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

Thank you!

- **Huge** thank-you to your TAs
  - Great team effort
  - Really invested in a successful course

**Do your course evaluations!!!**
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!

[From Lecture 1]

- 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 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>
<th></th>
<th>dynamically typed</th>
<th>statically typed</th>
</tr>
</thead>
<tbody>
<tr>
<td>functional</td>
<td>Racket</td>
<td>SML</td>
</tr>
<tr>
<td>object-oriented</td>
<td>Ruby</td>
<td>Java</td>
</tr>
</tbody>
</table>

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?