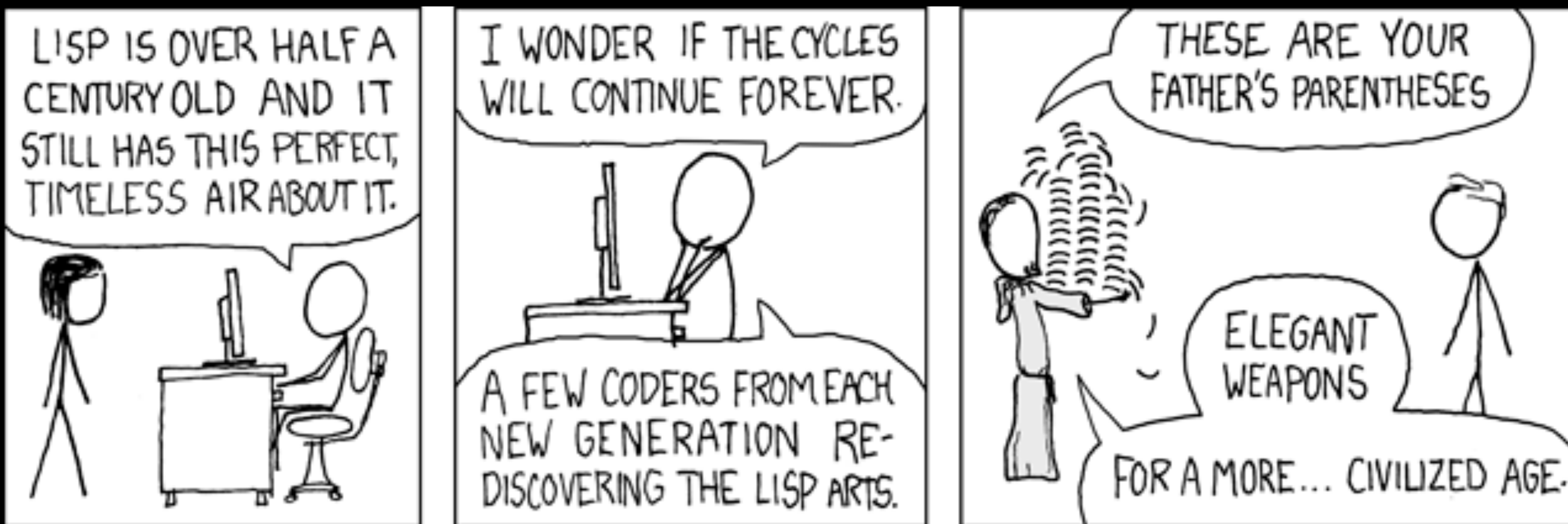


"Lisp Cycles", http://xkcd.com/297/

CS 152: *Programming Language Paradigms*

Introduction to Scheme

Prof. Tom Austin
San José State University

Key traits of Scheme

1. Functional
2. Dynamically typed
3. Minimal
4. Lots of lists!

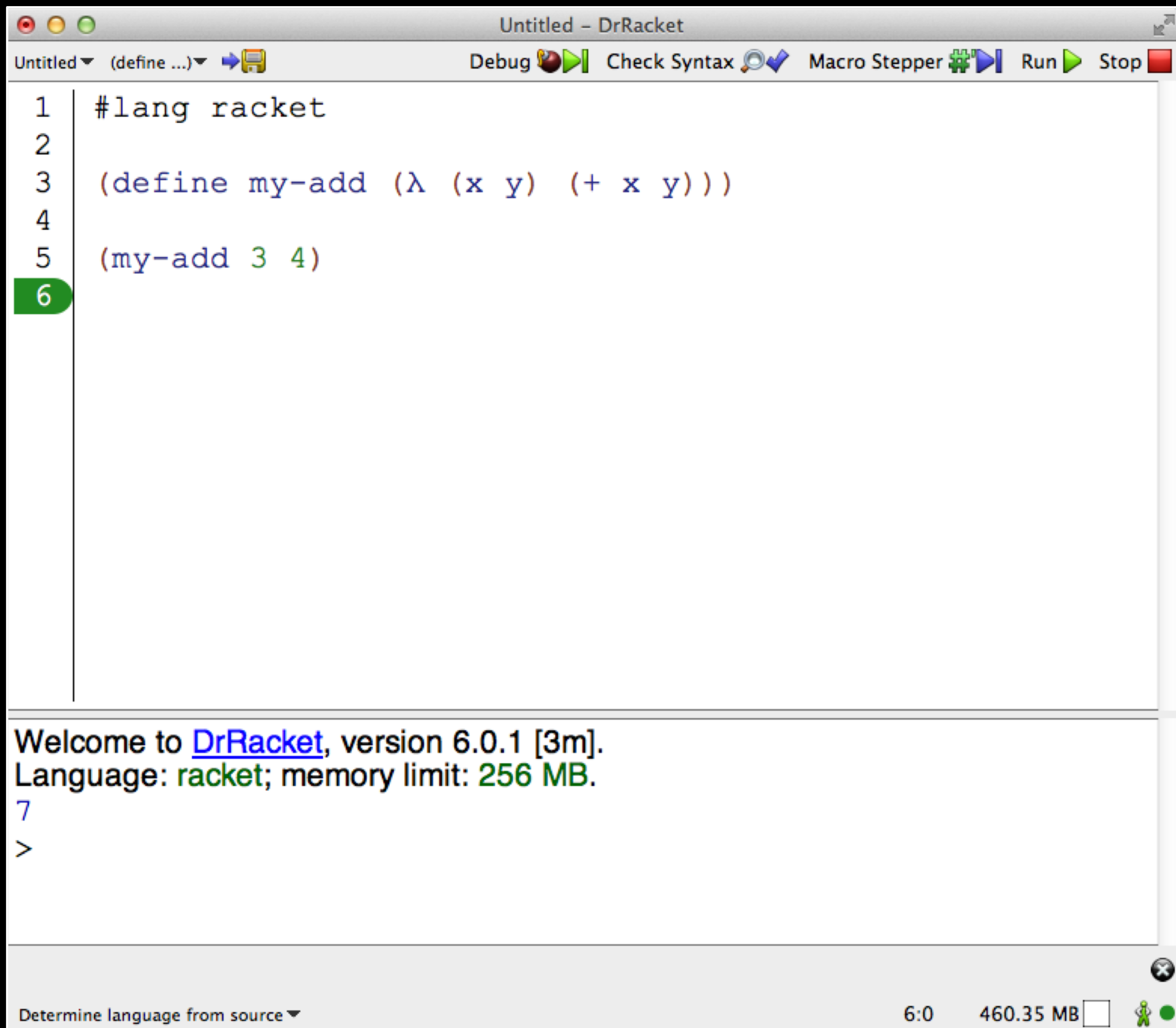
Interactive Racket

```
$ racket
Welcome to Racket
v6.0.1.
> (* (+ 2 3) 2)
10
>
```

Running Racket from Unix Command Line

```
$ cat hello-world.rkt
#lang racket
(displayln "Hello world")
$ racket hello-world.rkt
Hello world
$
```

DrRacket


Untitled – DrRacket
Untitled
(define ...)
Debug
Check Syntax
Macro Stepper
Run
Stop
#lang racket
(define my-add (λ (x y) (+ x y)))
(my-add 3 4)
Welcome to DrRacket, version 6.0.1 [3m].
Language: racket; memory limit: 256 MB.
7
>
Determine language from source
6:0
460.35 MB

Racket Simple Data Types

- Booleans: `#t, #f`
  - `(not #f)          =>       #t`
  - `(and #t #f)       =>       #f`
- Numbers: `32, 17`
  - `(/ 3 4)           =>       3/4`
  - `(expt 2 3)        =>       8`
- Characters: `#\c, #\h`

Racket Compound Data Types

- Strings
  - `(string #\S #\J #\S #\U)`
