COURSE DESCRIPTION FORM: MT-1004 Linear Algebra

INSTITUTION FAST School of Computing, National University of Computer and Emerging Sciences, Islamabad

PROGRAMs TO BE EVALUATED DS – **Fall 2024**

Course Description

(Fill out the following table for each course in your computer science curriculum. A filled out form should not be more than 2-3 pages.)

Course Code	MT-1004
Course Title	Linear Algebra
Credit Hours	3
Prerequisites by Course(s) and Topics	Nil
Grading Policy	Absolute Grading
Policy about missed assessment items in the course	Retake of missed assessment items (other than midterm/ final exam) will not be held. For a missed midterm/ final exam, an exam retake application along with necessary evidence are required to be submitted to the department secretary. The examination assessment and retake committee decide the exam retake cases.
Course Plagiarism Policy	Plagiarism in project or midterm/ final exam may result in F grade in the course. Plagiarism in an assignment will result in zero marks in the whole assignments category.
Assessment Instruments with Weights (homework, quizzes, midterms, final, programming assignments, lab work, etc.)	**100% Theory**

Assessment Item	**Number**	**Weight (%)**
Assignments and HomeWorks	18-20	15
Quiz	10-12	10
Sessional I & II	1	15 (Each)
Final Exam	1	45

Course Instructors	Sara Aziz, Sehrish Hassan Shigri
Lab Instructors (if any)	
Course Coordinator	
URL (if any)	
Current Catalog Description	Basic ideas and techniques to understand linear systems and their interpretation in terms of solutions. Vector-spaces and its properties, Eigen decomposition, linear transformations, orthogonality (Gram-Schmidt process) and least square solution to a system.

Textbook	Linear Algebra and its Applications (4th Edition) by David C. Lay.
Reference Material	**Elementary Linear Algebra,** by Howard Anton and Chris Rorres, John Wiley, 11th Edition.
Course Learning Outcomes	**A. Course Learning Outcomes (CLOs)** At the completion of the course, the students shall be able to: 1. Solve the system of linear equations. 2. Analyse properties of vector spaces. 3. Perform matrix transformations. 4. Apply Eigenvalue decomposition to a matrix.

B. Program Learning Outcomes

For each attribute below, indicate whether this attribute is covered in this course or not. Leave the cell blank if the enablement is little or non-existent.

1. Apply knowledge of mathematics, statistics, natural sciences, computing fundamentals, and a data specialization to the solution of complex data science problems.	
2. Identify, formulate, research literature, and analyze complex data problems, reaching substantiated conclusions using first principles of mathematics, statistics, natural sciences, computing and data sciences.	
3. Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations. 4. Conduct investigation of complex data science problems using research-based knowledge and research-based methods.	
5. Create, select, adapt and apply appropriate techniques, resources, and modern tools, including prediction and modelling for complex data science problems.	
6. Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues relevant to context of complex data science problems.	
7. Understand and evaluate sustainability and impact of data professional work in the solution of complex data science problems.	

8. Apply ethical principles and commit to professional ethics and responsibilities and norms of computing practice.	
9. Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.	
10. Communicate effectively on complex data science activities with the data professionals' community and with society at large. 11. Demonstrate knowledge and understanding of management principles and economic decision making and apply these to one's own work as a member or a team.	
12. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological changes.	

C. Mapping of CLOs on PLOs
(CLO: Course Learning Outcome, PLOs: Program Learning Outcome

		PLOs											
		1	2	3	4	5	6	7	8	9	10	11	12
CLOs	1	✔											
	2	✔											
	3	✔											
	4	✔											

Topics covered in the course with number of lectures on each topic (assume 15 weeks of instruction and 1.5 hours lecture duration)	**Topics**	**Lectures**
	System of Linear Equations & its solution. Applications of system of linear equations. Linear Transformation and its matrices. Introduction to multilinear maps, bilinear maps.	3

