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MAT 531: Math for Machine Learning
W 5:30-8:00 pm, Higgins 117
Credits: 3 credits
Grading: Standard A-F

Office Hours:

Office hours for the Fall 2026 Semester are on ground in Higgins 101D.

- MWF 11:00 am - 12:00 pm
- MWF 2:30-3:30 pm
- or by appointment

If you need to meet virtually we can make an appointment to do so via my WebEx Virtual Office: Higgins 101-DV (https://westconn.webex.com/meet/roccac)

Course Materials:

For this course you will need:

- For this course we will use a combination of Open Educational Resources, Library Reserves, and Handouts.
- Recommended Text: *Linear Algebra and it's Applications 6th edition* by Lay, Lay, and McDonald. For a majority of the class we will be looking at ideas from linear algebra and this is the text I will be using. There is a copy of the 5th edition on reserve in the library.
- You should have a notebook for this class.
- You will need an account on GitHub (`https://github.com/`) for this course.

Course Description and Outcomes:

In this course students will extend their knowledge of Calculus and Linear Algebra in preparation for understanding and utilizing machine learning algorithms. Building on prior knowledge of Linear Algebra students will study inner products and norms beyond the basic dot product, orthogonal projections, matrix decompositions (in particular, diagonalization and singular value decomposition) and be able to carry out linear regression. Their knowledge in Calculus will be extended to multiple dimensions allowing them to use derivatives to create approximations of higher dimensional functions, solve optimization problems analytically or through gradient descent, and solve constrained optimization problems with Lagrange multipliers. This course is only open to students enrolled in the MS in Artificial Intelligence program. Prerequisites: Acceptance in MS in AI, MAT 272: Linear Algebra and MAT 182: Calculus II (or equivalents)

After completing this course students will be able to

- identify the eigenvalues and eigenvectors of a matrix and apply them, where possible to diagonalize the matrix,
- apply the Gram-Schmidt orthogonalization process to create an orthonormal basis,

- apply orthogonal projection for dimensional reduction and linear regression,
- calculate the singular value decomposition of a matrix,
- evaluate partial derivatives and iterated integrals,
- explain and utilize gradient descent to find minimal values for a function,
- apply analytic techniques to find exact solutions to basic optimization problems, and
- employ Lagrange multipliers to find solutions to constrained optimization problems.

Course Content:

- Part 1: Linear Algebra "Basics"
  - Review basic matrix and vector operations
  - Eigenvectors, values, and Spaces
  - Diagonalization
- Part 2: "Advanced" Linear Algebra
  - Optimization
  - Matrix Decompositions
  - Approximations
- Part 3: Multivariable Calculus
  - Review key concepts from Calculus I & II
  - Extending Derivatives and Integrals to higher dimensions
  - Optimization with Calculus

Assessments and Grades:

Exercises (40%): For this course you will be given exercises through out the semester to help you understand the material. Some of these may be routine in nature but the majority will focus on demonstrating understanding of concepts. Some of the exercises will be robust enough that you won't be able to do them by hand, for these we will go through demonstrations using Python, Jupyter Notebooks, and Python libraries such as Numpy, Matplotlib, and Pandas.

Unit Exams (60%): There are two unit exams listed on the class calendar. For each, we will start class by doing a brief review based on questions you bring in and then, after a short break, you will complete the exams.

Class Calendar:

