

## CSE341: Programming Languages

### Lecture 26 Course Victory Lap

Brett Wortzman  
Summer 2019

Slides originally created by Dan Grossman

## Final Exam

As also indicated in forthcoming email:

- **This Friday, 12:00-1:00PM**
- 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
- Sample exams were written for two hours; our exam will include a subset of the material

Summer 2019

CSE341: Programming Languages

2

## Victory Lap

A victory lap is an extra trip around the track

- By the exhausted victors (us) ☺

Review course goals

- Slides from Introduction and (skipped) Course-Motivation

Some big themes and perspectives

- Stuff for five years from now more than for the final

**Please do your course evaluations!!!**



Summer 2019

CSE341: Programming Languages

3

## [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

Summer 2019

CSE341: Programming Languages

4

## [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)]



Summer 2019

CSE341: Programming Languages

5

What is the best programming language?

What characteristics would you want in a best programming language?

Summer 2019

CSE341: Programming Languages

6

What is the best kind of car?

What is the best kind of shoes?

## Cars / Shoes

Cars are used for rather different things:

- Winning a Formula 1 race
- Taking kids to soccer practice
- Off-roading
- Hauling a mattress
- Getting the wind in your hair
- Staying dry in the rain

Shoes:

- Playing basketball
- Going to a formal
- Going to the beach

## More on cars

- A good mechanic might have a specialty, but also understands how "cars" (not a particular make/model) work
  - The paint color isn't essential (syntax)
- A good mechanical engineer really knows how cars work, how to get the most out of them, and how to design better ones
  - I don't have a favorite kind of car or a favorite PL
- To learn how car pieces interact, it may make sense to start with a classic design rather than the latest model
  - A popular car may not be best
  - May especially not be best for learning how cars work

## All cars are the same

- To make it easier to rent cars, it is great that they all have steering wheels, brakes, windows, headlights, etc.
  - Yet it is still uncomfortable to learn a new one
  - Can you be a great driver if you only ever drive one car?
- And maybe PLs are more like cars, trucks, boats, and bikes
- So are all PLs really the same...

## Are all languages the same?

Yes:

- Any input-output behavior implementable in language X is implementable in language Y [Church-Turing thesis]
- Java, ML, and a language with one loop and three infinitely-large integers are "the same"

Yes:

- Same fundamentals reappear: variables, abstraction, one-of types, recursive definitions, ...

No:

- The human condition vs. different cultures (travel to learn more about home)
- The primitive/default in one language is awkward in another
- Beware "the Turing tarpit" and "Maslow's Hammer"

## Functional Programming

Why spend 60-80% of course using *functional languages*:

- Mutation is discouraged
- Higher-order functions are very convenient
- One-of types via constructs like datatypes

Because:

1. These features are invaluable for correct, elegant, efficient software (great way to think about computation)
2. Functional languages have always been ahead of their time
3. Functional languages well-suited to where computing is going

Most of course is on (1), so a few minutes on (2) and (3) ...

### Ahead of their time

All these were dismissed as “beautiful, worthless, slow things PL professors make you learn”

- Garbage collection (Java didn't exist in 1995, PL courses did)
- Generics (`List<T>` in Java, C#), much more like SML than C++
- XML for universal data representation (like Racket/Scheme/LISP/...)
- Higher-order functions (Ruby, Javascript, C#, now Java, ...)
- Type inference (C#, Scala, ...)
- Recursion (a big fight in 1960 about this – I'm told ☺)
- ...

Summer 2019

CSE341: Programming Languages

13

### 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!

Summer 2019

CSE341: Programming Languages

14

### 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

Summer 2019

CSE341: Programming Languages

15

### Is this real programming?

- The way we use ML/Racket/Ruby can make them seem almost “silly” precisely because lecture and homework focus on interesting language constructs
- “Real” programming needs file I/O, string operations, floating-point, graphics, project managers, testing frameworks, threads, build systems, ...
  - Many elegant languages have all that and more
    - Including Racket and Ruby
  - If we used Java the same way, Java would seem “silly” too

Summer 2019

CSE341: Programming Languages

16

### Our languages, together

SML, Racket, and Ruby (along with Java) are a useful *combination*

	dynamically typed	statically typed
functional	Racket	SML
object-oriented	Ruby	Java

*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]

Summer 2019

CSE341: Programming Languages

17

### Summary

- 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

Summer 2019

CSE341: Programming Languages

18

## *A note on reality*

Reasonable questions when deciding to use/learn a language:

- What libraries are available for reuse?
- What tools are available?
- What can get me a job?
- What does my boss tell me to do?
- What is the de facto industry standard?
- What do I already know?

Our course by design does not deal with these questions

- You have the rest of your life for that
- And technology *leaders* affect the answers

*Beware Maslow's Hammer*

Summer 2019

CSE341: Programming Languages

19

## *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

Summer 2019

CSE341: Programming Languages

20

## *What now?*

- Use what you learned whenever you reason about software!
- CSE 401
- CSE 402
- CSE 505

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

Some current UW projects

- 3D-printing tools
- Checker framework
- Rosette
- Language for microfluidics
- Verified software written in Coq (which is quite SML-like)

Summer 2019

CSE341: Programming Languages

21

## *The End*

Thank you for a great quarter!



Don't be a stranger!

*Time for ask-me-almost-anything questions?*

Summer 2019

CSE341: Programming Languages

22