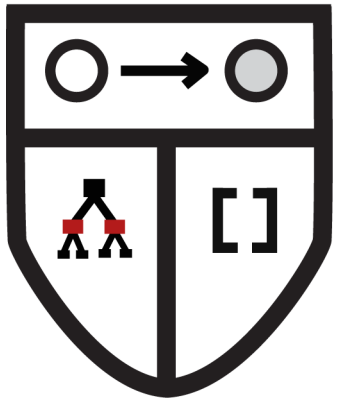

CS 3110

Victory Lap

Prof. Clarkson

Fall 2017

Today's music: *We are the Champions* by Queen

Victory Lap

Extra trip around the track by the exhausted victors – WE are the champions

Thank you!

Huge thank you to TAs and consultants!

Josh Acay, Harshita Bandlamudi, Chris Burke, Kevin Chavez, Alan Cheng, Drew Dunne, Ben Edwards, Anna Fang, Qiuren Fang, Nancy Gu, Quinn Halpin, Sitar Harel, Andrew Hirsch, Tyler Ishikawa, Keshav Iyer, Yifan Jia, Charles Jiang, Nathaniel Kaplan, Tin Kuo, Jeong Won Lee, Alex Libman, Zhiqiu Lin, Manvith Narahari, Arun Pidugu, Yuhuan Qiu, Aaron Rosenfeld, Shiv Roychowdhury, Brian Shi, Andrew Sikowitz, Andrei Talaba, Ram Vellanki, Eric Wang, Jenny Wang, Vicky Wang, Amber Wiens, Pakin Wirojwatanakul, Joshua Ying, Ryan Yoon, Jesse Yuan, Albert Zhang, Cynthia Zhao, Evan Zhao

Thank you!

Thank you to Piazza heroes!

Top Student "Endorsed Answer" Answerers

Name, Email	number of endorsed answers
Mark Anastos mwa37@cornell.edu, manastos98@gmail.com	19
Neil Sun ns664@cornell.edu	19
Daniel Weber dw475@cornell.edu	18
Karan Newatia kn348@cornell.edu	13
Theodore Bauer tjb272@cornell.edu	12
Anmol Kabra ak2426@cornell.edu	12
Yuchen Shen ys393@cornell.edu	10
Jehron Petty (jwp263) jwp263@cornell.edu	10
Scott Dickson sdd48@cornell.edu	9
Iris Zheng jz678@cornell.edu	9

Thank you!

And a huge thank you to all of **you!**

- You surmounted a daunting challenge
- You occasionally laughed at my dumb jokes ☺

I ❤️ 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

[Lec 1]
OCaml is awesome because of…

- Immutable programming
  - Variable's values cannot destructively be changed; makes reasoning about program easier!
- Algebraic datatypes and pattern matching
  - Makes definition and manipulation of complex data structures easy to express
- First-class functions
  - Functions can be passed around like ordinary values
- Static type-checking
  - Reduce number of run-time errors
- Automatic type inference
  - No burden to write down types of every single variable
- Parametric polymorphism
  - Enables construction of abstractions that work across many data types
- Garbage collection
  - Automated memory management eliminates many run-time errors
- Modules
  - Advanced system for structuring large systems

BIG IDEAS

1. Languages can be learned systematically

- 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. Immutability is an advantage

- No need to think about pointers or draw memory diagrams
- Think at a higher level of abstraction
- Programmer can alias or copy without worry
- Concurrent 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

- Interpretation of a (smallish) language is something you can implement yourself

- Domain specific languages (DSL): something you probably *will* implement for some project(s) in your career

4. Elegant abstractions *are* magic

From a small number of simple ideas...

...an explosion of code!

- language features: product types, union types
- higher order functions: map, fold, ...
- data structures: lists, trees, dictionaries, monads
- module systems: abstraction, functors

Computational Thinking

Jeanette Wing

- *Computational thinking is using abstraction and decomposition when... designing a large, complex system.*
- *Thinking like a computer scientist means more than being able to program a computer. It requires thinking at multiple levels of abstraction.*

https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf
https://www.microsoft.com/en-us/research/video/computational-thinking/

5. Building software is more than hacking

- **Design**: think before you type
- **Empathy**: write code to communicate
- **Assurance**: testing and verification
- **Teamwork**: accomplish more with others

6. CS has an intellectual history created by people like you

Big ideas

1. Languages can be learned systematically
2. Immutability is an advantage
3. Programming languages aren't magic
4. Elegant abstractions are magic
5. Building software is more than hacking
6. CS has an intellectual history created by people like you

Q&A

FAQs

- Why OCaml?
- When will I use FP again?

