MATH 203
Fall 2022
Linear Algebra

TTh4:30-5:45pm, Horizon Hall 1014

Instructor: Rebecca R.G. (she/her) **Email:** rrebhuhn@gmu.edu

Call me: Dr. R.G. **Office:** Exploratory 4406

Learning Assistants: Holly Miller, she/her (mmille77@gmu.edu) and Violet Nguyen, she/her (rnguye9@gmu.edu)

Office Hours: Dr. R.G.: in person in Exploratory 4406 and virtually via Zoom, time TBD. LA review sessions: TBD.

Course Description: This course is an introduction to linear algebra. The students will learn about systems of linear equations, linear independence, linear transformations, inverse of a matrix, determinants, vector spaces, eigenvalues and eigenvectors, and orthogonality. Linear algebra plays an essential role in mathematics and in other fields like computer science, engineering, physics, economics, and statistics. Students will also gain experience in problem solving techniques and mathematical collaboration.

Prerequisites: A C or better in Math 114.

Textbook: Linear Algebra for Team-Based Inquiry Learning by Steven Clontz and Drew Lewis, available for free at `https://teambasedinquirylearning.github.io/linear-algebra/2022/frontmatter.html`

Practice quiz problems can be found in the problem bank at `https://teambasedinquirylearning.github.io/linear-algebra/2022/exercises/#/bank/`.

Optional additional textbook (good for extra practice problems, and we'll cover one or two topics here that are not in the above book): *Linear Algebra and its Applications* by David C. Lay, Steven R. Lay, and Judi J. McDonald, 6th edition, Pearson 2020.

Other supplies: Whiteboard markers in 4 colors and a whiteboard eraser. I will have some I can loan out, but not enough for the whole class.

Covid safety/what to do if you're sick: Mason does not currently (as of 8/22) require masks on campus, but I will be wearing one and you are welcome to do so as well. If you are sick, please stay home and get tested as appropriate. I recommend sharing contact information with other students in the class to find out what material to make up. If you will miss multiple classes, quizzes, or an exam, please email me as soon as possible so I can work out an accommodation.

Course technology: You will need to bring a device (phone, tablet, laptop, etc.) to class that can access the online textbook, preferably one that can also run a second browser tab so you can do Octave computations during class. For quizzes, you will need a laptop or tablet that you are comfortable typing on to use Octave.

You will turn in work by submitting a single pdf of each assignment through Gradescope. There are various phone apps that will allow you to scan handwritten work and turn it into a single pdf–a quick Google search should find one. When submitting work, please make sure all pages are contained in the file, your writing is legible and not blurry, and all pages are in order and right side up. *Once you have uploaded the file to Gradescope, you will need to label which pages contain which problems.*

Grading: Grades will be a combination of demonstrated mastery of the learning objectives through weekly quizzes, and demonstrated understanding of the themes of the course through regular assigned problems. The following are the approximate grading criteria, with plus and minus grades being assigned for in-between scores:

Letter grade	Number of learning objectives met (out of 26)	Number of problems solved
A	24	10, at least 5 of which are from exams
B	22	6, at least 3 of which are from exams
C	20	2, at least 1 of which is from an exam
D	10	0
F	< 10	0

Learning objective quizzes: To demonstrate your knowledge of each learning objective in the course (see next item on syllabus), you will need to correctly solve a quiz problem. The purpose of these problems is to test your knowledge of the fundamental methods in the course. You will need to pass most learning objectives in order to pass the course.

Quiz problems will be graded successful/unsuccessful. Each topic will appear on multiple quizzes (for all but the last few learning objectives, at least 3 quizzes), so if you are not successful the first time a topic appears, you can try again. On a given quiz, you only need to answer questions for learning objectives you have not yet met. Problems will be labelled with the corresponding topic, and I will maintain a list of topics you have already mastered on Blackboard.

For example, a quiz might include 5 problems from 5 learning objectives, but you will choose 1-3 topics you have not yet successfully answered a quiz question for and answer only those problems.

Note that in order to get a problem correct, your answer must include enough detail for me to see how you solved it. This can be informal, but must be understandable.

Quizzes will be 25 minutes long and will be offered on Thursdays at the beginning of class. Bring a computer or tablet that you can use to run Octave (just need to open a browser and be comfortable typing on the device).

