

CSCI-400: Programming Languages (PL)

Colorado School of Mines

Spring 2021

1 Overview and Outcomes

Previous courses have examined how to write programs in individual languages such as Python or C++. In this class, we will take a broader view and study the key concepts and techniques that allow developers to design and implement programming languages. Ultimately, the course will improve your skill as a programmer and will deepen your understanding of how programming languages are designed and implemented.

Some students expect a “Programming Languages” course to be a survey of many different languages, but that is not the case. Learning “Programming Languages” is less about touring of the “zoo” of different languages and more about learning the “zen” that underlies all programming languages. Ultimately, learning these common and fundamental abstractions is the more valuable approach. We must all learn and use many different languages over our careers; understanding the fundamentals of programming languages will make this task easier and make us better programmers.

This course will emphasize *functional programming* for several reasons:

- Functional programming generalizes many programming constructs you have previously learned;
- Functional programming predicts the future of language development. Many programming languages that began in another style (imperative, object-oriented, etc.) are gradually gaining functional programming features over subsequent revisions;
- And functional programming helps us write correct (bug-free) programs. Functional languages offer many tools to reason about and ensure program correctness, both informally (in our heads) and formally (with an algorithm).

2 General Course Information

Instructor: Dr. Neil T. Dantam

TAs: Justin McGowen
Audrey Horne

Class Representatives: Joey Lovato
Amber Walker
Demeaus Wong

Prerequisites The official prerequisite is CSCI-306: Software Engineering, but as long as you have some programming experience, that should be sufficient. CSCI-358: Discrete Math is strongly recommended.

Textbooks and References

- **Primary Textbook** Clarkson et al. [Functional Programming in OCaml](#).

• Supplemental References

- Chris Okasaki. *Purely Functional Data Structures*. Cambridge University Press. 1998. ISBN-13: 978-0521663502.
- Chris Okasaki. [Purely Functional Data Structures](#). Ph.D. Thesis. CMU-CS-96-177. Carnegie Mellon University. 1996. (A “draft” version of the above book)
- Benjamin Pierce. *Types and Programming Languages*. 2002. ISBN-13: 978-0262162098
- Matthew Hennessy. *The Semantics of Programming Languages*.
- Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman. *Compilers: Principles, Techniques & Tools*. ISBN-13: 978-0321486813.

Online Resources

- Canvas: Grades
- [Piazza](#): Announcements, [Files](#), Questions, Discussion, Homework/Project help
- [MSOneDrive](#): [Files](#)
- [Course Github Organization](#): Project code distribution and submission
- [Isengard](#): ITS-managed Linux server with shell access
- [Google Calendar](#): Lecture and Office Hour Schedule
- Zoom: Remote office hours

Technology Requirements This course assumes you are able to access a GNU/Linux system (e.g., Debian, Ubuntu). If you do not run Linux on your personal workstation, you may use the ITS-managed [Isengard](#) server or install a virtual machine. The instructor does not recommend Microsoft’s “WSL” due to problems encountered by past students. If you attempt to use a non-Linux platform, the instructor and TAs can provide only very limited technical support.

- Students attending in face-to-face will need to bring a device to class. On days involving programming, this device should be a laptop with Linux access. Please contact the instructor if this would present difficulty for you.
- All students will need a device capable of running Zoom, either to attend the remote section or to join for office hours.

Who should I email/contact?

- **Miscellaneous basic policy questions** (when is the midterm? when is an assignment due?): Re-read the syllabus, check Canvas for announcements and assignments, check the course website, and ask any additional questions on Piazza.
- **Help with assignments or course topics**: Piazza, TA office hours, or instructor office hours. Private post on Piazza if the matter should be hidden from other students (e.g., something about your code or questions about your grade)

- **Solutions to in-class exercises:** Slides with completed exercises will be posted to [Piazza MSOneDrive](#) after the lecture.
- **Anything sensitive or confidential** (e.g., a health issue) Email the instructor about the issue and/or to schedule a meeting to discuss the issue.
- **Concerns/suggestions about course procedures** Email the instructor, TAs or class representatives about the issue and/or to schedule a meeting to discuss the issue.

