



Syllabus

CS/ECE/ME 532 – Matrix Methods in Machine Learning

Spring 2021

Number of credit hours: 3cr

Course Information

Canvas Course URL: <https://canvas.wisc.edu/>

Course Designations and Attributes:

Breadth - Physical Sci. Counts toward the Natural Sci req

Level - Advanced

L&S Credit - Counts as Liberal Arts and Science credit in L&S

Grad 50% - Counts toward 50% graduate coursework requirement

Meeting Time and Location: See Course Components below

Instructional Modality: Online Only

How Credit Hours are met by the Course: The credit standard for this course is met by an expectation of a minimum of 135 hours of student engagement with the course learning activities (at least 45 hours per credit), which include regularly scheduled web conferences, reading, case studies, writing, projects, team assignments, and other student work as described in this syllabus.

Instructors, Teaching Assistants (TAs), Peer Mentors

Instructor	Setion	Office Hours	Email
Prof. Matthew Malloy, PhD	001, 002	TBD	matthew.malloy@wisc.edu
Prof. Barry Van Veen, PhD	004	TBD	bvanveen@wisc.edu
Jianwei Ke, TA	001, 004	TBD	jke9@wisc.edu
Emad Sadeghi, TA	001, 002	TBD	ssadeghi@wisc.edu
Angelique Stepanenkov, peer mentor	004	TBD	stepanenkov@wisc.edu
Ruisu Zhang, peer mentor	002	TBD	rzhang345@wisc.edu

All office hours will be conducted remotely. **Office hour meeting details TBD.**

Course Sections

Section	Description	Instructor	Meeting Time
001	graduate	Prof. Matthew Malloy, PhD	9:30AM - 10:45AM Tuesday & Thursday
002	undergraduate section	Prof. Matthew Malloy, PhD	11:00AM - 12:15PM Tuesday & Thursday
004	undergraduate section	Prof. Barry Van Veen, PhD	11:00AM - 12:15PM Tuesday & Thursday

Official Course Description

Course Description

Introduction to machine learning that focuses on matrix methods and features real-world applications ranging from classification and clustering to denoising and data analysis. Mathematical topics include: linear equations, regression, regularization, the singular value decomposition, and iterative algorithms. Machine learning topics include: the lasso, support vector machines, kernel methods, clustering, dictionary learning, neural networks, and deep learning. Previous exposure to numerical computing (e.g. Matlab, **Python**, Julia, R) required.

Requisites

(MATH 222 or 276) and (E C E 203, COMP SCI 200, 220, 300, 301, 302, 310, or 320), or graduate/professional standing, or declared in Capstone Certificate in Computer Sciences for Professionals

Course Environment & Logistics

This online course has synchronous (live) web meetings on Tuesday and Thursday during the scheduled course period, and asynchronous discussion forums to facilitate communication, learning, and collaboration during the course. Regular and active student engagement is required throughout the course.

The course is taught using an active learning style. You don't really learn a topic unless you can apply it to solve problems. The active learning will take place as multiple layers. Very low stakes quizzes on the video lectures will contribute to your understanding of the concepts. Next, lightly-graded activities will be the focus of each class meeting and increase your mastery. Instructors, TA and peers will be available to help you overcome initial obstacles or misconceptions as you apply the material. You will reach the highest level of mastery on graded assignments.

