Comp Sci 321 — Programming Languages — Spring 2022

1 Course Description

Comp Sci 321 introduces the concepts behind some key elements of common programming languages. We will implement a series of interpreters that nail down the precise details of how various aspects of programming languages behave, as well as explore other implications of treating programs as data. The class involves a significant hands-on programming component; you will implement a number of interpreters and other meta-programs yourself.

2 Course Staff

Instructor  Vincent St-Amour
Email: stamourv@cs.northwestern.edu

Peer Mentors  Amy Guo, Ian Armstrong, Kelvin Forson, Linus Okoth, and Max Paik

3 Prerequisites

• Comp Sci 111 and Comp Sci 211 and Comp Sci 214
• Comfort with structural recursion and functional programming

4 Lectures

Lectures will be in person, and we will make a best effort attempt at recording them. The recordings will be available from Canvas. Please see the recording policy at the end of this document.

To ensure the health and safety of our community, DO NOT come to lecture if you have reason to believe you may be sick with COVID-19 (or anything else, really). Please watch the recordings instead and contact the instructor. Please see the COVID-19-related policies at the end of this document.

4.1 Questions

I love questions! Keep ’em coming.

During lecture, please ask questions using one of these two mechanisms:

• Raise your hand and ask verbally.

• If you prefer to ask anonymously and/or textually, reply to the Piazza (see later) post of the current lecture. A member of the course staff will then ask your question in your stead.
I also distinguish between two kinds of questions:

- **Clarification questions**: something is blocking your understanding of lecture material. If it doesn’t get addressed, you’ll have a hard time following what’s to come. I aim to answer all of these as we go, so no one gets left behind. Please ask these as they come, following the above protocol.

- **Curiosity questions**: “what if?” or “how about?” kinds of questions. Things that are nice to know, but not critical to understanding lecture material. These questions are great too, but in the interest of time, they’re best handled offline. To ask these kinds of questions, please either:
  - Ask me after lecture.
  - Make a new post on Piazza.

I’m relying on you to classify your questions and ask them on the right medium.

## 5 Office Hours

We will hold a combination of online and in-person office hours, circumstances permitting. We will maintain an up-to-date schedule (with locations) on the "Office Hours" page on Canvas. We will monitor attendance patterns and adjust the schedule to the best of our ability to limit crowding.

Online office hours will be held using the gather.town platform. Gather allows multiple concurrent students and TAs to get together and dynamically form groups as the need arises and supports screen sharing. There is an option for participants to “raise their hand”; please use this to get TAs’ attention.

The room we will use is at: [https://gather.town/P9g93W511VQobjhv/NU-Comp-Sci-321-OHs](https://gather.town/P9g93W511VQobjhv/NU-Comp-Sci-321-OHs)

See the "Office Hours" page on Canvas for the password to the room.

To ensure we can help people in a first-come first-served order, and to help us group up people with similar questions, we ask that you sign up when you have a question with this form: [https://forms.gle/domqFAcQ1vKmsH8q9](https://forms.gle/domqFAcQ1vKmsH8q9)

You can look at the state of the queue to give you an idea of how close you are to being next in line: [https://tinyurl.com/krdbradw](https://tinyurl.com/krdbradw)

The gather.town interface is generally discoverable, but some things may not be obvious, and its documentation is more or less nonexistent. So here are a few tips you may find helpful:

- Interactions are (mostly) based on proximity. To see and talk to someone, move close to them (with the arrow keys). You can find out where specific people are by clicking on their name in the participants pane on the left.

- If you’re working on your solution, possibly waiting for a TA to come help you, please stand on a chair at a table; each table is a private space. When in a private space, only other people in that space will be able to interact with you. This both reduces distractions from people walking by, and allows you and a TA to have a private conversation, so you can discuss your solution without risk of other people eavesdropping.

- To show your code to TAs, you can use the “share screen” feature. The button for it is at the bottom of the interface. Like other interactions, screen sharing will only be visible to other people in your space. Again, an effective way to keep your work private.

- There is a "raise hand" button at the bottom of the interface. Please use that to notify the TA(s) that you need their attention. And please lower it when they come to you, to minimize confusion (and so you can raise it again later if need be).

