Syllabus: Numerical Linear Algebra (MATH 412-01)

Course Information

SIS Class Number: Class 52623 (Spring Semester 2023-2024)

Prerequisites: MATH-221, -231 -341, and some programming knowledge

Credit Hours: 3

Schedule: Tuesdays and Thursdays, 9:30-10:45 in Gosnell Hall (GOS) 1154

Instructor Information

Name: Dr. Basca Jadamba **Office**: GOS 2312

Email: bxjsma@rit.edu **Phone**: (585) 475-3994

Office Hours: Wednesdays 4-5 and Fridays 10:30-11:30 in GOS 2312, and by appointments (these can be in-person or on Zoom)

Course Description

This course is a rigorous study of theoretical concepts and computational issues in linear algebra. Topics include analysis of direct methods for linear systems, error and stability, iterative methods for solving linear systems, matrix factorizations, eigenvalues, singular value decomposition, and applications such as least squares problems and systems of nonlinear equations. In-class examples and homework problems will feature some of the important applications.

Rationale

Although the systems of linear equations are of interest in their own right, they also appear constantly in other important branches of pure and applied mathematics. For example, most nonlinear problems can be solved only through the process of linear approximation. Moreover, most numerical methods designed for partial differential equations and integral equations boil down to linear systems. Since the linear systems emerging form real-world models are typically very large in size, they must be solved numerically. Therefore, practically almost all nontrivial problems in mathematics, science and engineering require techniques of numerical linear algebra.

Course Expectations

Attending the classes regularly and engaging during the class time is vital for your learning, therefore you should make every effort to attend classes and take good notes. If you are unable to attend a class for any reason (personal obligations, illness, job interview etc.) contact me by email as soon as you are able. With a notice of an absence, you will be provided an opportunity to fulfill class assignments and expectations without penalty.

In-Class Activities/Assignments, Learning Assistant

There will be short individual or group activities and discussions happening in-class regularly during the semester. You will be assigned grades based on your participation and submissions of the required assignments. A learning assistant (Clara Pitkins) will facilitate peer-to-peer discussions and activities in the classroom and will provide additional support to the students outside the classroom.

Homework

There will be biweekly homework assignments and you will be asked to turn in your work by using the Assignments drop box in myCourses. Homework assignments include both theoretical and practical programming exercises and you will be asked to turn in the answers to theoretical exercises (handwritten or typed) and **the results/outputs of any numerical simulations such as a set of numbers, figures, and tables** ('see code' is not acceptable). Please combine your handwritten/typed answers with the results of your programming exercises and submit a **single** pdf file. Scanning apps and tools (MS Word, Acrobat, ..) can help you to create a single pdf file. You will be asked to submit codes from the programming exercises separately (as individual files, not in a compressed directory such as .zip/.rar) (all through myCourses Assignments). These codes will be verified and run when necessary, and you will be assigned credits which is part of the homework assignment. You will be assigned partial credits for incorrect numbers/figures/tables in your submission after your codes are examined. You may discuss/collaborate with other students in this class for homework assignments, however, each student is expected to turn in their own work for credit (see also the section *Academic Integrity* below). Turn in your assignments on time; late work may not be accepted. Please contact me or Clara Pitkins if you have trouble completing an assignment!

Technology

Software: You can complete programing assignments using tools/languages such as Python, C++, MATLAB, R, Jupyter Notebook etc. Class examples and sample codes (in MATLAB) will be provided. MATLAB is convenient for matrix vector operations, and it is available in machines in computer labs throughout the campus (you can also use the online version on a browser). RIT also has MATLAB licenses for students and you can download it on your personal computer. Many labs on campus have MATLAB installed. Here is the link for information regarding MATLAB use at RIT (also contains instructions on how to download). The ITS Service Desk is your point of contact for your RIT Computer Account, network, or technology-related issues. The Service Desk can troubleshoot your technology issues and create a work request ticket and connect you with ITS specialists. Web form: help.rit.edu, phone: (585) 475-4357, in-person: Gannett Hall 1113.

Grading

Your final grade will be based on **homework assignments** (60%), **in-class activities** (15%), and a **final project** (25%). Two lowest activity scores and one lowest homework score will be dropped. The grading scale shown below will be used.

grade	A	A-	B+	B	B-	C+	C	C-	D	F
%	≥ 93	92-90	89-87	86-83	80-82	79-77	76-73	72-70	69-60	≤ 59

Class Materials and Help

myCourses: Class notes will be posted, however, these may not contain everything that we discuss during the lectures. Assignments and some sample codes will be also posted. Please check assignment due dates, important announcements, and your grades regularly.

Office hours/help: Make good use of the office hours and get your doubts clarified as soon as you can. You can make in-person or Zoom appointments with me or the Learning Assistant to ask questions or get help. The academic demands in this course and your other classes can be understandably difficult. It is normal to feel anxious about your academic ability, especially when unexpected life events emerge. Please connect with me about any difficulties you have in this course as soon as possible. I want you to get the additional help needed before the challenges become too much.

