Instructor: Christian Klevdal  
   Pronouns: he/him/his  
   Preferred address: Christian  
   Office: LCB 112  
   E-mail: klevdal@math.utah.edu  

Class Type: This is designated as interactive video conferencing. Lectures will be delivered synchronously using zoom during the class time. Students are expected to be computer literate and Canvas and zoom navigation skills are expected. Knowledge and navigation of Canvas and zoom is critical to access all features and resources of this course. In particular access to strong internet and adequate bandwidth is necessary.

Communication: Communication will take place via Canvas and Zoom. We will use Zoom for office hours and lectures, and Canvas for course materials and information. Some of the course information will be delivered via announcement quizzes on canvas. These can be completed at any before the last day of class, with unlimited tries. You will receive a small amount of extra credit for these quizzes.

Zoom link: Link: https://utah.zoom.us/j/96559284396. Meeting ID: 965 5928 4396. **You must use your university account associated to your umail when joining the lectures over Zoom.** This is because I have breakout rooms pre-assigned, but in order to work you need to be signed in with your umail.

Attendance: You are expected to attend lectures synchronously. Please let me know if you do not have reliable access to technology and/or internet, with adequate bandwidth.

Class Hours: MTWF, 9:40AM-10:30AM.

Office Hours: All office hours are conducted via Zoom.
   - Tuesday 5-6pm,
Thursday 2-3pm.


Webpage: All information concerning this class will be posted on the Canvas webpage of the class. Any important information will be given in class and on the Canvas webpage. You are responsible for checking the webpage on a regular basis (you can have the communication from Canvas forwarded to your email address).

Prerequisites: At least a C grade in Math 2210 OR Math 1260 OR Math 1321 OR Math 1320 OR (Math 1220 AND Full Major status in Computer Science OR Computer Engineering).

Course description: Linear algebra is the study of vector spaces. It is the single most important subject in mathematics, and has many applications in other areas of science. We will begin the course by reviewing systems of linear equations and their solutions. Several algorithms for finding solutions to systems of linear equations will be introduced. The next topics covered are vector spaces along with the critically important notions of linear independence, span and bases; and linear transformations which provide the abstract motivation for matrices. Finite dimensional vector spaces with be defined and we will prove a theorem that classifies finite dimensional vector spaces up to isomorphism. We will then cover eigenvalues and eigenvectors of linear transformations and determinants.

Expected Learning Outcomes: Upon successful completion of this course, a student should be able to:

1. Understand solutions of and techniques involved in the study of linear systems of equations.
   (a) Students will be able solve linear system of equations using techniques such as Gauss-Jordan elimination.
   (b) Students will understand how to use matrices to aid in computations with linear systems of equations.
   (c) Students will understand the significance of reduced row echelon form of matrices, and how this relates to the study of linear systems.

2. Understand abstract vector spaces and linear transformations.
   (a) Students will know the axioms of a vector space, and the definition of a linear transformation.
   (b) Students will understand the properties of vector spaces, in particular \( \mathbb{R}^n \)
   (c) Students will conceptualize matrices as linear transformations.
   (d) Students will understand the properties of vector spaces, in particular \( \mathbb{R}^n \) as a vector space.
   (e) Students will understand the classification of finite dimensional vector spaces. The students will learn that vector spaces isomorphic to \( \mathbb{R}^n \) have the same algebraic properties as \( \mathbb{R}^n \).

3. Connect the study of linear systems to the study of vector spaces and linear transformations. In particular, they will perform matrix computations and understand them as examples of abstract mathematical concepts.
   (a) Students will perform row reductions and put matrices into echelon forms. Students will connect this to several theorems regarding span, linear independence, determinant, invertibility, and rank.
   (b) Students will calculate matrix-vector and matrix-matrix products and think about these processes in the context of linear transformations.
   (c) Students will find determinants, eigenvectors, and eigenvalues and link these concepts to existence and uniqueness of solutions. Students use eigenvalues and eigenvectors to find a basis in which the properties of the linear transformation become transparent.
   (d) Students will compute dimension and bases of vector spaces and develop these ideas in context of linear transformations and change of coordinate systems.

4. Discover applications of linear algebra.
   (a) Students will have a written project about an application of linear algebra. Examples are the singular value decomposition in image processing and eigenvectors in the Google page rank algorithm.
5. Learn how to read/write mathematical proofs, and make arguments that are logically correct and rigorous.
   