- If you ever need to move through other people (e.g., you’re stuck somewhere), you can press "g" to enter "ghost" mode and move through obstacles.
6 Other Communication Channels

- We will post assignments, slides, etc. on Canvas. Programming assignments will also be submitted via Canvas.  
  **We expect you to check Canvas regularly.**
- We will use Piazza for discussion and announcements:
  [piazza.com/northwestern/spring2022/compsci321](piazza.com/northwestern/spring2022/compsci321)
  **We expect you to subscribe to the 321 Piazza board ASAP and monitor it regularly.**

In general, post questions to Piazza first. Course staff will monitor Piazza (as will many of your fellow students), which makes it the best option for getting answers quickly. Your fellow students may also benefit from the discussion. Any questions about the specifics of your solutions must be marked as private, however. For questions that require longer discussions/explanations, please attend office hours. If all else fails or for sensitive matters, send the instructor an email, either for discussion or to schedule an appointment.

**General advice for asking questions about code**

Be sure to tell us:

1. What did you try?
2. What was the result?
3. What did you expect instead?

And remember, *be precise*.

7 Software

321 is a programming-heavy class, both in lecture and in assignments. We will be using the `plai` dialect of Racket (and others) that comes with the Racket environment. You will need to install version 8.4 from:

[racket-lang.org](racket-lang.org)

Older versions you may already have installed may not work for this class.

7.1 Development Environment

The DrRacket IDE (which comes with Racket, and which you may have used in 111 and/or 214) has the most complete PLAI integration of any environment; that’s the one I encourage you to use, and the one we’ll use in lecture.

If you’re an Emacs user, I recommend Greg Hendershott’s excellent Racket mode; that’s what I usually use outside lectures.

If you’re already comfortable with other development environments, you can try searching for Racket plug-ins for it. I’ve heard VS Code has a good one (Magic Racket). I’m not directly familiar with any of them, though, *so caveat emptor.*

You’re welcome to use alternative environments if you wish, but neither I nor the course staff will be able to offer you support. You’ll be on your own.
8 Textbook


The course itself should be self-contained, but the textbook may still be useful as a source of alternate explanations.

9 Homeworks and Grading

Your grade will be determined entirely by your performance on programming assignments.

Homeworks will be posted on Canvas, and will also be submitted on Canvas. All homework assignments are individual. Homeworks will be due on Tuesdays at 11:59pm Chicago time.

Your homework each week will be graded automatically and you will receive one of three grades: correct (2), getting there (1), or not yet (0). Missing submissions are considered not yet.

Your final grade will be determined as follows:

- A grade of adequate on every assignment results in a final grade of C.
- Grades of correct increase final grades by one "tick" and grades of insufficient decrease them by one "tick"; they cancel each other out.
- The total number of "ticks" determine final grades as follows:

<table>
<thead>
<tr>
<th># Ticks</th>
<th>Letter Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>A</td>
</tr>
<tr>
<td>7, 8</td>
<td>A-</td>
</tr>
<tr>
<td>5, 6</td>
<td>B+</td>
</tr>
<tr>
<td>3, 4</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>B-</td>
</tr>
<tr>
<td>1</td>
<td>C+</td>
</tr>
<tr>
<td>0</td>
<td>C</td>
</tr>
<tr>
<td>-1</td>
<td>C-</td>
</tr>
<tr>
<td>-2</td>
<td>D</td>
</tr>
<tr>
<td>≤ -3</td>
<td>F</td>
</tr>
</tbody>
</table>

Resubmission Policy

To encourage you to revisit material you have not yet mastered, you will have the option to resubmit homework assignments after their original deadline. If your understanding of that homework has improved, hopefully so should your performance.

Each homework has two resubmission deadlines: second tries one week following the original deadline, and third tries two weeks after the original deadline. The last few deadlines of the quarter may deviate from that pattern; see the schedule later in this document.

When determining your overall grade, we will consider your best submission for each homework.

Late submissions will not be accepted; just submit to the next deadline. In extreme circumstances (e.g., you have to leave town for a funeral), you must contact your dean of students\(^1\) and have them contact me if they deem it necessary to give you an extension or make other accommodations.

