

Instructor: Nathan Pflueger (pronounced “fleeger”)
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office: SMUD 401

Times and locations: Tuesday and Thursday 1:05-2:20 SMUD 205

Course webpage <http://npflueger.com/222/> (I rarely use Moodle)

How to reach me Come to office hours! No appointment is needed. Besides that, I generally reply to email within 24 hours. However, **I may not read or reply to email on weekends, outside business hours, or on Thursdays**, which is the day I devote primarily to research.

Course content

A **proof assistant** is a computer program that verifies the integrity of mathematical reasoning. Such software addresses an aspiration predating the invention of computers: can we find certainty in our arguments by fully mechanizing them? Rather than writing every detail, the user specifies tactics and techniques to apply, and the software replies with what it could formalize and verify.

This course uses a proof assistant called **Lean 4**, which is powerful and usable enough to verify theorems at the cutting edge of mathematics research. The course emphasizes how the interactive window provided by Lean can help students learn to write and understand human-written proofs.

The course will have two main components, with different learning goals.

1. **Foundations.** Roughly half the course is devoted to mastering the foundational syntax and techniques of interactive proving in Lean 4. This part will revisit the main proof techniques from, e.g., Math 220, see how each is captured in Lean syntax, and see how Lean can assist and partially automate such proofs. This part will include traditional written assignments and quizzes, as well as a written midterm exam. The learning goals in this part include reinforcing fundamental proof techniques and developing fluency in writing, reading, and interpreting Lean code.
2. **Projects.** The other half of the course is devoted to student-driven projects. Students will develop a plan in consultation with me, tailored to their specific mathematical background and interests. Students will have substantial flexibility in the nature of their projects. Students will give a presentation on their project at the end of the course.

Background and prerequisites The only prerequisite is some experience with written proofs. No programming experience is expected.

Textbook There is no required physical textbook. We will cover a large portion of the online textbook *The Mechanics of Proof*, by Heather Macbeth.

The role of generative AI Some of the most striking recent developments in mathematics concern the use of generative AI to produce formalized proofs in Lean 4. However, **use of generative AI is neither required nor prohibited in this course**, and students will be expected to work without it for the foundational parts of the course. For class presentations, final projects, and some optional content, students may choose whether and to what extent to use generative AI. If such tools are used, students are expected to clearly describe what tools they have used and in what way.

Course structure

Class meetings will be a mixture of traditional lecture, interactive proof sessions in Lean 4, and student presentations. Attendance and class participation are crucial.

Grading: Grades are based on the following categories. The exact cutoffs for each letter grade are not set in advance; I calibrate them at the end based on the difficulty and score distribution of the exams. There is no set curve, but typically the median grade is around B+.

Class participation	5%	
In-class presentations	10%	
Homework	5%	usually due Wednesdays at 10pm
Quizzes	10 %	usually on Thursdays
Midterm Exam	35%	Thursday 10/29, in class
Final project	35 %	

There is no final exam in this course.

Homework: Homework assignments will be a mixture of Lean 4 code and written responses. Homework is a very important part of this class, but it does not play a large role in your grade. Its purpose is to **help you practice**, introduce some topics not covered in class, and give you space to think hard about problems, and **provide feedback on your writing**, not to pressure you to solve all problems perfectly. For this reason, **any score 80% or higher is considered a perfect score** when I compute final grades. I would rather that you try hard to write your own solution and receive constructive feedback on it than be tempted to copy a solution, for example.

Quizzes: The class will include periodic short quizzes, usually on Thursdays, but not on every Thursday. Quiz content may include short drills on recent material that has not yet appeared on a problem set, or problems adapted from the assignment due the previous day.

Presentations: Students will sometimes be asked to give short presentations in class. The nature of these presentations will depend on the background and interests of students in the class, and will be announced later. For example, a student might explain a current event related to formalized mathematics, a Lean library on a topic of interest, or their solution to a homework problem.