Wednesday	
9/2 Syllabus, Vector and Matrix Calculations	**1**
9/9 Intro to Github, Codespaces, Jupyter Notebooks, Basis and Change of Basis/Coordinates Matrices	**2**
9/16 Eigen - values, vectors & spaces, Diagonalization	**3**
9/23 Review and the ***Unit I Exam on Linear Algebra "Basics"***	**4**
9/30 Inner Products, Norms, Orthogonalization, and Least-Squares	**5**
10/7 Symmetric Matrices, Quadratic Forms, and Constrained Optimization with Matrices	**6**
10/14 Principal Component Analysis	**7**
10/21 Symmetric Matrices and Singular Value Decomposition	**8**
10/28 Review and the ***Unit II Exam on "Advanced" Linear Algebra***	**9**
11/4 Review of Calculus I & II	**10**
11/11 Extending Derivatives to Higher Dimensions	**11**
11/18 Optimization with Analytic Techniques and Lagrange Multipliers	**12**
11/25 Thanksgiving Break - ***No Class***	
12/2 Directional Derivatives, Gradients, Optimization by Gradient Descent	**13**
12/9 Review and the ***Unit III Exam on Multivariable Calculus***	**14**

Please note that 10/19/2026 is the day when midterm grades are submitted, 11/16/2026 is the last day students can withdraw from a class, 12/4/2026 is the last day of classes, and 12/7/2026 through 12/11/2026 is final exam week.

Departmental Course Outline:

Review Linear Algebra: Some in-class time will be spent on this material. Students should likely have seen this material, but time will be taken to review/cover it since linear algebra classes vary in material covered.

1. Bases for a Vector Space
    (a) Definition of Bases and Linear Independence
    (b) Dimension of a Vector Space
    (c) Change of Bases Matrices
2. Eigenvalues and Eigenvectors
    (a) Finding Eigenvalues and Eigenvectors
    (b) Diagonalizing Matrices
    (c) Eigenspaces

Extension of Linear Algebra:

1. Orthonormal Bases
    (a) Definition
    (b) Orthogonal Complements
    (c) Gram-Schmidt Orthogonalization
    (d) Least-Squares Regression
2. Inner Products
    (a) Definition of an Inner Product
    (b) Dot Product as an Inner Product
    (c) Inner Products which are not the Dot Product
    (d) Inner Products, Norms, and Orthogonality
    (e) Trend Analysis (Optional/Time Allowing)
    (f) Fourier Series (Optional/Time Allowing)
3. Symmetric Matrices
    (a) Definition and Characteristics
    (b) Quadratic Forms
    (c) Singular Value Decomposition
    (d) Constrained Optimization with Matrices
    (e) Principle Component Analysis (Optional/Time Allowing)

Multivariable Calculus

1. Functions of Several Variables
    (a) 3-Dimensional Graphs
    (b) Contour Diagrams
2. Partial Differentiation
    (a) Review of Differentiation and Extension to Multiple Dimensions
    (b) Finding Partial Derivatives
    (c) The Chain Rule
    (d) Linearization and Taylor Series
    (e) Directional Derivatives
    (f) The Gradient and Paths of Steepest Ascent
    (g) The Jacobian Matrix
    (h) The Hessian Matrix
3. Optimization
    (a) Analytic Techniques and Exact Solutions
    (b) Constrained Optimization with Lagrange Multipliers
    (c) Using Gradient Descent to Find Minimal Values
4. Integration
    (a) Integrating Over Multiple Variables
    (b) Determinant of the Jacobian and a Change of Variables

End User Agreement:

General Expectations: As a student in this class you are expected to:

- attend class and take notes,
- actively read material in each section, taking notes,
- review your notes on a regular basis,
- check your university email every day,
- check the class site **at least** every other day,
- begin studying for exams in a timely fashion,
- ask questions early and often,
- attend office hours,
- seek help in the math clinic, and
- complete assignments and readings on time.

Assignment Guidelines: (These apply to **all out of class work** done on paper.)

- Work done outside of class must always look neat, legible, and professional, adhering to given guidelines. Work must be very neatly written or preferably typed. The quality of your work will be factored into your grade, up to 10%. In extreme cases work may be rejected and then counted as late.
- An assignment is considered late after I have handed it back or gone over it in class. Late assignments are accepted but may receive at most 75% credit. Late assignments go to the absolute bottom of the stack of papers to be graded; **all on time work is graded before any late work.**
- If you work on an assignment as part of a group, then there may be no more than three individuals in the group and all your names must be on the assignment. You should hand in only one copy of the work.
- All work must be submitted in the manner directed.

