

# CS 320

## Principles of Programming Languages

# SYLLABUS

Spring 2019

(Last Updated: April 1, 2019)

IMPORTANT: The pdf version of this document that is posted on D2L will **not** be updated once the term has started. Its purpose is to maintain an accurate record of the course syllabus as of the date shown above, and as distributed in the first class. For updates and additional resources, please consult the D2L web pages.

## COURSE ORGANIZATION

### Instructor

Name	email	Office	Office Hours
Mark P Jones	<a href="mailto:mpj@pdx.edu">mpj@pdx.edu</a>	FAB 120-20	Mondays, 1-3pm (April 1 to June 3); or by appointment.

Where possible, personal meetings often work better than email, so please feel free to drop by my office at any time; Please knock, even if it looks like I am already busy; if I am busy, then we can at least arrange another, mutually convenient time to meet. I sometimes work without the main lights on (i.e., with just the glow from the display on my computer :-), so don't be discouraged if my room looks dark as you approach; I may still be lurking inside (and I will switch the lights on for visitors)!

If you send me an email to arrange a time to meet, **please include a list of the possible meeting times that would work for you**. This will help to shortcut the process of finding a mutually convenient time for us to meet. Of course, the more times you are able to suggest, the more likely it is that one or more of them will also work for me. (And if there's more than one viable option, then I'll always choose the earliest one, recognizing that most questions or issues are better addressed sooner rather than later.)

### Teaching Assistants

Name	email	Office Hours (in the Fishbowl)
Katie Casamento	<a href="mailto:cas28@pdx.edu">cas28@pdx.edu</a>	Thursdays, 2-3pm, or by appointment
Phuong Pham	<a href="mailto:phuong@pdx.edu">phuong@pdx.edu</a>	Mondays, Wednesdays, 4-6pm, or by appointment

We will rely on students in the course to let us know if the posted office hours times do not work, or if additional TA office hours should be added.

### Meeting Times and Locations

Lectures on Tuesday in EB 102, 10-11:50am. Every student must also sign up for one CS 320 lab session in FAB 88-09 (the Linux "particle" lab) on Tuesdays, Wednesdays, or Thursdays. Space in the lab is very limited and attendance at each lab will be restricted to the students who have registered for that particular time.

## **Class Web Page, Announcements, Etc.**

We will be using D2L (<http://d2l.pdx.edu>; Odin account required for login) as our primary website. Announcements, class materials (including lecture slides and assignments), discussion forums, and homework submission will be hosted at that site. All students are expected to subscribe for email notifications, at least for announcements and preferably also for discussions; this is necessary to ensure timely notification of important announcements, clarifications, and updates. If you do not know how to do this, please ask for help.

There is also a Slack channel for the course at [https://pdx-cs.slack.com/#cs320\\_spring\\_2019](https://pdx-cs.slack.com/#cs320_spring_2019) that is intended for informal communication and questions about the course. Use it freely. The instructor and TAs will monitor it regularly and jump in when that seems useful.

## **Course Description**

Syntax and semantics. Compilers and interpreters. Programs as data. Regular expressions and context free grammars. Programming paradigms, including procedural, functional, and object-oriented programming. Type systems, including dynamic and static typing disciplines. Binding, scope, data abstraction, and modularity. Denotational, operational, and axiomatic semantics. Introduction to program correctness. (The official description is available at <https://www.pdx.edu/computer-science/cs320>.)

## **Prerequisites**

This class requires CS 202, 251; passed with grades of C or better. These courses provide you with the background that you will need to understand the course material and develop solutions to the assignments that you will be given. It is assumed that you have experience programming in a high-level, object-oriented language (specifically, C++ or Java, from CS 202 and earlier classes). If you have not completed the prerequisites, then you may not have the background that you need to pass this class. In this case, by default, you will not be able to continue in the class and you should contact the instructor at the earliest opportunity to avoid an administrative drop.