Course Learning Outcomes

At the completion of this course, students will be able to:

1. Derive features from a data set using either intuition or standard feature sets.
2. Take a new sample and to classify the sample into one of a number of possible classes.
3. Appreciate the difference between supervised and unsupervised learning.
4. Implement classification systems in software and to assess the efficacy of their implementations.
5. Use matrices and vectors to represent data and functions
6. Set up, solve, and interpret the solution to systems of linear equations
7. Apply the singular value decomposition to solve a variety of machine learning problems
8. Apply ℓ_1 , ℓ_2 , and truncated singular value decomposition to regularize least squares problems
9. Derive and apply gradient descent-based techniques for solving a variety of machine learning problems
10. Demonstrate application of supervised learning techniques
11. Demonstrate application of unsupervised learning techniques
12. Teach a machine learning method or introduce a new application to their classmates

Key Topic to be Covered

- Machine learning and example problems
- Supervised and unsupervised learning
- Vectors, matrices, inner and outer products
- Orthogonality of vectors
- Inner products for representing polynomial and multi-dimensional functions
- Write classifier learning problem as a system of linear equations in matrix-vector form
- Conditions for exact solutions of systems of linear equations and rank of matrices
- Approximate solutions of systems of linear equations
- Cross validation for classification performance evaluation
- Tikhonov regularization
- Low-rank decomposition of matrices
- Applications of low-rank matrix decompositions
- Gram-Schmidt orthogonalization

- Singular Value Decomposition: finding the “best” subspace
- Principal Component Analysis (PCA) and best subspace approximation
- Page Rank algorithm
- Power iterations
- Matrix Completion
- Truncated SVD regularization
- Signal recovery
- Gradient descent
- Proximal gradient for regularized problems
- Stochastic gradient descent
- LASSO regularization
- Hinge Loss
- Neural networks and the backpropagation algorithm
- Kernel regression and the kernel trick
- Support vector machines

Required Textbook, Software & Other Course Materials

The course is organized and content is delivered through the course canvas page, which is available to enrolled students at <https://canvas.wisc.edu/>.

While there is no required textbook, the book [Lars Elden, Matrix Methods in Data Mining and Pattern Recognition](#) is recommended as supplemental material.

Software

Students are required to use Python for programming activities, and most will find it helpful to use Jupyter notebooks for an interactive Python environment. There are two primary options for using Jupyter notebooks – (1) using the Compute Aided Engineering environment (see the links on the course homepage), or (2) installing Python/Jupyter locally on your machine.

Campus provides students with [technology guidelines and recommendations](#) for online instruction. Students should consult these resources prior to the start of the semester.

Course Engagement

Course engagement happens during the course meeting times, and outside the meeting times through the course components.

Video lectures are assigned prior to each class meeting, and a corresponding quiz must be completed by 11:59 PM the evening before the class meeting period. The activities for the class meeting will be available at the start of class, and your work must be submitted by 11:59 PM. These activities should take less than 75 minutes to complete provided you come to class prepared and work on them with your peers during the live class meeting.

Assignments which are to be completed outside of class meeting time. Please start looking them over early so that you have plenty of time to ask questions. You are welcome to ask assignment related questions during class meetings and office hours.

Class Meetings

This course has a regularly scheduled live web meetings on Tuesday and Thursday during the scheduled class periods.

The class meetings are *active learning*, where you will work through activities in real-time, ask questions, get feedback, and engage with peers and faculty. You will be divided into small groups and are expected to participate in solving problems with your peers. Take this opportunity to meet some new people!

Class meetings details are TBD.

Please plan to share your video feed while in class meetings and office hours.

Office Hours

Office Hour Details are TBD.

Piazza

We will use Piazza for class discussion and Q&A. To access Piazza, click on Piazza in the left navigation menu in Canvas. Piazza is designed to provide input fast and efficiently from classmates, the TAs, and the instructors. Rather than emailing questions to the teaching staff, please post your questions on Piazza. For additional Piazza questions, please see [Piazza Support](#).

Course Components and Grading

The course consists of five graded components. The components and their relative weighting for the final grade are show in the table below.

Assignment	Percent of Final Grade	Due
Video Quizzes (drop lowest 6 scores)	10	11:59PM evening before class
Classroom Activities (drop lowest 3 scores)	25	11:59PM day of class
Assignments (drop 1 lowest score)	25	11:59PM sunday evening
Unit Quizzes (1st: 2%, 2nd–4th: 6%, 5th: 5%)	25	in-class
Integrative Summaries (Units: 2.2%, Course: 4%)	15	11:59PM day of unit quiz
Total	100	

Details are the components are provided below.