FAQ

- Q: Is the textbook “required?”
A: Most students will need to study the textbook to learn the topics in this course. In fact, many would also benefit from studying the alternate textbooks as well.
- Q: When/where are office hours?
A: The instructor will post office hours on Piazza the first or second week of the semester (it takes us some time to rearrange meeting schedules each semester). Instructor office hours are ~~in the instructor’s office, BB249~~ on Zoom. TA office hours ~~will be posted~~ are on Zoom.
- Q: What’s on the exam?
A: Exam questions will be similar to the homework assignments and will focus on evaluating understanding, application, and synthesis of the course topics (i.e., the upper levels of [Bloom’s taxonomy](#)). Questions will not focus on memorization, but one must know the key definitions and concepts to apply them. For the midterm, all topics covered up to the exam may be included. The final will be cumulative but will focus on topics covered after the midterm. The instructor will post a specific list of topics after preparing each exam, typically about a week before the exam date (in past semesters, the topic list included 80-90% of the lecture material).
- Q: When is the midterm?
A: Please see the tentative schedule in this document for an approximate time. The instructor will announce firm details about the midterm closer to the date and will post the details on Piazza.
- Q: When/where is the final exam?
A: The registrar schedules all final exams. Please see the [registrar’s website](#).
- Q: What’s my grade?
A: The exact answer is unknowable until the end of the semester. For an approximate answer, see section 3 and compare your scores to the class distribution, which will typically be posted on Piazza for major assignments.
- Q: Debug my code for me.
A: The instructor and TAs are here to help you with projects but typically cannot do the job of debugging for you. Plus, learning how to debug your own code is an absolutely necessary skill.
- Q: Can I have an extension on an assignment?
A: In case of extenuating circumstances (medical issue, personal emergency, etc.) of course; please contact the instructor/TA. In other cases, sometimes it may be appropriate to extend a deadline for the entire class (see “Fairness” in section 3).

- Q: How can I improve my grade?

A: Participate in lecture, come to office hours, study, ask questions, and start assignments early. (see “Fairness” and “Grading Corrections” in section 3)

3 Grading and Evaluation

The course score (percentage) will be computed as a weighted average of scores (points received over points possible) as follows:

Participation	10% (<i>c</i>)
Homeworks	10% (<i>h</i>)
Projects	50% (<i>p</i>)
Midterm Exam	15% (<i>m</i>)
Final Exam	15% (<i>f</i>)

$$\text{score} = .1 \left(\frac{h_{\text{recv.}}}{h_{\text{poss.}}} \right) + .1 \left(\frac{p_{\text{recv.}}}{p_{\text{poss.}}} \right) + .5 \left(\frac{m_{\text{recv.}}}{m_{\text{poss.}}} \right) + .15 \left(\frac{f_{\text{recv.}}}{f_{\text{poss.}}} \right)$$

Class Participation During most lectures, you will have a worksheet to practice the material. After the lecture is complete (i.e., we finish the set of slides corresponding to the worksheet), scan or photograph the worksheet and submit it on Canvas. Your participation grade will be based on making an honest effort on the exercises.

Exams There will be a midterm exam around the middle of the semester and a cumulative exam during finals week. The exams are an evaluation tool whose purpose is to produce a distribution of scores across all students that best distinguishes the extent of learning. Thus, please expect the exams to be very challenging.

Homeworks There will be several homeworks sets.

Projects There will be several programming projects in a functional language.

Letter Grades Letter grades will be based on a curve. It is expected—but not guaranteed—that score distributions will be normally distributed and letter grades will correspond to university and department norms. However, skewed student effort or score distributions may result in correspondingly skewed letter distributions.

Late Policy Late work will not be accepted. Please take care to manage your time so that you are able to submit your best work by the deadline.

Fairness It is import to evaluate all students as evenly as possible. While we will attempt to accommodate disabilities and extenuating circumstances (physical/mental health, school-related travel, and similar) to the greatest possible extend, it would be unfair to offer any further special treatment.

