MATH 8610 (ADVANCED NUMERICAL ANALYSIS I) SYLLABUS – SPRING 2023

General Information

- *Instructor:* Dr. Fei Xue
  Martin Hall O-203, (864) 656-5244, fxue@clemson.edu.

  Grader: Hossein Faridian
  Long Hall B02, (864)-656-3434, hfaridi@clemson.edu.
- *Required textbook:* Numerical Linear Algebra, *L. N. Trefethen and D. Bau, III*, SIAM 1997.

  Recommended reference books: Iterative methods for sparse linear systems (2nd edition), *Y. Saad*, SIAM 2013. Applied Numerical Linear Algebra, *J. Demmel*, SIAM 1997.
- *Meeting time and location:* Tu/Th 9:30-10:45am, Martin Hall E004.

  Office hours: Tu/Th 11:00am-12:00pm, or by appointment
- *Prerequisites:* MATH 8600; intermediate MATLAB programming skills.

Topics Outline

- Basic iterative methods for solving linear systems
- Problem conditioning and algorithm stability, particularly for solving linear systems
- Orthogonal transformations (Householder reflector and Givens rotation); QR factorization based on Gram-Schmidt and orthogonal transformations; applications to linear least squares
- Singular values decomposition; Oblique and orthogonal projectors; Golub-Kahan bidiagonalization
- Subspace iteration and QR iteration for eigenvalue computation; convergence of shifted QR iteration
- Krylov subspace methods: Arnoldi and Lanczos, conjugate gradient (CG) and the generalized minimal residual method (GMRES); convergence and preconditioning

Goals and objectives

At the end of the course semester, the student should be able to:

- generate and analyze approximate solutions to problems related to computational linear algebra;
- provide analytical justification for algorithms, including convergence estimates and error analysis;
- choose an appropriate algorithm for a given linear algebra problem;
- write efficient numerical software for basic numerical linear algebra algorithms;
- provide a written analysis of the algorithm used to solve the underlying problem, including advantages and disadvantages of the method;

Course Policies

- *Instructor's timeliness:* The instructor is supposed to be ready for lecture at the designated time of class. The instructor should also notify the students in a timely manner about possible being late for or cancellation of class. In case the instructor is late, the students should wait for 15 minutes; the class is considered formally cancelled if the instructor is late for more than 15 minutes.

- *Students attendance:* All students are required to attend the first scheduled day of classes. Students who cannot attend the first class are responsible for contacting the instructor to indicate their intent to remain in class. If a student does not attend the first class meeting or contact the instructor by the second meeting or the last day to add the course, whichever comes first, the instructor has the option of dropping the student from the roll.

  Students are expected to attend every class. In case of an expected absence, a student should inform the instructor at least 24 hours before the class. If an unexpected absence arises, a student should inform the instructor as soon as practical and later provide evidence for the excuse of absence. In either case, the student should make arrangements to submit or make up missed work.

- *Office hours:* I welcome your questions during the office hours. Out of official office hours, you can make an appointment with me at least 24 hours earlier to ask questions. Email questions are welcome anytime, and I will typically respond within 24 hours during school days, and within 48 hours over the weekend. In general, it is reasonable for the instructor to answer about 2-3 math questions that do not need long explanation for each student during each period of 24 hours during the school days and 48 hours over the weekend. In principle, I would answer primarily mathematics questions, and occasionally a couple of programming questions; however, since this is not a programming course, **it is the students' duty to design, program and debug their own code**. Programming skills are essential for the take-home portion of the Computational Math prelim exams. Please plan ahead; large number of questions during a short period of time is not encouraged.

- *Course Assessment:* The course overall numerical grade, out of 100, is a weighted average of the following assessment items.

Assessment item	Percentage	Note
Homework assignments	50%	Your total earned points over maximum possible points
Take-home midterm exam	20%	Tuesday 03/07/2023
In-class final exam	25%	Wednesday 05/03/2023, 8:00-10:30am
Class attendance	5%	0.5% penalty for each unexcused absence over 2 such absences in the semester
Extra credit	up to 5%	0.25% for each office hour visit with reasonable and specific questions, up to 2.5%; 0.25% for finding each mathematical typo in notes, homework, and exams, up to 2.5%

TABLE 0.1
Course Assessment of MATH 8610.

- *Homework submission:* Students are encouraged to use professional word and mathematics processing software (e.g., LaTeX) to do homework. Homework written on paper must be clean and legible.

  Homework assignments should be submitted at the designated due time. A 10% late penalty will be applied to homework submitted up to 24 hours after the due time, and 20% late penalty will be applied to those submitted more than 24 hours but no more than 48 hours late. No homework will be accepted more than 48 hours after the due time. In case the instructor grants an extension due to special circumstances to the entire class, no late submission will be accepted.