List of learning objectives for the course:

- LE1: Translate back and forth between a system of linear equations, a vector equation, and the corresponding augmented matrix.
- LE2: Explain why a matrix isn't in reduced row echelon form, and put a matrix in reduced row echelon form.
- LE3: Determine the number of solutions for a system of linear equations or a vector equation.
- LE4: Compute the solution set for a system of linear equations or a vector equation with infinitly many solutions.
- VS1: Explain why a given set with defined addition and scalar multiplication does satisfy a given vector space property, but nonetheless isn't a vector space.
- VS2: Determine if a Euclidean vector can be written as a linear combination of a given set of Euclidean vectors by solving an appropriate vector equation.
- VS3: Determine if a set of Euclidean vectors spans by solving appropriate vector equations.
- VS4: Determine if a subset of $\mathbb{R}^n$ is a subspace or not.
- VS5: Determine if a set of Euclidean vectors is linearly dependent or independent by solving an appropriate vector equation.
- VS6: Explain why a set of Euclidean vectors is or is not a basis of $\mathbb{R}^n$.
- VS7: Compute a basis for the subspace spanned by a given set of Euclidean vectors, and determine the dimension of the subspace.
- VS8: Answer questions about vector spaces of polynomials or matrices.

- VS9: Find a basis for the solution set of a homogeneous system of equations.
- AT1: Determine if a map between vector spaces of polynomials is linear or not.
- AT2: Translate back and forth between a linear transformation of Euclidean spaces and its standard matrix, and perform related computations.
- AT3: Compute a basis for the kernel and a basis for the image of a linear map, and verify that the rank-nullity theorem holds for a given linear map.
- AT4: Determine if a given linear map is injective and/or surjective.
- AT5: Compute a change of coordinates matrix between two bases of the same vector space, and use it to write a vector with respect to a new basis.
- MX1: Multiply matrices.
- MX2: Express row operations through matrix multiplication.
- MX3: Determine if a matrix is invertible, and if so, compute its inverse.
- GT1: Describe how a row operation affects the determinant of a matrix.
- GT2: Compute the determinant of a 4×4 matrix.
- GT3: Find the eigenvalues of a 2×2 matrix.
- GT4: Find a basis for the eigenspace of a 4×4 matrix associated with a given eigenvalue.
- OR1: Determine whether a set of vectors forms an orthogonal basis, and express a vector as a linear combination of the vectors in an orthogonal basis.

Exams: These must be taken in person. The midterm exam will take place during class on **Thursday, 10/13**, and will consist of 5 conceptual problems, which will count towards the "Number of problems solved" component of your grade. Each problem will be graded sufficient/insufficient. The final exam will take place on **Tuesday, 12/13 from 4:30-7:15pm** and will have 2 pieces. The first piece will be a final attempt at some of the learning objectives from the course, including objectives that have not been tested 3 times yet and other objectives that a number of students still need to pass. These will count towards the learning objective part of your grade. The second piece will consist of 5 conceptual problems, like the midterm, and will count towards the "Number of problems solved" part of your grade. Unlike the quizzes, which will directly test the skills from the class, the conceptual questions on the midterm and final will ask you to explain in words why you are choosing particular methods to solve the problems, compare techniques from multiple sections, or otherwise analyze your solutions. To prepare for these questions, attempt the homework and participate in class.

Conceptual problems: I will assign at least 6 conceptual problems during the semester. The purpose of these assignments is to get you to try harder problems that can't be solved by following a method in the textbook, and to give you an opportunity to practice your mathematical writing. You are not expected to be able to solve these right away, and you are strongly encouraged to discuss them with other members of the class. Each problem will initially be submitted for feedback only, and then you will have a chance to rewrite for credit.

These will count towards the "Number of problems solved" portion of your grade, and will be graded as correct/insufficient. You do not need to solve most of the problems in order to pass the class, but you will need to solve more of them to get an A or a B in the course. Since the problems will be difficult enough that you may not be able to answer all of them successfully, I recommend trying several of them even if you only want a C in the class.

