

**Changes may be made to this document, and to linked pages or files, before the semester starts. Some links may not work at all before Jan. 6.**

## Syllabus and course information

### MAS 4105 — Linear Algebra 1 Section 14G8 (14886), Spring 2023 MTWF 4th period (10:40–11:30), Matherly 6

[Link to class home page](#)

- [Instructor: Dr. David Groisser](#). All first-person pronouns (I, me, my, etc.) refer to Dr. Groisser.  
Teaching Assistant: [Andres Zuniga](#)
- [Prerequisites](#)
- [Modality](#)
- [Syllabus \(course content\)](#)
  - [Textbook](#)
  - [Schedule of lectures](#)
  - [Some advice on how to do well](#)
- [Communicating with Dr. Groisser outside class](#)
  - [Office hours](#)
  - [Emailing me](#)
  - [Communications from me](#)
- [Graded components of course](#)
  - [Exams](#)
  - [Homework](#)
- [Attendance policy](#)
  - [What if you miss an exam?](#)
- [Cheating](#)
  - [Student Honor Code](#)
- [My grading system for this course](#)
- [Scheduling appointments with Dr. Groisser outside office-hours](#)
- [In-class recording by students](#)
- [Accommodations for students with disabilities](#)
- [Teaching-evaluations](#)
- [UF Health and Wellness Resources](#)
- [Goals of course](#)

**Prerequisites:** Calculus 3 (MAC 2313 or MAC 3474) and Sets and Logic (MHF 3202), each with a grade of at least C. However, students who had to struggle to get through Sets and Logic with a C tend to have even greater difficulties in MAS4105, and are less likely to be able to earn a C in MAS4105.

**Modality:** All four weekly class meetings (Monday, Tuesday, Wednesday, Friday) will be face-to-face. The MWF meetings will be ordinary lectures by Dr. Groisser. On Tuesdays the class will meet with Teaching Assistant Andres Zuniga for Q&A and other discussion. Dr. Groisser won't spend MWF time going over homework; that's **part** of what the **mandatory** Tuesday class meetings are for.

**Syllabus (course content):** An introduction to vector spaces, linear transformations, and inner products. The general approach is theoretical (emphasizing theorems and proofs) rather than computational. We will cover chapters 1–6 of the textbook, with some omissions and (possibly) additions. General topics will include:

- real vector spaces; subspaces
- linear combinations; linear independence; basis; dimension
- linear transformations; rank; kernel; nullity
- relating linear transformations to matrices and matrix algebra
- using matrices to solve linear systems of equations
- eigenvalues and eigenvectors; diagonalization
- inner-product spaces

**Textbook:** Friedberg, Insel, and Spence, *Linear Algebra*, 5th edition (2019).

**Tentative, approximate weekly schedule of lectures.** Click [here](#). You should be reading the textbook *regularly*, keeping *ahead* of where we are in class. At worst, for material covered in class, you are expected to read the relevant pages of the textbook no later than one day after we cover that material in class. You may sometimes be assigned to read material that we don't have time to cover in class. This material should be read by whatever due-date is given for that reading.

## Some advice on how to do well

Your textbook has a section called "To the Student" that precedes Chapter 1. The advice in the three bullet points on p. xiii is **very good** and **very important**, and will apply to virtually any math class you take from here on out. Many professors, myself included, give similar advice in almost all their classes. **Part** of the book's advice (*don't ignore the rest; I'm just not copying it all!*), with some extra emphasis added by me, is:

***"Each new lesson usually introduces several important concepts or definitions that must be learned in order for subsequent sections to be understood. As a result, falling behind in your study by even a single day prevents you from understanding the material that follows. To be successful, you must learn the new material as it arises and not wait to study until you are less busy or an exam is imminent."***

You'll find what amounts to additional advice (not labeled as such) in several sections of this syllabus (and on the [homework page](#)).

