

# Algorithmic Foundations of Data Science

## MAT 5983 901 & CS 5483 901

Syllabus, Spring 2024, University of Texas at San Antonio

**Instructor:** Alperen A. Ergür  
**Time & Place:** TR 4:30 - 5:45 — San Pedro 1 Data Science — Room 200  
**Office Hours:** TR 3:30 pm- 4:15 pm at San Pedro Building, 410 B  
**Office:** TR San Pedro, 410 B, MWF NPB 3.324  
**E-mail:** alperen.ergur@utsa.edu

*The course syllabus is a general plan for the course;  
deviations announced to the class by the instructor may be necessary.*

**Eligibility:** You must have the course prerequisites listed below or equivalents. In case of doubt, consult with the instructor.

**Important Dates:** (subject to change)

All the exams below are take-home and will be submitted online.

Exam 1: Jan 31 - Feb 5

Exam 2: Feb 28 - March 4

Exam 3: April 26 - May 5

**Grading:** Participation: 40 % Exam 1: 10 % Exam 2: 20% Exam 3: 30%

The final letter grade is determined according to the following scale:

<b>A</b> = 92.1–100%	<b>A<sup>-</sup></b> = 90–92%
<b>B<sup>+</sup></b> = 86.1–89.9%	<b>B</b> = 82.1–86% , <b>B<sup>-</sup></b> = 80–82%
<b>C<sup>+</sup></b> = 76.1–79.9%	<b>C</b> = 70.1–76% , <b>C<sup>-</sup></b> = 68.1–70%
<b>D</b> = 60–68%	<b>F</b> = 0–59.9%

**Course Objective:** This course covers versatile methodologies that appear across many algorithms that process large data. The basic goals are:

- Gain a solid understanding of linear algebra based algorithms
- Understand fundamental facts from high dimensional probability and their applications in randomized dimensionality reduction algorithms
- Gain a solid background in basics of numerical optimization
- Understand how numerical optimization algorithms are used for data processing purposes, and be capable of modifying existing algorithms with better objective functions

**Prerequisite:** Enrollment in CS or Math as graduate student or approval of instructor.

**Textbook** We will use two online textbooks and one hard-copy textbook.

1. Mathematical for Machine Learning by Deisenroth, Faisal, and Ong.  
<https://mml-book.github.io/>
2. Algorithmic Foundations of Data Science by Blum, Hopcroft, Kannan.  
<https://www.cs.cornell.edu/jeh/book.pdf>
3. Optimization for Data Analysis by Recht and Wright.  
<https://www.cambridge.org/core/books/optimization-for-data-analysis/C02C3708905D236A>

**Expectations:** Being present with your attention in the lectures and gaining proficiency by paying the due respect to assigned exercise problems.

**Very Important Tip & HW policy:** I will assign exercise problems. You will need some practice to get used to probabilistic and algorithmic reasoning, and optimization perspective. All these takes time. Exercises problems will not collected or graded: I treat you as grown up graduate students. Your exam problems will have similar ideas to the exercise problems. Basically, your work on exercises is crucial for a productive learning experience and overall success in this class. Don't fret, I'll help you in the office hours.

**Course Schedule:** The course topics will be covered according to the following plan.

1. Independence, Angles, Projections
2. Eigenvalues, Singular Values, Best-Fit Subspaces
3. Vector Calculus, Automatic differentiation
4. Basic Probability Review
5. Probability in High-Dimensional Spaces
6. Linear Dimensionality Reduction
7. Streaming and Sketching Algorithms
8. Markov Chains
9. Non-linear Dimensionality Reduction
10. Optimization Perspective on Loss Functions and PCA
11. Basics of Smooth Optimization
12. Descent Methods and acceleration techniques
13. Stochastic Gradient Descent, Coordinate Descent
14. Basic Geometry of Constrained Optimization, Frank-Wolfe
15. Basics of Convex Geometry and sub-differential calculus
16. Subgradient and proximal-point methods
17. Duality and dual algorithms

**UTSA Guide to online learning** Please take a look at <https://odl.utsa.edu/guide/>

**Counseling Services:** Counseling Services provides confidential, professional services by staff psychologists, social workers, counselors and psychiatrists to help meet the personal and developmental needs of currently enrolled students. Services include individual brief therapy for personal and educational concerns, couples/relationship counseling, and group therapy on topics such as college adaptation, relationship concerns, sexual orientation, depression and anxiety. Counseling Services also screens for possible learning disabilities and has limited psychiatric services. Visit Counseling Services at <http://utsa.edu/counsel/> or call (210) 458-4140 (Main Campus) or (210) 458-2930 (Downtown Campus).