   (a) Students will understand the logic of several basic proof strategies, such as direct proof, proof by cases, proof by induction and proof by contradiction.
   
   (b) Students will use these proof strategies to prove theorems about vector spaces and linear transformations.
   
   (c) Students will be able produce clear, complete proofs, written in full English sentences.
   
   (d) Students will be able to understand clear and complete proofs written in textbooks.
   
   (e) Students should understand how the proofs of key properties of vector spaces and linear maps (such as the classification of finite dimensional vector spaces, and the rank-nullity theorem) are proven from the axioms of vector spaces.

**Class Culture:** We will model our class based on the axioms proposed by Federico Ardila:

Axiom 1 Mathematical talent is distributed equally among different groups, irrespective of geographic, demographic, and economic boundaries.

Axiom 2 Everyone can have joyful, meaningful, and empowering mathematical experiences.

Axiom 3 Mathematics is a powerful, malleable tool that can be shaped and used differently by various communities to serve their needs.

Axiom 4 Every student deserves to be treated with dignity and respect.

**Homework:** Homework will be scanned and turned in electronically through the Canvas page. The assignments and due dates will be posted through Canvas. Students are directed to follow the directions posted on the Canvas page on how to format their homework when they turn it in. Homework assignments need to have all work shown, be neat and organized with all pages in order, and **formatted in the specified manner** in order to be graded. Homework will be completed outside of class. The homework will be graded partially for completeness and partially for correctness. I will accept four late homework assignments, up to one week late, throughout the semester for full credit. It is not necessary nor recommended that you tell me why your homework is late. This policy is meant to be flexible enough to cover all reasons. If you need to turn a homework more than a week late for a documented reason, please contact me! You may (and are encouraged to) discuss the problems with others, but it is important to write up your own solutions. Any late homework assignments past the first four will not be accepted.

**Proof day:** One of the biggest goals of this course is to teach you how to write rigorous, mathematically correct proofs. This is likely a topic you have not covered in your previous math courses. Each week we will have one day dedicated to proof writing. I will lecture for about half of the class. Writing proofs requires lots of hands on experience, so you will spend the second half of class working individually or in groups practicing this (most likely with an activity sheet). It is unlikely that you will be able to complete all of these activity sheets during class, so you will have to finish them outside of class time. These worksheets will be graded for thoughtful and well explained answers.

**Graded proofs:** Over the course of the semester, I will have you turn in 7 graded proofs. These proofs are expected to be complete and rigorous, in particular, they need to be written in **full sentences**, and it should be clear to the reader what your proof is. I will give a list of theorems you can choose from to prove. Proofs will be collected in batches, according to the following schedule:

- Friday, September 18th. Two proofs due.
- Friday, October 30th. Two proofs due.
- Friday, December 11th. All seven proofs due. Grades are final.

Proofs submitted for the first two deadlines may be rewritten and submitted to be regraded at the final deadline. Proofs will not be accepted after the final deadline.

**Final project:** There will be one project, in place of a final exam. The project assignment will be posted on canvas two weeks before Thanksgiving break. The project will be a report on an application of linear algebra. Late projects will not be accepted, so please plan accordingly.
Exams: There will be two midterm exams. These midterms will be take home, and you will have 24 hours to complete them. I will announce the sections covered for the exams in a Canvas announcement and in class about a week before the exam, but expect that all material covered before the midterm will be tested. You must submit a scanned copy of your midterm to Canvas.

- Friday, October 16th: Midterm 1.
- Friday, November 20th: Midterm 2.
- Friday, December 11th: Project due.

Grading Policy: The grades will be calculated as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>10%</td>
</tr>
<tr>
<td>Proofs</td>
<td>10%</td>
</tr>
<tr>
<td>Worksheets</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm exams</td>
<td>40% (20% each)</td>
</tr>
<tr>
<td>Final Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Announcement quizzes</td>
<td>2% (extra credit)</td>
</tr>
</tbody>
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Online Grades: I will put your grades online on Canvas. You can get there easily from the main University of Utah website www.utah.edu. To log in, you use the same student id and password that you use for Campus Information System. I do my best to update the grades on a regular basis and keep everything accurate. However, I would advise you to check your grades often to make sure there were no data entry mistakes. I'm always happy to correct any mistakes I've made. You just need to let me know about them.

Gradescope: We'll be using a software, Gradescope, to grade exams in this class. You will be able to access your exams in Gradescope and request regrades there, directly in Gradescope. You will not receive any written exam work back on paper, as it will be uploaded to Gradescope instead.