A great many students don't do as well as they'd hoped, for reasons that can be chalked up to *not following their instructors' best advice from the start*. Much of my advice (and the book's) will

require more time, and more consistent effort, than you're used to putting into your classes. It's easy to dig yourself into a hole by thinking, "I've never had to work after every single class, or put in as many hours as following advice like this would take, and I've always done well. And the same goes for my friends. So I'll just continue to approach my math classes the way I've always done." By the time a student realizes that this plan isn't working, and asks his or her professor "What can I do to improve?" it's usually too late to make a big difference.

[Top of page](#)

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## Communicating with Dr. Groisser outside class

For anything that needs a response, the primary way to communicate with me outside class is to **see me in office hours**. The circumstances in which you may communicate with me by email are **limited**; see below.

- **Office Hours:**

- **In-person office hours:** **Tentatively**, Monday 5th period (11:45-12:35) and Wednesday 6th period (12:50-1:40). My office is Little Hall 308.

*I may **require** you to wear a mask at all times in my office*, since Little 308 is a small, poorly ventilated room in which I spend most of my workday.

My Monday office hour (above) and my Friday virtual office hour (below) may start a few minutes late, since I'm teaching in a different building the prior period.

- **Virtual office hours:** Friday 9th period (4:05-4:55). These will be set up as Zoom meetings in Canvas.

See also the [statement concerning office hours](#) in the [attendance policy](#).

Both for in-person and virtual office hours, please arrive early in the period or let me know to expect you later; otherwise I may not stay in my office or at my computer for the whole period.

**If you have the flu or similar contagious disease, or think you might, please do not come to my office.** (This request for common courtesy has been in all my syllabi since Fall 2009, pre-dating COVID-19 by more than ten years, as you can see at [http://dgarchive.com/classes/3473\\_f09/syllabus.html#officehrs](http://dgarchive.com/classes/3473_f09/syllabus.html#officehrs). It is also consistent with UF's current policy for attending classes.)

Students who can't make **any** of my scheduled office hours may see me by appointment on most weekdays (but **never on a Thursday**). See [Scheduling appointments with Dr. Groisser outside office-hours](#), later in this document.

- **Emailing me.**

I receive a ton of email, and replying is very time-consuming, so please be aware of the following:

- **THE EXISTENCE OF EMAIL DOES NOT EXTEND MY OFFICE HOURS.**
- **EMAIL IS NOT A SUBSTITUTE FOR SEEING ME IN OFFICE HOURS.**
- **I don't answer email that lacks an *informative* subject line and the sender's full name.** Students should also state **which of my classes they're in** (but this may be done in the body of the email rather than the subject line).
- **I will not answer math questions by email.** An interactive conversation is needed.

- **There are many non-math questions that I won't answer by email either.** In particular, I usually won't respond to email that asks questions that have already been answered in items you should have read (for example: this syllabus, the class home page, homework page(s), solutions handouts, emails I've sent to the class, and announcements I've posted in Canvas), or that were answered in a lecture or discussion that the student *elected* to miss for unapproved reasons, or that should be (or should have been) asked in office hours.

**Your TA's email policy may be less strict than mine**, but *do not abuse his generosity with his time*. You should not expect him to be available 24/7, or to answer math questions by email, or to respond promptly to emails sent outside of whatever hours he sets.

- For student emails that deserve individual replies, in general I reply **only during my next office hour** or as soon thereafter as I can. (As stated earlier, "The existence of email does not extend my office hours.") Students who email me a question on a day I have an office hour, and don't explain why they're emailing me instead of attending my office hour, usually will not receive a response.
- I don't provide individualized grade information by email.
- I won't open attachments (or follow links) that look suspicious to me. I generally delete, without fully reading, any email that contains these.
- My email address is located [here](#).