  - `"Spartans"`
- Lists: `'(1 2 3 4)`
  - `(car '(1 2 3 4)) => 1`
  - `(cdr '(1 2 3 4)) => '(2 3 4)`
  - `(cons 9 '(8 7)) => '(9 8 7)`

Setting values

```
(define zed "Zed")
```

Global variables only

Setting values

```
(define zed "Zed")
(displayln zed)

{let
  ([z2 (string-append zed zed)]
   [sum (+ 1 2 3 4 5)])
  (displayln z2)
  (displayln sum)}
```

Setting values

```
(define zed "Zed")
(displayln zed)

{let
  ([z2 (string-append zed zed)]
   [sum (+ 1 2 3 4 5)])
  (displayln z2)
  (displayln sum)}
```

List of local variables

Setting values

```
(define zed "Zed")
(displayln zed)

{let
  ([z2 (string-append zed zed)]
   [sum (+ 1 2 3 4 5)])
  (displayln z2)
  (displayln sum)}
```

Variable names

Setting values

```
(define zed "Zed")
(displayln zed)

{let
  ([z2 (string-append zed zed)]
   [sum (+ 1 2 3 4 5)])
  (displayln z2)
  (displayln sum)}
```

Variable definitions

Setting values

```
(define zed "Zed")
(displayln zed)

{let
  ([z2 (string-append zed zed)]
   [sum (+ 1 2 3 4 5)])
  (displayln z2)
  (displayln sum)}
```

Scope of variables

All the data types discussed so far are called *s-expressions* (s for symbolic).