1. Video Lectures and Quizzes

Video lectures are the primary source of content delivery for the course. Video lectures are approximately 10 minutes each, and there are 1-5 video lectures assigned per week. Videos lectures are followed by a short quiz. Video Lecture Quizzes contain five questions and are not timed. You have one attempt per quiz.

2. Classroom Activities

Activities are completed in small groups during the scheduled course time. The activities should take less than 75 minutes to complete provided you are prepared and engaged during the class period. Activities must be scanned/saved as PDF and uploaded through Canvas. Learn more about [how to use phone apps to scan to pdf](#).

3. Assignments

There are approximately 8-10 assignments. Assignments go deeper and are more involved than activities. Assignments must be scanned/saved as PDF and uploaded through Canvas. Learn more about [how to use phone apps to scan to pdf](#).

4. Unit Quizzes

There will be five unit quizzes covering the six units (Unit 1, Unit 2, Unit 3&4, Unit 5, and Unit 6). The unit quizzes will be timed and take place during the class meeting time. You may access course and other reference materials during a unit quiz. However, you are not permitted to consult with anyone other than the instructional staff.

5. Integrative Summary Assignment

You will create a series of summaries throughout the course to help you understand the material and put it in context. A full description of the components of this assignment are given in a separate document. The integrative summary assignments consist of three parts: 1) a recommended 3-5 bullet points describing the main concepts in each activity and corresponding videos for your own records, a ≤ 75 -word paragraph summarizing each unit, and a ≤ 100 -word paragraph summarizing the course.

Course Grading Scale

Assignment of letter grades is based on the following percentages. We reserve the right to curve the grade in exceptional circumstances, but only in a way that will improve the grade earned. Undergraduate letter grades are assigned according to:

Grade	A	AB	B	BC	C	D	F
Score	≥ 91	≥ 86	≥ 80	≥ 72	≥ 65	≥ 58	< 58

Graduate letter grades are assigned according to:

Grade	A	AB	B	BC	C	D	F
Score	≥ 92	≥ 87	≥ 80	≥ 72	≥ 65	≥ 58	< 58

Late Submission

Due dates are hard deadlines, and **extensions are not granted**, as solutions are released immediately after the submission deadline. Late submissions are allowed, but reduced by 50% provided the late work is submitted prior to grading. Work submitted after grading will receive no credit. Note that your lowest assignments, activities, and video lecture quizzes will be dropped as specified in the Course Components and Grading table.

Subject to Change Notice

All material, assignments, and deadlines are subject to change. It is the student's responsibility to be aware of all course timelines, announcements, and communications from her or his instructor pertaining to changes in course assignments and due dates. The instructor will communicate any changes to students well in advance.

How to Succeed in This Course

In summary, to succeed in this course, students are recommended to

- Check your [UW \(wisc.edu\)](https://wisc.edu) email daily
- Login to the course site daily
- Check the course Piazza site daily
- Actively participate in the class meetings
- Be prepared for every class meeting by completing the pre-class work
- Be proactive seeking answers to your questions
- Create a study schedule and stay current on assignments
- Connect with classmates both in and out of class meetings
- Work on assignments during office hours so you can seek immediate help

- Talk with your instructor immediately if you are struggling or an unexpected issue arises
- Review the following [Netiquette Guidelines](#)

Student Participation, Preparation Time, and Attendance

- It is critical that you devote enough time to this online course. **You should plan on spending an average of 10 hours per week** on the various course components.
- Online courses require you to more actively guide your own learning. Create a study schedule to stay on track, and plan to visit the course daily to keep up with reading the announcements, participating in the online Teams sessions, completing the activities, etc.
- Successful Participation involves regularly engaging in course learning activities and assessments during the course. It may also involve both individual and collaborative components and will call upon you to develop and practice real world communication, leadership, and teamwork skills by interacting with fellow students, instructors, and other experts.
- Online courses also require you to be more proactive seeking answers to questions. Don't wait to ask questions. Ask your peers and instructors in class or office hours.