Some examples of email-content that would be **okay** to send me are:

- "The link for [this item] on [this page] seems to be broken [or: takes me to the wrong page]."
- "I think there's a typo in the homework assignment. You listed exercise 1.2/3g, but exercise 1.2/3 doesn't have a part (g). Would you please clarify what you intended to assign?"  
*For clarifications to homework assignments, I'll usually take action ASAP after seeing your message. But once I'm done with my fix, I may only send the entire class message about the update (or post one), rather than replying to the individual student(s) who notified me of the problem.*
- "I'm planning on coming to your office hour tomorrow, but I can't get there till 30 minutes after it starts. I just wanted to let you know to expect me late."
- "I won't be in class on such-and-such date, for such-and-such reason."
- "I'm applying for a summer program [or scholarship, graduate school, etc.]. Would you be willing to write a letter of recommendation for me? The deadline is [month/day]."
- **Communications from me or your TA.** You are required to read fully, and reasonably promptly, any communications from me or your TA. These communications include, but may not be limited to, emails (either to the class listserv or to you personally) and announcements on Canvas.

[Top of page](#)

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**Graded components of course.** Your final grade will be determined by:

- Two midterms (hour exams), each counting for 20% of final grade.
- A cumulative final exam, counting for 30% of final grade.
- Homework, totaling 30% of final grade.

*I reserve the right to adjust the above percentages in individual cases, to a student's benefit, if I feel that circumstances warrant. I will not answer any questions about hypothetical situations in which I might do this.*

## Exams

- Each midterm will be held on a Wednesday, so that the Tuesday discussion session can be used as a review. **I estimate that the date for the first exam will be either Feb. 15 or Feb. 22, and that the date for the second exam will be either Mar. 22 or Mar. 29.** I'll give you roughly a week's notice, or more, before each midterm. ("Roughly a week" means that I may let you know on a Wednesday night that an exam will be given the following Wednesday in class.) Before finalizing midterm dates, I'll want to be confident that we'll have gotten through certain material before the exams, which is hard to do far ahead of time in a course of this type.
- **The final exam will be a two-hour exam given Tues. May 2, starting at 3:00 p.m., in our usual classroom. By registering for this section of this course, you are agreeing to be available for an in-person two-hour exam on this date at this time.** The date and time are set by the Registrar's Office; faculty members aren't permitted to change these, or to give cumulative final exams during a regular class meeting. **You are expected to arrange your post-semester travel plans accordingly, and are strongly advised to make those plans NOW. I will have little sympathy for students who state they are "unable" to take the final exam at its scheduled time, or that to do so would pose a hardship. If you voluntarily put yourself in this position, expect a zero for your final-exam score.**
- On any exam: unless I say otherwise, you are responsible for knowing any material I cover in class, any subject covered in homework, and all the material in the textbook sections we've covered or you've been assigned to read.
- You will do best if, after every lecture, you study as if you're having an exam on that topic the next day. **One of the surest ways to do poorly, at least in my class, is to put off studying until shortly before an exam.** Exam-preparation is something you do all semester long by **keeping up with the lectures and homework.**

## Homework:

- **It is impossible to overstate the importance of doing *all* the homework.**
- You should start on each homework problem within a day of its appearance on the [homework page](#).
- Often, a difficulty you may have with a homework problem is something that either I or your TA would be able to help you surmount. The earlier you start working on an assignment, the greater the chance that I or your TA will have an office hour before the assignment is due.
- When I start posting problems for an assignment, you'll often see wording like "Assignment X (not yet complete)"; I remove the "(not yet complete)" once all the problems are posted. I wait until we've covered certain material to post certain problems, to avoid misleading you into thinking you already ought to be able to do problems you don't yet have the tools for.
- Your graded homework will (usually, for most students) have corrections and/or comments on it, made by your TA, by me, or by both of us. **It is EXCEEDINGLY important that you read all of these *promptly*, and make sure you understand them** (or ask either the TA or me to explain any of these that you don't understand). This should be done **before you start writing up the next assignment you're handing in (or before the next exam, whichever comes first)**. Writing mathematics, especially proofs, is a large component of this course. You are expected to **improve** in this as the semester moves along. Once a mistake has been corrected on one of your assignments, your TA and I should not see the same type of mistake in your future work (or at least should see it less and less often). Mistakes that you lost few if any points for early in the semester, will be more costly later in the semester.