Grading Corrections Grading changes will only be made for grading errors. It is not possible to change grades in response to disagreements about point allocation, partial credit, letter grade cutoffs, etc., because such changes would be unfair to the rest of the class. Grading corrections will only be made for the following errors:

1. *Arithmetic*: The grader incorrectly summed your points.
2. *Code*: An error in the grading environment or scripts incorrectly tested your code.
3. *Written*: The grader incorrectly understood your answer.

Projects Expectations and Grading

- Projects will include a coding portion and a report portion.
- Code will be graded objectively. Code must produce the correct output to receive credit. Incorrect output, no output, compilation errors, or runtime errors will not receive credit. **Please double-check your submitted code to ensure that minor errors will not result in major test failures.**
- Code tests will include edge cases. Think through all possible conditions for your program.
- Report grading will evaluate your overall understanding for the project area.

Written Work Format and submit your written work as follows. Improper submission or formatting may result in a penalty on assignments.

- For FERPA compliance, **all work submitted on physical paper must** include a cover sheet ~~on all written work~~ that contains only your name and no answers or other work. **Electronic submissions do not need a cover sheet.**
- Write your name on *every page* of all written work. If the work cannot be matched to you, you cannot receive credit for it.
- Include page numbers and total page count in written reports to ensure pages are properly ordered and no pages are overlooked.
- Handwritten work must be *clearly legible* to receive credit.
- Submit electronic reports, homeworks, etc. in PDF format. Do not submit word processor files because these are inconsistently formatted by different software.
- Work must be readable when printed in black and white.

Projects Expectations and Grading

- Code must produce the correct output to receive credit for test cases. Incorrect output, no output, compilation errors, or runtime errors will not receive credit. **Please double-check your submitted code to ensure that minor errors will not result in major test failures.**
- Code tests will include edge cases. Think through all possible conditions for your program.

4 Tentative Schedule

Sure to change as the semester progresses. Updated 2021-04-24.

W	Date	Topic	WS.	References
Part I: Functional Programming				
1	Tue Jan 12	00: Introduction		Clarkson 1
	Thu Jan 14	01: Basics		Clarkson 2, Pierce 5, Hennessy 1.1, 2.1-2.3, 3
2	Tue Jan 19	02: Lambda		Pierce 5.2
	Thu Jan 21	03: Tools: Linux/Git	–	Git Docs
3	Tue Jan 26	04: Func. Prog. Intro.		Hennessy 3, Okasaki 1-2
	Thu Jan 28	05: Tools: OCaml/JS	–	OCaml tutorial & reference, JS spec, MDN
4	Tue Feb 2	<i>Career Day (no class)</i>		
	Thu Feb 4	06: Higher order functions		Clarkson 4
5	Tue Feb 9	<i>Lab Day</i>		
	Thu Feb 11	07: Algebraic Data Types		Clarkson 3, Pierce 11
Part II.a: Implementing a Functional Language, Syntax and Parsing				
6	Tue Feb 16	<i>President's Day (no class)</i>		
	Thu Feb 18	08: Persistent Data Struct.		Clarkson 5.2.6, 9.4, Okasaki 2-3
7	Tue Feb 23	09: Syntax		Clarkson 10.1, Hennessy 1.2, Aho 4
	Thu Feb 25	<i>Lab Day</i>		
8	Tue Mar 2	10: Lexing		Clarkson 10.1, Hennessy 1.2, Aho 3
	Thu Mar 4	11: Parsing		Aho 4.4, 4.5, 4.8
Part II.b: Implementing a Functional Language, Typing & Evaluation				
9	Tue Mar 9	12: Induction		Clarkson 11, Pierce 2.4, 3.1-3.3
	Thu Mar 11	13: Semantics		Clarkson 10.2, Pierce 3.4-3.5
10	Tue Mar 16	Review		
	Wed Mar 17	MIDTERM (common exam)		
	Thu Mar 18	<i>No Class</i>		
11	Tue Mar 23	14: Environments		Clarkson 10.2-10.3, Pierce 3.4-3.5, 7
	Thu Mar 25	<i>Lab Day</i>		
12	Tue Mar 30	<i>Spring Break</i>		
	Thu Apr 1	<i>Spring Break</i>		
13	Tue Apr 6	15: Typing		Clarkson 10.4, Pierce 8-9, Clarkson 10.5, Pierce 22
	Thu Apr 8	<i>Lab Day</i>		
14	Tue Apr 13	16: Type Inference		Clarkson 10.4, Pierce 8-9, Clarkson 10.5, Pierce 22
	Thu Apr 15	<i>Lab Day</i>		
15	Tue Apr 20	17: Mutability		Clarkson 8, Pierce 11.2-11.3, 13
	Thu Apr 22	<i>Lab Day</i>		
Part III: Extra Bits				
16	Tue Apr 27	18: Amortized Analysis		Clarkson 9.3, Okasaki 5, Tarjan
	Thu Apr 29	<i>Lab Day</i>		
17	Tue May 4	<i>Review Week</i>		
	Thu May 6	<i>Review Week</i>		
18	Tue May 11	<i>Finals Week</i>		
	Thu May 13	<i>Finals Week</i>		

