MATH 2270-002 Linear Algebra

MoWeFr 12:55-01:45 pm in LCB 215
and Tu 12:55-01:45 pm in LCB 225

Instructor: Ben Briggs
Email: briggs@math.utah.edu
Office: JWB 317
Office Hours: Monday 10-11am and Wednesday 2-3pm.
Prerequisites: C or better in MATH 2210 or MATH 1260 or MATH 1280 or MATH 1321 or MATH 1320.
Canvas: We will use Canvas for posting course announcements and grades. Students should check the Canvas page regularly for information. Email notifications and correspondence will be sent to the student’s UMail address ([u-number]@utah.edu).

Content and expected learning outcomes: This course is a mixture of concrete/computational math and abstract/geometric math. On the concrete side we will work with vectors and matrices and use these to solve linear equations (and other problems). On the abstract side we will talk about vector spaces (like the 2D plane or 3D space) and linear transformations between them, and all of the geometry that goes on here. One of the most important things in the course will be learning how to translate between these two sides, and hopefully see it all as one big picture.

The key topics covered include Euclidean space, linear systems, Gaussian elimination, determinants, inverses, vector spaces, linear transformations, quadratic forms, least squares and linear programming, eigenvalues and eigenvectors, and diagonalization.

In more detail, at the end of the course, students should:

- be able to solve linear systems/equations concretely using vectors and matrices
- be able to understand these linear systems and their solutions geometrically in terms of vector spaces. In particular, you should understand how matrices can represent linear transformations.
- understand general properties of vector spaces, examples of vector spaces, how to recognise when something is a vector space, and how to compare different vector spaces. In particular understand the vector space \( \mathbb{R}^n \).
- understand the notion of subspace of a vector space, and use this to think about solutions to linear systems.
- find bases and compute dimensions of vector spaces and connect this conceptually with the notion of rank.
- understand what is a coordinate system, how to change coordinates, what this means abstractly (for vector spaces) and concretely (for vectors and matrices).
- perform matrix computations (like row reduction) and understand the context and use of these computations in linear algebra.
• more specifically: you will be able to put matrices into echelon form, and be able to use this along with several theorems regarding span, linear independence and rank.

• calculate products of matrices and think about these in the context of linear transformations.

• understand various ways to decide when a matrix is invertible—for example with determinants—and be able to invert matrices. and link these concepts to existence and uniqueness of solutions.

• find eigenvectors, and eigenvalues and understand what these mean geometrically, for vector spaces linear transformations.

• understand orthogonal projections and Gram-Schmidt orthogonalization.

Course Structure.

In Class Quizzes: Each Tuesday (except the day before midterm) at the beginning of class there will be short quiz. The quiz will be credit/no-credit: if you make any reasonable attempt you will get full points. This is intended as a warm up and to encourage attendance.

Homework Assignments: Each Wednesday (except when we have midterm) a homework assignment will be due. The grader will choose a few questions each week to grade out of a total of ten points. You have to personally hand the assignment in at the beginning on class.

Midterm Exams: There will be two one-hour midterm exams. These will occupy the second half of class in the usual room AEB 310.

Midterm 1 will cover chapters 1-3, it will be held on Wednesday, October 2nd 12:55-01:45 pm.

Midterm 2 will cover chapters 4-5 it will be held on Wednesday, November 6th 12:55-01:45 pm.

Final Exam (40%): This will be a two-hour, cumulative exam. It could include any content from chapters 1-7. Our final exam is scheduled for Thursday December 12 1:00 - 3:00 pm.

Grades: Your final percentage will be calculated from your homework and exam percentages according to the following weights:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class quizzes</td>
<td>10%</td>
</tr>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm 1</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm 2</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam</td>
<td>30%</td>
</tr>
</tbody>
</table>

Your final grade will be calculated from your final percentage according to the following rule:

A   = 88-100,  A−  = 85-87,  B+  = 82-84,  B   = 73-81,
B−  = 70-72,  C+  = 67-69,  C   = 58-66,  C−  = 55-57,

This grade scheme could change: with good reason and with fair warning, these boundaries might be altered during the semester.

Additional Resources

• Tutoring Center & Computer Lab- There is free tutoring in the T. Benny Rushing Mathematics Student Center (room 155, the lower level between JWB and LCB), as well as a computer lab. For more information see http://www.math.utah.edu/undergrad/mathcenter.php
• **Private Tutoring:** University Tutoring Services, 330 SSB. There is also a list of tutors at the math department office JWB 233.

