Instructor:	Akil Narayan
Email:	akil@sci.utah.edu
Phone:	801-581-8984
Office:	WEB 4666, LCB 116
Office hours:	Wed 10:45-11:50am, Thu 12-1pm
TA:	Claire Plunkett
Email:	plunkett@math.utah.edu
Office Hours:	Mon 4-5pm, Tues 11:30am-12:30pm
Office hours location:	Virtual (zoom, same link as for class)

Class type: IVC (synchronous online)

Class time and location: MWF, 11:50am-12:40pm, Zoom

Attendance policy: Attendance during synchronous lectures is *not* a part of your grade. However, I strongly recommend that you attend the synchronous Zoom lectures. Recordings of the lectures will be made available to all class participants.

Course webpage: http://www.sci.utah.edu/~akil/math6610
Note: Scores for graded assignments and recorded video lectures will be posted on Canvas.

Course Information: This is a 3-credit course.

Learning objectives: Upon successful completion of this course, a student should be able to:

- Understand, utilize, and manipulate standard metrics on vectors and matrices
- Analyze and compute standard matrix decompositions: QR, LU, SVD, Cholesky
- Formulate notions of conditioning and stability for linear and nonlinear problems
- Solve linear systems via direct and iterative methods
- Understand theory and algorithms for rational and polynomial approximations
- Utilize polynomial approximations for differentiation and integration/quadrature
- Be comfortable using LaTeX document typesetting, version control with git, and either the MATLAB or Python programming environment

Technical requirements: Due to both the technical content of this course and the special nature of this semester, the following technology access is **required**:

- access to a computer with Internet access (on which the below software can be used)
- the Zoom software, preferably with a working microphone and video camera (for access to synchronous class lectures and office hours)
- a relatively modern web browser (for access to the class website and to Canvas)
- a computer programming language (a high-level, interpreted, non-compiled language is highly recommended; some options are Matlab, Python, R, Julia; my recommendation is Python)
- the LaTeX typesetting sytem
- the Git version control system (for submission of homework assignments; strictly speaking this is optional but *highly* recommended)

Prerequisites: Undergraduate level knowledge of linear algebra and proof-based analysis is expected. Some prior experience with a programming language is highly recommended.

Course description: Mathematical analysis of numerical methods in linear algebra, interpolation, integration, differentiation, approximation (including least squares, Fourier analysis, and wavelets), initial- and boundary-value problems of ordinary and partial differential equations.

Text: L. N. Trefethen and D. Bau III, *Numerical Linear Algebra*, SIAM (1997), ISBN-10 0-89871-361-7.
Class lectures will *not* correspond directly to particular sections of any particular text. However, the text above is considered a mandatory reference texts: in particular, some homework assigments will feature problems from this text.

Class meetings: This class meets virtually and synchronously via Zoom 3 times per week. Class meetings will primarily be lecture-based, which will include a discussion of theory and numerical practice. Video recordings of the lectures will be uploaded on Canvas.

Homework: Four homework sets will be assigned, collected, and graded throughout the semester. These assignments will be posted on the course website and announced during class. Students will have approximately 2 weeks work time for each assignment. Late assignments of any form will <u>*not*</u> be accepted without **prior** approval from the instructor. Homework assignments will consist of analysis along with programming exercises.

You are **required** to submit your assignment electronically via the version control system Git. Submissions requiring mathematical analysis <u>**must**</u> be composed and submitted in the LaTeX typesetting system. Submission requiring programming **must include** source code used to generate any results or figures.

You are welcome to work on homework assignments in groups, but each student is required to submit his/her own individually-composed, written, and submitted assignment. During the first two weeks of the semester, detailed instructions for homework submission will be provided in class.

Exams: This course will have 1 midterm exam, and 1 final exam. At present the midterm exam is planned to be a written exam that will be proctored virtually. Details of this will be provided closer to exam time.

The final exam is a cumulative exam, administered in the same format as the midterm exam. The final exam will be held on Monday, December 7 from 10:30am-12:30pm. Proctoring details will be discussed during class time later in the semester.

Unless otherwise specified, **neither calculators nor notes of any kind are allowed on any of the exams**.

Grading: Your course grade will be computed as follows.