Note that programs themselves are also s-expressions. **Programs are data.**

Lambdas (λ)

```
(lambda
  (x)
  (* x x))
```

Also known as "functions"

Lambdas (λ)

```
(λ
  (x)
  (* x x))
```

In DrRacket,
λ can be typed
with Ctrl + \

Lambdas (λ)

```
(lambda
  (x)
  (* x x))
```

Parameter list

Lambdas (λ)

```
(lambda
  (x)
  (* x x))
```

Function body

Lambdas (λ)

```
((lambda
   (x)
   (* x x))
 3)
```

Evaluates to 9

Lambdas (λ)

```
(define square
   (lambda (x)(* x x)))
(square 4)
```

Alternate Format

```
(define (square x)
   (* x x))
(square 4)
```

If Statements

```
(if (< x 0)
    (+ x 1)
    (- x 1))
```

If Statements

```
(if (< x 0)
    (+ x 1)
    (- x 1))
```

Condition

If Statements

```
(if (< x 0)
    (+ x 1)
    (- x 1))
```

"Then" branch

If Statements

```
(if (< x 0)
    (+ x 1)
    (- x 1))
```

"Else" branch

Cond Statements

```
(cond
    [(< x 0) "Negative"]
    [(> x 0) "Positive"]
    [else "Zero"])
```

Scheme does not let you reassign variables

"If you say that a is 5, you can't say it's something else later, because you just said it was 5. What are you, some kind of liar?"

--Miran Lipovača

Recursion

- Base case
  - when to stop
- Recursive step
  - calls function with a **smaller version** of the same problem

Algorithm to count Russian dolls

Recursive step

- Open doll
- *Count number dolls in the inner doll*
- Add 1 to the count

Base case

- No inside dolls
- return 1

An iterative definition of a `count-elems` function

Set count to 0.

For each element:

    Add 1 to the count.

The answer is the count.

BAD!!! Not the way that functional programmers do things.

A *recursive* definition of a `count-elems` function

Base case:

If a list is empty, then the answer is 0.

Recursive step:

Otherwise, the answer is 1 more than the size of the tail of the list.

Recursive Example

```
(define (count-elems lst)
  (cond [(= 0 (length lst)) 0]
        [else (+ 1
          (count-elems (cdr lst))
)]))

(count-elems '())
(count-elems '(1 2 3 4))
```

Recursive Example

Base case

```
(define (count-elems lst)
   (cond [(= 0 (length lst)) 0]
         [else (+ 1
            (count-elems (cdr lst))
)]))

(count-elems '())
(count-elems '(1 2 3 4))
```

Recursive Example

```
(define (count-elems lst)
  (cond [(= 0 (length lst)) 0]
        [else (+ 1
          (count-elems (cdr lst))
)]))
```

Recursive step

```
(count-elems '())
(count-elems '(1 2 3 4))
```

```
    (count-elems '(1 2 3 4))
=>  (+ 1 (count-elems '(2 3 4)))
=>  (+ 1 (+ 1 (count-elems '(3 4))))
=>  (+ 1 (+ 1 (+ 1 (count-elems '(4)))))
=>  (+ 1 (+ 1 (+ 1 (+ 1
                    (count-elems '())))))
=>  (+ 1 (+ 1 (+ 1 (+ 1 0))))
=>  (+ 1 (+ 1 (+ 1 1)))
=>  (+ 1 (+ 1 2))
=>  (+ 1 3)
=>  4
```

Mutual recursion

```
(define (is-even? n)
  (if (= n 0)
      #t
      (not (is-odd? (- n 1)))))

(define (is-odd? n)
  (if (= n 0)
      #f
      (not (is-even? (- n 1)))))
```

Text Adventure Example
(in class)

Lab1

Part 1: Implement a `max-num` function.
(Don't use the `max` function for this lab).

Part 2: Implement the "fizzbuzz" game.
sample run:

```
> fizzbuzz 15
"1 2 fizz 4 buzz fizz 7 8
fizz buzz 11 fizz 13 14
fizzbuzz"
```

First homework

Java example with large num

```
public class Test {
 public void main(String[] args){
    System.out.println(
        999999999999999999999 * 2);
    }
}
```

```
$ javac Test.java
Test.java:3: error: integer
number too large:
999999999999999999999

System.out.println(999999999
999999999999 * 2);
                   ^

1 error
```

Racket example

```
$ racket
Welcome to Racket v6.0.1.
> (* 2 999999999999999999999)
1999999999999999999998
>
```

HW1: implement a BigNum module

HW1 explores how you might support big numbers in Racket if it did *not* support them.

- Use a list of 'blocks' of digits, least significant block first. So 9,073,201 is stored as:
  ```
  '(201 73 9)
  ```
- Starter code is available at http://www.cs.sjsu.edu/~austin/cs152-summer18/hw/hw1/.

Before next class

- Read chapters 3-5 of *Teach Yourself Scheme*.
- If you accidentally see `set!` in chapter 5, pluck out your eyes lest you become impure.
  - Alternately, just never use `set!` (or get a 0 on your homework/exam).