CS 578 Programming Language Semantics – Spring 2022

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Office Hours: by appt.
Course web page: http://www.cs.pdx.edu/~apt/cs578

Description

This course provides an introduction to the mathematics of program meaning (semantics) using the framework of type systems and typed languages. Topics include operational semantics; inductive proof techniques; the lambda-calculus; type safety; basic and advanced types systems including references, exceptions, and subtyping; polymorphic types; and logical relations.

Prerequisites

The theoretical material in the course is self-contained, so there are no specific prerequisites, but a reasonable level of mathematical maturity is assumed. For example, you should be comfortable with proofs by induction, simple set theory, and elementary logic, to the level of a rigorous undergraduate discrete math course.

You should also be familiar with basic concepts from the study of programming languages, such as grammars, abstract syntax, evaluation, and compilation, to the level of CS558.

Programming exercises will be in the OCaml language. Previous exposure to a functional language such as Scala (to the level of CS558) or Haskell (as in CS557) is assumed.

Readings

We will use the textbook "Types and Programming Languages," by Benjamin C. Pierce, MIT Press, 2002. Additional readings, made available on the course web page, may be assigned from time to time.

Requirements

There will be weekly homework assignments, a midterm, and a final exam. Exams will probably be in-class, closed-book. The homework assignments will include both theory problems and short OCaml programming exercises. Since answers are provided to many assignment questions in the back of the book, the assignments will be scored mainly based on whether you turn them in or not; hence, they won’t count for much of the grade. But doing them will be essential preparation for the exams.

Homework assignments must be typeset using the latex system, and submitted in both .tex and .pdf form.

The course grade will be distributed as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
</tr>
<tr>
<td>Midterm</td>
<td>30%</td>
</tr>
<tr>
<td>Final</td>
<td>40%</td>
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</table>

Although it will not be formally assessed, class participation is strongly encouraged, and may affect borderline grades.

Computing Facilities

Some of the homework exercises will require use of the OCaml language; any recent version will do. It is installed on the CS department linux systems. It is also very easy to install on your own personal machine (and doesn’t require many resources).
Latex is also available on the department linux systems, online using Overleaf, or can be installed on your own machine (easy, but has a large footprint).

**Individual Work**

It is permitted (even encouraged) for you to work together on homework assignments. However, all homework submissions must be written up (and typed in) individually; an important part of the course is learning how to write down theoretical arguments, even after they are clear in your own mind.

Exams must be completed individually without any collaboration. Cheating on an exam will result in an automatic zero grade and the initiation of disciplinary action at the University level.

**Classroom Requirements for All Students and Faculty Due to Covid-19**

The University has established rules and policies to make the return to the classroom as safe as possible. It is required for everyone to follow all the Return to Campus rules and policies. To participate in this class, PSU requires students to comply with the following.

**Vaccination**

Be vaccinated against COVID-19 and complete the COVID-19 vaccination attestation form (https://www.pdx.edu/covid-19-response/vaccinations). Those students with medical or nonmedical exemptions or who will not be on campus at all must complete the process described on “COVID-19 Vaccine Exemption Request Form” to establish those exemptions.

**Health Check, Illness, Exposure or Positive Test for COVID-19**

- Complete the required self-check for COVID-19 symptoms before coming to campus each day (see https://www.pdx.edu/health-counseling/sites/g/files/znldhr771/files/2021-04/Student_COVID_Check_4.19.21.pdf).
- If you are feeling sick or have been exposed to COVID-19, do not come to campus. Call SHAC to discuss your symptoms and situation (503.725.2800). They will advise you on testing, quarantine, and when you can return to campus.
- If you test positive for COVID-19, report your result to SHAC (https://docs.google.com/forms/d/e/1FAIpQLSfu4kQiNOxPlV0F0lsY290e4vyyefE3R0Z4Dmz-ADIImOIsYQ/viewform) and do not come to campus. SHAC will advise you on quarantine, notification of close contacts and when you can return to campus.
- Please notify the instructor should you need to miss a class period for any of these reasons so that we can discuss strategies to support your learning during this time.
- If the instructor becomes ill or need to quarantine during the term, either they or the department chair will notify you via PSU email about their absence and how course instruction will continue.

