# 61A Extra Lecture 8

Thursday, April 2

## Announcements

- Extra Homework 3 due Thursday 4/16 @ 11:59pm
  - Extending the object system created in Extra Lecture 6
- Extra Homework 4 due Thursday 4/23 @ 11:59pm (Warning: same day as Project 4 is due!)
  - Complete the three extensions to Project 4 described today



## Homoiconicity

## A Scheme Expression is a Scheme List

Scheme programs consist of expressions, which can be:

- Primitive expressions: 2 3.3 true + quotient
- Combinations: (quotient 10 2) (not true)

The built-in Scheme list data structure (which is a linked list) can represent combinations

```
scm> (list 'quotient 10 2)
(quotient 10 2)
scm> (eval (list 'quotient 10 2))
5
```

In such a language, it is straightforward to write a program that writes a program

(Demo)



## Homoiconic Languages

Languages have both a concrete syntax and an abstract syntax

(Python Demo)

A language is *homoiconic* if the abstract syntax can be read from the concrete syntax

(Scheme Demo)

Quotation is actually a combination in disguise

(Quote Demo)



## Macros

## Macros Perform Code Transformations

A macro is an operation performed on the source code of a program before evaluation

Macros exist in many languages, but are easiest to define correctly in homoiconic languages

Scheme has a **define-macro** special form that defines a source code transformation

```
(define-macro (twice expr)
  (list 'begin expr expr))
```

```
> (twice (print 2))
2
2
```

Evaluation procedure of a macro call expression:

- Evaluate the operator sub-expression, which evaluates to a macro
- Call the macro procedure on the operand expressions *without evaluating them first*
- Evaluate the expression returned from the macro procedure

(Demo)



## Problem 1

Define a macro that evaluates an expression for each value in a sequence

```
(define (map fn vals)
  (if (null? vals)
      ()
      (cons (fn (car vals))
            (map fn (cdr vals)))))

scm> (map (lambda (x) (* x x)) '(2 3 4 5))
(4 9 16 25)

(define-macro (for sym expr vals)
  (list 'map ____________________(list 'lambda (list sym) expr) vals)_____________________)

scm> (for x (* x x) '(2 3 4 5))
(4 9 16 25)
```

## Quasi-Quoting

(Demo)

## Variable-Length Parameter Lists

(Demo)

## Problem 2

Define a function nest that builds a nested list containing its arguments

```
(define (nest first . rest)
  (if (null? rest)
      (list first)
      (list first (apply nest rest))))
```

```
scm> (nest 3)
(3)
scm> (nest 3 4 5 6)
(3 (4 (5 (6))))
```

## Temporary Symbols

(Demo)