

# LINEAR ALGEBRA

## MATHEMATICS 2000-B

Spring 2019

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<b>Office Location:</b>	Searles 103	<b>Office Phone:</b>	(207) 725-3572
<b>Class Sessions:</b>	MWF 11:45–12:40	<b>Classroom:</b>	Searles 215

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### Course Webpage

All regular announcements, instructor office hours, daily homeworks, group projects, handouts, and individual grades will be posted on Blackboard

<http://blackboard.bowdoin.edu>

Check this site on a regular basis to track your progress. General course policies, syllabus, tentative schedule and outline of the course will be also available as pdf files on Blackboard.

### Office Hours

- TBA. These time slots are common for all the courses I am teaching this semester.
- If you can't make it to any of the weekly office hours, you can email me to schedule appointments with me. These will depend on my availability.
- I am usually in the office every weekday about 10-4PM. *If my door is open*, you are welcome to knock on my door and come in with quick questions.
- Any and all questions are welcome in class or in my office, but be aware that I will not simply "give you the answer" to any problem. Big-picture questions beyond "How do I solve this problem?" are highly encouraged.
- I also welcome questions through email. Though I strive to answer all email questions as clearly as possible, please realize that certain questions are best answered in a face-to-face discussion.

### Prerequisites

In order to be considered for admission into Math 2000 you must either have

1. completed Bowdoin's Math 1800, or
2. been given a mathematics placement of Math 2000 when you entered Bowdoin.

If you do not satisfy at least one of these two conditions you will need the permission of the Chair of the Mathematics Department in order to register for Math 2000.

### Textbooks and Supplies

- *Linear Algebra and Its Applications*, 5<sup>th</sup> edition, by David C. Lay.
- *A scientific calculator*

The use of calculators is NOT permitted for all in-class exams. But you may certainly use them when completing homework assignments, and occasionally this may be required.

### Course Description

At the heart of Linear Algebra is an interplay between linear equations, matrix algebra, and geometry. It has a broad range of applications within the sciences and other areas of mathematics, from geometry and computer graphics to differential equations and the dynamics of populations.

Linear Algebra begins with the study of systems of linear equations and their solutions. These systems can be viewed geometrically as vector equations, and alternatively as matrix equations. A major goal of the course will be to understand long-term behavior of linear systems over time, through the techniques of eigenvectors and eigenvalues of matrices. We will also learn how inner products allow us to find the closest approximate solution to equations for which no exact solution exists.

### The MCSR Distribution Requirement

Math 2000 can be used to satisfy Bowdoin's Mathematical, Computational, or Statistical Reasoning (MCSR) distribution requirement, through the development of the mathematical tools of linear equations, vectors, and matrices, and also through the application of such techniques to linear models in science and engineering.

### The Components of the Course

- You will need to **read the textbook**. In particular, the designated sections of the text should be read prior to the class sessions for which they are assigned. This will get updated in the 'Prep Assignment' section of the Blackboard menu. You do not need to submit the solutions for the practice problems in the prep assignment, but you should try to work them out yourself to solidify your understanding. We will explain the material and work out harder examples from the section in class.
- **Daily Assignments** will contain questions based on the textbook readings and class work. These assignments with their due dates will be regularly posted on Blackboard. The typical due date pattern is:
  - Monday's homework is due Friday same week,
  - Wednesday and Friday's homeworks are due Wednesday next week.

As is typical for linear algebra courses in the Mathematics Department, homework will generally be corrected by student graders who work under my supervision; this is done to ensure that you regularly receive graded assignments in a timely manner.

- There will be five or six longer **Extra Credit Collaborative Projects** built around more challenging questions from the exercises, to showcase interesting applications of the study materials. Electronic copies of the assignment details will be available on Blackboard. These will be due typically within seven to ten days.
- we will use some of the class sessions to work on practice problems. Paper copy of **Handouts** will be provided and an electronic copy will be available on Blackboard. Depending on how much we are able to cover during class period, part of it might get assigned as homework.
- Additionally, there will be occasional quizzes and **two Midterms** given during the semester, as well as a **Final Examination** at the end of the semester. The midterms will be during Monday class times. The final exam will be according to the Registrar's office schedule. All exams will emphasize the concepts of the course.

