King Fahd University of Petroleum and Minerals
Department of Mathematics & Statistics

Math 405 Learning from Data

Syllabus (Term 221)
Dr. Slim J. Belhaiza

Title: Math 405 Learning from Data

Credit: 3-0-3

Textbook: Linear Algebra and Learning from Data, by Prof. Gilbert Strang, WELLESLEY- CAMBRIDGE PRESS, 2018.

Reference Textbook: Neural Network Design, M.T. Hagan, H.B. Demuth, M.H. Beale, O. De Jesus, 2nd Edition, Amazon, 2014.

Addition Readings: Mathematics of Neural Networks, Chap.1, S. J. Belhaiza, 2022.

Description: Basic vector and matrix operations, Factorizations, Least-Square Estimation, Matrix Completion, Special Matrices, Fourier Transforms, Linear Regression and Neural Networks.

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

1. Describe linear algebra and statistics fundamental to many data science algorithms.
2. Apply linear algebra concepts to probability and statistics.
3. Apply linear algebra to optimization problems.
4. Use linear algebra and statistics in selected machine learning algorithms.

Main objectives :

1. Introduce topics from linear algebra, statistics, and optimization related to data science.
2. Discuss selected applications in Regression and Neural Networks using numerical software, toolboxes, and libraries.

Grading Policy:

1. Exam I	**Material:** (1.1-1.9) **Date**: **Place:**	20% (60 points)
2. Exam II	**Material:** (1.10-1.4*) **Date**: **Place: TBA**	20% (60 points)
3. Final Exam	**Material:** (Comprehensive) **Date**: **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 the examples, homework theoretical and practical problems.

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

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

Week	Dates (2022)	Sec.	Topics
1	Aug. 28 - Sep 1	1.1	Multiplication Ax Using Columns of A
		1.2	Matrix-Matrix Multiplication AB.
2	Sep. 4 - 8	1.3	The Four Fundamental Subspaces
		1.4	Elimination and $A = LU$
3	Sep. 11 - 15	1.5	Orthogonal Matrices and Subspaces
		1.6	Eigenvalues and Eigenvectors
4	Sep. 18 - 22	1.7	Symmetric Positive Definite Matrices
		1.8	Singular Values and Singular Vectors in the SVD
Thursday 22nd September: National Day Holiday			
5	Sep. 25 – Sep. 29	1.9	Principal Components and the Best Low Rank Matrix
		1.10	Rayleigh Quotients and Generalized Eigenvalues
First Major Exam: TBA [1.1 to 1.9]			
6	Oct. 2 - 6	1.12	Factoring Matrices and Tensors: Positive and Sparse
		2.1	Numerical Linear Algebra
7	Oct. 9 - 13	2.2	Least Squares
		2.2	Least Squares (Continue)
8	Oct. 16 - 20	2.3	Three Bases for the Column Space
		3.1	Changes in A^{-1} from Changes in A.
9	Oct. 23 - 27	1.1*	The Error Function
		1.2*	Steepest Descent Algorithm
10	Oct. 30- Nov. 3	1.3*	Newton-Raphson Algorithm
		1.4*	Conjugate Gradient Algorithm
Second Major Exam: TBA [1.10 to 1.4*]			
11	Nov. 6 – 10	1.5*	Activation Functions
		1.6*	Backpropagation
12	Nov. 13 – 17	1.7*	Learning and Training
		1.8*	Pattern Recognition
13	Nov. 20 – 24	2.1*	Introduction to Time Series
		2.2*	Linear Regression
Midterm Break: Nov. 27 – Dec. 1			
14-15	Dec. 4 – 8 Dec. 11 -15		Review and Pace Adjustment
			Review and Pace Adjustment
Final Exam: TBA			

*: additional reading reference.