Communicating with the Instructor

The "Three before me" policy encourages students to check the following sources of information before contacting the instructor: course syllabus, course Announcements, and Piazza posts. This eliminates redundancy and expedites the process. You are encouraged to answer questions from other students when you know the answer, in order to provide timely assistance. If you have questions of a personal nature, relating to a personal emergency, an assignment grade, or other private matter, you are welcome to contact your instructor via email. Please allow up to 24 hours for your instructor to respond.

Collaboration

You are encouraged to discuss activity and assignment problems with your classmates online or in person. However, the work you submit must be your own. This means you wrote all of the code you use and can explain or rederive all results you submit. The instructional staff is available to answer questions on activities and assignments.

Links to Useful Resources

- [University Health Services](#)
- [Undergraduate Academic Advising and Career Services](#)
- [Office of the Registrar](#)
- [Office of Student Financial Aid](#)
- [Dean of Student Office](#)

Recommendation Letter Requests

Some of you will be applying for graduate school and need recommendation letters to support your application. With very few exceptions, we are unable to provide a recommendation based solely on our interaction in this class. A good recommendation letter - one that will help your application - needs to describe your characteristics and capabilities in detail. It is impossible to develop that level of knowledge based on interaction in a single, large enrollment course. It will be more helpful to your application to include a detailed letter from someone that knows you than to a brief, unspecific letter from the professor in your machine learning course. Depth of knowledge about you is far more important for your application than the expertise of the writer. Hence, we recommend you focus your requests for letters on individuals that have taught you in multiple classes or worked with you outside of the classroom.

Privacy of Student Information & Digital Tools: Teaching & Learning Analytics & Proctoring Statement

The privacy and security of faculty, staff and students' personal information is a top priority for UW-Madison. The university carefully reviews and vets all campus-supported digital tools used to support teaching and learning, to help support success through learning analytics, and to enable proctoring capabilities. UW-Madison takes necessary steps to ensure that the providers of such tools prioritize proper handling of sensitive data in alignment with FERPA, industry standards and best practices.

Under the Family Educational Rights and Privacy Act (FERPA which protects the privacy of student education records), student consent is not required for the university to share with school officials those student education records necessary for carrying out those university functions in which they have legitimate educational interest. 34 CFR 99.31(a)(1)(i)(B). FERPA specifically allows universities to designate vendors such as digital tool providers as school officials, and accordingly to share with them personally identifiable information from student education records if they perform appropriate services for the university and are subject to all applicable requirements governing the use, disclosure and protection of student data.

Privacy of Student Records and the Usage of Audio Recorded Lectures

See information about [privacy of student records and the usage of audio-recorded lectures](#).

Usage of Audio Recorded Lectures Statement: Lecture materials and recordings for ECE/CS/ME 532 are protected intellectual property at UW-Madison. Students in this course may use the materials and recordings for their personal use related to participation in this class. Students may also take notes solely for their personal use. If a lecture is not already recorded, you are not authorized to record our lectures without our permission unless you are considered by the university to be a qualified student with a disability requiring accommodation. [Regent Policy Document 4-1] Students may not copy or have lecture materials and recordings outside of class, including posting on internet sites or selling to commercial entities. Students are also prohibited from providing or selling their personal notes to anyone else or being paid for taking notes by any person or commercial firm without the instructors' express written permission. Unauthorized use of these copyrighted lecture materials and recordings constitutes copyright infringement and may be addressed under the university's policies, UWS Chapters 14 and 17, governing student academic and non-academic misconduct.