### Grading Policy

- Grades will be given for each daily assignments, quizzes, and exams. In addition, each lab will include a short assignment that will be collected and graded. Both your score and how it ranks relative to the other scores in the class will determine your final grade.
- *You can get an additional 10% score by completing the extra credit collaborative projects.*
- *Scores will NOT be curved. However, the cutoff percentage for letter grades will be set at my discretion.*

The individual weights are as follows:

Assignments .....	20%
Quizzes, class work and class participation .....	10%
Midterm 1 .....	20%
Midterm 2 .....	20%
Final exam .....	30%

### Important Dates

Midterm # 1 .....	Monday, February 18, 2019
Midterm # 2 .....	Monday, April 8, 2019
Final Exam .....	TBA, sometime between May 13-18, 2019

Please let me know immediately of any problems with these dates. Please note that the date of the final exam is set by the Registrar's office and cannot be altered. Individual changes in final exam dates are allowed only for particularly serious situations such as three exams in a two-day period.

### Assignment and Projects Policies

- *Often there will be no example in the text or in class work that exactly mirrors an assigned problem or project. This is by design.* To learn how to apply the principles discussed in the text and the class sessions, you cannot merely copy procedures you see laid out in examples.

- Homeworks are extremely important, as it is the best way for you to engage with the material on a regular basis. The problems assigned will be carefully chosen to highlight essential concepts. I also expect that in case you need extra practice with a certain concept, you will seek *extra, unassigned problems from the textbook to work out*; I am always happy to discuss how to locate good practice problems in your book.
- You are encouraged to work on the **daily assignments** with others, but you must write your final solution in your own words and you must complete and attach an **Assignment Cover Sheet** with every submission. This sheet can be downloaded from Blackboard. Assignments will need to be submitted to me personally at the beginning of the classes.
- You are allowed to work in groups of size **at most 3 (three)** to work on the **extra credit collaborative projects**. All members of the group must not only participate in the analysis of the project but should discuss the specific phrasing and organization of the final submission. Final submissions must include a **Collaboration Report** (downloadable from Blackboard) on which the signatures of all participants must appear along with *brief but substantive* discussions of the issues confronted at your meetings. If any group member did not participate in an important aspect of the assignment, this must be stated in the Report. *One submission for your entire group will suffice.*
- The point of the homeworks is for you to work out what you do and don't understand. You should help each other to understand the materials and come and ask me if all of you get stuck together. When your graded homework has been handed back to you, you should go through it and see if you understand what has been written on it by the grader. If you don't, you should come to office hours and ask.
- As you are solving problems in this course, remember that getting the "answer" is only one of the steps. Don't think of what you write as just showing your instructor that you have done the homework. Write as if you were explaining what you are doing to one of your classmates who missed that day of class. Think of writing as part of the process of learning. The more carefully and clearly you write your mathematics, the more likely it is to be correct, and the more likely you will be to remember it. Correct answers without explanation will not reap full credit, but clear explanations with an incorrect answer can certainly earn partial credit.

### Advice on Collaborative Learning

Collaborative learning teams are said to attain higher level thinking and preserve information for longer times than students working individually. You are strongly encouraged to work together, both in-class and on homeworks, throughout this course. As a member of a group you are responsible not only for your own learning but also for the learning of the other members of your group. This means that when the work is completed and submitted, every member of the group should be able to explain how to solve all the problems. Here are some ideas that past students have come up with to help your group function at its full potential.

- **Schedule enough meetings**, well in advance, and make sure to attend every one of them.
- **Be prepared**. Prior to meeting do the readings and think about the problems.
- **Contribute** to the assignment solutions. Make sure that everyone is equally involved.
- **Listen carefully** and with respect to each other. Don't interrupt and don't tune out.

- **Ask for help** when you need it.
- **Give help** when it is requested.
- **Criticize ideas, not people.** Be tolerant, respectful, and caring.
- **Never agree to something you don't understand.** Don't rush to the finish before others.