Expectations You should expect to spend at least eight hours studying and working on problem sets outside of class each week. Of that time, I recommend that you spend at least two hours reviewing your notes, the textbook, and previous assignments. Distributing your practice and review throughout the semester will be much more effective than concentrating your review and studying right before exams or due dates. You are expected to attend class every day, arrive on time, and be respectful. You are expected to know about any announcements made in class or by email.

I encourage you to **stop me to ask questions**. Active participation helps put your brain in the mode that allows it to make new connections and learn well. If you are feeling lost, there is almost certainly someone else feeling the same thing; asking a question may help many of your classmates as well!

Course policies

Dropped assignments To compensate for illness and other emergencies, your **lowest two homework scores will be dropped**. If you cannot make a due date due to an emergency, my advice is to skip the assignment, but study and understand the problems when you have time, and focus on keeping up with the new material in the course. You do not need to apologize or provide any reasons for skipping an assignment or turning it in unfinished; please choose what is best for your time, health, and well-being. Remember that **the primary purpose of the homework is not evaluation, but to help you learn the material and guide your studying**, so you should still work through all problems on any assignment you drop, and ask me about them as needed.

Homework deadlines and late policy Homework will be **due at 10pm**, typically on Wednesdays, via Gradescope. To allow for technical difficulties or other last-minute issues, Gradescope will allow you to submit homework after the deadline, however your score will be reduced by 2% **per hour** after the deadline (scaled continuously, e.g. being fifteen minutes late results in a 0.5% deduction). Please try to turn in your work by the due time (I don't want to be responsible for lost sleep!), but don't worry about short delays. **I generally do not grant extensions**, but instead drop two assignments (see above).

Missed exams The midterm date is listed above. **Put it on your calendar now**. Exam dates/times are fixed and may not be rescheduled except in the case of an extenuating circumstance (illness, emergency, religious conflict, etc.) with a note from a health professional or dean. In such a case, please let me know at the start of the semester, or as soon as possible. Other than by reason of a valid extenuating circumstance, a missed exam will be counted as 0.

Accommodations I strive to make this course welcoming to all students. If you would like to discuss your learning needs with me, please schedule a meeting so that we can work together to support your academic success. Anyone who may require an accommodation based on the impact of a disability should contact me to make arrangements. I rely on Accessibility Services for assistance in verifying the need for accommodations and developing accommodation strategies, so you should contact them at accessibility@amherst.edu or 413-542-2337. If you require accommodations on exams, please arrange this with me at least one week in advance.

Intellectual responsibility

- **Homework:** Mathematics is a collaborative subject; open and generous communication is one of its core values. Therefore you are strongly encouraged to work with other students, ask many questions, and learn from as many people as possible. However, you must write up the solution yourself. **All your submitted work must be your work, written in your own words**. Copying solutions from other students, solutions manuals, online databases, or generative AI is plagiarism; such copying will result in a 0 on the assignment and will be reported to Community Standards. You are also expected to **list each person you worked with** on the front of your homework assignment.
- **Exams:** You will be allowed **one page of notes (front and back)** for each exam. No calculators or other aids are permitted. Cell phones should be stowed out of sight during exams. Use of cell phones or other devices during the exams will be grounds to receive a 0 on the exam. You are bound by the college's honor code, and all work must be entirely your own on exams.

For homework and exams, I reserve the right to give no credit for any work that appears suspicious.

Tips and resources

Come to office hours! I am happy to answer your questions and also talk about the course in general. Even if you don't have specific questions, you can come to review material, listen to other students' questions, or just to chat. There is a desk in my office and several just outside where you are welcome to work, chat, and listen in. Office hours are the best way I have to learn about you and how you're doing in the course and the college, so please visit!

Focus on practice and improvement. Every homework problem, or example from class or the book is an opportunity to practice. Take these opportunities, and make the most of them!

Distribute your practice. Study a bit every day, not just before exams. Treat every homework problem as a chance to practice and study.

Actively seek opportunities to practice. Ask me questions, ask classmates questions, read examples in the book, and try problems that haven't been assigned.