Questions about the *scoring* of homework problems should be directed to your TA, rather than to me.

- The homework page includes important [rules](#) regarding homework-submission.

**Grading:** See [My grading system for this course](#), below, for additional information.

[Top of page](#)

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## Attendance policy

- As UF has advised, **students with a contagious illness (or reasonable suspicion of one) should not come to class.**
- *Healthy* students are expected to attend **every** lecture and discussion, barring such things as family emergencies, weddings, funerals, UF-sanctioned extracurricular activities, and religious holidays (see below). Potentially excusable absences that you know about in advance will not be treated as excused unless you inform me of them in advance.

I expect students to arrive *on time* and to pay attention for all 50 minutes of the period. In most classrooms, arriving late is disruptive (as is leaving early). If a non-optional time commitment (e.g. a class the previous period in a distant location) will force you to be late on a regular basis, let me know at the start of the semester.

- **Religious Holidays.** The following is part of the [University of Florida Policy on Religious Holidays](#). "Students, **upon prior notification of their instructors**, shall be excused from class or other scheduled academic activity to observe a religious holy day of their faith."
- **Students who choose (for reasons other than those of the types above) not to attend class regularly are forfeiting the right to my help in office hours, including explanations of their mistakes on homework and exams.** These students should also not expect replies to their emails, even for questions like "Is there an exam tomorrow?" or "Have you decided when the next exam will be?" Also be aware that the [University of Florida Attendance Policies](#) contain the following paragraph:

*The university recognizes the right of the individual professor to make attendance mandatory. After due warning, professors may prohibit further attendance and subsequently assign a failing grade for excessive absences.*

**I am giving you now your due warning that I may prohibit further attendance and subsequently assign a failing grade for excessive absences.** I reserve the right to impose a less extreme penalty instead.

- This is a **FOUR credit-hour** class. *Attending the discussions for the entire period is **not optional***, regardless of whether you personally have questions, or whether the only questions you had have been answered before the period is over. **DO NOT treat the discussion sections as if they were simply office-hours.**
- If you are absent from lecture or discussion, for any reason, you should obtain *written* notes from a classmate. (**Students are not permitted to share their own recordings of lectures with each other**, if they make any such recordings. See [In-class recording by students](#) below.)
- If you miss class the day I return an exam or homework, you'll have to pick up your exam or

homework from my office. I expect you to do this within a week (unless you are ill or quarantining); I will not hold onto your exam indefinitely. The same is true of any handouts that you missed receiving in class.

### Classroom decorum:

- Reading the newspaper, reading messages on your phone, looking at your computer, talking, texting, etc., are rude and disruptive. **No electronic devices are to be used in class without explicit permission from me.** If you generally take notes by writing in a tablet, see me to get permission. I may ask at any time to see what notes you've taken.
- Please avoid disruptive or distracting noises, such as the tapping of pencils or feet, or the zipping or unzipping of backpacks several minutes before the end of class.

### What if you miss an exam?

If you miss an exam for a valid reason, and supply me with satisfactory documentation *promptly*, I will work out with you some way that is as fair as is feasible for you to make up the missing grade-component. Except in very large classes (which I don't teach) with cookie-cutter exams (which I don't give), there is no such thing as an equitable make-up exam. Thus, the way I have you make up the missing grade-component may or may not be via an exam. If you miss an exam for a reason that I do not consider valid (consistent with UF policy on which absences should be excused), or do not supply me with satisfactory documentation within two days, you should expect to receive a zero for that exam. If extenuating circumstances cause a reasonable delay in your providing me with satisfactory documentation, I may treat your exam-absence as valid and documented. (However, I will be the sole judge of what is "satisfactory", "extenuating", and "reasonable".)

