King Fahd University of Petroleum and Minerals
Department of Mathematics

Math 557 Applied Linear Algebra

Syllabus (Term 251)
Dr. Slim Belhaiza

Title: Math 557 Applied Linear Algebra

Credit: 3-0-3

Lecture Notes*: MATH 557: Advanced Linear Algebra, by Dr. Slim Belhaiza, 2025.

Textbook: Numerical Linear Algebra and Matrix Factorization, by Prof. Tom Lyche, SPRINGER, 2020.

Reference Textbook: Numerical Linear Algebra with Application, by Prof. William Ford, ELSEVIER, 2015.

Description: Basic concepts from linear algebra and numerical analysis. Direct methods for large, sparse linear systems, Cholesky and LU factorizations. Regularization of ill-conditioned least squares problems. SVD and QR factorizations. Sensitivity and conditioning of linear systems and least square problems. Stationary and non-stationary iterative methods, multigrid methods. Matrix theory, including spectral decompositions and eigenvalue perturbation theory. Eigenvalue and QR algorithm, and computations of SVD. Applications.

Learning Outcome: Upon successful completion of this course, a student should be able to:

1. Apply fundamental numerical linear algebraic concepts.
2. Estimate stability of solutions to linear algebraic equations & eigenvalue problems.
3. Utilize factorizations for efficiently solving linear systems and least squares problems.
4. Use the underlying principles of iterative algorithms for computing and selecting eigenvalues and finding singular values.
5. Estimate the speed of convergence and computational complexity of the selected numerical algorithms.

Main objectives :

1. Discuss linear algebra techniques for matrix factorization.
2. Study computation of eigenvalues, least squares problems, and error analysis.
3. Discuss selected applications in statistics and optimization.

Grading Policy:

1. Midterm Exam	**Material: TBA** **Date**: TBA **Place: TBA**	20% (60 points)
2. Project	**Material:** **Date**: **Place:**	20% (60 points)
3. Final Exam	**Material:** (Comprehensive) **Date**: **TBA** **Place: TBA**	35% (105 points)
4. Class Work	**i) Homeworks:** Theoretical and practical assignments. .	20% (60 points)
	ii) Class Activities: Class participation and attendance.	5% (15 points)

Exam Questions: The questions of the common exams are based on examples, homework, theoretical and practical problems.

Attendance: Attendance is a University Requirement. A DN grade will be awarded to any student with 9 unexcused absences.

Academic Integrity: All KFUPM policies regarding ethics apply to this course.

Week	Sections in Lecture Notes	Topics
1		Review of Matrices
	1.1	CR Factorization
2	1.2	Spectral Factorization
	1.3	LU Elimination
3	1.4	Diagonalization
	1.5	Cholesky Factorization
4	1.6	Singular Vector Decomposition
	1.7	Principal Component Analysis
5	1.8	Generalized Eigenvalues and Singular Values
	1.9	Non-Negative Matrix Factorization
6	2.1	Pseudo-Inverse Matrix and Gram-Schmidt Algorithm
	2.4	Changes in A^{-1} and A^{+}
7	2.5	Changes in Eigenvalues and Singular Values
8	2.7	Matrix Completion
	2.8	Clustering and K-Means
9	3.1	The Error Function
		Project Phase I
10	3.2	Gradient Methods
	3.2	Conjugate Gradient Algorithm
11	3.3	Activation Functions
		Project Phase II
12	3.4	Backpropagation
	3.5	Learning and training
13	3.6	Pattern Recognition
14	**Catch-Up and Review Classes**	
15		**Project Phase III**