King Fahd University of Petroleum and Minerals
Department of Mathematics

Math 559 Numerical Linear Algebra

Syllabus (Term 241)
Dr. Slim Belhaiza

Title: Math 559 Numerical Linear Algebra

Credit: 3-0-3

Lecture Notes: MATH 559: Numerical Linear Algebra, by Dr. Slim Belhaiza, 2024.

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: Concepts from linear algebra and numerical analysis. Direct methods for large, sparse linear systems. Cholesky, LU, QR, and SVD factorizations. Sensitivity and conditioning of linear systems and least square problems. Iterative methods. Numerical methods for eigenvalues. Computations of SVD. Computer software and applications.

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

1. Apply linear algebra techniques for matrix factorization.
2. Apply linear algebra concepts to statistics.
3. Apply linear algebra tools to optimization problems.
4. Implement numerical linear algebra algorithms.

Main objectives :

1. Discuss linear algebra techniques for matrix factorization.
2. 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	Dates (2024)	Sec.	Topics
1	Aug. 25 - 29		Review of Matrices
		1.1	CR Factorization
2	Sep. 1 - 5	1.2	Spectral Factorization
		1.3	LU Elimination
3	Sep. 8 - 12	1.4	Diagonalization
		1.5	Cholesky Factorization
4	Sep. 15 - 19	1.6	Singular Vector Decomposition
		1.7	Generalized Eigenvalues and Singular Values
Sunday 22nd and Monday 23rd September: National Day Holidays			
5	Sep. 24 – Sep. 26	1.8	Non-Negative Matrix Factorization
		2.1	Split Algorithm and Arnoldi Iteration
6	Sep. 29 – Oct. 03	2.2	Pseudo-Inverse Matrix and Gram-Schmidt Algorithm
		2.4	Changes in A^{-1} and A^{+}
7	Oct. 6 - 10	2.5	Changes in Eigenvalues and Singular Values
		2.6	Split Algorithms for l^2+l^1
8	Oct. 13 - 17	2.7	Matrix Completion
		2.8	Clustering and K-Means
Midterm Exam: TBA [1.1 to 2.5]			
9	Oct. 20 – 25	3.1	The Error Function
			Project Phase I
10	Oct. 27 – Nov. 1	3.2	Gradient Methods
		3.2	Conjugate Gradient Algorithm
11	Nov. 3 – 7	3.3	Activation Functions
			Project Phase II
Nov. 10 – 14: Midterm Break			
12	Nov. 17-21	3.4	Backpropagation
		3.5	Learning and training
13	Nov. 24-28	3.6	Pattern Recognition
14	Dec. 1-5	**Catch-Up and Review Classes**	
15	Dec. 8 -12		**Project Phase III**
Final Exam: TBA [Comprehensive]			