If you are too ill to take an exam, please notify me by email before the exam starts (if possible).

[Top of page](#)

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## Cheating

**Student Honor Code.** UF students are bound by The Honor Pledge, which states:

We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

The Honor Code, which can be found [here](#), specifies a number of behaviors that are in violation of this code. As stated at the given link,

*Cheating includes but is not limited to:*

- *Using any materials or resources prepared by another Student without the other Student's express Consent **or** without proper attribution to the other Student.*
- *Using **any** materials or resources, **through any medium**, which the Faculty has not given **express** permission to use and that may confer an academic benefit to the Student.*
- ...
- *Collaborating with another person, **through any medium**, on **any** academic activity, when Faculty has expressly prohibited collaboration.*

In addition, students are obligated to report to appropriate personnel any condition that facilitates academic misconduct.

**The "You cheat, you fail" rule:** In my class, the penalty for cheating is a failing grade (E) for the course (if the student doesn't drop). I will not tolerate students who take advantage either of their classmates or of me, causing me to waste time on police-work. If you cheat, do not expect a second chance from me.

**If you're going to be tempted to use unauthorized sources when doing your homework, you're going to be very uncomfortable in my class.**

Cheating on homework, through the use of unauthorized sources, has been the downfall of many of my students the last few years (six in my MAS4105 section last semester). Even when I've imposed a grade penalty as minimal as one grade-point off the course grade, almost every student who's been caught cheating has dropped my class rather than take the grade penalty. (Whether they dropped because cheating had been their only hope of getting even a C, or because they simply have wanted to avoid a lower grade than they were used to getting, or because they were too ashamed to stay in my class, I don't know in most cases, but I think there were students in each category.)

**Some truths that students in my class will need to accept are:**

- **Your need or want for a certain grade does not entitle you to that grade**, even if you've never gotten a lower grade in the past.
- **You learn more by struggling with a problem unsuccessfully for hours, and having it rattling around in your brain for days, than by looking at someone else's solution.**
- **Not all students will be able to solve all assigned problems.** Not all students *should* be able to solve all assigned problems. Students are not all equally strong at mathematics, and some assigned problems are intentionally challenging. It is not a terrible thing if the best students have some opportunities to solve problems that their peers can't solve.
- If you can't do a homework problem successfully on your own (using only authorized sources, which include consultation with me or your TA), **you shouldn't get credit for it**—whether that's the situation with just one problem or with practically every problem on an assignment. This is true **regardless of the impact on your grade.**

If you can't figure out how to do a homework problem, the right thing to do is **not to hand it in** (or to hand in only the parts you *do* think you did successfully). **It is never right to hand in someone else's work as if it were your own, or to get unauthorized help.** These things *are* **real cheating**, no matter how common they are, and whether or not you've done them before. They are *not* victimless crimes.

[Top of page](#)

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## **My grading system for this course**

1. After each homework or exam, I decide grade cutoffs for that item according to the philosophy "A = excellent, B = good, C = satisfactory, D = unsatisfactory but passing". In setting these cutoffs, *I do not have a predetermined grade curve or predetermined percentages for letter grades.*
2. At the end of the semester, I compute a numerical "raw score" for each student, on a 1000 point scale, using the weighting scheme [stated earlier](#): 20% (200 points) for each midterm, 30% (300 points) for



the final exam, 30% (300 points) for the homework.

On the exams themselves, you'll see point-totals different from the ones above. These are rescaled appropriately in the raw-score computation. For example, if point-values for the problems on the first midterm add up to 138, your exam score will be multiplied by 200/138 in the above computation.

Similarly, the homework assignments will not all be the same length and will not all count equally; they will count proportionally to the number of points in each assignment. For example, if the point-values of the homework assignments add up to 249, then your homework-point total will be multiplied by 300/249 in the raw-score computation.