\(^1\)Joe Holtgrieve (jjh@northwestern.edu) for McCormick students, Liz Fekete Trubey (eft@northwestern.edu) for Weinberg students, and others for students in other schools.
10 Academic Integrity

Collaboration is a really good thing and we encourage it. On the other hand, cheating is a very serious offense, which carries serious consequences. It’s OK to meet with colleagues, form study groups, discuss assignments with them, compare alternative approaches, go over examples from textbooks or other sources. But it is never ok to share code or homework solutions, or even to see each other’s code or solutions. What you turn in must be your own work. Copying (or even studying) code, solution sets, etc., from anywhere (e.g., other people, web, GitHub) is strictly prohibited. Tools which automatically generate code for you (e.g., GitHub copilot) are also strictly prohibited. If you discuss your work with other people, please acknowledge them by listing their names in your submission.

It is also forbidden to share, post, or otherwise publicise course materials. This includes (but is not limited to) homeworks, exams, solutions, or your own submissions. This extends even after the quarter ends; course material remains private information which you may not share or reproduce.

It is the responsibility of every student in this class to be familiar with and to adhere to the Academic Integrity Policies of Northwestern University and the McCormick School of Engineering:

www.mccormick.northwestern.edu/students/undergraduate/academic-integrity.html

Any suspicion of violation of these policies will be reported immediately to the Associate Dean for Undergraduate Studies. If you are in doubt whether your actions constitute a violation of the above policies, ask the instructor (preferably before doing what you’re unsure about).

11 Welcoming Environment

I consider this classroom to be a place where you will be treated with respect. I welcome all students, and expect all of you to do the same. Together, we can create an environment where everyone feels welcome and can engage fully in our community.

Each student has something of value to contribute, especially in engineering disciplines where empathy, communication, and teamwork elevate our contributions to society (and lack thereof can lead to disaster). Individual differences can deepen our understanding of one another, the world around us and our lifelong role as engineers.

(Credit: Adapted from statements by the ASEE and Prof. Emma DeCosta)
# 12 Tentative Schedule

Dates and content are subject to change. Any changes will be announced on Piazza.

<table>
<thead>
<tr>
<th>Date</th>
<th>Homeworks</th>
<th>Lecture</th>
<th>Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thu 3/31</td>
<td>1 out</td>
<td>Intro</td>
<td>§1, §2</td>
</tr>
<tr>
<td>Tue 4/5</td>
<td>2 out</td>
<td>Variables and Binding</td>
<td>§3</td>
</tr>
<tr>
<td>Thu 4/7</td>
<td>1 due, 3 out</td>
<td>Functions and Parsing</td>
<td>§4</td>
</tr>
<tr>
<td>Tue 4/12</td>
<td>4 out</td>
<td>Deferred Substitution</td>
<td>§5</td>
</tr>
<tr>
<td>Thu 4/14</td>
<td>2 due</td>
<td>Higher-Order Functions I</td>
<td>§6</td>
</tr>
<tr>
<td>Tue 4/19</td>
<td>5 out</td>
<td>Capture-Avoiding Substitution, Compilation</td>
<td>§6, §9</td>
</tr>
<tr>
<td>Thu 4/21</td>
<td>3 due</td>
<td>Higher-Order Functions II, Recursion I</td>
<td></td>
</tr>
<tr>
<td>Tue 4/26</td>
<td>4 due, 6 out</td>
<td>Recursion II, State I</td>
<td>§10, §12, §13</td>
</tr>
<tr>
<td>Thu 4/28</td>
<td></td>
<td>State II</td>
<td>§13</td>
</tr>
<tr>
<td>Tue 5/3</td>
<td>5 due, 7 out</td>
<td>Control I</td>
<td>§18, §19</td>
</tr>
<tr>
<td>Thu 5/5</td>
<td></td>
<td>Control II</td>
<td>§18, §19</td>
</tr>
<tr>
<td>Tue 5/10</td>
<td>6 due</td>
<td>Garbage Collection: Intro</td>
<td>§21</td>
</tr>
<tr>
<td>Thu 5/12</td>
<td></td>
<td>Garbage Collection: Mark-and-Sweep I</td>
<td></td>
</tr>
<tr>
<td>Tue 5/17</td>
<td>8 out</td>
<td>Garbage Collection: Mark-and-Sweep II</td>
<td>§24</td>
</tr>
<tr>
<td>Thu 5/19</td>
<td>7 due</td>
<td>Garbage Collection: Copying, Types: Intro</td>
<td></td>
</tr>
<tr>
<td>Tue 5/24</td>
<td></td>
<td>Types: Typing Rules</td>
<td>§25</td>
</tr>
<tr>
<td>Thu 5/26</td>
<td>8 due, 9 out</td>
<td>Types: Typechecking</td>
<td></td>
</tr>
<tr>
<td>Tue 5/31</td>
<td></td>
<td>Types: Type Soundness, Extensions</td>
<td>§28</td>
</tr>
<tr>
<td>Thu 6/2</td>
<td>9 due</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>Thu 6/9</td>
<td>8 3rd try, 9 2nd try due</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13 Miscellaneous Policies