A Note on Disability

RIT is committed to providing academic adjustments to students with disabilities. If you would like to request academic adjustments such as testing modifications due to a disability, please contact the Disability Services Office (DSO). Contact information for the DSO and information about how to request adjustments can be found at https://www.rit.edu/disabilityservices/. After you receive academic adjustment approval, it is imperative that you see me during office hours so that we can work out whatever arrangement is necessary.

Academic Integrity

The RIT Academic Integrity policy is found at
https://www.rit.edu/academicaffairs/policiesmanual/d080. A breach of student academic integrity falls into three basic areas: cheating, duplicate submission, and plagiarism (see the definitions of these terms using the above link) and any violations of these will be dealt according to the procedure listed in the policy above.

Plagiarism

Plagiarism is a serious offense and is in violation of the RIT Student Academic Integrity Policy. If you are unsure of what constitutes plagiarism in written documents, a good description can be found here. Plagiarism does not just occur in written documents; it also occurs in homework solutions and in code. While it is perfectly natural to search out such solutions/code online, it is unacceptable (and it is considered plagiarism) to copy solutions/code written by others and submit it as your own (this includes homework solutions and code that is written by your fellow students!). Even making minor changes to code, such as changing variable names, function names, or formatting, etc., is not enough to allow you to

claim your solution/code as your own because the underlying structure of the solution/code remains unchanged. If you do consult any online sources of code, and you use them in whole or in part in what you submit, you must properly attribute the corresponding sections to their original source, as you would add quotations, footnotes, or references in a written document.

Use of Class Copyrighted Material

All course materials students receive or to which students have online access are protected by copyright laws. Students may use course materials and make copies for their own use as needed, but unauthorized distribution and/or uploading of materials without the instructor's permission is strictly prohibited. RIT Policy C03.2 (Copyright Policy) addresses this issue. For example, uploading completed homework, or other assignments to any study site constitutes a violation of this policy. Students who engage in the unauthorized distribution of copyrighted materials may be held in violation of the University's Code of Conduct, and/or liable under Federal and State laws.

Statement on Title IX

Title IX violations are taken very seriously at RIT. RIT is committed to investigate complaints of sexual discrimination, sexual harassment, sexual assault and other sexual misconduct to ensure that appropriate action is taken to stop the behavior, prevent its recurrence, and remedy its effects. Please view the Title IX Rights and Resources at RIT.

Textbooks (Optional)

1. *Numerical Linear Algebra*, Lloyd N. Trefethen, David Bau III, SIAM, 1997.
2. *Numerical Mathematics and Computing*, E. Ward Cheney, David R. Kincaid, Cengage Learning; 7th edition, 2012.
3. *Numerical Linear Algebra and Applications*, Second Edition, Biswa Nath Datta, SIAM, 2009.

Topics

The material covered in class are divided into the following chapters:

Chapter 1. Direct Methods for Solving Systems of Linear Equations

Chapter 2. Error Analysis

Chapter 3. Iterative Methods

Chapter 4. Eigenvalues

Chapter 5. Applications

See section *Schedule* for a breakdown of chapters into topics.

Schedule

The schedule is approximate and it is subject to change.

Week	Dates	Topic	Due
1	01/16, 01/18	Review of Linear Algebra **Ch. 1**: Gaussian Elimination	
2	01/23, 01/25	Pivoting, LU Factorization Cholesky Factorization	
3	01/30, 02/01*	Cholesky Factorization **Ch. 2**: Vector and Matrix Norms	*-Hw1 due
4	02/06, 02/08	Vector and Matrix Norms Rounding Errors, Stability	
5	02/13, 02/15*	Condition Numbers, Sensitivity Error Bounds, Residual	*-Hw2 due
6	02/20, 02/22	**Ch. 3**: Gauss-Jacobi Method Gauss-Seidel Method	
7	02/27, 02/29*	Successive Over-Relaxation Method	*-Hw3 due
8	03/05, 03/07	**Ch. 4**: Power Method, Inverse Power Method, Shifts	
	03/10-03/17	**Spring Break**	
9	03/19, 03/21*	Rayleigh Quotient Iteration Orthogonal Matrices	*-Hw4 due
10	03/26, 03/28	QR Factorization QR Algorithm	
11	04/02, 04/04*	Hessenberg Form Singular Value Decomposition	*-Hw5 due
12	04/09, 04/11	Singular Value Decomposition	
13	04/16, 04/18*	**Ch. 5**: Least Squares, Normal Equations, Pseudo-Inverse	*-Hw6 due
14	04/23, 04/25	Newton/Quasi-Newton Methods for Systems of Nonlin. Equations	
15	05/02*		*-Final project