3. By applying the same weighting scheme to the cutoffs for exams and homework, I construct raw-score grade cutoffs for each of the grades A, B, C, D. The cutoffs I use for A- and B+ are the trisection points of the interval from the B cutoff to the A cutoff; the cutoffs for the B-, C+, C-, and D+ grades are computed analogously.

The grades that UF currently allows instructors to assign are A, A-, B+, B, B-, C+, C, C-, D+, D, D-, and E. (**For grade-point equivalencies of these grades, see [this catalog page](#).**) All of these are grades possible in this class, except the D-.

In my philosophy (and that of my own college professors) of what a minus-grade means, a B-, for example, is *not* the lower end of the B range; it is *somewhat below* the bottom of the B range, and means that your work falls a little short of "good". (Said another way: another professor whose regards your work as "a little short of 'good' ", but who regards B- as meaning "the low end of the 'good' range", would *not* assign you a B- ; he/she would assign you a C+.) This philosophy is consistent with the degree-requirements for most majors at UF: courses count towards your major only if you get a "flat" C or higher, because a C- means that your performance was *less than* satisfactory—not that it was *barely* satisfactory—and therefore that you did not satisfactorily complete the course. This philosophy is also consistent with UF's [S-U grade option](#).

For similar reasons, I have never given the D- grade. "D" means "unsatisfactory but passing". My D cutoff is the rock bottom of what I consider to be the "passing" range, so anything below that is a failing grade, which at UF is the E grade. (*Note*: Because a C is usually needed for a course to count towards requirements for majors, minors, etc., an unfortunate number of faculty, advisors, and students have come to refer to every grade less than C as "failing". *This is not the correct meaning of "failing grade", nor has it ever been*; again see [this catalog page](#).)

Since I don't determine the exam-grade cutoffs ahead of time, I can't tell you in advance exactly how many points you'll need to get a particular grade for the course.

[Top of page](#)

## Scheduling appointments with Dr. Groisser outside office-hours

- Before asking to make an appointment outside of my scheduled office hours, please *make sure you have first checked when all my office hours are*. Even though my office hours are *really easy* to find (in this syllabus and on my home webpage), more than half the conversations I have with students who think they can't make my scheduled office hours go something like this:

Student: "There's something I wanted to ask you about, but I have a class that meets MWF period X" [where period X is the time of, say, my Wednesday office hour that semester].

Me: "What about my Monday period Y or Friday period Z office hours?"

Student: "Oh, I didn't realize you had a period Y or period Z office hour. Yes, Monday period Y [or Friday period Z] would work for me. I'll see you then!"

- Scheduling an appointment usually requires some back-and-forth questions about possible and/or convenient times. Usually, coming up to me at the end of class (rather than sending me an email) is the most efficient way to handle this. Email is inefficient for this. But in case you *do* try to handle this by email, here are some do's and don'ts for what to send me:

"I'd like to meet with you, but I have a conflict with each of the three days/times of each of your three regular office hours." [So far, so good. Student has indicated awareness that I have office hours at three different days and times, and has not (yet) asked any questions.]

- **[DON'T WRITE THIS:]** "Are you available any other times this week?"  
**This is the wrong question to ask by email**, even if directly followed by a second question like, "If so, what times could you meet?" The times that are most convenient for me might be times you have a conflict with. If I answer with only those times, we'll need at least one extra round of (avoidable!) back-and-forth emails. To give any answer that could avoid several rounds of back-and-forth email (other than "Speak to me after class"), I have to spend time a lot of time thinking about my answer. Also, I either have to spend time *writing* some sort of preference-order list, or wind up with you choosing a time that's really not convenient but that I put down in case your schedule conflicted with anything else.
- **[DO WRITE SOMETHING LIKE THIS:]** "Here is the full schedule of times I *can't* meet during the week" [followed by a listing of all classes, work conflicts, etc.], or "Here is a list of all the times I *could* possibly meet during the week" [followed by an appropriate list]." It's okay if, **in addition**, you state your preferences among the times that are possible for you. What's **not** okay is stating *only* your preferred times and asking me to choose from among them.

