CSCI-B522: Programming Language Foundations

Carlo Angiuli

Spring 2026

Location: Mondays and Wednesdays, 11:10am–12:25pm, Ballantine Hall 315.

Instructor: Carlo Angiuli (cangiuli@iu.edu), Luddy Hall 3008.

Assistant instructor: Sujin Woo (woosuj@iu.edu).

Website: carloangiuli.com/courses/b522-sp26

Office hours: Carlo: Tuesdays, 10:00am–11:00am, or by appointment.

Sujin: Fridays, 1:00pm–3:00pm, in or near Luddy Hall 3014.

Course description

This is a graduate course on the theoretical foundations of programming languages. We will learn fundamental techniques for formally defining programming languages and for proving properties of those languages and the programs written in them.

By the end of the course, students will be able to:

- formally define a variety of programming languages by their statics (type systems) and dynamics (operational semantics),
- prove theorems relating a language's statics and dynamics,
- formally define and reason about equivalence of program fragments, and
- appreciate the importance of compositionality and abstraction in the design of programming languages.

Throughout the semester we will consider the following techniques as they apply to a range of *core calculi*, or idealized programming languages:

- abstract syntax with binding *(including inference rules and type systems)*,
- operational semantics *(various approaches)*,
- type safety *(progress and preservation)*,
- logical relations *(unary and binary)*, and
- observational equivalence *(including parametricity and its consequences)*.

This is my second time teaching this course, so please bear with me as the course continues to evolve throughout the semester. Unlike some incarnations of this class, we will not use Agda or any other proof assistant. As a result, a solid grasp of mathematical proof and reasoning will be important for success in this class.

Many students in this class are considering or already pursuing research in programming languages; I hope that this course will deepen those students' interest in the subject and provide a basic foundation that will help them in their future studies.

Prerequisites Formally, this course is open to graduate students who have taken CSCI-B510 and CSCI-B521/C311/H311, or at the instructor's discretion. I welcome any graduate or motivated undergraduate student who has taken B521/C311/H311 and a proof-based discrete mathematics course (such as CSCI-C241).

Course materials

Lecture notes I will endeavor to regularly post lecture notes for the content covered in this course. These notes may vary widely in quality and depth, and will not in general be an adequate substitute for attending lecture and taking your own notes.[1] Unless stated otherwise, I intend for my lectures to be the primary resource for course content, with my lecture notes and the following textbook as supplements.

Textbook The course will *very loosely* follow the "PFPL" textbook:

> Robert Harper. *Practical Foundations for Programming Languages.* Second Edition. Cambridge University Press, 2016.

You do *not* need to purchase this book. But PFPL is an excellent reference for a large fragment of programming language theory and we will not have time to cover all of it, so those of you particularly interested in the subject may wish to own a copy.

A substantial portion of the second edition is available on the author's website (`https://www.cs.cmu.edu/~rwh/pfpl/abbrev.pdf`), and the complete text of the *first edition* is available online for IU students (`https://ebookcentral.proquest.com/lib/iub-ebooks/detail.action?docID=1113098`).

Course policies

These policies are subject to change.

Communication Most information will be posted to the course website, but I will send any time-sensitive announcements by email using Canvas. I have also posted to Canvas an invite to a (optional) course Discord server for discussion among students and with course staff. Anyone auditing or informally attending the course

[1] You are welcome and encouraged to share notes and discuss the course amongst yourselves, although this is also not a long-term substitute for attending lecture.

should contact me at the beginning of the semester to ensure they receive these announcements.

The best ways to reach me are by email, in person after lecture, on the course Discord, or in my office when my door is open.

Attendance Lectures will be primarily conducted at the blackboard and will not be recorded, and I will say many things not written in PFPL or my lecture notes. It is therefore crucial that you attend lecture. While I am lecturing, I encourage you to stop me whenever you have a question.

Assignments The only way to learn theory is by doing it. I will assign written problem sets about every other week that you will have about two weeks to complete, preferably typeset using LaTeX. The purpose of these assignments is to force you to think in depth about the topics we have discussed, and to give me a chance to correct any misunderstandings.

Your submissions should reflect your own work and understanding, but you can discuss the problems with your classmates as long as you follow the *whiteboard policy*: you can work through a problem with your classmates at the whiteboard, but you must erase the whiteboard and wait two hours before typing up your solution. In other words, you must independently produce your solution without referring to notes taken during discussions with classmates.

Exams There will be a midterm exam and a final exam. I will announce their dates and formats as soon as they are determined.

Grading Your numerical grade will be computed as follows:

- 60% problem sets, weighted roughly equally
- 20% midterm exam
- 20% final exam

I will assign letter grades based on these numerical grades, taking into consideration the overall numerical grade distribution and your participation. Letter grade cutoffs will be at least as generous as the standard 90%, 80%, etc. Students who demonstrate an understanding of the main course objectives and techniques can expect to earn a satisfactory grade.

University policies

Academic integrity Students at IU are expected to adhere to the standards contained in the Code of Student Rights, Responsibilities, & Conduct available at https://policies.iu.edu/policies/stu-00-student-code. Academic misconduct is defined as any activity that tends to undermine the academic integrity of the institution,

including but not limited to cheating, fabrication, plagiarism, interference, violation of course rules, and facilitating academic dishonesty.

Accommodations Every attempt will be made to provide accessibility measures to students with qualifying medical conditions (e.g. mental health, learning, chronic health, physical, hearing, vision, neurological, etc.), under the Americans with Disabilities Act. You must have established your eligibility for support services through Accessible Educational Services (AES) for qualifying medical conditions. Note that services are confidential, may take time to put in place, and are forward moving. Captions and alternate media for print materials may take three or more weeks to get produced. Please contact AES (iubaes@iu.edu) as soon as possible if accessibility measures are needed.

Bias incident reporting Bias-based incident reports can be made by students, faculty, and staff. Any act of discrimination or harassment based on race, ethnicity, religious affiliation, gender, gender identity, sexual orientation or disability can be reported through any of the options:

- fill out an online report at https://reportincident.iu.edu;
- call the Dean of Students Office at (812) 855-8187.

Reports can be made anonymously at https://reportincident.iu.edu.

Sexual misconduct & Title IX IU policy prohibits sexual misconduct in any form, including sexual harassment, sexual assault, stalking, sexual exploitation, and dating and domestic violence. If you have experienced sexual misconduct, or know someone who has, the University can help. If you are seeking help and would like to speak to someone confidentially, you can make an appointment with the IU Sexual Assault Crisis Services at (812) 855-8900, or contact a Confidential Victim Advocate at (812) 856-2469 or cva@indiana.edu.

University policy requires me to share certain information brought to my attention about potential sexual misconduct with the campus Deputy Sexual Misconduct & Title IX Coordinator or the University Sexual Misconduct & Title IX Coordinator. In that event, those individuals will work to ensure that appropriate measures are taken and resources are made available. Protecting student privacy is of utmost concern, and information will only be shared with those that need to know to ensure the University can respond and assist. I encourage you to visit http://stopsexualviolence.iu.edu to learn more.