- Homework 40%
- Midterm exam 25%
- Final exam 35%

Final letter grades will be assigned based on the following scheme:

- 92% - 100% — A
- 90% - 91% — A−

- 88% - 89% — B+
- 82% - 87% — B
- 80% - 81% — B−
- 78% - 79% — C+
- 72% - 77% — C
- 70% - 71% — C−
- 68% - 69% — D+
- 62% - 67% — D
- 60% - 61% — D−
- 0% - 59% — E

Important dates:

Sep 4		Last day to add, drop (delete), elect CR/NC, or audit classes
Oct 9		Midterm
Oct 16		Last day to withdraw from classes
Nov 27		Last day to reverse CR/NC option
Dec 4		Reading Day
Dec 7	**10:30am**	Final exam

Class communication: An email list is set up with which I shall send out information not communicated during class. This email list will also be used to communicate class information in the case of unusual circumstances affecting the the logistics of the class. If you are not officially registered for the class but wish to be on the roster, please discuss it with me.

If you are registered for the course, but do not receive the course email announcements to your University of Utah email address, please notify me immediately. It is not possible for me to arrange delivery of these emails to a non-UUtah account.

The section website will also be used to communicate more technical matter of the class (e.g. homework sets, lecture summaries, etc.).

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to change that may be necessitated by a revised semester calendar or other circumstances. The above two methods, in addition to the coursewide website and Canvas pages, are reliable means of getting information about changes to the course.

Communication with the instructor: The most reliable and preferred means of contacting me is via email. Communication through Canvas will also work. One-on-one meetings can also be set up with me outside of office hours; please set up such meetings with me via email.

COVID-19 considerations: Students must self-report if they test positive for COVID-19 via `coronavirus.utah.edu`. All class activities will take place virtually via Zoom or similar software.

Student responsibilities and integrity: All students are expected to maintain professional behavior in the classroom setting, according to the Student Code, spelled out in the Student Handbook. Students have specific rights in the classroom as detailed in Article III of the Code. The Code also specifies proscribed conduct (Article XI) that involves cheating on tests,

plagiarism, and/or collusion, as well as fraud, theft, etc. Students should read the Code carefully and know they are responsible for the content. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behaviors, and I will do so, beginning with verbal warnings and progressing to dismissal from and class and a failing grade. Students have the right to appeal such action to the Student Behavior Committee.
`http://regulations.utah.edu/academics/6-400.php`

Inclusivity: It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

Discrimination and Harassment: If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or Office of the Dean of Students, 270 Union Building, 801-581-7066. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS). Please see Student Bill of Rights, section E `http://regulations.utah.edu/academics/6-400.php`. I will listen and believe you if someone is threatening you.

Names/Pronouns: Canvas allows students to change the name that is displayed AND allows them to add their pronouns to their Canvas name. Class rosters are provided to the instructor with the student's legal name as well as "Preferred first name" (if previously entered by you in the Student Profile section of your CIS account, which managed can be managed at any time). While CIS refers to this as merely a preference, I will honor you by referring to you with the name and pronoun that feels best for you in class or on assignments. Please advise me of any name or pronoun changes so I can help create a learning environment in which you, your name, and your pronoun are respected. If you need any assistance or support, please reach out to the LGBT Resource Center: `https://lgbt.utah.edu/campus/faculty_resources.php`

English Language Learners: If you are an English language learner, please be aware of several resources on campus that will support you with your language and writing development. These resources include: the Writing Center (`http://writingcenter.utah.edu/`); the Writing Program (`http://writing-program.utah.edu/`); the English Language Institute (`http://continue.utah.edu/eli/`). Please let me know if there is any additional support you would like to discuss for this class. **Undocumented Student Support**: Immigration is a complex phenomenon with broad impact—those who are directly affected by it, as well as those who are indirectly affected by their relationships with family members, friends, and loved ones. If your immigration status presents obstacles to engaging in specific activities or fulfilling specific course criteria, confidential arrangements may be requested from the Dream Center. Arrangements with the Dream Center will not jeopardize your student status, your financial aid, or any other part of your residence. The Dream Center offers a wide range of resources to support undocumented students (with and without DACA) as well as students from mixed-status families. To learn more, please contact the Dream Center at 801-213-3697 or visit `dream.utah.edu`.

Veterans: If you are a student veteran, the University of Utah has a Veterans Support Center located in Room 161 in the Olpin Union Building. Hours: M-F 8-5pm.Please visit their website

for more information about what support they offer, a list of ongoing events and links to outside resources: `http://veteranscenter.utah.edu/`.

Student wellness: Personal concerns such as stress, anxiety, relationship difficulties,depression, cross-cultural differences, etc., can interfere with a student's ability to succeed and thrive at the University of Utah. For helpful resources contact the Center for Student Wellness at `www.wellness.utah.edu` or 801-581-7776.

Student Success Advocates: The mission of Student Success Advocates is to support students in making the most of their University of Utah experience (ssa.utah.edu). They can assist with mentoring, resources, etc. Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact a Student Success Advocate for support (`https://asuu.utah.edu/displaced-students`).

The Americans with Disabilities Act: The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, 801-581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability Services.

Addressing Sexual Misconduct: Title IX makes it clear that violence and harassment based on sex and gender (which Includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students,270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677 (COPS).

Safety: The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit `safeu.utah.edu`.

University Counseling Center The University Counseling Center (UCC) provides developmental, preventive, and therapeutic services and programs that promote the intellectual, emotional, cultural, and social development of University of Utah students. They advocate a philosophy of acceptance, compassion, and support for those they serve, as well as for each other. They aspire to respect cultural, individual and role differences as they continually work toward creating a safe and affirming climate for individuals of all ages, cultures, ethnicities, genders, gender identities, languages, mental and physical abilities, national origins, races, religions, sexual orientations, sizes and socioeconomic statuses.

Office of the Dean of Students: The Office of the Dean of Students is dedicated to being a resource to students through support, advocacy, involvement, and accountability. It serves as a support for students facing challenges to their success as students, and assists with the interpretation of University policy and regulations. Please consider reaching out to the Office of Dean of Students for any questions, issues and concerns. 200 South Central Campus Dr.,

Suite 270. Monday-Friday 8 am-5 pm.

Semester calendar
(Subject to change!)

Day	Date	Topic
Monday	August 24, 2020	Hello
Wednesday	August 26, 2020	Submission tools: Git, LaTeX, Matlab/Python
Friday	August 28, 2020	Linear algebraic preliminaries
Monday	August 31, 2020	Projections and permutations
Wednesday	September 2, 2020	Eigenvalues and eigenvectors
Friday	September 4, 2020	Eigenvalues and eigenvectors
Monday	September 7, 2020	NO CLASS: Labor Day
Wednesday	September 9, 2020	Rayleigh Quotients, spectral variational characterizations
Friday	September 11, 2020	(IEEE) floating-point arithmetic
Monday	September 14, 2020	Linear stability
Wednesday	September 16, 2020	Linear stability, II
Friday	September 18, 2020	Applications of stability
Monday	September 21, 2020	The spectral theorem
Wednesday	September 23, 2020	The singular value decomposition
Friday	September 25, 2020	Orthogonalization and the QR decomposition
Monday	September 28, 2020	Algorithms: Gram-Schmidt
Wednesday	September 30, 2020	Algorithms: Householder
Friday	October 2, 2020	Linear least-squares problems
Monday	October 5, 2020	More on least-squares problems
Wednesday	October 7, 2020	Review
Friday	October 11, 2020	**MIDTERM EXAM**
Monday	October 12, 2020	Gaussian elimination and the LU decomposition
Wednesday	October 14, 2020	Pivoting and stability
Friday	October 16, 2020	Cholesky factorizations
Monday	October 19, 2020	Cholesky factorizations
Wednesday	October 21, 2020	Eigenvalue algorithms: Power and inverse iteration
Friday	October 23, 2020	Eigenvalue algorithms: Rayleigh iteration
Monday	October 26, 2020	Eigenvalue algorithms: The QR algorithm
Wednesday	October 28, 2020	Eigenvalue algorithms: The QR algorithm with shifts
Friday	October 30, 2020	Iterative methods for linear problems, I
Monday	November 2, 2020	Iterative methods for linear problems, II
Wednesday	November 4, 2020	Nonlinear equations
Friday	November 6, 2020	Nonlinear equations, II
Monday	November 9, 2020	Fourier approximation and interpolation
Wednesday	November 11, 2020	Polynomial approximation and interpolation, I
Friday	November 13, 2020	Polynomial approximation and interpolation, II
Monday	November 16, 2020	Rational approximation
Wednesday	November 18, 2020	The AAA algorithm
Friday	November 20, 2020	Numerical integration
Monday	November 23, 2020	Numerical integration
Wednesday	November 25, 2020	Numerical differentiation
Friday	November 27, 2020	NO CLASS: Thanksgiving break
Monday	November 30, 2020	Lagrange interpolation, divided differences
Wednesday	December 2, 2020	Orthogonal polynomials
Friday	December 4, 2020	NO CLASS: Reading day
Monday	December 7, 2020	**FINAL EXAM**: 10:30am