[Top of page](#)

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### In-class recording by students

Students are allowed to record video or audio of class **lectures**. However, **the purposes for which these recordings may be used are strictly controlled**. The only allowable purposes are (1) for **personal** educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. **All other purposes are prohibited**. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A class lecture does not include private conversations between students, or between a student and the instructor, that happen to take place during a class session. Recording of these conversations is prohibited.

**Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student.** Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. **A student who publishes a recording without written consent may be subject to a civil cause of action** instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

[Top of page](#)

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**Accommodations for students with disabilities.** If you wish to request accommodation for a disability you must first register with the [Disability Resource Center](#). It is always important that you share your accommodation letter with your instructor, and discuss your accommodations, as early as possible in the semester. **"Discuss" does not mean merely "notify"; it means *more than just having the DRC email me your accommodation letter. Initiating a discussion of your accommodation, is the responsibility of the student.***

**Teaching-evaluations.** Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at [gatorevals.aa.ufl.edu/students/](http://gatorevals.aa.ufl.edu/students/). Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals or via [ufl.bluera.com/ufl/](http://ufl.bluera.com/ufl/). Summaries of course-evaluation results are available to students at [gatorevals.aa.ufl.edu/public-results/](http://gatorevals.aa.ufl.edu/public-results/).

### UF Health and Wellness Resources:

- **U Matter, We Care initiative.** If you or someone you know is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu), 352-392-1575, or visit [umatter.ufl.edu/](http://umatter.ufl.edu/) to refer or report a concern, and a team member will reach out to the distressed student.
- **Contact information for the Counseling and Wellness Center.** Visit [counseling.ufl.edu/](http://counseling.ufl.edu/) or call 352-392-1575 for information on crisis services as well as non-crisis services.
- **Student Health Care Center.** Call 352-392-1161 for 24/7 information to help you find the care you need, or visit [shcc.ufl.edu/](http://shcc.ufl.edu/).
- **University Police Department.** Visit [police.ufl.edu/](http://police.ufl.edu/) or call 352-392-1111 (or 9-1-1 for emergencies).
- **UF Health Shands Emergency Room / Trauma Center.** For immediate medical care call 352-733-0111 or go to the emergency room at 1515 SW Archer Road, Gainesville, FL 32608; [ufhealth.org/emergency-room-trauma-center](http://ufhealth.org/emergency-room-trauma-center).

[Top of page](#)

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### Goals of course:

- For the student to become accustomed to communicating mathematical ideas precisely and clearly, in written form.
- For the student to know the meanings and definitions of the following terms;
  - (real) vector space; subspace; sum and direct sum of two subspaces; complementary subspaces (or a complement of a subspace); linear combination; span; linear dependence and independence; basis; dimension; finite- and infinite-dimensional; convex set;
  - linear transformation and related terminology: injective; surjective; bijective; isomorphism; isomorphic; identity linear transformation; inverse; invertible; kernel; null space; image; range; rank; nullity; eigenvalue; eigenvector; characteristic polynomial; algebraic and geometric multiplicities of an eigenvalue; eigenspace; determinant;
  - matrix-related terminology: column space; row space; null space; rank; nullity; transpose; square matrix; inverse; invertible; diagonal matrix; upper- and lower-triangular matrix; symmetric matrix; anti- or skew-symmetric matrix; identity matrix; the same eigenvalue/vector-related terminology as

for linear transformations; diagonalizable matrix; determinant (recursive definition); elementary row operations; row-reduction;

