Department of Mathematics, University of Utah
Topics: Randomized NLA for Data Science and Machine Learning
Math 7870 Section 001 – Spring 2026
Course Information and Syllabus
Updated January 7, 2026

Instructor:	Akil Narayan
Email:	akil@sci.utah.edu
Office:	WEB 4666 and LCB 116
Office hours:	Tues 9:45-10:40am, LCB 116, or by appointment

Class type: In Person

Class time and location: TTh 10:45am-12:05pm M LI 1735

Attendance policy: Attendance during lectures is *not* a part of your grade. However, I strongly recommend that you attend the lectures.

Course webpage: http://www.sci.utah.edu/~akil/math7870. This webpage will contain posted lecture notes and assignments.

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

Course Information: This is a variable, 1-3 credit course.

Prerequisites: The are no explicit prerequisites. However, I assume assume familiarity with (numerical) linear algebra and probability/statistics at an advanced undergraduate level. It is helpful, but not required, to have experience with proof-based real and convex analysis.

Course description: This course is a gentle journey through the land of randomized methods, focused on core (numerical) linear algebra tasks, and if time permits with some exploration of stochastic optimization methods. Topics and discussions that are germane for algorithm and software development will also be part of the course. We'll begin by exploring some mathematical foundations in high-dimensional probability forming much of the backbone of randomized numerical linear algebra. We will then discuss how these foundations inspire core algorithms in randomized numerical linear algebra. Implications for data science and machine learning applications will be explored.

Text: None. Much of the material in this course is compiled from existing literature and lecture notes, which form a set of (optional) reading material for the course.

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.

Homework: There will be one "homework"/project assignment, with a due date sometime in the middle of the semester.

Presentation: Each student is expected to deliver one in-class presentation near the end of the semester that discusses a topic of their choice with relevance to the course. I will provide an example list of topics partway through the semester. Students already undertaking research projects at the University are encourged to present on their research project with a focus on how the course topic does or could play a role in the project.

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

- Homework/project 50%
- Presentation 50%

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:

Jan 16	Last day to add, drop, audit, and elect CR/NC
Mar 6	Last day to withdraw from classes
Apr 17	Last day to reverse CR/NC option
Apr 22	Reading Day

Learning objectives: By the end of this course, students will be able to (i) articulate and describe the mathematical background for randomized numerical linear algebra, (ii) understand and implement basic versions of randomized approaches for linear algebra, (iii) describe appropriate use cases for these algorithms and motivation for software, (iv) explain how randomized methods are used in basic stochastic optimization settings, (v) describe the relevance of these approaches in machine learning applications.

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.

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 (email and Canvas), in addition to the coursewide website, 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, 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.

All written information in this course can 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 Section Q of the Instruction & Evaluation regulations `http://regulations.utah.edu/academics/6-100.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
`disability.utah.edu` 162 Union Building l
200 S. Central Campus Dr.
Salt Lake City, UT 84112

Safety at the U: The University of Utah values the safety of all campus community members. You will receive important emergency alerts and safety messages regarding campus safety via text message. For more safety information and to view available training resources, including helpful videos, visit `safeu.utah.edu`.

To report suspicious activity or to request a courtesy escort, contact:

Campus Police & Department of Public Safety
801-585-COPS (801-585-2677)
`dps.utah.edu`
1735 E. S. Campus Dr.
Salt Lake City, UT 84112

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 university officials:

Title IX Coordinator & Office of Equal Opportunity and Affirmative Action
801-581-8365
`oeo.utah.edu`
135 Park Building
201 Presidents' Cir.
Salt Lake City, UT 84112

Office of the Dean of Students
801-581-7066
`deanofstudents.utah.edu`
270 Union Building
200 S. Central Campus Dr.
Salt Lake City, UT 84112

To file a police report, contact:

Campus Police & Department of Public Safety
801-585-COPS (801-585-2677)
dps.utah.edu
1735 E. S. Campus Dr.
Salt Lake City, UT 84112

If you do not feel comfortable reporting to authorities, the U's Victim-Survivor Advocates provide free, confidential, and trauma-informed support services to students, faculty, and staff who have experienced interpersonal violence.

To privately explore options and resources available to you with an advocate, contact:
Center for Campus Wellness
801-581-7776
wellness.utah.edu
328 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 details on plagiarism and other important course conduct issues, see the U's Code of Student Rights and Responsibilities, http://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.

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.

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/`.

Accessibility: I make efforts to ensure that the materials in this course are web content accessible. If you are unable to view any components of documents I distribute, please contact me so I can attempt to address the issue.

References: Material from this class will be pulled from the following resources:

Drineas, Petros and Michael W. Mahoney (2017). *Lectures on Randomized Numerical Linear Algebra*. DOI: 10.48550/arXiv.1712.08880. arXiv: 1712.08880.

Halko, N., P. G. Martinsson, and J. A. Tropp (2011). "Finding Structure with Randomness: Probabilistic Algorithms for Constructing Approximate Matrix Decompositions". In: *SIAM Review* 53.2, pp. 217–288. ISSN: 0036-1445. DOI: 10.1137/090771806.

Kannan, Ravindran and Santosh Vempala (2017). "Randomized Algorithms in Numerical Linear Algebra". In: *Acta Numerica* 26, pp. 95–135. ISSN: 0962-4929, 1474-0508. DOI: 10.1017/S0962492917000058.

Mahoney, Michael W. (2011). "Randomized Algorithms for Matrices and Data". In: *Foundations and Trends® in Machine Learning* 3.2, pp. 123–224. ISSN: 1935-8237. DOI: 10.1561/2200000035. arXiv: 1104.5557.

— (2016). *Lecture Notes on Randomized Linear Algebra*. DOI: 10.48550/arXiv.1608.04481. arXiv: 1608.04481.

Martinsson, Per-Gunnar (2019). *Randomized Methods for Matrix Computations*. DOI: 10.48550/arXiv.1607.01649. arXiv: 1607.01649.

Martinsson, Per-Gunnar and Joel A. Tropp (2020). "Randomized Numerical Linear Algebra: Foundations and Algorithms". In: *Acta Numerica* 29, pp. 403–572. ISSN: 0962-4929, 1474-0508. DOI: 10.1017/S0962492920000021.

Murray, Riley et al. (2023). *Randomized Numerical Linear Algebra: A Perspective on the Field with an Eye to Software*. Tech. rep. UCB/EECS-2023-19. URL: http://www2.eecs.berkeley.edu/Pubs/TechRpts/2023/EECS-2023-19.html.

Tropp, Joel A. (2015). "An Introduction to Matrix Concentration Inequalities". In: *arXiv:1501.01571 [cs, math, stat]*. arXiv: 1501.01571.

Vershynin, Roman (2018). *High-Dimensional Probability: An Introduction with Applications in Data Science*. Cambridge University Press. ISBN: 978-1-108-41519-4.

Woodruff, David P. (2014). "Sketching as a Tool for Numerical Linear Algebra". In: *Foundations and Trends® in Theoretical Computer Science* 10.1–2, pp. 1–157. ISSN: 1551-305X, 1551-3068. DOI: 10.1561/0400000060. arXiv: 1411.4357.