- *Grading Scale:* Course letter grade will be issued based on your overall numerical grade as follows. Quality points will be assigned toward your GPA as follows: A: 4.00, A−: 3.66, B+: 3.34, B: 3.00, B−: 2.66, C+: 2.34, C: 2.00, C−: 1.66, F: 0.00.

MATH 8610 letter grade	MATH 8610 numerical grade	A reference 8000-level numerical grade
A	$[87.5, 105]$	$[93, 100]$
A−	$[82.5, 87.5)$	$[90, 93)$
B+	$[77.5, 82.5)$	$[87, 90)$
B	$[72.5, 77.5)$	$[83, 87)$
B−	$[67.5, 72.5)$	$[80, 83)$
C+	$[62.5, 67.5)$	$[77, 80)$
C	$[57.5, 62.5)$	$[73, 77)$
C−	$[52.5, 57.5)$	$[70, 73)$
F	$[0, 52.5)$	$[0, 70)$

TABLE 0.2
Grading scale of MATH 8610.

Important Notes about Grading : PLEASE read the following grading guidelines carefully.

(i) The numerical grade will NOT be rounded or curved, because the above grading scale is more lenient than many 8000-level course grading scales.

(ii) The grading scale will be strictly and unconditionally enforced, without exceptions.

(iii) Grades are earned by performance (i.e., mathematical/programming correctness of submitted work) and is an objective reflection of it; the instructor has no subjectivity involved in grading.

(iv) No other factors than those listed in Table 0.1 will be considered, such as how hard a student has been working, how much a student would like to have a particular grade, how other course' assessment and/or grading scale are compared to this course, how well the instructor and a student know each other or have a personal opinion of each other, etc.

(v) If you truly believe that you deserve a higher numerical or letter grade than the ones you receive, please discuss with the instructor directly; show evidence to support your claims. The instructor will carefully listen and respond. In case that you cannot resolve a dispute over your grade with the instructor, you may read the guidelines of Academic Grievances, discussed in Clemson University Graduate School Policies and Procedures 2022-2023, Section 2.8, and consult with SMSS Associate Director of Graduate Studies. SMSS administration usually remains neutral in such a dispute.

Course Etiquette

All course related interactions will be conducted in a professional manner. Any e-mail correspondence with the instructor must adhere to proper professional standards. Reasonable hygiene is expected. At least 24 hours notice is required for "by appointment" office hours.

Academic Integrity

"As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity."

An academic environment of integrity is one in which students, faculty and staff interact with each other from a position of mutual trustworthiness. As a member of the consortium of institutions comprising the International Center for Academic Integrity, Clemson University has committed itself to preparing a

community of scholars dedicated to integrity in teaching, research, scholarship, mentorship and the acquisition and display of professional values of trust, honesty, fairness, responsibility, respect, and courage. Clemson graduate students are expected avail themselves of the many opportunities and resources both on and off campus to learn how to engage in professional practice with integrity. The Graduate School and the community of scholars engaged in graduate-level education will respond vigorously and expeditiously to charges of violations of academic integrity.

Violations of academic integrity include violations in coursework, research, independent projects, practica, internships, comprehensive and qualifying exams, theses and dissertations and other publications or works submitted as requirements for receipt of a degree. Non-degree seeking students may also be charged with violations of academic integrity.

For homework assignments, you may discuss with classmates the general concept or high-level ideas of problem solutions, and may work together on one or two crucial steps of solution to a complex problem, but not much more. In the later case, you must specify all the students (no more than three for each homework) you discuss with. However, the final problem solution in mathematics, phrasing, organization and presentation, and code development and debugging, must be completed by each student independently. Any mathematical ideas or code found from electronic or hard copy references can be used as a hint only, and cannot be adopted directly and completely; they must be cited clearly.

For the midterm and the final exams, you are not allowed to use unauthorized materials and/or assistance of any form, including textbooks, lecture notes, "cheat sheet", homework assignments and/or solutions, online resources through any electronic devices, or work accomplished by someone else. You must work completely on your own, without communications with any person other than the instructor. You can use scrap paper and, with the permission of the instructor, non-programmable calculators.

Violations of the principles outlined in the graduate philosophy on academic integrity will be pursued to the fullest extent according to the procedures outlined in Clemson University Graduate School Policies and Procedures 2022-2023, Section 2.9.

Disability Access

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities. Students are encouraged to contact Student Accessibility Services to discuss their individual needs for accommodation.

Students with disabilities who need accommodations should make an appointment with the Director of Accessibility Services to discuss specific needs within the first month of classes. Students should present a Accommodation Letter from Student Accessibility Services is located in Suite 239 Academic Success Building ((864) 656-6848; studentaccess@lists.clemson.edu). Please be aware that accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.

The Clemson University Title IX (Sexual Harassment)

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination of participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. Alesia Smith serves as Clemson's Title IX Coordinator and may be reached at alesias@clemson.edu or (864) 656-3181.