5 Policies

5.1 Mines Policies and Resources

[Mines Policies and Resources](#)

5.2 CS Collaboration Policies

[CS Collaboration Policies](#)

5.3 Course Policies

5.3.1 Laptop and Smartphone Policy

- Lecture slides are posted in advance. You are strongly encouraged to use your laptop or phone to follow along during lecture and to review slides during exercises.
- Note-taking on laptops, tablets, etc. is welcome if you find it useful.
- Please refrain from using laptops, phones, etc. for non-class activities, e.g., email, web browsing, games, during classtime, as it is distracting to other students.

5.3.2 Netiquette

Text DOs

- Ask questions and engage in conversations as often as possible—feel free to contact the instructor and TAs via the discussion forum for questions.
- When asking “tech support” questions, provide sufficient detail to diagnose and, if possible, reproduce the issue, including commands that were run, output of those commands, log files, and operating system and software versions.
- Be patient and respectful of others and their ideas and opinions they post online.
- Remember to be thoughtful and use professional language. Keep in mind that things often come across differently in written text, so review your writing before posting.
- Be prepared for some delays in response time, as “virtual” communication tends to be slower than “face-to-face” communication. Ask questions well in advance to deadlines to ensure sufficient time for a response.
- If the instructor does not respond to an important email for a few days, please send a reminder. Faculty receive a large number of emails and sometimes messages get lost or overlooked.
- Contact the instructor if you feel that inappropriate content or behavior has occurred as part of the course.

Text DON'Ts

- Use inappropriate language—this includes, but is not limited to, the use of curse words, swearing, or language that is derogatory.
- Post inappropriate materials—for example, accidentally posting/showing a picture that is not appropriate for the course content.
- Post screenshots of text output (post text as text).
- Post in ALL CAPS, as this is perceived as shouting and avoid abbreviations and informal language (“I’ll C U L&R”).
- Vent, rant, or send heated messages, even if you feel frustrated or provoked. Please instead communicate any specific concerns privately to the instructor, TAs, or class representatives; we want to improve the course and to accommodate any extenuating circumstances. Similarly, if you should happen to receive a heated message, do not respond to it.
- Except for course content questions on Piazza, send an email or post to the entire class, unless you feel that everyone must read it.

Video DOs

- Find a quiet place to log in.
- Use headphones. Echo cancellation works sometimes, but is imperfect.
- Test your microphone beforehand to ensure that the recorded audio is clear. Some builtin microphones produce speech that is difficult to understand.
- Mute your microphone when not speaking to avoid inadvertent noise that may distract others.
- Turn on your camera. Nonverbal communication is important.
- Position any light source in front of you and behind the camera to best illuminate your face.
- Engage in the discussion. Ask questions; ask followup questions; acknowledge responses.
- Use a wired network connection if possible. Wireless connections may be less reliable.
- Plug laptops or mobile devices into wall power – battery use can adversely affect video quality.
- Dress appropriately.