• **Departmental Videos:** The math department has a full set of lecture videos which you are welcome to use to supplement our course material. These can be found at http://www.math.utah.edu/lectures/

**Calculators:** Calculators will not be allowed on exams. They may be used on homework, but it is in your best interest not to become too dependent on your calculator since they will not be allowed on exams.

**Cheating:** If you cheat on any assignment, I will give you a zero on that assignment. Depending on the severity of the cheating, I may decide to fail you from the class. In all cases of academic dishonesty, I will report the incident to the Dean of Students.

**Student Responsibilities:** All students are expected to maintain professional behavior in the classroom setting, according to the Student Code, spelled out in the Student Handbook. Students have specific rights in the classroom as detailed in Article III of the Code. The Code also specifies proscribed conduct (Article XI) that involves cheating on tests, plagiarism, and/or collusion, as well as fraud, theft, etc. Students should read the Code carefully and know they are responsible for the content. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behaviors, and I will do so, beginning with verbal warnings and progressing to dismissal from and class and a failing grade. Students have the right to appeal such action to the Student Behavior Committee. http://regulations.utah.edu/academics/6-400.php

**ADA Statement:** The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability & Access, 162 Olpin Union Building, 801-581-5020. CDA will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability & Access.

**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 the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677 (COPS).

**Student Names and Personal Pronouns:** 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). While CIS refers to this as merely a preference, I will honor you by referring to you with the name and pronoun that feels best for you in class, on papers, exams, group projects, etc. Please advise me of any name or pronoun changes (and update CIS) so I can help create a learning environment in which you, your name, and your pronoun will be respected. If you need assistance getting your preferred name on your UIDcard, please visit the LGBT Resource Center Room 409 in the Olpin Union Building, or email bpeacock@sa.utah.edu to schedule a time to drop by. The LGBT Resource Center hours are M-F 8am-5pm, and 8am-6pm on Tuesdays.

**Wellness Statement:** Personal concerns such as stress, anxiety, relationship difficulties, depression, cross-cultural differences, etc., can interfere with a student’s ability to succeed and thrive at the University of
Utah. For helpful resources contact the Center for Student Wellness at www.wellness.utah.edu or 801-581-7776.

**Campus Safety:** The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu.
Week-by-Week:
This is a rough plan for the semester, we will probably end up drifting off course pretty quickly.

Week 1  1.1 Systems of linear equations; 1.2 Row reduction and Echelon forms; 1.3 Vector equations
Week 2  1.4 Matrix equations; 1.5 Solution sets of linear systems; 1.6 Applications of linear systems

Friday, August 30th is the last day to drop

Week 3  1.7 Linear independence; 1.8 Introduction to linear transformations; 1.9 The matrix of a linear transformation

Week 4  2.1 Matrix operations; 2.2 The inverse of a matrix; 2.3 Characterizations of invertible matrices
Week 5  2.4 Partitioned matrices; 2.5 Matrix factorizations

Week 6  3.1 Introduction to determinants; 3.2 Properties of determinants; 3.3 Cramer's rule, volume, and linear transformations

Week 7  4.1 Vector spaces and subspaces; 4.2 Null spaces, column spaces, and linear transformations

Midterm 1 Wednesday, October 2nd 12:55-01:45 pm.

Fall break

Week 8  4.3 Linearly independent sets and bases; 4.4 Coordinate systems

Friday, October 18th is the last day to withdraw

Week 9  4.5 The dimension of a vector space; 4.6 Rank; 4.7 Change of basis
Week 10  5.1 Eigenvectors and eigenvalues; 5.2 The characteristic equation; 5.3 Diagonalization
Week 11  5.4 Eigenvectors and linear transformations; 5.5 Complex eigenvalues; 5.6 Discrete dynamical systems

Midterm 2 Wednesday, November 6th 12:55-01:45 pm.

Week 12  6.1 Inner product, length, and orthogonality; 6.2 Orthogonal sets; 6.3 Orthogonal projections
Week 13  6.4 The Gram-Schmidt process; 6.5 Least squares problems
Week 14  7.1 Diagonalization of symmetric matrices; 7.2 Quadratic forms; 7.3 Constrained optimization;
         7.4 The singular value decomposition

Final exam Thursday December 12 1:00-3:00 pm