**Student Code of Conduct and Scholastic Dishonesty:** The Student Code of Conduct is Section B of the Appendices in the Student Information Bulletin. Scholastic Dishonesty is listed in the Student Code of Conduct (Sec. B of the Appendices) under Sec. 203 <http://catalog.utsa.edu/policies/administrativepoliciesandprocedures/studentcodeofconduct/>

**Students with Disabilities:** The University of Texas at San Antonio in compliance with the Americans with Disabilities Act and Section 504 of the Rehabilitation Act provides “reasonable accommodations” to students with disabilities. Only those students who have officially registered with Student Disability Services and requested accommodations for this course will be eligible for disability accommodations. Instructors at UTSA must be provided an official notification of accommodation through Student Disability Services. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at [www.utsa.edu/disability](http://www.utsa.edu/disability) or by calling Student Disability Services at (210) 458-4157. Accommodations are not retroactive.

**Transitory/Minor Medical Issues:** In situations where a student experiences a transitory/minor medical condition (e.g. broken limb, acute illness, minor surgery) that impacts their ability to attend classes, access classes or perform tasks within the classroom over a limited period of time, the student should refer to the class attendance policy in their syllabus.

**Supplemental Instruction:** Supplemental Instruction offers student-led study groups using collaborative learning for historically difficult classes. Supported courses and schedules can be found on the TRC website. You can call the SI office if you have questions or for more information at (210) 458-7251.

**Tutoring Services:** Tomás Rivera Center (TRC) may assist in building study skills and tutoring in course content. The TRC has several locations at the Main Campus and is also located at the Downtown Campus. For more information, visit the Tutoring Services web page or call (210) 458-4694 on the Main Campus and (210) 458-2838 on the Downtown Campus.

**Academic Success Coaching:** The Tomás Rivera Center (TRC) Academic Success Coaching Program offers one-on-one study skills assistance through Academic Coaching. Students meet by appointment with a professional to develop more effective study strategies and techniques that can be used across courses. Group workshops are also offered each semester to help students defeat common academic challenges. Find out more information on the TRC

Academic Success Coaching website or call (210) 458-4694.

**Sexual Harassment and Sexual Misconduct:** UTSA is committed to providing an environment free from all forms of discrimination and sexual harassment, including sexual misconduct, sexual assault, domestic violence, dating violence, and stalking. If a student has experienced or experiences any of these incidents, know that UTSA has resources to help.

UTSA faculty have the responsibility to create a learning environment that is safe and free from hostility. State and federal law as well as UTSA's Handbook of Operating Procedures (HOP 9.24) require that instructors must report incidents of sexual harassment and sexual misconduct they learn about to the Title IX Coordinator or a Deputy Title IX Coordinator. This means that if a student tells their instructor about a situation (including classroom discussions, written work and/or one-on-one meetings) involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking, the instructor must report it to the EOS/Title IX Office. Although the faculty member must report the situation, the student will still have options about how their case will be handled, including whether or not they wish to pursue a formal complaint. The university's goal is to make sure students are aware of the range of options available to them and have access to the resources they need.

If a student wishes to speak to someone confidentially, they can contact any of the following on-campus resources, who are not required to report the incident to the EOS/Title IX Office: (1) Counseling Services at 210-458-4140; (2) Student Health Services at 210-458-4142; or (3) PEACE Center at 210-458-4077.

**The Roadrunner Creed:** The University of Texas at San Antonio is a community of scholars, where integrity, excellence, inclusiveness, respect, collaboration, and innovation are fostered.

*As a Roadrunner, I will: Uphold the highest standards of academic and personal integrity by practicing and expecting fair and ethical conduct; Respect and accept individual differences, recognizing the inherent dignity of each person; Contribute to campus life and the larger community through my active engagement; and Support the fearless exploration of dreams and ideas in the advancement of ingenuity, creativity, and discovery. Guided by these principles now and forever, I am a Roadrunner!*