	Elementary Matrices. Inverse of a matrix. Brief introduction of determinants and its applications.	3	
	Field & Vector Space, Sub-spaces. Basis and Dimension of vector space, Null space, Row space, Column spaces and its properties.	6	
	Eigen-Decomposition. Solution for System of ODE's with the help of Eigen values & Eigenvectors.	6	
	Inner product. Orthogonal and orthonormal vectors, Gram-Schmidt process for finding orthonormal basis. Pseudo inverse and Penrose Inverse of general matrices. Affine combination, affine independence, affine transformation.	8	
	Orthogonality. Gram-Schmidt process & QR-decomposition, and least square solution of linear system, Positive Definite Matrices, Singular Value Decomposition	6	

Laboratory Projects/Experiments Done in the Course				
Programming Assignments Done in the Course	Python			
Class Time Spent per Week (in percentage)	**Theory (%)**	**Problem Analysis (%)**	**Solution Design (%)**	**Social and Ethical Issues (%)**
	10	20	60	10
Oral and Written Communications				

COURSE CONTENTS

Weeks	Contents/ Topics	Courseware Events (Lab/ Case Study/ Quiz/ Assignment/.)	Comments
Week-01	Introduction to system of linear equations. Graphical Explanation of the solution of system of linear equations. Elementary Row Operations, Row Echelon form & Reduced Row Echelon form of a matrix. Consistent & inconstant System. Parametric form of solution (infinite solutions).	H.W # 1	
Week-02	Linear Combinations and span of vectors. Homogenous System. Explanation of solution using notion of span. Comparison of solution of non-homogeneous system and corresponding homogeneous system.	H.W # 2 Quiz #1	

Week-03	Linear dependence and independence, Bases of R^n. Introduction to Algebraic Structures: Groups, Rings, Fields, Vector Spaces.	H.W #3 Quiz # 2	
Week-04	The Notion of Subspaces. The Four Fundamental Subspaces – Null Space, Row space, Column space, Left Null Space. Bases and dimension of these subspaces.	H.W # 4 Quiz # 3 Assignment # 01	
Week-05	Linear transformations. Matrix of linear transformation. Kernel and Range of linear transformation. One-to-one and onto Linear transformations. The notion of Isomorphism – Isomorphic Spaces.	H.W #5	
Week-06	Linear Independence; Basis and Dimension of a **Vector Spaces** $(P_n(x), M_{n*n})$ using their isomorphism with R^n.	H.W # 6 Quiz # 4	
Week-07	Elementary matrices, Matrix decomposition using elementary matrices. Inverse of matrix with the help of elementary matrices. Determinants and their applications: Cramer's rule and its geometrical interpretation.	H.W # 7 Quiz #5	
Week-08	Change of Basis, change-of-coordinates matrix. Eigenvalues & Eigenvectors, concept of algebraic and geometric multiplicity, eigen vector basis and its importance, Diagonalization.	H.W # 8 Quiz # 6	
Week-09	Eigenvectors and linear transformation. Complex eigenvalues and corresponding eigenvectors.Discrete Dynamical Systems & Solution for System of ODE's with the help of Eigenvalues & Eigenvectors. The behavior of the solution after large time (Concept of attractor, repeller, saddle point, convergence/divergence of the solution)	H.W # 9	
Week-10	Inner product spaces, concept of different norm of a vector. Orthogonal and orthonormal vectors, Orthogonal Sets, Orthogonal projectons. Gram-Schmidt process for finding orthonormal basis.	H.W # 10	
Week-11	QR-Decomposition. Least square method to find best approximate solution of an inconsistent system. Pseudo inverse and Penrose Inverse of general matrices.	H.W #11 Quiz # 7	
Week-12	Orthogonal Decomposition & Quadratic Form. Constraint Optimization. Positive Definite Matrices, Singular Value Decomposition. Principal Component Analysis (PCA).	H.W # 12 Quiz # 8	
Week-13	Affine combination, affine independence, affine transformation (Section 8.1, 8.2 and 8.3)	H.W # 13 Quiz # 9 Assignment # 02	
Week-14	Introduction to multilinear maps, bilinear maps as tensors of rank 2, symmetric and alternating tensors, tensor product and wedge product (Book of Loring W. Tu. Section 3 chapter 1).	H.W # 14 Quiz # 10	
Week-15	Tensor Decomposition, Tensor SVD.	H.W # 15 Quiz # 11	
Week-16	Revision		