APPLIED LINEAR ALGEBRA – MATH 557 – TERM 241

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Office Hours	**Face-Face:** Sunday and Tuesday After Class (In Class) **Online:** by **appointment** through TEAMS	**Website**	https://mshahrani.website/

Textbook:

Lyche, T. (2020). Numerical Linear Algebra and Matrix Factorizations (Vol. 22). Springer International Publishing. https://doi.org/10.1007/978-3-030-36468-7

References:

1. Trefethen, L., & Bau, D. (1997). *Numerical Linear Algebra*. Society for Industrial and Applied Mathematics.
2. Layton, W., & Sussman, M. (2020). Numerical Linear Algebra. World Scientific.
3. Xue, D. (2020). Linear Algebra and Matrix Computations with MATLAB®. Berlin, Boston: De Gruyter. https://doi.org/10.1515/9783110666991
4. David Kincaid & Ward Cheney. (2002). Numerical Analysis: Mathematics of Scientific Computing, Third Edition. American Mathematical Society.

Description:

Basics 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.

Course Main Objectives

(1) Introduce various iterative and factorization techniques for solving large sparse linear systems of equations. (2) Discuss dense linear systems. (3) Study computation of eigenvalues, least squares problems, and error analysis.

Student Learning Outcomes:

After completion of the course, the students should be able to:

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

Grading Policy:

- 25%: Programming Assignments & Tests (with Julia)
- 25%: Project.
- 20%: Midterm Exam
- 30%: Final comprehensive exam

Evaluation:

Final grade is according to the scale.

GRADE	RANGE
A+	[90%, 100%]
A	[80%, 90%)
B+	[75%, 80%)
B	[70%, 75%)
C+	[65%, 70%)
C	[55%, 65%)
D+	[50%, 55%)
D	[45%, 50%)
F	[0%, 45%)

Numerical Computation

In this course, implementation and programming assignments will be carried out through Julia programming language

Julia Resources

1. Ben Lauwens and Allen B. Downey. Think Julia. O'Reilly Media, June 2019.
2. Other Books can be found here.

Project Guidelines:

Form teams of three students and select a project topic. If you encounter difficulties in finding a suitable project, please consult with me, and I will provide suggestions.

- **Week 3**: Submit a one-page project proposal.
- **Week 8**: Submit a one-page progress report.
- **Week 14**: Deliver a 20-minute presentation of your project to the class.
- **Week 15**: Submit the final report, which should not exceed 20 pages. Ensure that the report's similarity index is below 20%.

Course Schedule:

Week	Date	Topic		Notes
1	Aug 25 – 29	**Chapter 1**	Review of basic concepts in linear algebra	
2	Sep 01 – 05	**Chapter 2**	Diagonally Dominant Tridiagonal Matrices	
3	Sep 08 – 12	**Chapter 3**	Gaussian Elimination and LU Factorizations	**Project Proposal**
4	Sep 15 – 19	**Chapter 4**	LDL*Factorization and Positive Definite Matrices	
5	Sep 22 – 26	**Chapter 5**	Orthonormal and Unitary Transformations	**National Day (22 & 23)**
6	Sep 29 – Oct 03	**Chapter 6**	Eigenpairs and Similarity Transformations	
7	Oct 06 – 10	**Chapter 7**	The Singular Value Decomposition	**Midterm Exam**
8	Oct 13 – 17	**Chapter 8**	Matrix Norms and Perturbation Theory for Linear Systems	
9	Oct 20 – 24	**Chapter 9**	Least Squares	**Project Progress Report**
10	Oct 27 – 31	**Chapter 12**	The Classical Iterative Methods	
11	Nov 03 – 07	**Chapter 13**	The Conjugate Gradient Method	
	Nov 10 – 14	Midterm Break		
12	Nov 17 – 21	**Chapter 14**	Numerical Eigenvalue Problems	
13	Nov 24 – 28	**Chapter 15**	The QR Algorithm	
14	Dec 01 – 05	Project Presentations		
15	Dec 08 – 12	Review		**Project Final Report**

FINAL EXAM – See Registrar website.