Final Exam

As also indicated in class-list email:

• Next **Tuesday, 2:30-4:20PM**
• Intention is to focus primarily on material since the midterm
  – Including topics on homeworks and not on homeworks
  – May also have a little ML, just like the course has had
• You will need to write code and English
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

Do your course evaluations!!!
Thank you!

• **Huge** thank-you to your TAs
  – Great team effort
  – Really invested in a successful course
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
  - Occasionally laughed at stuff 😊

- 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
[From Lecture 1]

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
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
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
The End

This really is my favorite course and it probably always will be

Don’t be a stranger!

Time for ask-me-anything questions?