- terminology related to linear systems of equations: solution; solution set; homogeneous and non-homogeneous; general solution; solution space (in the homogeneous case); consistent; inconsistent; equivalent systems of equations;
  - inner product; inner-product space; norm; unit vector; orthogonal vectors; orthonormal set; orthonormal basis; Gram-Schmidt process;
  - time permitting: orthogonal complement of a subspace (finite-dimensional case); orthogonal projection; orthogonal transformation; orthogonal matrix.
- For the student to
- know that the inverse of an invertible linear transformation is linear;
  - know basic matrix algebra;
  - know that, for invertible matrices, "transpose" commutes with "inverse";
  - know, in the finite-dimensional setting, the equivalence of several criteria for invertibility of a linear transformation or matrix, including the determinant criterion;
  - be able to compute, by hand, the inverses of invertible  $2 \times 2$  and  $3 \times 3$  matrices;
  - know that there is a general formula for the inverse of a general invertible matrix; time permitting, know the formula itself;
  - be able to determine (with proof) whether a given subset of a vector space is a subspace;
  - know the relationships between finite-dimensional linear transformations and matrices, including that composition of linear transformations corresponds to multiplication of matrices; clearly understand the difference between a linear transformation and a matrix; be able to translate between statements about linear transformations and the corresponding statements about matrices; be able to compute the matrix of a linear transformation with respect to given finite bases; know the change-of-basis formula for such a matrix (or be able to compute the new matrix, with or without having memorized a formula);
  - be able to recast a finite system of linear equations in finitely many variables as a matrix equation; know that, in the homogeneous case, the solution-space is a subspace, and be able to find a basis; be able, in the non-homogeneous case, to determine whether the system has a solution, and if so, to write down the solution in the form (particular solution) + (general solution of the associated homogeneous equation)" where the second term is given in terms of a basis of the relevant null-space; know how to accomplish the preceding using row-reduction; (time permitting) know Cramer's Rule;
  - know (not necessarily with proof) the properties of the determinant-function on square matrices: behavior with respect to elementary row and column operations; multiplicativity; invariance under transpose; invariance under change-of-basis;  $\det(A^{-1}) = 1/\det(A)$ ;
  - be able to compute a determinant using elementary row and column operations;
  - know the relation between the characteristic polynomial and eigenvalues;
  - know that a system of linear equations with at least two solutions has infinitely many, and that that a

system of linear equations with more variables than unknowns has either no solutions or infinitely many;

- know the statements of basic theorems of elementary linear algebra, including: the "rank plus nullity" theorem; that a basis can be obtained from a linearly independent (respectively, spanning) set by adding (resp., deleting) vectors; characterization of bases as minimal spanning sets and maximal linearly-independent sets; all bases of a given finite-dimensional vector space have the same number of elements; every finite-dimensional real vector space is isomorphic to  $\mathbb{R}^n$  for some  $n$ ; the kernel and image of a linear transformation are subspaces of the domain and codomain respectively;  $\text{rank}(A) = \text{rank}(A^t)$  (or "row rank = column rank") for a matrix  $A$ ; linear independence of eigenvectors corresponding to distinct eigenvalues;
- use mathematical terminology and notation correctly;
- be able to write complete, mathematically correct, grammatically nearly-perfect proofs involving linear-algebraic terms and concepts (including proofs of linear dependence/independence and proofs by induction in a linear-algebraic context);
- be able to prove those theorems of basic linear algebra whose proofs are not too long;
- be able, on a timed exam, to come up with proofs of true linear-algebraic statements previously not seen by the student, when such statements follow quickly and easily from definitions and theorems that the student is expected to know;
- be able to produce an orthonormal basis of a low-dimensional vector space or subspace via the Gram-Schmidt process;
- For the student to be able to produce an example of:
  - a vector space of any given finite dimension;
  - an example of a finite-dimensional real vector space that is not explicitly  $\mathbb{R}^n$ ;
  - an infinite-dimensional vector space;
  - a linear and a non-linear transformation between two given vector spaces;
  - a non-diagonalizable matrix;
  - a system of at least two linear equations in at least two unknowns with
 

{	no solutions;
	a unique solution;
	infinitely many solutions.

[Top of page](#)