The registrar has a lot of things they want me to tell you.

13.1 Academic Integrity Statement

Students in this course are required to comply with the policies found in the booklet, "Academic Integrity at Northwestern University: A Basic Guide". All papers submitted for credit in this course must be submitted electronically unless otherwise instructed by the professor. Your written work may be tested for plagiarized content. For details regarding academic integrity at Northwestern or to download the guide, visit: https://www.northwestern.edu/provost/policies/academic-integrity/index.html

13.2 Accessibility Statement

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university’s established accommodation process (e: accessiblenu@northwestern.edu; p: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

13.3 COVID-19 Classroom Expectations Statement

Students, faculty, and staff must comply with University expectations regarding appropriate classroom behavior, including those outlined below and in the COVID-19 Code of Conduct. With respect to classroom procedures, this includes:

- Policies regarding masking and social distancing evolve as the public health situation changes. Students are responsible for understanding and complying with current masking, testing, Symptom Tracking, and social distancing requirements.

- In some classes, masking and/or social distancing may be required as a result of an Americans with Disabilities Act (ADA) accommodation for the instructor or a student in the class even when not generally required on campus. In such cases, the instructor will notify the class.

- No food is allowed inside classrooms. Drinks are permitted, but please keep your face covering on and use a straw.

- Faculty may assign seats in some classes to help facilitate contact tracing in the event that a student tests positive for COVID-19. Students must sit in their assigned seats.

If a student fails to comply with the COVID-19 Code of Conduct or other University expectations related to COVID-19, the instructor may ask the student to leave the class. The instructor is asked to report the incident to the Office of Community Standards for additional follow-up.

13.4 COVID-19 Testing Compliance Statement

To protect the health of our community, Northwestern University requires unvaccinated students who are in on-campus programs to be tested for COVID-19 twice per week.

Students who fail to comply with current or future COVID-19 testing protocols will be referred to the Office of Community standards to face disciplinary action, including escalation up to restriction from campus and suspension.
13.5 Exceptions to Class Modality

Class sessions for this course will occur in person. Individual students will not be granted permission to attend remotely except as the result of an Americans with Disabilities Act (ADA) accommodation as determined by AccessibleNU.

Maintaining the health of the community remains our priority. If you are ill for any reason, please do not attend class.

Students who are ill, must quarantine, or experience a personal emergency should contact the instructor as soon as possible to arrange to complete coursework.

Should public health recommendations prevent us from holding class in person on a given day, the instructor or the university will notify students.

13.6 Recording Policy

This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University’s Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

13.7 Support for Wellness and Mental Health

Northwestern University is committed to supporting the wellness of our students. Student Affairs has multiple resources to support student wellness and mental health. If you are feeling distressed or overwhelmed, please reach out for help. Students can access confidential resources through the Counseling and Psychological Services (CAPS), Religious and Spiritual Life (RSL) and the Center for Awareness, Response and Education (CARE). Additional information on all of the resources mentioned above can be found here:

https://www.northwestern.edu/counseling/
https://www.northwestern.edu/religious-life/
https://www.northwestern.edu/care/