Your write-ups of homework problems should be in full sentences, and should be written so that a classmate can follow your argument without prior knowledge of the problem. You may work

together on the homework, but must write up your assignment separately and in your own words. **Please list everyone you worked with on the homework and all sources you consulted.**

If you want someone to read your write-up and give you individual feedback, ask at the end of class, email one of us, or come to our office hours/review sessions. We will not generally have time during class to read individual write-ups.

During class: During class, you will work with a group of 3-4 students on problems in the textbook. The purpose of class time is for you to build an understanding of how each topic works, practice explaining material to your peers, and learn the techniques that will be tested via the learning objectives.

On the first day of class we will write a set of norms for working effectively in groups, and you will be expected to adhere to these guidelines.

The LA's and I will walk around helping groups during class time. We will prioritize answering questions asked by the whole group, and will generally not have time to read individual write-ups during class. If you want someone to read your write-up and give you individual feedback, ask at the end of class, email one of us, or come to our office hours/review sessions.

Blackboard: All course materials and grades will be posted on Blackboard, and you will turn in assignments through Gradescope. Please check Blackboard and Gradescope regularly to keep up to date with announcements and class material and to ensure your grades have been recorded correctly.

Late Policy: Quizzes cannot be taken late, but you will have multiple opportunities to demonstrate mastery of each topic. Late homework will be accepted without penalty until I have started grading the assignment. This usually means you have a day or two to turn in late work. If you will need more flexibility than this, talk to me as early as possible so we can find an accommodation that will work for both of us.

Getting help: Dr. R.G. and the two LA's will hold office hours both in person and virtually. In addition to coming to office hours to ask questions, you can use the space to meet other students from class and work on the homework together. You can also email questions to Dr. R.G.

Email Policy: Students must use their GMU email account to receive important University information, including communications related to this class. Please check your GMU email regularly, and only email me from that account. I will try to respond to all emails within 24 hours, or by Monday if questions are sent over the weekend. If 48 hours have passed and you have not received a response, send a follow-up email.

Students with Disabilities: If you have learning needs and have been evaluated or are in the process of being evaluated by Mason's Disability Services (http://ds.gmu.edu), please let me know so that I may make certain you are receiving the support you need.

Academic Integrity: By putting your name on your assignments, you are acknowledging the integrity of your work. If you have any questions about academic integrity, please either consult with us or go to https://oai.gmu.edu/mason-honor-code/

Quizzes and exams must be taken alone, without discussing your work with other people or consulting sources. Working together on quizzes or exams is a violation of academic integrity.

You are strongly encouraged to discuss the homework with your classmates and to work together. Please come to office hours to ask for help as well. However, everything you submit must be your own work, and should reflect your own understanding. Copying a problem solution from a classmate, the internet, or any other source is a violation of academic integrity. If you have any questions about the difference between working together and copying, or how to cite your sources, please come talk to me.

Mandatory Reporting: As a faculty member, I am designated as a "Responsible Employee," and must report all disclosures of sexual assault, interpersonal violence, and stalking to Mason's Title IX Coordinator per University Policy. If you wish to speak with someone confidentially, please contact one of Mason's confidential resources, such as Student Support and Advocacy Center (SSAC) at 703-993-3686 or Counseling and Psychology Services (CAPS) at 703-993-2380. The 24-hour Sexual and Intimate Partner Violence Crisis Line for Mason is 703-380-1434. You may also seek assistance from Mason's Title IX Coordinator by calling 703-993-8730 or email titleix@gmu.edu.

Tentative Class Calendar:

Date	**Learning objective**
8/23	Introduction and setting of class norms
8/25	LE1
8/30	LE2
9/1	LE3
9/6	LE4
9/8	VS1
9/13	VS2
9/15	VS3
9/20	VS4
9/22	VS5
9/27	VS6
9/29	VS7
10/4	VS8
10/6	VS9
10/11	No class (Monday classes meet instead)
10/13	Midterm exam during class time
10/18	AT1
10/20	AT2
10/25	AT3
10/27	AT4
11/1	AT5
11/3	MX1
11/8	MX2
11/10	MX3
11/15	GT1
11/17	GT2
11/22	GT3
11/24	No class–Thanksgiving break
11/29	GT4
12/1	OR1
12/13	Final exam 4:30-7:15pm