Grades: Final letter grades will be determined by overall percentage as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>93% – 100%</td>
</tr>
<tr>
<td>A-</td>
<td>90% – 92.9%</td>
</tr>
<tr>
<td>B+</td>
<td>87% – 89.9%</td>
</tr>
<tr>
<td>B</td>
<td>83% – 86.9%</td>
</tr>
<tr>
<td>B-</td>
<td>80% – 82.9%</td>
</tr>
<tr>
<td>C</td>
<td>73% – 76.9%</td>
</tr>
<tr>
<td>C+</td>
<td>77% – 79.9%</td>
</tr>
<tr>
<td>D</td>
<td>67% – 69.9%</td>
</tr>
<tr>
<td>D+</td>
<td>63% – 66.9%</td>
</tr>
<tr>
<td>D-</td>
<td>60% – 62.9%</td>
</tr>
<tr>
<td>E</td>
<td>0% – 59.9%</td>
</tr>
</tbody>
</table>

Inclusivity Statement: It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students’ learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: age, color, disability, gender, gender identity, gender expression, national origin, political affiliation, race, religion, sexual orientation, and veteran status, and other unique identities. 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. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

Names/Pronouns: Canvas allows students to change the name that is displayed AND allows them to add their pronouns to their Canvas name. 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 managed 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 and pronoun that feels best for you in class or on assignments. Please advise me of any name or pronoun changes so I can help create a learning environment in which you, your name, and your pronoun are respected. If you need any assistance or support, please reach out to the LGBT Resource Center. https://lgbt.utah.edu/campus/faculty_resources.php

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.
Undocumented 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 (with and without DACA) 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.

University Counseling Center: The University Counseling Center (UCC) provides developmental, preventive, and therapeutic services and programs that promote the intellectual, emotional, cultural, and social development of University of Utah students. They advocate a philosophy of acceptance, compassion, and support for those they serve, as well as for each other. They aspire to respect cultural, individual and role differences as they continually work toward creating a safe and affirming climate for individuals of all ages, cultures, ethnicities, genders, gender identities, languages, mental and physical abilities, national origins, races, religions, sexual orientations, sizes and socioeconomic statuses.

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 and Access, 162 Olpin Union Building, 581-5020 (V/TDD). CDA will work with you and the instructor to make arrangements for accommodations. All information in this course can be made available in alternative format with prior notification to the Center for Disability and Access.

Veterans Center: If you are a student veteran, the U 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/. Please also let me know if you need any additional support in this class for any reason.

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. You 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, collusion, fraud, theft, etc. Students should read the Code carefully and know you are responsible for the content. According to Faculty Rules and Regulations, it is the faculty responsibility to enforce responsible classroom behaviors, beginning with verbal warnings and progressing to dismissal from 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

Student Names and Personal Pronouns: Class rosters are provided to the instructor with the students 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 U-ID card, 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.

Safety Statement: 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.

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, veterans 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).
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 https://wellness.utah.edu/ or 801-581-7776.

Dean of Students Office: The Dean of Students Office is dedicated to being a resource for students through support, advocacy, involvement, and accountability. It serves as a support for students facing challenges to their success as students, and assist with the interpretation of university policy and regulations. Please consider reaching out to the Office of the Dean of Students for any questions, issues and concerns. https://deanofstudents.utah.edu/ or 801-581-7066

Tutoring: Free online tutoring: The math department offers free online tutoring. See the webpage http://www.math.utah.edu/ for more information.
Private tutoring: University Tutoring Services, 330 SSB (they offer inexpensive tutoring). There is also a list of tutors at the Math Department office in JWB 233.

Cheating: If you cheat on any homework or exam, I will give you a grade of zero for that work. Depending on the severity of the cheating, I may decide to fail you from the class. In all cases, I will report the incident to the Dean of Students, and to the International Students Office in the case of an international student.

Disclaimer: If I do any modification to this syllabus, I will let you know in class and update the webpage.

Some important dates for this class:

- Monday, August 24th: First day of class
- Friday, September 4th: Last day to drop and add class
- Monday, September 7th: Labor day
- Friday, October 16th: Midterm 1
- Friday, October 30th: Midterm 2
- Friday, November 6th: Last day to withdraw
- Friday, November 27th: Last day to reverse C/NC option
- Friday, December 11th: Project due