### Low scores and late submission policies

- You can **replace up to three quiz grades** by going to a mathematics or related talk, and turning in a 1–2 page summary of the talk. Talks from other departments with a math flavor to them can also count. (eg: biology, chemistry, computer science, digital and computational studies, earth and oceanographic science, economics, education, environmental studies, neuroscience and physics are all good places to look) For talk announcements, check out the posters around Searles, Druckenmiller, Kanbar, Adams, VAC and elsewhere. Also check the Bowdoin events calendar, dept. websites, the digest, e-mail announcements, and the ES newsletter.
- In general, late submission (even 15 mins late) of homework assignments will **NOT** be accepted. In extenuating circumstances, with proper prior notice, I will try to provide extensions to individuals. If I am not present to receive your submission, you can put it in the Math 2000-B homework box located at the South end of Searles' first floor hallway.
- I will drop two of your lowest *daily assignment* scores, no-questions-asked.
- If you think you are going to miss any quiz or exam for unavoidable reasons, please notify me beforehand. Missed exams can only be made up at my discretion, and are subject to a lost fraction of the grade.

### Class Participation

Student participation is an integral part of this class and is highly valued. Everyone is expected to make thoughtful contributions in the form of questions, statements, and reasoned arguments. You might be also occasionally invited to present something on the board. Whenever possible, there will be opportunities for you to work through practice problems in small groups during our class meetings. This is a chance for you to learn in an active way, collaborating with your peers. Please express yourself within the bounds of courtesy and respect. Please share your thoughts and be willing to listen attentively to perspectives that may differ from your own.

### Class Attendance

You cannot be an effective and involved member of the class unless you are present! Please try to be punctual as well. If you are late to the occasional quizzes that are administered at the beginning of the class, you will *not* be allowed any extra time.

### General Policy

- Be courteous when using mobile devices. Make sure your cell phone is turned fully off, or silent. If you must make or receive a call, please go outside the classroom.
- Use of laptops or tablets is permitted for note-taking but only with prior permission. Please turn off your Wi-fi and sound.
- The final exam is based on all material covered in class. If you have to miss a lecture, then I strongly recommend you study the material you missed before you return to class. I recommend doing the following steps:
  - Look at the tentative course schedule from Blackboard.
  - Read the relevant sections from the textbooks, class note, internet etc.
  - Find someone who was in class and make a copy of their notes,

Once you have done these steps, and you still need more clarification on lectures you missed, email me to schedule an appointment.

- *For any communication regarding this course, please email me from your bowdoin.edu email address. This is mainly for identity verification purposes.*

### Miscellaneous Items of Interest

- It is my intent that students from all backgrounds and perspectives receive **equitable access and opportunity** in this course, that students' learning needs be addressed both in and out of class, and that the diversity students bring to this class be viewed as a resource, strength and benefit. It is my intent to employ materials and engage in activities and dialogue that are respectful of: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture. Please share your preferences for your name and pronouns.
- No student is required to take an examination or fulfill other scheduled course requirements on recognized **religious holidays**. Students are expected to declare their intention to observe these holidays at the beginning of the semester.
- Students with **documented accommodations** have a right to have these met. I encourage you to see me in the first 2 week of class to discuss how your accommodations may support your learning process in this course. I highly encourage all students to meet with me in the first few weeks of class (or as soon as you become aware of your needs) to discuss your learning preferences, challenges you may face learning this semester, and how we can create an effective learning experience for you. *In particular, I understand that the quizzes at the beginning of class can present a challenge, and I'm eager to discuss options with you.* If you are interested in learning more about accommodations please see Lesley Levy in the Office of Student Accessibility

<https://www.bowdoin.edu/accessibility/student-accessibility-office/index.html>

- As a student, you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or

lack of motivation. These **mental health concerns** or stressful events may lead to diminished academic performance or reduced ability to participate in daily activities. Bowdoin College is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. You can learn more about the broad range of confidential mental health services available on campus at:

<https://www.bowdoin.edu/counseling/>

- As a faculty member I am considered a **Responsible Employee**, per the [Student Sexual Misconduct and Gender Based Violence Policy](#). While my goal is for you to be able to share information related to your life experiences through discussion and written work, I want to be make sure you understand that as a Responsible Employee I am required to report disclosures of sexual misconduct, dating violence, stalking, and/or sexual and gender-based harassment to the University's Title IX Coordinator, Benje Douglas. My reporting to Benje does NOT mean that any actions will be taken beyond him reaching out to you and trying to schedule a time to talk to see what assistance you might need to be successful as a student here at Bowdoin. For more information please check out:

[www.bowdoin.edu/title-ix](http://www.bowdoin.edu/title-ix)

### The Honor Code

I support and adhere to the principles of [The Bowdoin College Academic Honor Code](#). Your work should never be directly copied from another student and I will expect that *you are not reading solution manuals* for this textbook. In particular, I will assume all members of the class are trustworthy in their dealings with me as well as their fellow classmates. However, should a violation of this trust be discovered, it will be reported to the Judiciary Board. The goal is not vengeance against those who violate the Code but fairness for those who adhere to it. If you have any questions about the appropriateness of a particular situation, please communicate with me.

### Tentative Course outline and Schedule

The following is a preliminary outline of the topics that we hope to cover. This is an idealized plan, and it *may be adjusted as the semester progresses*. But it should give some indication of the major major topics to be covered in this class.

#### A. System of Linear Equations

- Solving systems of linear equations, §1.1-1.2
- Vector and matrix equations, §1.3-1.4
- Solutions via linear systems, §1.5
- Applications, §1.6
- Linear independence, §1.7
- Linear transformations, §1.8-1.9
- Linear models in applications, §1.10

#### B. Matrix algebra and Determinants.

- Basic operations, §2.1
- Invertible matrices, §2.2-2.3
- The Leontief input-output model, §2.6
- Subspaces, bases, dimension, and rank, §2.8-2.9
- Determinants and their properties, §3.1-3.3

**C. Vector Spaces.**

- Vector spaces, subspaces, and linear transformations, §4.1
- Bases, §4.3
- Coordinate systems, §4.4
- Dimension and rank, §4.5-4.6

**D. Eigenvectors and Eigenvalues.**

- Motivation: Markov chains, §4.9
- Basic concepts, §5.1
- Characteristic equation, §5.2
- Diagonalization, §5.3
- Change of basis, §4.7
- Eigenvectors and linear transformations, §5.4
- Application to discrete dynamical systems, §5.6

**E. Inner Products and Orthogonality.**

- Inner products and orthogonality, §6.1
- Orthogonal sets and projections, §6.2-6.3
- Gram-Schmidt process, §6.4
- Application: least-squares problems, §6.5



Monday	Wednesday	Friday
	23-Jan	25-Jan
	Syllabus Overview + 1.1	1.1-1.2
28-Jan	30-Jan	1-Feb
1.2	1.3	1.4
4-Feb	6-Feb	8-Feb
1.5	Handout 1	1.7
11-Feb	13-Feb	15-Feb
1.8-1.9 + Project 1 (Linear Transformations of the Plane)	Handout 2	Review
18-Feb	20-Feb	22-Feb
Midterm 1	Handout 3	1.10
25-Feb	27-Feb	1-Mar
2.1 + Project 2 (Adjacency Matrix of a Graph)	2.2	2.3 + Project 3 (Cryptography)
4-Mar	6-Mar	8-Mar
2.6	Handout 4	3.1-3.2
11-Mar	13-Mar	15-Mar
Spring Vacation	Spring Vacation	Spring Vacation
18-Mar	20-Mar	22-Mar
Spring Vacation	Spring Vacation	Spring Vacation
25-Mar	27-Mar	29-Mar
4.1	4.2	4.3
1-Apr	3-Apr	5-Apr
Handout 5	4.4	Review
8-Apr	10-Apr	12-Apr
Midterm 2	4.5-4.6 + Project 4 (Subspaces)	Handout 6
15-Apr	17-Apr	19-Apr
4.9 + Project 5 (Markov Chains and Long Range Predictions)	5.1	5.2
22-Apr	24-Apr	26-Apr
Handout 7	5.3	4.7
29-Apr	1-May	3-May
5.4	5.6 + Project 6 (Spotted Owl Population)	Handout 8
6-May	8-May	
6.1-6.3	Review	