Lahore University of Management Sciences

Course Outline

Math 4418-Numerical Linear Algebra/Math 543-Advanced Numerical Linear Algebra

Fall 2020-2021

Instructor	**Dr. Zahra Lakdawala**
Room No.	Zoom
Office Hours	Per Appointment
Email	zahra.lakdawala@lums.edu.pk
Telephone	Whatsapp group will be created
Secretary/TA	Shazia Zafar and Noreen Sohail /TBA
TA Office Hours	TBA
Course URL (if any)	

Course Basics				
Credit Hours	4			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	120 minutes
Recitation/Lab (per week)	Nbr of Lec(s) Per Week		Duration	
Tutorial (per week)	Nbr of Lec(s) Per Week		Duration	

COURSE DESCRIPTION

Linear Algebra is one of the most widely used topics in the mathematical sciences. In the course of Linear Algebra we learnt standard techniques for basic linear algebra tasks including the solution of linear systems, finding eigenvalues/eigenvectors and orthogonalisation of bases. However, these techniques are usually computationally too intensive to be used for the large matrices encountered in practical applications.
This course will focus on the fundamental concepts of numerical linear algebra introducing the practical issues to practical applications. It will teach you how to analyze and apply certain algorithms in a reliable and computationally efficient way.
We will focus on the following: direct and iterative methods for solving simultaneous linear equations; matrix factorization, decomposition, and transformation; conditioning, stability and efficiency; computation of eigenvalues and eigenvectors. Since many real world problems ultimately reduce to linear algebra concepts and algorithms, there will be a strong emphasis on understanding the advantages and disadvantages, and the limits of applicability for all the covered techniques.
The course includes significant computing-related assignments will require the use of a computer and basic programming skills (Python). The theoretical material will be assessed in an examination over LMS/Zoom.

COURSE PREREQUISITE(S)

- Fundamentals of linear algebra and calculus.
- Fundamentals of programming.

Lahore University of Management Sciences

LEARNING OUTCOMES	
•	Introduce and understand numerical linear algebra: matrix factorization, conditioning a matrix for numerical stability, error analysis for numerical algorithms and solving systems of equations
•	Illustrate the power of linear algebra by implementing them. The exercises/assignments will range from routine computations to concepts that require some thought.
•	Drawing attention to the limitations of numerical methods, e.g. truncation errors, approximation errors etc
•	Discuss the implications of problem conditioning and the consequences of using floating-point arithmetic
•	Perform scientific investigation of method by implementing it in Python
•	Identify the need for numerical linear algebra techniques to solve sub-problems for a range of applications

Grading Breakup and Policy
Assignment(s): 40% (take-home) Midterm Examination: 30% Final Examination: 30%

Examination Detail	
Midterm Exam	Duration: 2 hours Exam Specifications: Supervised over Zoom/LMS
Final Exam	Duration: 2 hours Exam Specifications: Supervised over Zoom/LMS

Lahore University of Management Sciences

COURSE OVERVIEW			
Week/ Lecture/ Module	Topics	Recommended Readings	Objectives/ Application
LA Review + Python Labs: Introduction to numpy package	• **Matrix Vector Multiplication** • **Orthogonal vectors and matrices** • **Vector Norms** • **Matrix Norms**	**Lecture 1-3**	
Singular Value Decomposition + Python Labs		**Lecture 4-5**	
QR Factorization and Least Squares + Python Labs	• **Projectors** • **QR Factorization** • **Gram-Schmidt Orthogonalization** • **Householder Reflectors** • **Least Squares Problems**	**Lecture 6-11**	
Conditioning and Stability + Python Labs	• **Conditioning and Condition Numbers** • **Floating point arithmetic** • **Stability of Householder QR and back substitution** • **Conditioning and stability of least squares**	**Lecture 12-19**	
System of Equations + Python Labs	• **Gaussian Elimination, Pivoting, Stability** • **Cholesky Factorization**	**Lecture 20-23**	
Eigenvalues + Python Labs	• **Eigenvalue problems** • **Eigenvalue algorithms** • **Hessenberg forms** • **Rayleigh quotient and Inverse iteration** • **QR Algorithm with and without shifts** • **Other eigenvalue algorithms (Jacobi, bisection, divide and conquer)** • **Computing SVD**	**Lecture 24-31**	

Textbook(s)/Supplementary Readings
“Numerical Linear Algebra” by Trefethen and Bau.