

Syllabus

CAS CS 400: Type Theory and Mechanized Reasoning is a course about the use of computers for proving mathematical theorems and properties about programs. We will introduce several concepts from the field of computer science known as *formal methods* but will ultimately focus on type theory, the logical formalism underlying much of the recent work on computer proving and proof mechanization. See the course webpage for more details on the coverage of topics.

Minutae

- **Course Code:** CAS CS 400
- **Course Title:** Type Theory and Mechanized Reasoning
- **Semester:** Spring 2024
- **Instructor:** Nathan Mull
- **Meeting:** Monday and Wednesday, 12:20PM-1:35PM, *CDS B62*
- **Office Hours:** Thursday, 2:00PM-3:00PM, *CDS 907*
- **Prerequisites:** CAS CS 131, 320, 330

Course Organization

This is a topics course intended for third and fourth year students—with a emphasis on breadth over depth—which will require a healthy amount of independent work. We meet twice a week, covering roughly one topic per week. There are **no labs** for this course, but I will hold office hours to provide one-on-one assistance. Announcements and discussions will happen on the course Slack page.

Lectures

Slides and/or notes will be posted before every meeting, but you are not expected to have prepare anything beforehand, except for having tried to understand the

material from the lecture before. **I will not take attendance** but you should expect to participate in lectures if you want to succeed in this course.

Material

All relevant material for the course will be linked on the course webpage. You are expected to check the webpage consistently for possible updates to material. Assignments and projects will also be hosted on a course GitHub repository. Although it is not required I *highly recommend* cloning this repository and keeping track of updates and errata by pulling down changes (you can also use this in a workflow for working on assignments). Outside the material created for this course, I will refer to, among others, the following resources freely available online:

- Logic and Mechanized Reasoning by Jeremy Avigad, Marjin J. H. Heule, and Wojciech Nawrocki
- Type Theory and Functional Programming by Simon Thompson
- Open Logic Project

Requisites

Given the nature of this course, the workload is subject to change, but is likely to be primarily independent work and study. There are no plans as of writing this syllabus to hold exams, but there will be a final project presentation.

Assignments

There will be roughly ten weekly assignments, intended to exercise your understanding of the previous week's material. They will consist of written problems and programming problems in Agda (and occasionally Python). They will also include progress reports on projects. I will drop your two lowest assignment grades.

Assignments will be submitted via Gradescope. If you are unfamiliar with Gradescope, see their get-started page for information and tutorials.

Final Project

There will be a final project in this course. Given the size of the course, you will be expected to work in a group with one, two or three people. The topic of the final project is open-ended. If there is a project you think you will want to work on, feel free to ask about it and I can approve it. Otherwise, there will be roughly three options for what can count as a final project.

- *Implementation.* We will see a number of algorithms in this course for which we won't be able to go in full detail. You could implement one of these algorithms.
- *Proof.* Agda is a language for theorem proving. You could find your favorite theorem in discrete math (or in this course) and prove it in Agda.
- *Survey.* There are several languages like Agda which have dependent types, but are very different. You could learn about one of these languages and put together a short survey on it.

The final project will have a *written* component and a *presentation* component. The written component will be a short (think 3-5 page) report on the project you did. It should give a high-level view of what you accomplished, your approach, and the challenges you faced. In the case you do a survey for the final project, there will be slightly more emphasis on this written part. The presentation component will be a short (think 15 minute) talk about your project, covering what is covered in the survey, but with more interaction and more example.

I will expect that the main work of the project will start after the spring recess, but you will be expected to have a rough idea your group and the kind of project you will be doing before then. After the spring recess, we will set aside some time in our meetings to talk about the project and do one-on-one advising.

Participation

Since this course is new, there will be a lot that will need improvement. Participating in this course will consist in participating in weekly Google forms. It may also in part be helping maintain material for the course.

Grading

Your final grade in the course will be determined by the following breakdown:

- 40% Homework (8 assignments, 5% each)
- 30% Mini project (2 15% each)
- 25% Final project
- 5% Participation

Cut-offs for letter grades will be determined at the end of the course. I cannot guarantee what the cut-off will be, but you will not receive a letter grade lower than the one determined by your raw percentage.

Policies and Guidelines

There are a number of policies and guidelines that are consistent across all courses I teach. I keep a record of these on my personal webpage, and reproduce them here for convenience.

There are a number of university policies and course guidelines you should be aware of. *Read them carefully and completely.* Also keep in mind that, although I am required to use specific language in some cases, I stand behind these policies sincerely and seriously, and I hope you feel comfortable reaching out to me about any of them if you need to. See the BU Policies page for a complete collection of university's policies.¹

Academic Integrity

Please read the BU's academic conduct code. This is taken very seriously at BU and I take it seriously in the courses I teach.