Email Etiquette Guidelines: When sending an email you must include the course number and semester in the subject line. For example, if you are taking MAT 314 in Fall 1592 then the the subject line should begin with "[MAT 314 Fall 1592]." Also, you should always begin with a salutation such as "Dear Dr. Rocca" and end with a closing such as "Sincerely, I. Newton."

Technology Use: You are free to use tablets, computers, or voice recorders in the classroom to support the learning of the content, i.e. for note taking, recording, taking pictures of the board etc.. ***Cell phones are not allowed as they are a consistent distraction***. Technology use will be further restricted if it becomes disruptive, a distraction, or invades others privacy.

Exam Makeup Policy: To qualify for a makeup exam you must have a valid reason for missing the exam and, if at all possible, let me know ahead of time that you are missing the exam. You will need to meet with me in order to arrange a time for a make up exam. If you do not have a valid reason, do not give prior notice when possible, or simply do not show up for an exam, you are not entitled to a makeup. If you fail to show up for your makeup exam, you will not be given a second opportunity.

Time on Task: As a 3 credit class you should expect to average 7.5 to 8.5 hours of work a week including class time. Some weeks you may get away with less and some may require more.

Attendance: Unless otherwise stated, there is no specific policy for attendance in this course. However, if you have **three consecutive unexcused absences** I am required to report to the University that you have **stopped attending**.

Academic Honesty: If on any assignment, quiz, or exam you turn in someone else's work, regardless of the source, as if it were your own you will receive a zero on that assignment, quiz, or exam. If you are caught doing this three times you will receive an F in the course and the Dean will be informed of your academic dishonesty.
(https://www.wcsu.edu/faculty-handbook/2019-2020/policies-pertaining-to-students/academic-honesty-policy/)

Accommodations: If you have need of an accommodation for testing or note taking, please visit AccessAbility Services, located in the HAAS Library room 406 (http://www.wcsu.edu/accessability).

You and Your Grades:

- "A" (Exceptional) range 90% to 100%:
  The student has demonstrated significant mastery of the appropriate knowledge and skills relevant to the course. The student is able to solve standard formulaic exercises and most nonstandard problems which require deeper insight.
- "B" (Good) range 80% to 90%:
  The student has demonstrated mastery of the appropriate knowledge and skills relevant to the course. The student is able to solve standard formulaic exercises and some nonstandard problems which require deeper insight.
- "C" (Adequate) range 70% to 80%:
  The student has demonstrated adequate mastery of the appropriate knowledge and skills relevant to the course. The student is able to solve most standard formulaic exercises but struggles with nonstandard problems which require deeper insight.
- "D" (Inadequate) range 60% to 70%:
  The student has demonstrated inadequate or incomplete mastery of the appropriate knowledge and skills relevant to the course. The student is able to solve some standard formulaic exercises but few if any nonstandard problems which require deeper insight.
- "F" (Unacceptable) below 60%:
  The student has demonstrated essentially no mastery of the appropriate knowledge and skills relevant to the course. The student is unable to solve most standard formulaic exercises and essentially no nonstandard problems which require deeper insight.

Inspire Your Professors:

What to do:

- Show up, on time, ready to learn.
- Ask, and try to answer, questions.
- Put in the time and do the scut work.
- Seek help when you need it, utilize the resources available to you.
- Be an active participant in class and in your own education.
- Be curious about everything and be here to learn.

What not to do:

- Don't ask "What is this good for?" or "Did I miss anything?" or "Does this have to be so hard?"
- Don't say "I don't get *it*."
- Don't fiddle with your phone or computer.
- Don't wander in late and rush out early.
- Don't disappear for extended periods of time in the middle of class.
- Try not to repeat questions that have just been asked and answered, sometimes multiple times.
- Don't just grub for points.
- Don't be a passive passenger to your own education.