

# SCHEME

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## COMPUTER SCIENCE MENTORS 61A

October 23 to October 26, 2017

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Scheme is a programming language, much like Python. In fact, many of Python's design features were inspired by Scheme. The point of learning this language is twofold: one, we're looking into what parts of Python generalize to other languages. Two, we want to start thinking about how to design and build (an interpreter for) a programming language, and it turns out Scheme is a nice one to build. In fact, we'll show you enough of the language in this hour to write recursive procedures. This section covers the basics. You'll learn the rest in lab and discussion. It's pretty awesome that we'll be picking up a whole new programming language within an hour.

Visit [scheme.cs61a.org](http://scheme.cs61a.org) to try the online interpreter. Type `(demo 'autopair)` and the interpreter will automatically draw box-and-pointer diagrams whenever an expression evaluates to a Scheme pair.

## 1 What Would Scheme Print?

1. What will Scheme output? Draw box-and-pointer diagrams to help determine this.

```
scm> 3.14
```

**Solution:** 3.14

```
scm> pi
```

**Solution:** Error

```
scm> (define pi 3.14)
```

**Solution:** pi

```
scm> pi
```

**Solution:** 3.14

```
scm> 'pi
```

**Solution:** pi

```
scm> (if 2 3 4)
```

**Solution:** 3

```
scm> (if 0 3 4)
```

**Solution:** 3

```
scm> (if #f 3 4)
```

**Solution:** 4

```
scm> (if nil 3 (/ 1 0))
```

**Solution:** 3

```
scm> (if (= 1 2)
         'a
         (if (= 1 (- 2 1))
              'b
              'c))
```

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```
scm> (define n 5)
```

```
scm> (cond ((> n 6) 'a)
```

```
scm> (define (factorial n)
      (if (= n 0)
          1
          (* n (factorial (- n 1)) )))
```

**Solution:** factorial

```
scm> (factorial 5)
```

**Solution:** 120

```
scm> (= 2 3)
```

**Solution:** #f

```
scm> (= '() '())
```

**Solution:** Error

```
scm> (eq? '() '())
```

**Solution:** #t

```
scm> (eq? nil nil)
```

**Solution:** #t

```
scm> (eq? '() nil)
```

**Solution:** #t

## 2 Code Writing in Scheme

2. **Hailstone yet again** Define a program called `hailstone`, which takes in two numbers `seed` and `n`, and returns the  $n$ th hailstone number in the sequence starting at `seed`. Assume the hailstone sequence starting at `seed` is longer or equal to `n`. As a reminder, to get the next number in the sequence, if the number is even, divide by two. Else, multiply by 3 and add 1.

### Useful procedures

- `quotient`: floor divides, much like `//` in python  
(`quotient 103 10`) outputs 10
- `remainder`: takes two numbers and computes the remainder of dividing the first number by the second  
(`remainder 103 10`) outputs 3

### Solution:

```
(define (hailstone seed n)
  (if (= n 0)
      seed
      (if (= 0 (remainder seed 2))
          (hailstone
            (quotient seed 2)
            (- n 1))
          (hailstone
            (+ 1 (* seed 3))
            (- n 1))
          )
      )
  )
)
```

### 3 Scheme Lists

```
scm> (pair? (cons 1 2))
```

**Solution:** #t

```
scm> (list? (cons 1 2))
```

**Solution:** #f

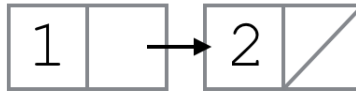
```
scm> (cons 1 2)
```

**Solution:** (1 . 2)



```
scm> (cons 1 (cons 2 nil))
```

**Solution:** (1 2)



```
scm> (null? (cdr (cons 1 nil)))
```

**Solution:** #t

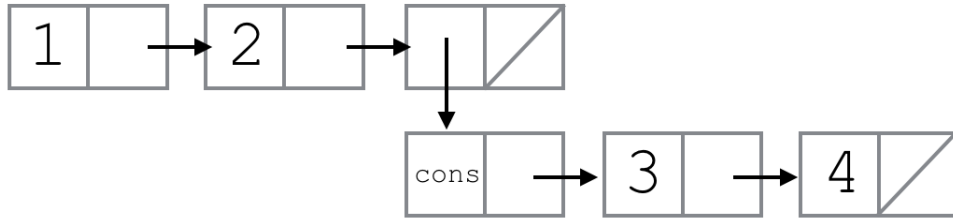
```
scm> (cons 1 '(2 3 4 5))
```

**Solution:** (1 2 3 4 5)



```
scm> (cons 1 '(2 (cons 3 4)))
```

**Solution:** (1 2 (cons 3 4))



```
scm> (define a (cons 1 (cons 2 3)))
```

**Solution:**

a

```
scm> a
```

**Solution:**

(1 2 . 3)

```
scm> (car a)
```

**Solution:**

1

```
scm> (cdr a)
```

**Solution:**

(2 . 3)

How can we get the 3 out of a?

**Solution:**

(cdr (cdr a))

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## 4 More Code Writing in Scheme

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3. Define `well-formed`, which determines whether `lst` is a well-formed list or not. Assume that `lst` only contains numbers.

```
; Doctests
> (well-formed '())
true
> (well-formed '(1 2 3))
true
; List doesn't end in nil
> (well-formed (cons 1 2))
false
; You do NOT need to check nested lists
> (well-formed (cons (cons 1 2) nil))
true
```

**Solution:**

```
; well-formed with nested if statements
(define (well-formed lst)
  (if (null? lst)
      #t
      (if (number? lst)
          #f
          (well-formed (cdr lst)))))

; well-formed with a cond statement
(define (well-formed lst)
  (cond ((null? lst) #t)
        ((number? lst) #f)
        (else (well-formed (cdr lst)))))
```

4. Define `is-prefix`, which takes in a list `p` and a list `lst` and determines if `p` is a prefix of `lst`.

```
; Doctests:
> (is-prefix '() '())
true
> (is-prefix '() '(1 2))
true
> (is-prefix '(1) '(1 2))
true
> (is-prefix '(2) '(1 2))
false
; Note here p is longer than lst
> (is-prefix '(1 2) '(1))
false
```

**Solution:**

```
; is-prefix with nested if statements
(define (is-prefix p lst)
  (if (null? p)
      #t
      (if (null? lst)
          #f
          (and
            (= (car p) (car lst))
            (is-prefix (cdr p) (cdr lst))))))

; is-prefix with a cond statement
(define (is-prefix p lst)
  (cond ((null? p) #t)
        ((null? lst) #f)
        (else (and (= (car p) (car lst))
                    (is-prefix (cdr p) (cdr lst))))))
```