**Failure to Comply with Any of these Rules**

The University has given the instructor the authority to require your compliance with these policies. If you do not comply with these requirements, the instructor may ask you to leave the classroom or may need to cancel the class session entirely.

In addition, failure to comply with these requirements may result in a referral to the Office of the Dean of Student Life to consider charges under PSU’s Code of Conduct. A student found to have violated a university rule (or rules)
through the due process of student conduct might face disciplinary and educational sanctions (or consequences). For a complete list of sanctions, see Section 14 of the Student Code of Conduct & Responsibility (https://www.pdx.edu/dean-student-life/psu-code-student-conduct-and-responsibility).

Guidance May Change

Please note that the University rules, policies, and guidance may change at any time at the direction of the CDC, State, or County requirements. Please review the University’s main COVID-19 Response webpage (https://www.pdx.edu/covid-19-response) and look for emails from the University on these topics.

Title IX Reporting Obligations

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 (https://www.pdx.edu/diversity/equity-compliance) or the Office of the Dean of Student Life (https://www.pdx.edu/student-life/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 by scheduling on-line (https://psuwrc.youcanbook.me) or another confidential employee found on the sexual misconduct resource webpage (https://www.pdx.edu/sexual-assault/get-help).

Disabilities

If you have, or think you may have, a disability that may affect your work in this class and feel you need accommodations, contact the Disability Resource Center to schedule an appointment and initiate a conversation about reasonable accommodations. Visit the DRC online at https://www.pdx.edu/disability-resource-center. If you already have accommodations from the DRC, please contact the instructor so we can discuss them.

Recording

This class may be recorded. Our use of recording technology is governed by FERPA, the Acceptable Use Policy, and PSU’s Student Code of Conduct. A record of all meetings and recordings is kept and stored by PSU, in accordance with the Acceptable Use Policy and FERPA. The instructor will not share recordings of your class activities outside of course participants, which include your fellow students, TAs/GAs/Mentors, and any guest faculty or community based learning partners that we may engage with. You may not share recordings outside of this course. Doing so may result in disciplinary action.
## Tentative Schedule

This schedule is highly subject to change. You should always attempt to do the reading *before* the relevant class meeting.

<table>
<thead>
<tr>
<th>dates</th>
<th>Pierce chapters</th>
<th>topics</th>
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<tbody>
<tr>
<td>Mar 29 &amp; 31</td>
<td>1,(2),3,4</td>
<td>Introduction; Syntax and Operational Semantics</td>
</tr>
<tr>
<td>Apr 5 &amp; 7</td>
<td>5,6,7</td>
<td>Untyped lambda-calculus</td>
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<tr>
<td>Apr 12 &amp; 14</td>
<td>8,9,10</td>
<td>Types; Simply-typed lambda-calculus</td>
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<tr>
<td>Apr 19 &amp; 21</td>
<td>11</td>
<td>Extensions to lambda-calculus</td>
</tr>
<tr>
<td>Apr 26 &amp; 28</td>
<td>12,13,14</td>
<td>Normalization; References and Exceptions</td>
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<tr>
<td>May 3</td>
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<td><strong>Midterm</strong> (in-class)</td>
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<tr>
<td>May 5</td>
<td>15,19</td>
<td>Subtyping</td>
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<tr>
<td>May 10 &amp; 12</td>
<td>20,21,22</td>
<td>Recursive Types; Type Reconstruction</td>
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<tr>
<td>May 17 &amp; 19</td>
<td>23,24,25</td>
<td>Universal and Existential Types</td>
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<tr>
<td>May 24 &amp; 26</td>
<td>29,30</td>
<td>Higher-order Systems</td>
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<tr>
<td>May 31 &amp; Jun 2</td>
<td>TBA</td>
<td>Logical relations and their applications</td>
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<tr>
<td>Jun 7</td>
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<td><strong>Final Exam</strong> <em>(10:15-12:05)</em></td>
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