CSE 505:
Concepts of Programming Languages

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Lecture 1— Course Introduction

Today

- Administrative stuff
- Course motivation and goals
  - A Java example
- Course overview
- Course pitfalls
- Caml tutorial, part 1
  - Advice: play with it between now and Monday (e.g., hw1, problem 1)

Course facts

- Dan Grossman, CSE556, djg
- TA: Jonathan Beall, CSE440, jibb
- Office hours:
  - Dan: Wednesday 2–3 plus appt plus stop by...
  - Jonathan: Tuesday 1:30–2:30
- Web page for:
  - mailing list
  - "homework 0"
  - homework 1, fairly carefully pipelined with first lectures
    * Do not wait to do it all

Coursework

- 5 homeworks
  - "paper/pencil" (LaTeXrecommended?)
  - programming (Caml required)
  - where you'll probably learn the most
  - do challenge problems if you *want* but not technically "extra"
- 2 exams
  - "my" reference sheet plus "your" reference sheet
- Textbook: mostly for "middle few weeks of course"
  - won't follow it much
  - possibly enough copies floating around the department

Academic integrity

- If you violate the rules, I will enforce the maximum penalty allowed
  - and I'll be personally offended
  - far more important than your grade
- Rough guidelines
  - can sketch idea together
  - cannot look at code solutions
- Ask questions and always describe what you did
- Please *do* work together and learn from each other...

Graduate-School Success

- Success in 505 (a graduate course) comes from:
  - Learning and enjoying the material
  - Challenging yourself
  - Managing the "big picture" and the details
- Success has nothing to do with:
  - Scrounging for grading points
  - "Doing better than the person next to you"
- The person next to you is your colleague for the next 5–50 years

Logistical Advice

- Take notes:
  - Slides (and some proofs) posted, but they are enough to teach from not to learn from
  - Will work through many examples by hand
- Arrive on time:
  - Unlike many CS people, I start and end punctually
  - Missing the first n minutes is so much more costly than missing the last n minutes
  - I *know* you can get here on time (cf. exam days)

Programming-language concepts

Focus on *semantic* concepts:

What do programs mean (do/compute/produce/represent)?

How to define a language *precisely*?

English is a poor *metalanguage*

Aspects of meaning:

equivalence, termination, determinism, type, ...

Does it matter?

Novices write programs that "work as expected," so why be rigorous/precise/pedantic?

- The world runs on software

  Web-servers and nuclear reactors don't "seem to work"

- You buy language implementations—what do they do?
- Software is buggy—semantics assigns blame
- Real languages have many features: building them from well-understood foundations is good engineering
- Never say "nobody would write that" (surprising interactions)

Also: Rigor is a hallmark of quality research

Java example

```
class A { int f() { return 0; } }
class B {
   int g(A x) {
     try { return x.f(); }
     finally { s }
   }
}
```

For all s, is it equivalent for g's body to be "`return 0;`"?

Motivation: code optimizer, code maintainer, ...

Punch-line

Not equivalent:

- Extend `A`
- `x` could be `null`
- `s` could modify global state, *diverge*, throw, ...
- `s` could return

A silly example, but:

- PL makes you a good adversary, programmer
- PL gives you the tools to argue equivalence (hard!)

Course goals

1. Learn intellectual tools for describing program behavior
2. Investigate concepts essential to most languages
   - mutation and iteration
   - scope and functions
   - objects
   - threads
3. Write programs to "connect theory with the code"
4. Sketch applicability to "real" languages
5. Provide background for current PL research
   (less important for most of you)

Course nongoals

- Study syntax; learn to specify grammars, parsers
  - Transforming $\mathbf{3 + 4}$ or $\mathbf{(+\ 3\ 4)}$ or $\mathbf{+(3, 4)}$ to "application of plus operator to constants three and four"
  - stop me when I get too sloppy
- Learn specific programming languages (but some ML)
- Denotational and axiomatic semantics
  - Would include them if I had 25 weeks
  - Will explain what they are later

What we will do

- Define really small languages
  - Usually Turing complete
  - Always unsuitable for real programming
- Study them rigorously via *operational models*
- Extend them to realistic languages less rigorously
- Digress for cool results (this is fun!?!)

- Do programming assignments in Caml...

Caml

- Caml is an awesome, high-level language
- We will use a tiny core subset of it that is well-suited for manipulating recursive data structures (like programs!)
- You mostly have to learn it outside of class (start today!)
  - But feel free to ask me for advice
  - Even after the course
- Resources on course webpage
- I am not a language zealot, but knowing ML makes you a better programmer

Pitfalls

How to hate this course and get the wrong idea:

- Forget that we made simple models to focus on essentials
- Don't quite get inductive definitions and proofs
- Don't try other ways to model/prove the idea
  - You'll probably be wrong
  - And therefore you'll learn more
- Think PL people focus on only obvious facts (need to start there)

Final Metacomment

Acknowledging others is crucial...

This course will draw heavily on:

- Previous versions of the course (Borning, Chambers)
- Similar courses elsewhere (Felleisen, Flatt, Harper, Morrisett, Myers, Pierce, Rugina, Walker, ...)
- Texts (Pierce, Wynskel, ...)

This is a course, not my work.

Caml tutorial

- "Let go of Java/C"
- If you have seen SML, Haskell, Scheme, Lisp, etc. this will feel more familiar
- Give us some small code snippets so we have a common experience we can talk about.
- Also see me use the tools.
- A note later on Seminal.

Seminal

- This is optional, but Ben Lerner and I would be ever-so grateful for your informed feedback.
- An additional, complementary style of type-error message.
- No other change to compiler (parsing, code-generation, etc.)
- See "Running Caml locally" on the course website.