Today’s music: "We are the Champions" by Queen
Victory Lap

Extra trip around the track by the exhausted victors (us) 😊
Thank you!

Huge thank you to TAs and consultants!
Thank you!

Piazza heroes:

**Top Student Contributors**

- **Suraj Bhatia**
  217 contributions; 84 days online
- **Tongcheng Li**
  177 contributions; 93 days online
- **Ross Tannenbaum**
  143 contributions; 97 days online
- **Howon Song**
  127 contributions; 82 days online
- **Alexander Sommer**
  116 contributions; 74 days online
Thank you!

And a huge thank you to all of you!

– You surmounted a daunting challenge
– You occasionally laughed at my dumb jokes 😊

I <3 this course. You make it all worthwhile.
What did we learn?

• You feel exhausted...
• You're tired of coding...

...step back and think about what happened along the way
What did we learn?

From the syllabus:
- Alternative programming paradigms, especially functional and concurrent programming
- Writing and using specifications
- Modular programming and data abstraction
- Reasoning about program correctness
- Reasoning about system performance
- Useful and efficient data structures

...and some cross-cutting, big ideas...
1. Syntax and Semantics

• Every language feature can be defined in isolation from other features, with rules for:
  – syntax
  – static semantics (typing rules)
  – dynamic semantics (evaluation rules)

• Divide-and-conquer!

• Entire language can be defined mathematically and precisely
  – SML is. Read *The Definition of Standard ML (Revised)* (Tofte, Harper, MacQueen, 1997).

• Learning to think about software in this “PL” way has made you a better programmer even when you go back to old ways
  – And given you the mental tools and experience you need for a lifetime of confidently picking up new languages and ideas
2. Benefits of Immutability

• Programmer can alias or copy without worry

• Parallel programming easier with immutable data

• But mutability is appropriate when you need to model inherently state-based phenomena — or implement some efficient data structures
3. Programming languages aren’t magic

• Pattern matching is something you can implement yourself

• Interpretation of a language is something you can implement yourself

• From a small set of elegant primitives with precise semantics, we have built a world that runs on software!
4. CS has an intellectual history created by people like you
What next?

• Follow-on courses:
  – CS 4110 Programming Languages and Logics (how to define and reason about programming languages)
  – CS 4120 Compilers (how to implement programming languages)

• Join the course staff?
  – CS department will send out email with URL for application site

• Stay in touch
  – Tell me when 3110 helps you out with future courses (or jobs!)
  – Ask me cool PL questions
  – Drop by to tell me about the rest of your time in CS (and beyond!)… I really do like to know

• **GO DO AMAZING THINGS WITH YOUR LIFE**
Finally

• The most important idea of this course:
  – complicated artifacts can be broken down into small pieces
  – you can then study those small pieces and understand how they work in isolation
  – then you can understand why their aggregation achieves some goals

• Examples: the OCaml language, a module you designed, a formal logic

• That kind of analysis is applicable anywhere, not just programming
Please hold still for 1 more minute

WRAP-UP FOR TODAY
Final

- Tuesday, December 16, 9-11:30 am
- Covers everything in the course
  - except for guest lectures by Prof. Constable and Dr. Minsky
- Will not be a sample final posted on Piazza
  - We've only had 1 week of material since Prelim2!
  - (and you know what kinds of questions to expect by now)
- Office hours:
  - I will try to get some extra consulting hours scheduled before final
  - I'm out of town for a research meeting for the week prior
- Three rooms, will be assigned by netid
- Closed book
  - But you may have three pages of notes
  - 8.5x11” two-sided
Final Grades

• Fill out the course eval to get your +1%
  – Take time on this, especially the free response questions
• Today's office hours are the last for the +1% Meet Your Professor
• Participation +3%:
  – I'll be at the Tournament on Saturday and can manually fix any serial number issues with iClicker
  – but you have to bring your serial number(s) with you
• Final grades will be uploaded to registrar approx. 24 hours after final exam scores are released on CMS
  – < 24 hours after that, the registrar locks them, and I can't change them
Upcoming events

• **PS6 due today**, no late passes
• Tournament submissions due Saturday, 1 minute before noon
• Tournament: Saturday, 5 pm
• Final: December 16, 9 am

This is...
This is victory.
THIS HAS BEEN
3110

Music: End credits from Final Fantasy IX