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

ES-304: Linear Algebra II **Fall 2023**

Pre-Requisite: MT-201
Courses for which this course is a Pre-requisite: n/a
Instructor: Dr. Babar Zaman
Email: babar.zaman@giki.edu.pk
Office: G-22, FES
Phone: 2244
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 introduce the basic notions and 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. The essential goal of the course is thus to make the students comfortable with the *language* of matrices and vectors so that not only they are familiar with the important terms and notions related to vectors and matrices, but that they are also able to apply important operations on vectors and matrices to different type of problems including physical and real-world problems.

Course Contents

1. **Linear equations in Linear Algebra** - Systems of Linear Equations, Row Reduction and Echelon Forms, Vector and Matrix Equations, Solution Sets of Linear Systems, Applications of Linear, Linear Independence, Introduction to Linear Transformations
2. **Matrix Algebra** – Matrix inverse, Characterization of invertible matrices, Partitioned matrices, and Matrix factorization
3. **Determinants**- Properties of determinants, Cramer's rule, and linear transformations
4. **Vector Spaces**- Vector spaces and subspaces, null space, linearly independent sets, Bases, and linear transformations
5. **Eigenvalues and Eigenvectors** -Eigenvalues and eigenvectors, characteristic equation, diagonalization
6. **Orthogonality and least squares** – Inner product and orthogonality, Gram Schmidt process, Least-squares Problems
7. **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, 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	1-2 Quiz	1-2 Quizzes	1-2 Quizzes		
Midterm Exam	1 Mid Qs.	1 Mid Qs.	1 Mid Qs..		
Final Exam	1-2 Final Qs.	1-2 Final Qs.	1-2 Final Qs.		
Project				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	10%
Midterm exam	25%

Final exam	40%

Text and Reference Books

Text book:

- Linear Algebra and its Applications – David C. Lay, Steven R. Lay, Judi J. McDonald (6th Edition – Global Edition, 2022, Pearson, USA).

Reference book:

- Elementary Linear Algebra with Applications – Howard Anton, Chris Rorres (11th Edition 2013, Wiley, USA).
- • Linear Algebra and Its Applications – Gilbert Strang (4th Edition 2005, USA).

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 exam.
- 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 CMS portal**. It is the responsibility of the students to regularly check the portal for important information and material.
- **Please do not make the class noisy**. As 3rd year students, it is expected of you to act maturely in the classes. You are allowed to go out of the class quietly if there is something urgent that needs your attention.
- **80% attendance is mandatory** to be allowed to sit in the final examination as per institute's policy. No relaxations will be allowed

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 Matrix Algebra (Chapter 2)
- Week 4 Lectures Matrix Algebra (Chapter 2)
- Week 5 Lectures Determinants (Chapter 3)
- Week 6 lectures Vector Spaces (Chapter 4)
- Week 7 lectures Vector Spaces (Chapter 4)
- Week 8 lectures Eigenvalues and Eigenvectors (Chapter 5)

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