Victory Lap

A victory lap is an extra trip around the track
  – By the exhausted victors (us)

Review course goals
  – Slides from Introduction and Course-Motivation

Some big themes and perspectives
  – Stuff for five years from now more than for the final

Maybe time for open Q&A

Please fill out the course evaluation!!!
We’ve come a long way

First Day of Class
March 30

(Almost) Last Day of Class
June 3
Thank you!

• **Huge** thank-you to your TAs
  – Great team effort
  – Really invested in a successful course
  – Many message boards posts, assignments graded
  – Many hours of teaching and prepping sections
  – SUPER hard working and high energy team 😊
Thank you!

• And a huge thank you to all of you
  – Great attitude about a very different view of software
  – Good class attendance and questions
  – Willingness to work with us during this crazy quarter

• Computer science ought to be challenging and fun!
• Many essential concepts relevant in any programming language
  – And how these pieces fit together

• Use ML, Racket, and Ruby languages:
  – They let many of the concepts “shine”
  – Using multiple languages shows how the same concept can “look different” or actually be slightly different
  – In many ways simpler than Java

• Big focus on functional programming
  – Not using mutation (assignment statements) (!)
  – Using first-class functions (can’t explain that yet)
  – But many other topics too
Learning to think about software in this “PL” way will make you a better programmer even if/when you go back to old ways.

It will also give you the mental tools and experience you need for a lifetime of confidently picking up new languages and ideas.

[Somewhat in the style of *The Karate Kid* movies (1984, 2010)]
[From Course Motivation]

• No such thing as a “best” PL

• Fundamental concepts easier to teach in some (multiple) PLs

• A good PL is a relevant, elegant interface for writing software
  – There is no substitute for precise understanding of PL semantics

• Functional languages have been on the leading edge for decades
  – Ideas have been absorbed by the mainstream, but very slowly
  – First-class functions and avoiding mutation increasingly essential
  – Meanwhile, use the ideas to be a better C/Java/PHP hacker

• Many great alternatives to ML, Racket, and Ruby, but each was chosen for a reason and for how they complement each other
[From Course Motivation]

SML, Racket, and Ruby are a useful combination for us.

<table>
<thead>
<tr>
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<th>dynamically typed</th>
<th>statically typed</th>
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<tbody>
<tr>
<td>functional</td>
<td>Racket</td>
<td>SML</td>
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<tr>
<td>object-oriented</td>
<td>Ruby</td>
<td>Java</td>
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ML: polymorphic types, pattern-matching, abstract types & modules
Racket: dynamic typing, “good” macros, minimalist syntax, eval
Ruby: classes but not types, very OOP, mixins
[and much more]

Really wish we had more time:
Haskell: laziness, purity, type classes, monads
Prolog: unification and backtracking
[and much more]
Benefits of No Mutation

[An incomplete list]

1. Can freely alias or copy values/objects: Unit 1
2. More functions/modules are equivalent: Unit 4
3. No need to make local copies of data: Unit 5
4. Depth subtyping is sound: Unit 8

State updates are appropriate when you are modeling a phenomenon that is inherently state-based
   – A fold over a collection (e.g., summing a list) is not!
Some other highlights

• Function closures are really powerful and convenient…
  – … and implementing them is not magic

• Datatypes and pattern-matching are really convenient…
  – … and exactly the opposite of OOP decomposition

• Sound static typing prevents certain errors…
  – … and is inherently approximate

• Subtyping and generics allow different kinds of code reuse…
  – … and combine synergistically

• Modularity is really important; languages can help
More high-level takeaways

• Every choice involves tradeoffs
  – Type systems: Convenience vs. protection
  – Syntax: Conciseness vs. precision
  – Eagerness: Simplicity vs. performance
  – Purity: Clarify vs. usefulness

• Just because you can, doesn’t mean you should (and vice versa!)
  – Mutation: makes reasoning harder
  – Wildcards/defaults: hides errors
  – Depth subtyping: prevents soundness (only if mutation allowed!)

• Programming languages are hard
  – Have sympathy next time you wonder “why can’t Language X just allow this?”
Wat?

Wat
@garybernhardt

https://www.destroyallsoftware.com/talks/wat
From the syllabus

Successful course participants will:

• Internalize an accurate understanding of what functional and object-oriented programs mean

• Develop the skills necessary to learn new programming languages quickly

• Master specific language concepts such that they can recognize them in strange guises

• Learn to evaluate the power and elegance of programming languages and their constructs

• Attain reasonable proficiency in the ML, Racket, and Ruby languages and, as a by-product, become more proficient in languages they already know
What now?

- Use what you learned whenever you reason about software!
- CSE 401 – Compilers
- CSE 402 – Domain-specific Languages
- CSE 490P – Advanced PLs and Verification (lots of proofs)
- CSE 505 – Principles of PLs (formal semantics, more proofs)

Does PL research design new general-purpose languages?
- Not really; it does cool stuff with same intellectual tools!
- Check out [http://www.uwplse.org](http://www.uwplse.org)
The End

Don’t be a stranger!