering Knowledge)	C3 (Application)
CLO3	Be able to demonstrate understanding of advanced linear algebra concepts, such as Gram-Schmidt, Least-Squares, Singular Value Decomposition etc., and solve associated problems	PLO1 (Engineering Knowledge)	C3 (Application)
CLO4	Analyze and solve applied engineering problem requiring tools from advanced linear algebra.	PLO 4 (Investigation)	C5 (Evaluating)
CLO5	Efficiently work in a team to investigate and solve problems related to applied linear algebra.	PLO 9 (Individual and Teamwork)	A2 (Respond)

Tentative CLOs Assessment Mechanism					
	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
Quizzes	2-3 Quizzes	2 Quizzes	1-2 Quizzes		
Midterm Exam	2-3 Mid Qs.	1 Mid Qs.			
Final Exam		1-2 Final Qs.	2-3 Final Qs.		
Project / CEP				1 Project on a Complex Engineering Problem (CEP)	1 Project Report Section

Grading policy	
Assessment items	**Weightage**
5*Announced Quizzes	15%
5*Assignments	10%
Project on Complex Engineering Problem +Teamwork	10%
Midterm exam	25%
Final exam	40%

Text and Reference Books

Textbook:

- David C. Lay, S. R. Lay, J. J. McDonald, *Linear Algebra and its Applications*, 6th Global Edition, Pearson, 2022.

Reference book:

- Gilbert Stang, *Introduction to Linear Algebra*, 6th edition, Wellesley-Cambridge Press, 2023.

FES Academic Honesty Policy

FES follows a strict Academic Honesty Policy that applies to this course as well. Any violations can lead to deduction of marks, referral to faculty Academic Honesty Committee, issuing of warning letter (with copy to parents), referral to Institute Disciplinary Committee, award of F grade in course or entire semester, and possible removal from rolls of the institute. Students must read and adhere to the policy available on webpage and with Student Office

Administrative Instructions

- **Preparing for the announced quizzes (based on assignments) is the best way to do well in this course**, as they will be interspersed throughout the semester, and you will have ample amount to prepare IF you plan nicely. Anyone who has done the assignments himself/herself is expected to do well in quizzes, midterm and final exams.
- All the lectures as well as the assessments including assignments, quizzes, midterm, and final exam) will be made from the book topics covered in the lectures. Hence, **make sure that you read the book topics thoroughly** and NOT rely ONLY on the slides, which are made only to assist in lecturing.
- **Quizzes/Assignments due dates** will be announced well in advance. **The dates will not be changed**, hence make sure to plan your other commitments accordingly.
- **All course material (lecture slides, assignments, marks, announcements etc.) will be communicated to students via MS Teams Group** for the course. It is the responsibility of the students to regularly check the MS Teams group for important information and material.
- **Please respect the decorum of the class.** It is expected of you to act maturely in the classes. Being punctual, being quiet in the class, discreetly entering/leaving the class for any emergency are some examples of respecting the decorum.
- **80% attendance is mandatory** to be allowed to sit in the final examination as per institute's policy.

Tentative Lectures Breakdown:

- Week 1 Lectures Linear equations in Linear Algebra (Chapter 1)
- Week 2 Lectures Linear equations in Linear Algebra (Chapter 1)
- Week 3 Lectures Linear equations in Linear Algebra (Chapter 1)
- Week 4 Lectures Matrix Algebra (Chapter 2)
- Week 5 Lectures Matrix Algebra (Chapter 2)

- Week 6 lectures Vector Spaces (Chapter 4)
- Week 7 lectures Vector Spaces (Chapter 4)
- Week 8 lectures Vector Spaces (Chapter 4)

-------- MID-TERM ----------

- Week 9 lectures Eigenvalues and Eigenvectors (Chapter 5)
- Week 10 lectures Eigenvalues and Eigenvectors (Chapter 5)
- Week 11 lectures Orthogonality and Least Squares (Chapter 6)
- Week 12 lectures Orthogonality and Least Squares (Chapter 6)
- Week 13 lectures Orthogonality and Least Squares (Chapter 6)
- Week 14 lectures Symmetric Matrices and Quadratic Forms (Chapter 7)
- Week 15 lectures Symmetric Matrices and Quadratic Forms (Chapter 7)

Reviewed / Approved by: