

DEPARTMENT OF MATHEMATICS, UNIVERSITY OF UTAH
Analysis of Numerical Methods I
Math 6610 Section 001 – Fall 2026
Course Information and Syllabus
Updated August 21, 2026

Instructor: Akil Narayan
Email: akil@sci.utah.edu
Office: WEB 4666 and LCB 116

Office hours: TBA
TBA

Class type: In Person

Class time and location: MWF 11:50am-12:40pm JWB 333

Attendance policy: Attendance during lectures is *not* a part of your grade. However, I strongly recommend that you attend the lectures; attendance is an essential ingredient for success in this course.

Course webpage: <http://www.sci.utah.edu/~akil/math6610>. This webpage will contain posted lecture notes and assignments.

Canvas: Graded assignments will be collected on Canvas and grades will also be posted on Canvas.

Course Information: This is a 3-credit course.

Prerequisites: “C” or better in Math 5620.

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: Suggested: *Numerical Linear Algebra*, by Trefethen and Bau

The material from this courses will be compiled from a few different sources. The lecture slides will serve as a comprehensive list of topics discussed in this class. I will attempt to cite appropriate references in the slides that relate to topics covered.

Class meetings: Most meetings of this course will be lecture-style meetings, but I heartily encourage you to participate in class, in particular with questions and related discussions.

Discussion: I will schedule 2 one-on-one 30-minute meetings with each student over the course of the semester. Each student will receive full credit for simply attending and making an effort to engage in discussion in each meeting. These meetings will be technical discussions where I might ask students to explain some homework problems or walk through topics we’ve discussed in class.

Homework: Homework is worth 25% of your cumulative grade. Homework is graded on a completion basis, and will be collected approximately every week. Late homework assignments will generally **not** be accepted without approval from me in advance of the due date. However, your lowest homework assignment grade over the semester will be dropped.

Each homework assignment is worth equal weight and the lowest score for a single homework assignment over the semester will be dropped. You are welcome (and encouraged) to work on the homework assignment in groups, *but each student must submit individual work*.

Midterm exams: The 3 midterm exams are collectively worth 35% of your cumulative grade. The exams will be held during class meeting time, and will be closed-book, closed-notes, and no calculator is allowed.

Final Exam: This course will have a single in-class comprehensive final exam. The final exam will be held on Tuesday, December 15 from 10:30am-12:30pm in JWB 333, in accordance with university policy. The final exam, worth 25% of your grade, is closed-book and closed-notes, and no calculators will be allowed.

Grading: In summary, your course grade will be computed as follows.

- Homework 25%
- Discussion 15%
- Midterm exams 35%
- Final exam 25%

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:

Sept 4	Last day to add, drop, or audit classes
Sept 25	Midterm Exam 1
Oct 23	Midterm Exam 2
Nov 13	Last day to withdraw from classes and elect CR/NC
Nov 23	Midterm Exam 3
Dec 4	Last day to reverse CR/NC option
Dec 11	Reading Day
Dec 15 10:30am	Final exam

The use of AI: Generative artificial intelligence tools, usually large language models (“LLM’s”) often just referred to as “AI”, can be a productive tool, *if used appropriately*. In this class, you will not have access to AI on in-class exams, which comprise a majority of your grade. Plan accordingly.

This does *not* mean that you shouldn’t use AI. For example, using AI tools to explore concepts, check your solutions, and/or learn new topics in a narrative/conversational style is acceptable.

In planning for how to use AI, please consult the University webpage on student usage of AI: <https://ai.utah.edu/ai-student-guide/>. In particular, “Level of AI Usage” 2 or below is acceptable for this class. Please consider the University-approved tools explained on that page.

For your general edification in mathematics, you may also want to consider reading the Leiden Declaration on Artificial Intelligence and Mathematics for a glimpse of how the profession is addressing AI usage. <https://leidendeclaration.ai/#declaration>

Learning objectives: This is a PhD qualifier course that covers some of the essentials of numerical analysis, focusing specifically on (numerical) linear algebra and (numerical) approximation. By the end of this course, students will be able to:

- Analyze conditioning, sensitivity, finite-precision effects, and numerical stability.
- Derive and apply LU, Cholesky, QR, and SVD factorizations and assess resulting solutions.
- Derive and analyze power, inverse, Rayleigh-quotient, and shifted-QR eigenvalue iterations.
- Select and analyze direct, iterative, Krylov, and Newton-type methods for linear, nonlinear, and optimization problems.
- Construct and assess Fourier and polynomial approximations using appropriate convergence and error criteria.
- Communicate mathematical reasoning and computational results clearly.

Class communication: I will use the email list provided by University information services to communicate information. 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. Some email communications will also be duplicated as announcements on Canvas.

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.

This syllabus is subject to change at the discretion of the instructor. Any changes, including those necessitated by a major campus emergency, a revised semester calendar, or other circumstances, will be communicated through University email, Canvas, and the course webpage.

Communication with the instructor: The most reliable and preferred means of contacting me is via email, and I typically respond in less than 24 hours. Communication through the messaging system in Canvas will also work, but possibly with a slightly longer response time.

University-wide policies

Americans With Disabilities Act (ADA) The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities.

According to Title II regulations for the Americans with Disabilities Act (ADA), federal law requires all educational content made available to students digitally at the University of Utah to meet WCAG 2.1 AA standards to ensure compatibility with assistive technology tools. If you find that any content throughout a course is not compatible or need additional assistance interpreting any of the content available, please contact your instructor.

All written information in this course can also be made available in an alternative format with prior notification to the Center for Disability & Access (CDA), <https://disability.utah.edu/>. CDA will work with you and the instructor to make arrangements for accommodations. Prior notice is appreciated. To read the full accommodations policy for the University of Utah, please see Policy 5-117: ADA Policy, Reasonable Accommodation and Access, <https://regulations.utah.edu/human-resources/5-117.php>.

In compliance with ADA requirements, some students may need to record course content. Any recordings of course content are for personal use only, should not be shared, and should never be made publicly available. In addition, recordings must be destroyed at the conclusion of the course.

If you will need accommodations in this class, or for more information about what support they provide, contact:

Center for Disability & Access

801-581-5020

<https://disability.utah.edu/>

Third Floor, Room 350

Student Services Building

201 S. 1460 E.

Salt Lake City, UT 84112

Safety at the U: The University of Utah is committed to the safety and well-being of all members of our campus community. In the event of an emergency, the University sends out Campus Alerts by SMS text message and email. These alerts may include specific instructions such as HOLD, SECURE, LOCKDOWN, EVACUATE, or SHELTER, also known as the Standard Response Protocol, <https://emergency.utah.edu/srp/>.

To ensure you receive these and other important safety notifications, verify that your contact information is current in the Campus Information System, <https://portal.app.utah.edu/>.

Policy 1-004: Violence in the Workplace and Academic Environment, <https://regulations.utah.edu/general/1-004.php>, includes information on how to report incidents of violence, threats, intimidation, and other concerning behaviors from students, faculty, staff, or guests. Additional safety and security procedures, including crime reporting, emergency response, hazing prevention, missing student notifications, and fire safety, are outlined in Policy 1-011: Campus Security, <https://regulations.utah.edu/general/1-011.php>.

To learn more about public safety resources, active threat preparedness, other safety trainings, or the University of Utah's Annual Security & Fire Safety Report, contact:

Department of Public Safety

801-585-2677

911 for Emergencies

<https://publicsafety.utah.edu/>

1658 East 500 South

Salt Lake City, UT 84112

Additional information on University safety resources can be found at <https://safeu.utah.edu/>.

Addressing Discrimination & Sexual Misconduct: The University of Utah is committed to providing and fostering an environment that is safe and free from prohibited discrimination, which includes sexual misconduct. The University prohibits discrimination against individuals on the basis of race, ethnicity, color, religion, national origin, age, disability, sex, sexual orientation, gender, gender identity, gender expression, pregnancy, pregnancy-related conditions, genetic information, or protected veteran status — these are known as Protected Classes.

The University Non-Discrimination Policy (Policy 1-012), <https://regulations.utah.edu/general/1-012.php>, is how the University addresses issues of discrimination and sexual misconduct. This policy applies to all University Programs and Activities, including all operations, academic and administrative units, and other members of the University community. This includes faculty, staff, students, patients, visitors, and other participants in University Programs or Activities.

This policy is also how the University complies with Title IX of the Education Amendments of 1972, which requires the University to respond to reports and complaints that involve possible

sex discrimination, monitor outcomes, identify patterns, and address issues. More information is available at <https://sexualassault.utah.edu/>.

Responsible employees are Mandatory Reporters required under University policy to inform the Office of Equal Opportunity (OEO) of all reports of discrimination or sexual misconduct. These obligations apply despite any requests for confidentiality made by the individuals disclosing the information or involved in the alleged incident. Some employees, such as campus security authorities and those classified as confidential, may not be required to report to OEO but may have other reporting obligations. Information about the OEO reporting process is available at <https://oeo.utah.edu/>.

If you are not a Mandatory Reporter, but you or someone you know has experienced possible discrimination, including sexual misconduct, you are encouraged to report it to university officials.

For more information about University non-discrimination policies and procedures, contact:

Office of Equal Opportunity and Title IX

801-581-8365

<https://oeo.utah.edu/>

383 S. University Street

Level 1, OEO Suite

Salt Lake City, UT 84112

Office of the Dean of Students

801-581-7066

<https://deanofstudents.utah.edu/>

270 Union Building

200 S. Central Campus Dr.

Salt Lake City, UT 84112

To file a police report, contact:

University of Utah Police Division (UUPD)

801-585-COPS (801-585-2677)

911 for Emergencies

<https://police.utah.edu/>

1658 East 500 South

Salt Lake City, UT 84112

UUPD Crime Victim Advocates are available 24/7 to assist victims of crime with questions about filing a report, safety planning, and support in navigating the criminal justice process. Information shared with UUPD Crime Victim Advocates may also be shared with UUPD and OEO. You are not required to share any information with the Crime Victim Advocates in order to receive information.

If you do not feel comfortable reporting to authorities, the Center for Campus Wellness Victim Survivor Advocates provide free, fully confidential, and trauma-informed support services to students, faculty, and staff who have experienced interpersonal violence. The Center for Campus Wellness Victim Survivor Advocates are not Mandatory Reporters.

To privately explore options and resources available to you with an advocate, contact:

Center for Campus Wellness

801-581-7776

<https://wellness.utah.edu/>

350 Student Services Building

201 S. 1460 E.

Salt Lake City, UT 84112

Academic Misconduct It is expected that students comply with University of Utah policies regarding academic honesty, including but not limited to refraining from cheating, plagiarizing, misrepresenting one's work, and/or inappropriately collaborating. This includes the use of generative artificial intelligence (AI) tools without citation, documentation, or authorization. Students are expected to adhere to the prescribed professional and ethical standards of the profession/discipline for which they are preparing.

Any student who engages in academic dishonesty or who violates the professional and ethical standards for their profession/discipline may be subject to academic sanctions as per the University of Utah's Student Code: Policy 6-410: Student Academic Performance, Academic Conduct, and Professional and Ethical Conduct, <https://regulations.utah.edu/academics/6-410.php>.

Plagiarism and cheating are serious offenses and may be punished by failure on an individual assignment, and/or failure in the course. Academic misconduct, according to the University of Utah Student Code:

"...Includes, but is not limited to, cheating, misrepresenting one's work, inappropriately collaborating, plagiarism, and fabrication or falsification of information...It also includes facilitating academic misconduct by intentionally helping or attempting to help another to commit an act of academic misconduct."

For further details on plagiarism and other important course conduct issues, see the U's Code of Student Rights and Responsibilities, <https://regulations.utah.edu/academics/6-400.php>.

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. To contact the Office of the Dean of Students, please email deanofstudents@utah.edu or call 801-581-7066. There is more information at <https://deanofstudents.utah.edu>.

Basic Needs Student Support Statement: Success at The University of Utah includes learning about and using available resources. The Basic Needs Collective (BNC) is a coordinated resource referral hub. They educate about and connect students to campus and community resources to help them meet their basic needs. As a central location for resource referrals related to food, housing, health insurance, managing finances, legal services, mental health, etc., any student experiencing difficulty with basic needs is encouraged to contact them. Drop into their office located in the Union basement or schedule with them online for an in-person or virtual visit through their webpage: <https://basicneeds.utah.edu/>.

Community: It is my intent that students from all backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the community of students in this class be viewed as a resource, strength, and benefit. It is my intent to present materials and activities that are respectful to all. 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.

Classroom Social Interactions: Canvas allows students to change the name that is displayed. 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 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 that feels best for you in class or on assignments. Please advise me of any name changes so I can help create a learning environment in which you are respected. If you need any assistance or support, please reach out to the Center for Student Access and Resources: <https://studentresources.utah.edu>

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.

Immigrant 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 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/>.

Semester calendar

(Subject to change!)

DAY	DATE	TOPIC
Monday	August 24, 2026	Hello
Wednesday	August 26, 2026	Linear algebra review
Friday	August 28, 2026	Linear algebra review
Monday	August 31, 2026	Orthogonal, projection, permutation matrices
Wednesday	September 2, 2026	Eigenvalues
Friday	September 4, 2026	Eigenvalues
Monday	September 7, 2026	No class: Labor Day
Wednesday	September 9, 2026	Eigenvalues
Friday	September 11, 2026	Normal matrices
Monday	September 14, 2026	The SVD
Wednesday	September 16, 2026	The SVD
Friday	September 18, 2026	Low-rank approximation
Monday	September 21, 2026	SVD applications
Wednesday	September 23, 2026	Finite-precision arithmetic
Friday	September 25, 2026	Midterm Exam 1
Monday	September 28, 2026	Conditioning and sensitivity
Wednesday	September 30, 2026	Numerical stability
Friday	October 2, 2026	Gaussian elimination (LU)
Monday	October 5, 2026	Gaussian elimination (LU)
Wednesday	October 7, 2026	The Cholesky decomposition
Friday	October 9, 2026	The QR decomposition
Monday	October 12, 2026	No class: Fall Break
Wednesday	October 14, 2026	No class: Fall Break
Friday	October 16, 2026	No class: Fall Break
Monday	October 19, 2026	Least squares and orthogonal triangularization
Wednesday	October 21, 2026	Power, inverse, Rayleigh iteration
Friday	October 23, 2026	Midterm Exam 2
Monday	October 26, 2026	Power, inverse, Rayleigh iteration
Wednesday	October 28, 2026	Power, inverse, Rayleigh iteration
Friday	October 30, 2026	The QR algorithm
Monday	November 2, 2026	The QR algorithm with shifts
Wednesday	November 4, 2026	The QR algorithm with shifts
Friday	November 6, 2026	Iterative methods for linear systems
Monday	November 9, 2026	Krylov subspace methods
Wednesday	November 11, 2026	Krylov subspace methods
Friday	November 13, 2026	Nonlinear systems
Monday	November 16, 2026	Nonlinear systems
Wednesday	November 18, 2026	Numerical optimization
Friday	November 20, 2026	Numerical optimization
Monday	November 23, 2026	Midterm Exam 3
Wednesday	November 25, 2026	Fourier Series, I
Friday	November 27, 2026	No class: Thanksgiving break
Monday	November 30, 2026	Fourier Series, II
Wednesday	December 2, 2026	Fourier Series approximation
Friday	December 4, 2026	Fourier Series approximation
Monday	December 7, 2026	Polynomial approximation
Wednesday	December 9, 2026	Polynomial approximation
Friday	December 11, 2026	No class: Reading Day
Tuesday	December 15, 2026	Final Exam: 10:30am-12:30pm