Video DON'Ts

- Post zoom links publicly, on social media, etc. Bad actors may join the meeting and post distracting or inappropriate material.
- Post offtopic messages in the chat. It is distracting to others.
- Share private windows such as personal email.

6 COVID Addendum

6.1 Course Procedures

This section describes the planned procedures for a socially-distanced or remote course. The department and instructor have discussed extensively over the past summer and semester how to best support your education and safety. While these procedures require additional effort from both students and the instructor, they are our best response to the current situation.

Be ready for change We cannot fully predict the course of the virus, but we can prepare. We will follow the data and guidance of medical experts.

In case of illness If you or a family member become ill or face specific COVID-related challenges, please contact the instructor. We will make whatever accommodations are appropriate to deal with these extenuating circumstances.

Class Representatives The instructor has organized a few students in the course to collect and communicate concerns relating to the unusual challenges that we are facing. These class representatives will regularly meet with the instructor and TAs to identify responses, changes, and improvements to course procedures. Please do communicate any concerns or suggestions regarding class procedures to the instructor, TAs, or the class representatives.

Required Technology

- Microphone
- Headphones
- Webcam
- Zoom
- Media player supporting H.264 and AAC

Prerecorded lectures The instructor will prerecord lectures to the greatest possible extent to support both remote students and the reduced face-to-face time of the hybrid course. Please understand that recording lectures requires a significant time commitment from the instructor.

Study Groups Social and peer learning is a vital aspect of the university experience. To support peer learning in our current, distanced environment, the instructor will facilitate organized study groups of around 4 students. The study groups may, but need not, be the same as project groups. Study groups should work together to discuss lectures and exercises.

Possibility to Alternate In-Class Attendance If necessary, we will divide the class in halves to attend on alternating days. Smaller groups reduce in-person contact and may provide a better atmosphere for discussion. Students should watch any posted lecture videos prior to attendance, so that reduced in-class time can focus on questions and exercises.

Project Collaboration Please use the full array of software collaboration tools to support collaboration on group projects: git, github, email, text chat, video chat, etc.

Remote Office Hours All instructor and TA office hours will be remote, via Zoom.

6.2 Oredigger Promise: We Climb Together

Orediggers climb together. Orediggers look out for each other. It will take a shared commitment from each and every one of us to stop the spread of COVID-19, open campus and be together at Mines this year. We take great pride in being a top engineering and applied sciences university and we will strive to be the exemplar in preventing the spread of COVID-19 in a university setting.

Therefore, as a member of the Oredigger community, I promise to protect classmates and colleagues, our families and neighbors, and myself by adopting the practices and attitudes summarized below; I will:

- Complete training sessions to learn required safety practices and expectations for learning, working, and living on campus.
- Monitor my health daily. I will report to a medical professional if I experience any of the COVID-19 symptoms: fever of 100.4F or higher, dry cough, difficulty breathing or shortness of breath, chills, unusual muscle aches, sore throat, or new loss of taste or smell.
- Stay home if I have COVID-19-related symptoms, even if I feel well enough to come to campus.
- Isolate and self-quarantine for the prescribed period of time after exposure to someone who is ill or has tested positive for COVID-19.
- Maintain appropriate social distancing in all settings, both on- and off-campus.
- Wear an appropriate face covering over my mouth and nose when indoors and in any other setting where it is difficult to maintain social distancing, and use any other protective gear prescribed by the university.
- Wash my hands frequently using soap and water or hand sanitizer. Contribute to the cleaning of classroom surfaces as requested.
- Carefully observe and follow campus and building instructional signs and directions.
- Participate in COVID-19 testing and contact tracing to preserve the wellness of the community.
- Be positive and gracious when others provide safety reminders and suggestions.
- Be attentive and helpful to anyone around who may be in need of support.