CS 360: Programming Languages

Welcome!

We have 14 weeks to learn *the fundamental concepts* of programming languages.

With hard work, patience, and an open mind, this course makes you a much better programmer

- Even in languages we won't use
- Learn the core ideas around which *every* language is built, despite countless surface-level differences and variations
- *Poor* course summary: "We learned Scheme and Java"

Today's class:

- Course mechanics
- *[A rain-check on motivation]*
- Dive into Racket

Concise to-do list

In the next 24-48 hours:

1. Find course web page: go to http://www.rhodes.edu/kirlin and click on our class.

2. Read course syllabus.

3. Get set up using DrRacket.
   - Installation/configuration/use instructions on web page (soon)
   - Essential; no reason to delay

Office hours

- Regular hours and locations on syllabus and webpage.
  - Changes as necessary announced on email list.

- Use them
  - *Please visit me.*
  - Ideally not *just* for homework questions (but that's good too).

Textbooks, or lack thereof

- No required textbook
  - I will provide online references for details you want/need to know.
  - Lots of additional online resources we will use to cover Racket and Java.

Laptops

- There will be times when we will be programming in class in partners.
- I will announce these times in advance and suggest you bring a laptop if you can.
- I will make sure each pair of people has a computer between them.

Projects

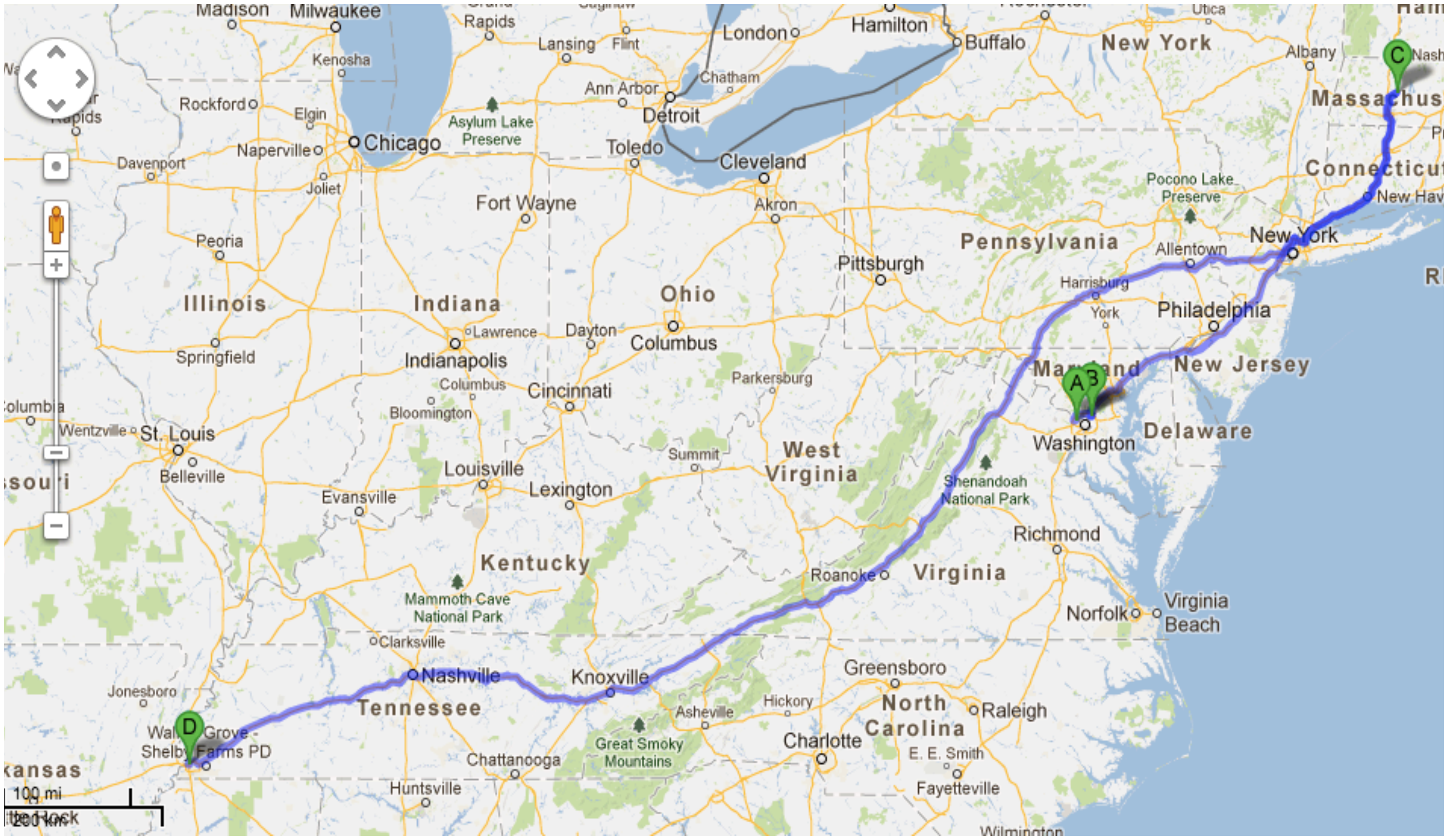
- Roughly seven total, including a final project
- To be done individually, unless otherwise specified (final project probably in pairs)
- Doing the homework involves:
  1. Understanding the concepts being addressed
  2. Writing code demonstrating understanding of the concepts
  3. Testing your code to ensure you understand and have correct programs
  4. "Playing around" with variations, incorrect answers, etc.