I encourage students to work and study in groups, it's a useful way to learn, but when you write down your solutions to an assignment, you should do it from your own memory, without looking at anyone's work. It is just as important that you *never* let anyone use your work. All parties are culpable in cases of academic misconduct.

¹This page is based on a syllabus for CAS CS 132 provided to me by Mark Crovella, and on the syllabus of CMSC 19911 by Ravi Chugh, Andrew McNutt and Sam Cohen.

If you work with others, consult materials found on the Internet, or use an AI assistant, you should cite your sources. This is a useful skill in any setting, and so I recommend being as conservative as possible regarding what you cite. In any assignment, these **citations should appear at the top of the submission** (in comments if the submission is code). Some examples:

- I discussed problem 1 and 2 with Leah Smith. She helped me understand X and Y aspects of the problem.
- I saw the stack overflow post stackoverflow.com/questions/6681284/python-numpy-arrays which informed my solution.
- I helped Zihan Guo with problem 4. I told them to try using X.
- I asked chatGPT "what's the largest eigenvalue of this matrix?" but asked it not to show me how to solve for it.

It can be tricky determining when a citation is necessary. When in doubt, err on the side of longer, more descriptive citations. And again, **all parties are culpable**. Those who share their work with others (this includes sending files and screen sharing) receive the same attention as those who use that work. Please email me immediately if you are unsure about a particular situation.

The line between collaboration, abuse of online resources, and misconduct has become incredibly blurry, and cases are becoming more difficult to navigate. There are obvious prohibitions:

- Don't share your solutions with anyone else
- Don't use the solutions of other students
- Don't ask homework questions online on sites like Stack Overflow
- Don't ask an AI assistant for a solution to a homework question
- Don't consult a solution posted online, even to verify your own

It would be unreasonable to believe that these things never happen, or that I can recognize every case that it happens. But I have to depend on the integrity of all of you (students), which also means that I have to take seriously cases of academic misconduct if they do unfortunately come up. Use your best judgment and remember:

- I and the course staff care about your success in this course. We provide a number of avenues to ask for help, please use them.
- You will have to answer questions on exams without external aids (and in interviews when you apply for a job).
- If you don't know how to start thinking about a problem, *it's okay to ask for pointers on how to start* in office hours and Piazza. We can't give you any part of the answer, but we may be able to put you in the right direction.
- We build in safe-guards (like dropped homework assignments) in the case you are unable to complete an assignment.

Disability Statement

If you require disability accommodations, please contact me as soon as possible. You should provide me with the appropriate documentation, available through BU's Disability and Access Services. If there's a policy you see that I'm failing to comply with, please reach out with suggestions. And if you'd like accommodations that are not covered by existing services or policies, feel free to contact me and we can see what we can do. I want everyone to feel able to fully participate in the course.

Diversity Statement

My aim is to present material in a way that respects the diversity of the student body. If I fail to do this, please make me aware. Any suggestions are welcomed and appreciated. I also expect students taking any course of mine to appreciate and respect the unique opportunity they have to participate in a diverse student body.

Sexual Misconduct

Please read BU's Sexual Misconduct Policy and review the entire page for information about talking to someone confidentially about experiences of sexual misconduct, filing a report, and any other relevant information. Above all, you should feel safe, and able to be productive. If this is not the case, please reach out to me or someone else immediately.

The university is legally obligated to investigate reports of sexual misconduct, and therefore it cannot guarantee the confidentiality of a report, but it will consider a request for confidentiality and respect it to the extent possible. I am also required to report incidents of sexual misconduct and **cannot guarantee confidentiality**. I must provide our Title IX coordinator with relevant details such as the names of those involved in the incident.

A Comment on Generative AI

We're going to be talking about the role of AI assistants in education for the next decade, and the truth is that no one knows at this moment what we're going to do about it. You are the first generation that this is impacting, and not just in college, but likely when you leave as well.

This can be a good thing. You have the ability to shape your relationship with these tools (even if that means you choose not to use them, or even to fight against their use). But as this is happening, we still need to run courses at universities.

It would be drastic for me to prohibit the use of AI assistants, but they **should not be used to solve homework assignments directly**. I've seen some very powerful and creative ways that they have been used to aid learning. Some ideas:

- Ask explicitly for the solution not to be given.
- Ask about high-level ideas, like analogies or mnemonics.
- Ask for explanations about how code works, or why a piece of code is not working.

If you have any other suggestions please let me know. The point is, it's possible to use these tools in productive ways. Remember, **they're not perfect**, they can be wrong, it can sometimes be easy to tell when a solution was produced by an AI assistant, and you won't have access to them in exams.