Languages are tools

Languages are tools

- There's no universally perfect tool
- There's no universally perfect language
- **OCaml was good for this course** because:
  - good mix of functional & imperative features
  - relatively easy to reason about meaning of programs
  - From the Turing Award citation for Robin Milner:
    ML was way ahead of its time. It is built on clean and well-articulated mathematical ideas, teased apart so that they can be studied independently and relatively easily remixed and reused. ML has influenced many practical languages, including Java, Scala, and Microsoft's F#. Indeed, no serious language designer should ignore this example of good design.
- **But OCaml isn't perfect** (see above)

FAQs

- Why OCaml?
- When will I use FP again?

FAQs

- Why OCaml?
- ~~When will I use FP again?~~ Why did I study FP?

Why study functional programming?

1. Functional languages teach you that programming transcends programming in a language (assuming you you have only programmed in imperative languages)
2. Functional languages predict the future
3. (Functional languages are *sometimes* used in industry)
4. Functional languages are elegant

Why study functional programming?

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Analogy: studying a foreign language

- Learn about another culture; incorporate aspects into your own life
- Shed preconceptions and prejudices about others
- Understand your native language better

Alan J. Perlis

1922-1990

"A language that doesn't affect the way you think about programming is not worth knowing."

First recipient of the Turing Award

for his "influence in the area of advanced programming techniques and compiler construction"

Why study functional programming?

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Functional languages predict the future

- Garbage collection
  Java [1995], LISP [1958]
- Generics
  Java 5 [2004], ML [1990]
- Higher-order functions
  C#3.0 [2007], Java 8 [2014], LISP [1958]
- Type inference
  C++11 [2011], Java 7 [2011] and 8, ML [1990]
- **What's next?**

Why study functional programming?

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Functional languages in the real world

- Java 8 
- F#, C# 3.0, LINQ 
- Scala   
- Haskell   
- Erlang   
- OCaml  

  https://ocaml.org/learn/companies.html 

Why study functional programming?

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2. Functional languages predict the future
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Elegant


Neat
Stylish
Dignified
Refined
Simple
Graceful
Effective
Precise
Consistent
Tasteful

Elegant

Neat Stylish

Beautiful

Precise Consistent

Tasteful

FINAL MATTERS

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)
- Learn another functional language?
  - Racket or Haskell
- Join the course staff?
  - CS department collects applications
  - If you get an A of any kind, apply in May 2018 to be on my staff for Fall 2018

What next?

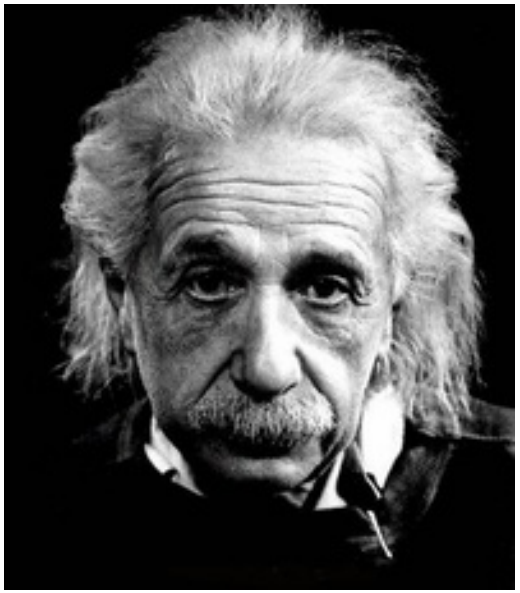
- Stay in touch
  - Tell me when 3110 helps you out with future courses (or jobs!)
  - Ask me cool PL questions
  - Drop by to tell me about the rest of your time in CS (and beyond!)… I really do like to know

- Crossing the finish line is just the beginning of the next race…
  DO AMAZING THINGS WITH YOUR LIFE

Final Exam

- Wednesday, 12/06/17, 9:00-11:30 am, Statler Auditorium
- Covers everything in the course
- You may have **three** pages of notes
- (remaining details posted on Piazza)
- Final grades will be in CMS about 7-10 days after exam

Finally



1879-1955

"Education is what remains after one has forgotten everything one learned in school." –Albert Einstein

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: a module you designed, or the OCaml language

- That kind of analysis is applicable anywhere, not just programming

Upcoming events

- [yesterday] A5 due, but no late penalties through Friday
- [by 12/06/17 8:00 am] submit a course eval; worth 1% of final grade; take time on this, especially the free response questions

This is …

This is victory.

THIS HAS BEEN 3110

Music: End credits from Final Fantasy IX