  We grade only (2), but focusing on (2) makes the homework harder

Academic Integrity

- Rule of thumb – don’t look at anyone else’s code, correct or incorrect.
- You are to complete assignments individually.
- You may discuss assignments in general terms with other students including a discussion of how to approach a problem, but the code you write must be your own.
- You may get help when you are stuck, but this help should be limited and should never involve details of how to code a solution.
- You may not have another person (current student, former student, tutor, friend, anyone) "walk you through" how to solve an assignment.
- a la CS 141

A little about me



A little about you

- Name
- Year at Rhodes (first-year, sophomore, etc.)
- Where you're from
- Your favorite movie of all time

Questions?

Anything I forgot about course mechanics before we discuss, you know, programming languages?

What this course is about

- Many essential concepts relevant in any programming language
  - And how these pieces fit together
- Use Racket and Java (possibly others) because:
  - They let many of the concepts "shine"
  - Using multiple languages shows how the same concept can "look different" or actually be slightly different
    in another language
- A big focus on *functional programming*
  - Not using *mutation* (assignment statements) (!)
  - Using *first-class functions* (can't explain that yet)

Let's start over

- For at least the next two weeks, *"let go of C++ and Python"*
  - Learn Racket as a "totally new way of programming"
  - Later we'll contrast with what you know
  - Saying "oh that is kind of like that thing in C++/Python" will confuse you, slow you down, and make you learn less

- In a few weeks, we'll have the background to
  - Intelligently motivate the course
  - Understand how functional programming is often simple, powerful, and good style – even when using Python or C++
  - Understand why functional programming is increasingly important in the "real world" even if Scheme isn't a widely popular language in industry.

My claim

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.

A strange environment

- The next few weeks will use
  - The Racket language (a variant of Scheme)
  - The DrRacket editing environment
  - A read-eval-print-loop (REPL) for evaluating programs
- *You* need to get things installed, configured, and usable
  - On your own machine
  - Instructions are online (read carefully; ask questions)
- Working in strange environments is a CS life skill

A very simple Racket program

```
; My first Racket program

(define x 3)

(define y 7)

(define z (- x y))

(define q (* (+ x 2) (- z 3)))

(define abs-of-z (if (< z 0) (- z) z))

(define abs-of-z-simpler (abs z))
```

Racket from the beginning

- A program is a sequence of *definitions* and *expressions*
  - A *definition* binds a value to a variable.
  - An *expression* is something that can be evaluated.
  - Expressions **always** evaluate to a *value* (definitions **never** do).

- Each binding or expression is evaluated in the order they appear, using the *environment* produced by any previous definitions and expressions.
  - Environment holds variables and their values (bindings).
  - A value is the result of evaluating an expression.

Semantics

- Syntax is how you write something.
- Semantics is what that something means.
  - Type-checking (at run time in Racket)
  - Evaluation (as the program runs)

  - What's an environment?

Definitions

```
(define q (* (+ x 2) (- z 3)))
```

More generally:

```
(define x e)
```

- *Syntax*:
  - *Keyword* **`define`**
  - *Variable* ***`x`***
  - *Expression* ***`e`***
    - many forms of these, most containing subexpressions
- *Semantics*:
  - Evaluate the expression ***`e`*** and add a binding to the current *environment*.

Expressions

- We will see many kinds of expressions:

  ```
  3   1/4   #f   #t    x   (+ e1 e2)  (* e1 e2)
  (if test e1 e2)
  ```

- Can get arbitrarily large since any subexpression can contain subsubexpressions, etc.
- Syntax and semantics vary depending on type of expression.

Expressions: Variables

- Syntax:
  - sequence of letters, digits, hyphen, underscore, not starting with digit
  - sometimes called *identifiers*
- Type-checking:
  - Not applicable
- Evaluation:
  - Look up value in current environment

Expressions: Addition

- Syntax:

  `(+ e1 e2)` where ***`e1`*** and ***`e2`*** are expressions

- Type-checking:

  If ***`e1`*** and ***`e2`*** have type **`integer`**,

  then ***`(+ e1 e2)`*** has type **`integer`**

  (also **`rational`**, **`real`**, **`complex`)**

- Evaluation:

  If ***`e1`*** evaluates to **`v1`** and ***`e2`*** evaluates to **`v2`**,

  then ***`(+ e1 e2)`*** evaluates to sum of **`v1`** and **`v2`**

Expressions: Values

- All values are expressions
- Not all expressions are values
- A value “evaluates to itself” in “zero steps”
- Examples:
  - `34`, `17`, `42` have type **`integer`**
  - `#t`, `#f` have type **`boolean`**

A slightly tougher one

What are the syntax, typing rules, and evaluation rules for conditional expressions?

What are the syntax, typing rules, and evaluation rules for less-than expressions?

The foundation we need

We have many more expressions to learn before we can write “anything interesting”

Syntax, typing rules, evaluation rules will guide us the whole way!

Preview of what’s to come:

- Mutation (a.k.a. assignment): use new bindings instead
- Statements: everything is an expression (well, except definitions)
- Loops: use recursion instead

Pragmatics

Lecture has emphasized building up from simple pieces

But in practice you make mistakes and get inscrutable messages

Example gotcha: **`(define x = 7)`** instead of **`(define x 7)`**

Work on developing resilience to mistakes

- Slow down
- Don't panic
- Read what you wrote very carefully