Students' Rules, Rights & Responsibilities

During the global COVID-19 pandemic, we must prioritize our collective health and safety to keep ourselves, our campus, and our community safe. As a university community, we must work together to prevent the spread of the virus and to promote the collective health and welfare of our campus and surrounding community.

UW-Madison Badger Pledge

Campus Guidance on the use of Face Coverings. Face coverings must be correctly worn on campus at all times and in all places (both outside and inside), except by students in their assigned residence hall rooms; by employees when alone in a private, unshared lab or office; when traveling alone in a private vehicle; and when exercising outside in a way that maintains 6 feet of distance from other people.

Students with disabilities or medical conditions who are unable to wear a face covering should contact the McBurney Disability Resource Center or their Access Consultant if they are already affiliated. Students requesting an accommodation unrelated to disability or medical condition, should contact the Dean of Students Office.

Students who choose not to wear a face covering may not attend in-person classes, unless they are approved for an accommodation or exemption. All other students not wearing a face covering will be asked to put one on or leave the classroom. Students who refuse to wear face coverings appropriately or adhere to other stated requirements will be reported to the Office of Student Conduct and Community Standards and will not be allowed to return to the classroom until they agree to comply with the face covering policy. An instructor may cancel or suspend a course in-person meeting if a person is in the classroom without an approved face covering in position over their nose and mouth and refuses to immediately comply.

Quarantine or Isolation Due to COVID-19

Student should continually monitor themselves for COVID-19 symptoms and get tested for the virus if they have symptoms or have been in close contact with someone with COVID-19. Student should reach out to instructors as soon as possible if they become ill or need to isolate or quarantine, in order to make alternate plans for how to proceed with the course. Students are strongly encouraged to communicate with their Instructor concerning their illness and the anticipated extent of their absence from the course (either in-person or remote). The instructor will work with the student to provide alternative ways to complete the course work.

Course Evaluations: Digital Course Evaluation (AEFIS)

UW-Madison now uses an online course evaluation survey tool, [AEFIS](#). In most instances, you will receive an official email two weeks prior to the end of the semester when your course evaluation is available. You will receive a link to log into the course evaluation with your NetID where you can complete the evaluation and submit it, anonymously. Your participation is an integral component of this course, and your feedback is important to us. We strongly encourage you to participate in the course evaluation.

Diversity & Inclusion Statement

Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background - people who as students, faculty, and staff serve Wisconsin and the world.

Academic Integrity Statement

By virtue of enrollment, each student agrees to uphold the high academic standards of the University of Wisconsin-Madison; academic misconduct is behavior that negatively impacts the integrity of the institution. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of disciplinary action include, but is not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension, or expulsion.

Common examples of academic misconduct include:

- Collaborating on or discussing a unit quiz with anyone other than the instructor
- Copying someone else's code – even with modifications
- Copying someone else's solution or text
- Submitting an assignment as your own work when a part or all of the assignment is the work of another person
- Submitting an assignment that contains ideas or research of others without appropriately identifying the sources of those ideas

Consequently:

1. Students may not submit their own previously submitted work from another without the permission of the course's principal instructor and with proper citation.
2. Students may not share their work with another student regardless of the forum or means, unless authorized by the principal instructor.
3. Asking a classmate for their advice on how to solve activities and assignments is acceptable. However, all work you submit must represent your own individual effort. This means that you did not copy (or copy with modifications) someone else's code, and that you can explain all answers you submit.
4. You are not allowed to discuss any content of unit quizzes with anyone other than the instructional staff.
5. It is the responsibility of the student to understand all the details of the syllabus and UW-Madison policies. Lack of understanding regarding how to properly cite, the presence of specific course policies, and University expectations, does not excuse behavior.

Accommodations for Students with Disabilities Statement

The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform Prof. Van Veen and Prof. Lee of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. We will work either directly with the student or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. (See: [McBurney Disability Resource Center](#))

Academic Calendar & Religious Observances

See: <https://secfac.wisc.edu/academic-calendar/#religious-observances>