## **Course Objectives/Student Learning Outcomes**

Upon the successful completion of this course students will be able to:

1. Explain the distinction between language syntax and semantics.
2. Describe the similarities and differences between interpreters and compilers.
3. Explain the phase structure of a typical compiler and the role of each phase.
4. Use regular expressions and context-free grammars to describe the syntax of simple programming languages.
5. Illustrate the features and characteristics of different programming paradigms, including procedural, functional, and object-oriented programming.
6. Explain the concepts of binding, scope, block structure, and lifetime, and apply them to resolving variable uses to their binding sites in a variety of languages.
7. Describe and apply the basic concepts of type systems, including primitive types, compound, and recursive types, abstract data types, and type equivalence models.
8. Describe the strengths and limitations of static and dynamic typing disciplines.
9. Describe and apply the basic concepts of data abstraction, encapsulation, object-oriented classes, and modules.

10. Explain basic approaches and applications for the formalization of programming language semantics.

## Outline of Course Content (SUBJECT TO CHANGE)

The following outline represents a tentative schedule for the course and is subject to change.

Week	Lecture Date	Lecture Topic	
1	April 2	Course overview. Syntax and Semantics. Program equivalence, and the distinction between syntactic and semantic equivalences. Representation of programs as abstract syntax trees. Distinctions between concrete and abstract syntax and between static and dynamic semantics.	Functional Programming. Haskell. Programming without side effects. Recursion. Processing structured data. First-class functions. Binding and scope.
2	9	Programs that manipulate programs as data. Basic principles in the function and construction of interpreters, compilers, program generators, and program analysis tools.	
3	16	Techniques for describing language syntax. Context-free grammars, and common usage patterns.	
4	23	Type systems. A type as a set of values together with operations. Primitive types. Compound types. Product and sum types. Recursive types. Parameterized types.	
5	30	Type checking. Association of types to variables and values. Dynamic and static typing disciplines. Type safety. Decidability issues. Interpreting type error messages.	Scripting languages. Python.
6	May 7	Midterm exam. (Post-midterm) Review.	
7	14	Stateful objects. Classes, fields, methods, and constructors. Subclasses, inheritance, method overriding, and dynamic dispatch. Object lifetime.	Object-oriented programming. Java.
8	21	Abstract types. Modularity and encapsulation.	
9	28	Techniques for formalization of programming language semantics, including denotational, operational, and axiomatic approaches.	
10	June 4	Introduction to program correctness. Program specification using predicate logic. Application of formal semantics, and the role of tools for mechanized reasoning.	

In accordance with [University Guidelines](#), the final exam is scheduled for Tuesday, June 11, 10:15am-12:05pm in the usual meeting room, EB 102.

## Course Requirements and Method of Evaluation

The course will be assessed by a combination of exams, homework exercises, and (possibly) in-class quizzes.

There will be one midterm exam (in Week 6) and one final exam (in Finals week), both of which will be *closed-book*. Exams are scheduled in advance and, unless a prior arrangement is made, a grade of zero will be recorded for missed exams.

The midterm will contribute 25% of your overall grade for the class, while the final will contribute 35%. The remaining 40% will be determined by a combination of homework assignments and in-class quizzes. The number and frequency of homework assignments and quizzes will be determined by balancing the need for timely feedback and grading with consideration of the class size and the available resources. In many (but not

necessarily all) cases, the homework assignment for a given week is likely to be a continuation of work that was begun in the lab sessions for that week.

A general expectation is that answers should include appropriate explanation, justification, or commentary to support your answers and show that you understand why your answer is correct. The grading schemes for individual assignments will typically include points specifically for these items, so writing only the final answer to a question, even if it is correct, may not earn full marks.

For questions that require programming, you will often be asked to include evidence of "thoughtful testing". The intent here is that you aim for quality of tests rather than quantity, focusing on which aspects of your solution are exercised by your tests, the handling of edge cases, and the steps that you took to determine what the correct behavior or result should be. If you just show the output from running a program without including further commentary to justify or explain the results, then all you are really doing is showing that your program runs, and not that it is correct.

There may be some assignments that are not formally assessed. This might include written exercises, additional reading, or watching prepared videos, etc. These will be designed to help you master the subject, to keep pace with the lectures, and to prepare for the exams, so it will be very important for you to keep up to date with those exercises.

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## RESOURCES

### Required Texts and/or Required Reading List

The slides and other materials that are presented in lectures and on the course web site are *required* reading.

There is no *required* textbook for this class, but all students are strongly encouraged to do background reading in parallel with the coverage of topics in class. There are many textbooks on the subjects of this course, including a good range that are available in the PSU library. However, we do not expect you to buy or have access to any particular text: for example, we will not set exercises that come from a text book, or require you to have read specific sections of any particular book. Of course, there are plenty of good resources on the Internet of direct relevance to this course that can be found on sites like Wikipedia or simply by searching on Google.

### Computing Facilities

The assignments for this course will require the use of a variety of programming language implementations. Students may develop their solutions on any machine and operating system on which these implementations are available. At a minimum, all of the systems that we use will be installed on the departmental Linux systems that can be accessed in person in the lab area, or remotely via ssh/putty.

### The Importance of Asking for Help

A fundamental assumption and expectation of this course is that students will ask for help or clarification if they have any problems understanding the course materials, or the work that is required for an assignment. As general guidelines:

- Questions may be asked in person (during lectures, or office hours, for example) or online using the D2L forums (preferred) or email (for personal matters, or lower-priority questions).

- In general, we will prioritize conversations on public forums (e.g., D2L and Slack) over individual email because public postings have the potential to benefit the largest possible group of people. We will also prioritize conversations in persistent forums (e.g., D2L) over those that are more transient (e.g., Slack) because the former are more likely to serve as a reference for other students exploring similar questions or topics. If you send a message by email, we will still try to respond as quickly as possible, but may need to respond to public postings first or to other individual email messages that arrived before yours.
- Anonymous posting on D2L is permitted for those who are uncomfortable about posting questions under their own name.
- To avoid a breach of academic integrity (see details below), do not include specifics of your solution in public postings on D2L/Slack/etc.; instead, please try to phrase your questions, comments, or answers in general terms.
- If you do send a question by email, please use a regular email system. The "email" facility that is built in to D2L generates invalid sender addresses, that are not recognized by the PSU mail system.
- You should ensure that you are subscribed to receive notifications when news items or new forum messages are posted on D2L. If you do not subscribe for these updates, then you may miss important announcements, clarifications, or updates.
- If you are not comfortable or do not have time to ask for help, then you may find that the course is (perhaps considerably) more difficult than intended. In this situation, you may want to consider whether it is appropriate for you to be taking the course at this time: please contact the instructor if you have any concerns about this.

**"Shouldn't I be able to do this by myself?"** Students sometimes say that they want to be able to do the assignments by themselves without any additional input. That's a commendable attitude, but it is **NOT** appropriate in this class and it is not representative of how things work in the real world where practical projects typically rely on the need for interaction with customers, peers, supervisors, and other colleagues with more experience or different perspectives. Another common problem may occur for a student who is struggling to phrase their question. If you find yourself in this position, you are encouraged to review the relevant course materials (and question or reference text, where appropriate): can you identify the parts that make sense to you, and the parts that are unclear? The more precisely you can identify the source of any confusion or uncertainty, the easier it will be to provide specific guidance. For example, perhaps you can point to a specific item on a slide, or a particular phrase or paragraph in an assignment text that doesn't make sense to you? Does it appear to contradict something you've seen elsewhere, or use vocabulary or terminology that isn't familiar to you, for example? But even if you cannot pin down all the details, the process of trying to formulate a question can, itself, be helpful in clarifying the source of a misunderstanding. And even if you still cannot formulate a very specific question, we'll still do our best to help you.

**"I don't want to embarrass myself."** Another common concern is a fear of embarrassment or a sense of shyness: a student may worry that their questions will reveal a gap in their understanding, or even just the fact that they started late or weren't paying attention in class when a topic was covered in class. Although it can be difficult to overcome these fears, in a class of any reasonable size, it's almost certain that any question that one student has, will also be on the mind of or directly relevant to other students too. As such, when a student asks a question, particularly in a public forum such as during the lecture or on D2L, there is an enormous potential benefit to other people. For starters, there is a very real chance that you and other students will learn useful things in the process. Moreover, the instructors will also gain new insights about the way that the material was taught or understood—including gaps or mistakes in the way the ideas were



presented—which they can then use as input to clarify, expand, and improve the treatment. For these reasons, we strongly encourage you to ask questions in "public" settings where possible, but for those who still feel uncomfortable about this, we will also accept and do our best to respond to "private" enquiries.

**"You're probably too busy."** Some students hold back from asking questions because they think that the instructor or TAs might be too busy. It's true that we may be busy, but please don't forget that we are here (and are being paid!) to help you learn. Interacting with you and answering your questions is one of the best ways we have to help you do that. You're certainly not "bothering us" or "wasting our time" when you ask us questions: you're just giving us a chance to do our job and help you learn the course material!

**The Danger of "spinning your wheels":** Students sometimes mention that they have been working on a question for "many hours" before getting in touch to ask a question. By the time this happens, they have invested a lot of time and energy in a specific problem, but have little to show for it, and are understandably feeling more than a little frustrated. In some cases, a student may say this because they want to assure us that they have made a serious attempt to understand the material and solve the problem themselves; it may well be that many hours have passed on the clock in the process, but that time may not have been spent productively, and the end result might be that it takes much longer for a student to complete an assignment as a result of some relatively small misunderstanding or detail that could have been clarified quite quickly. It is definitely a good idea for students to spend and invest real time and energy to understand and work through problems on their own; many of us learn a great deal as a result of struggling with a problem, and perhaps failing to find a solution in our first few attempts to solve it. However, it is also important to develop enough self awareness to be able to tell when you are simply "letting your wheels spin", essentially making no progress and failing to use your limited time in a productive way. A good first step if you feel this happening to you is to take a break: do something else, take some physical exercise, sleep, etc. But ultimately, this may just be a sign that you need to reach out for help or clarification.

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## POLICIES

### Academic Integrity

We follow the standard guidelines for academic integrity. This is important because a breach of academic integrity by one student undermines the efforts and achievements of the other students in the class who have made honest and legitimate attempts to study for and complete assignments and exams. It is permissible to *discuss* assignments with other students, but you must *develop* the solution yourself. *Do not, under any circumstances, copy any part of another person's solution and submit it as your own.* Unless you are given explicit written instructions to the contrary, sharing of code or test cases is not permitted. In particular, posting or soliciting all or part of your solution on D2L or any other public forum, media, or site may be considered a breach of academic integrity. Writing code for use by another person, or using another person's code in any form (even with their permission) will be considered cheating. Cheating on an assignment or exam will result in an automatic zero grade for that piece of work, and the initiation of disciplinary action at the University level. Please refer to <http://www.pdx.edu/dos/codeofconduct> for details of the general PSU Student Code of Conduct. Any student with questions about academic integrity issues, either relating to their own behavior, or with concerns about the behavior of other students, should contact the instructor. All such matters will be treated in confidence.

Always remember that the instructor and the TA are here to help you to succeed in this class; if you find yourself in a difficult position, **do not be tempted to cheat**, and instead get in touch to ask for some help or guidance.

## Discrimination and Misconduct

- Portland State is committed to fostering a safe, productive learning environment. Title IX and our school policy prohibit gender or sex-based discrimination and sexual misconduct (including harassment, domestic and dating violence, sexual assault, and stalking).
- We expect a culture of professionalism and mutual respect in our department and class. You may report any incident of discrimination or discriminatory harassment, including sexual harassment, to either the [Office of Equity and Compliance](#) or the [Office of the Dean of Student Life](#).
- Please be aware that members of the faculty have the responsibility to report any instances of sexual harassment, sexual violence and/or other forms of prohibited discrimination to PSU's Title IX Coordinator, the Office of Equity and Compliance or the Dean of Student Life and **cannot keep information confidential**.
- If you would rather share information about sexual harassment or sexual violence to a confidential employee who does not have this reporting responsibility, you can contact a confidential advocate at 503-725-5672 or [on-line](#), or another confidential employee found on the [sexual misconduct resource webpage](#).
- For more information about your obligations and resources for sex/gender discrimination and sexual violence (Title IX), please complete the required student module [Creating a Safe Campus](#) in your D2L.

## Disabilities and Accommodations

We will do everything possible to provide accommodations, with full confidentiality, to any student who needs them. All accommodations must be approved by the Disability Resource Center, which establishes fair and consistent standards across campus. Students with a documented disability who are registered with the Disability Resource Center are responsible for ensuring that their specific requirements are clearly communicated to the instructor at the earliest possible opportunity, either directly or via the DRC. Students should take steps to notify the instructor as soon as possible if they feel that their needs are not being met. If you have accommodations that include taking tests at the University test center, then you are strongly recommended to schedule those tests so that they coincide with the time that the other students are taking the test in the main classroom. It is important that you take steps to make the necessary reservations at the earliest possible opportunity, noting that the times and dates for both the midterm and final exams are already fixed for 5/7 and 6/11, respectively, as described above. The instructor is happy to provide additional guidance to any student in this situation, but it is the student's responsibility to make the appropriate arrangements and to share those details with the instructor in a timely manner.

## Other Policies and Guidance

In addition to the specific items described above, we adopt the following policies and guidance:

1. By default, all deadlines are firm. At the discretion of the instructor, penalties may be assessed for late submissions.
2. No homework or exam submissions can be accepted once a sample solution has been distributed and/or discussed in class or online.
3. In general, writing only the correct answer may not earn you full marks for an assignment, and you

should also be prepared to include appropriate explanation, justification, commentary etc. The intent here is that you should be able, not only to say *what* the correct answer is but also to explain *why* it is the correct answer.

4. We are unable to provide detailed feedback on draft versions of assignment solutions prior to submission; feedback of that kind might be considered as providing an unfair advantage over other students who are not able to get their work "reviewed" prior to submission. We are happy, however, to address any questions that might help to clarify the expectations and requirements for an assignment.
5. Students are solely responsible for ensuring that their attempts to upload homework solutions to D2L are successful. A "miscellaneous uploads" dropbox will be provided for students to submit material after the deadline for a given assignment has passed, but there is no guarantee that items submitted there will be accepted or considered for grading. Any student who uses the miscellaneous uploads dropbox should also notify the instructor directly.
6. We try hard to ensure that grading is fair and accurate. But we also acknowledge that, as with any human process, there will always be a possibility for mistakes. In addition, even if the grading is correct, a student may not always understand why they have been assigned a specific score. For these reasons, students are welcome to seek clarification/explanation for grading decisions at any time during the term before final grades are submitted. We will never reduce the grade awarded as a result of reviewing work in this way, but there is also no guarantee that any grades will be increased as a result of review. Reviews of grading are appropriate whenever they might help to improve understanding or learning, but they should not be used as a matter of routine, and should not be used primarily as a way to try to boost scores. Reviews of this kind are typically only useful (and hence should usually only be requested) after sample solutions and grading guides have been distributed by the instructor and reviewed by the student.
7. To ensure consistency, all questions about matters that are potentially subjective—such as possible grading errors or determining whether an exceptional circumstance warrants an extension of a deadline—should be addressed to and answered by the primary instructor.
8. We will try to be as flexible as possible in accommodating special circumstances. If you anticipate a specific issue, please talk to us to make arrangements in advance. Note, however, that it will not be possible for any student to take either the midterm or final exam at an earlier time than is posted in the schedule.
9. As specified in Oregon law ([ORS 165.40 6\(b\)](#)), recording of oral communications that are part of regularly scheduled classes is permitted if the recording device is not concealed. To respect the privacy of students and to avoid actions that might discourage or inhibit participation in class, please treat any such recordings as "for personal use only".

Every student should send an email to the instructor before the second lecture to indicate that they have read and understood this syllabus.

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