MATH 426/MATH 626 - Numerical Linear Algebra | SPRING 2022

Instructor Information

Instructor: Kourosh Zarringhalam
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Office: W03-0154

Online Class Meetings and Virtual Office Hours

Class Meeting Time: In person, on TuTh 2:00PM - 3:15PM
Location: University Hall Y04-4130

Office Hours: By appointment only on TuTh 1:00PM - 2:00PM

Course Information

Course Title: Numerical Linear Algebra
Credits: 4

Description: Linear Algebra plays a fundamental role in mathematical data sciences. Many algorithms in statistics, machine learning, and optimization rely on matrix computation techniques and systems of linear equations. The main goal of the course is to introduce algorithmic and mathematical foundations of matrix computations. Topics include linear algebraic systems, the Singular Value Decomposition (SVD) and the Principal Component Analysis (PCA), Matrix Factorizations techniques, such as LU, QR, NMF, and Cholesky and their applications. We will discuss eigenvalue estimation, including iterative and direct methods, such as Householder methods, tri-diagonalization, and power methods. We will discuss concepts of numerical analysis that are important in the practical implementation of algorithms, such as stability and convergence. The methods and their applications will be illustrated using the R programing language. Basics of the R programming language as well as writing interactive R Markdown documents will be covered during the course. We will use Markdown and Latex for text formatting. Being able to communicate mathematical ideas in written text is essential and Latex is a proper tool for this purpose. These topics will be covered during the course and no prior knowledge is required.

Prerequisites: MATH 260 for undergraduate students, MATH 625 for graduate students or permission from instructor.

Required Texts: *Numerical Linear Algebra*. Lloyd N. Trefethen, David Bau, III. ISBN-13: 978-0898713619 ISBN-10: 0898713617.

Prerequisite Skills: Content from the classes MATH 260, CS110, and familiarity with computer programming.

Objectives: By fully participating in this course, you should be able to:

1. Perform all basic operations with matrices using a computer program.
2. Understand and implement various matrix factorization methods and their numerous applications.
3. Solve linear systems of equations using elimination and alternative numerical methods, such as LU decomposition, QR factorization, SVD and Iterative methods

4. Analyze stability of matrix computation algorithms.
5. Implement algorithms in Linear Algebra for data analysis applications (dimensionality reduction, least-squares methods).
6. Find the Perron-Frobenius pair of positive matrices.
7. Implement Eigenvalue/Eigenvector algorithms using QR and iterative methods.
8. Program in R.
9. Write R Markdown and Latex documents.

Core Competencies: The objectives for this course focus on the following core competencies: *Use of Numerical Linear Algebra in scientific computing.*

Assignments: A total of 5-7 Homework/Projects will be assigned during the semester. Homework assignments will include both theoretical and programming exercises. Late submissions will not be accepted. You must typeset the assignments using Latex or R Markdown. Handwritten assignments will not be accepted.

Exams: There will be a total of 3 exams. Their tentative dates are:

Exam	Date
Exam 1	**03/09/2023**
Exam 2	**04/20/2023**
Exam 3	**TBA**

Course Rubric:

Tests/Assignments/Deliverables	Number	Grade %
1. Assignments	**5-7**	**35%**
2. Exams	**3**	**60%**
4. Class Participation	**N/A**	**5%**

Assignment Description: The Assignments contain theoretical questions and implementation of algorithms discussed during the course.

Note: Graduate students will be assigned additional theoretical and programming questions in assignment as well as in the midterm and final examinations. For example, graduate students may be required to implement non-negative matrix factorization (NMF) using trust-region optimization algorithms, while undergraduate students will be assigned HW problems to perform and apply NMF using built in functions toward specific applications. Additionally, graduate students will be more extensively tested on theoretical grounds, such as proofs of existence of certain matrix decompositions.

Course Policies: Participation includes active contribution to class discussions and completion of all assignments and tests before the deadlines. Class participation and attendance is required and is part of your grade.

Late Work – Late work will not be accepted. There is no make up for assignments. Exams can be made up only for legitimate reasons, such as sickness. Students must contact the office of Dean of Students and provide proper paperwork and documentation and request a formal excuse.

Grading

Grading: Grade type for the course is a whole or partial letter grade. (Please see table below) Note: the lowest passing grade for a graduate student is a "C". Grades lower than a "C" that are submitted by faculty will automatically be recorded as an "F". Please see the Graduate Catalog or website for more detailed information on the University's grading policy.

Grading Policy			
	Letter Grade	**Percentage**	**Quality Points**
	A	93-100%	4.00
	A-	90-92%	3.75
	B+	87-89%	3.25
	B	83-86%	3.00
	B-	80-82%	2.75
	C+	77-79%	2.25
	C	73-76%	2.00
	F	0-72%	0.0
	INC	**A grade of Incomplete (INC) is not automatically awarded when a student fails to complete a course. Incompletes are given at the discretion of the instructor. They are awarded when satisfactory work has been accomplished in the majority of the course work, but the student is unable to complete course requirements as a result of circumstances beyond his/her control. The student must negotiate with and receive the approval of the course instructor prior to the end of the course in order to receive a grade of incomplete. Contract of completion terms is required.**	N/A
	IF	Received for failure to comply with contracted completion terms.	N/A
	W	Received if withdrawal occurs before the withdrawal deadline.	N/A
	AU	Audit (only permitted on space-available basis)	N/A
	NA	Not Attending (student appeared on roster, but never attended class. Student is still responsible for tuition and fee charges unless withdrawal form is submitted before deadline. NA has no effect on cumulative GPA.)	N/A

Accommodations

The University of Massachusetts Boston is committed to providing reasonable academic accommodations for all students with disabilities. This syllabus is available in alternate format upon request. Students with disabilities who need accommodations in this course must contact the instructor to discuss needed accommodations. Accommodations will be provided after the student has met with the instructor to request accommodations. Students must be registered with the Ross Center for Disability Services, CC UL 211 (617.287.7430) before requesting accommodations from the instructor. http://www.umb.edu/academics/vpass/disability/. After registration with the Ross Center, a student should present and discuss the accommodations with the professor. Although a

student can request accommodations at any time, we recommend that students inform the professor of the need for accommodations by the end of the Drop/Add period to ensure that accommodations are available for the entirety of the course.

Academic Integrity and The Code of Student Conduct

It is the expressed policy of the University that every aspect of academic life not only formal coursework situation, but all relationships and interactions connected to the educational process shall be conducted in an absolutely and uncompromisingly honest manner. The University presupposes that any submission of work for academic credit indicates that the work is the student's own and is in compliance with university policies. In cases where academic dishonesty is discovered after completion of a course or degree program, sanctions may be imposed retroactively, up to and including revocation of the degree. Any student who reasonably believes another student has committed an act of academic dishonesty should inform the course instructor of the alleged violation. These policies are spelled out in the Code of Student Conduct. Students are required to adhere to the Code of Student Conduct, including requirements for academic honesty, as delineated in the University of Massachusetts Boston Graduate Catalogue and on their website and in relevant program student handbook(s) or websites. UMB Code of Student Conduct

You are encouraged to visit and review the UMass website on Plagiarism*:* Plagiarism Prevention & Awareness: Home