CS 61A
Fall 2024

Scheme, Scheme Lists

Discussion 9: November 6, 2024

Switch to Pensieve:

- **Everyone**: Go to pensieve.co, log in with your @berkeley.edu email, and **enter your group number** (which was in the email that assigned you to this lab).

Once you're on Pensieve, you don't need to return to this page; Pensieve has all the same content (but more features). If for some reason Penseive doesn't work, return to this page and continue with the discussion.

Getting Started

To get help from a TA, If you do not have an in-person TA, you can reach your TA using this Zoom link.

If there are fewer than 3 people in your group, feel free to merge your group with another group in the room.

Everybody say your name, and then figure out who most recently pet a dog. (Feel free to share dog photos. Even cat photos are acceptable.)

Scheme

Q1: Perfect Fit

Definition: A perfect square is `k*k` for some integer `k`.

Implement `fit`, which takes non-negative integers `total` and `n`. It returns whether there are `n` **different** positive perfect squares that sum to `total`.

Important: Don't use the Scheme interpreter to tell you whether you've implemented it correctly. Discuss! On the final exam, you won't have an interpreter.

```
; Return whether there are n perfect squares with no repeats that sum to total

(define (fit total n)
    (define (f total n k)
        (if (and (= n 0) (= total 0))
            #t
        (if (< total (* k k))
            #f
        (or (f total n (+ k 1)) (f (- total (* k k)) (- n 1) (+ k 1)))
        )))
    (f total n 1))

(expect (fit 10 2) #t)  ; 1*1 + 3*3
(expect (fit 9 1)  #t)  ; 3*3
(expect (fit 9 2)  #f)  ;
(expect (fit 9 3)  #f)  ; 1*1 + 2*2 + 2*2 doesn't count because of repeated 2*2
(expect (fit 25 1)  #t) ; 5*5
(expect (fit 25 2)  #t) ; 3*3 + 4*4
```

Use the `(or _ _)` special form to combine two recursive calls: one that uses `k*k` in the sum and one that does not. The first should subtract `k*k` from `total` and subtract 1 from `n`; the other should leaves `total` and `n` unchanged.

Presentation Time: As a group, come up with one sentence describing how your implementation makes sure that all `n` positive perfect squares are **different** (no repeats). Once your group agrees on an answer, pick someone who hasn't presented to the course staff recently to share your group's answer with your TA (in person or on Zoom).

Scheme Lists & Quotation

Scheme lists are linked lists. Lightning review:

- `nil` and `()` are the same thing: the empty list.
- `(cons first rest)` constructs a linked list with `first` as its first element. and `rest` as the rest of the list, which should always be a list.
- `(car s)` returns the first element of the list `s`.
- `(cdr s)` returns the rest of the list `s`.
- `(list ...)` takes n arguments and returns a list of length n with those arguments as elements.
- `(append ...)` takes n lists as arguments and returns a list of all of the elements of those lists.
- `(draw s)` draws the linked list structure of a list `s`. It only works on code.cs61a.org/scheme. **Try it now with something like `(draw (cons 1 nil))`.**

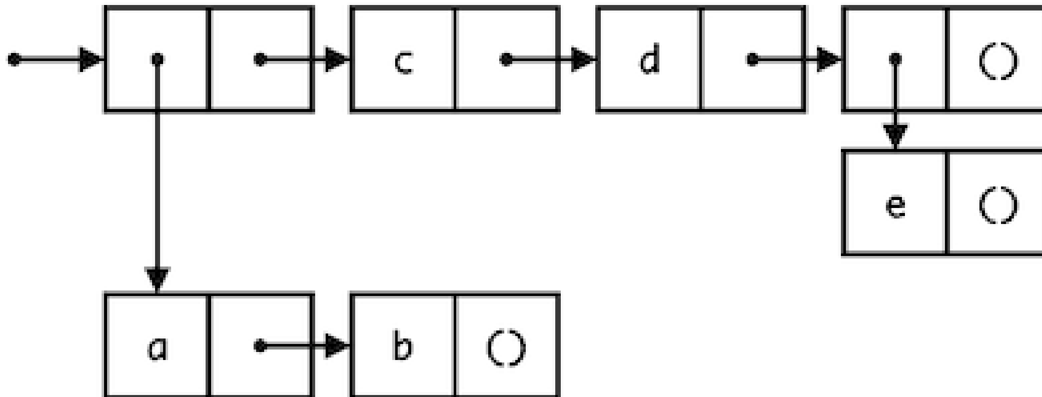
Quoting an expression leaves it unevaluated. Examples: * `'four` and `(quote four)` both evaluate to the symbol `four`. * `'(2 3 4)` and `(quote (2 3 4))` both evaluate to a list containing three elements: 2, 3, and 4. * `'(2 3 four)` and `(quote (2 3 four))` evaluate to a list containing 2, 3, and the symbol `four`.

Here's an important difference between `list` and quotation:

```
scm> (list 2 (+ 3 4))
(2 7)
scm> '(2 (+ 3 4))
(2 (+ 3 4))
```

Q2: Nested Lists

Create the nested list depicted below three different ways: using `list`, `quote`, and `cons`.



First, describe the list together: "It looks like there are four elements, and the first element is …" If you get stuck, look at the hint below. (But try to describe it yourself first!)

A four-element list in which the first element is a list containing both `a` and `b`, the second element is `c`, the third element is `d`, and the fourth element is a list containing just `e`.

Next, use calls to `list` to construct this list. If you run this code and then `(draw with-list)` in code.cs61a.org, the `draw` procedure will draw what you've built.

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.

```
(define with-list
    (list
        (list 'a 'b) 'c 'd (list 'e)
    )
)
; (draw with-list)  ; Uncomment this line to draw with-list
```

Every call to list creates a list, and there are three different lists in this diagram: a list containing `a` and `b`: `(list 'a 'b)`, a list containing `e`: `(list 'e)`, and the whole list of four elements: `(list _ 'c 'd _)`. Try to put these expressions together.

Now, use `quote` to construct this list.

```
(define with-quote
    '(
        (a b) c d (e)
    )

)
; (draw with-quote)  ; Uncomment this line to draw with-quote
```

One quoted expression is enough, but it needs to match the structure of the linked list using Scheme notation. So, your task is to figure out how this list would be displayed in Scheme.

The nested list drawn above is a four-element list with lists as its first and last elements: `((a b) c d (e))`. Quoting that expression will create the list.

Now, use `cons` to construct this list. Don't use `list`. You can use `first` in your answer.

```
(define first
    (cons 'a (cons 'b nil)))
```

```
(define with-cons
    (cons
        first (cons 'c (cons 'd (cons (cons 'e nil) nil)))
    )
)
; (draw with-cons)  ; Uncomment this line to draw with-cons
```

The provided `first` is the first element of the result, so the answer takes the form:

```
first ____
```

You can either fill in the blank with a quoted three-element list:

```
'(___ ___ ___)
   c   d  (e)
```

or with nested calls to `cons`:

```
(cons ___ (cons ___ (cons ___ nil)))
       c         d        (e)
```

Q3: Pair Up

Implement `pair-up`, which takes a list `s`. It returns a list of lists that together contain all of the elements of `s` in order. Each list in the result should have 2 elements. The last one can have up to 3.

Look at the examples together to make sure everyone understands what this procedure does.

```
;;; Return a list of pairs containing the elements of s.
;;;
;;; scm> (pair-up '(3 4 5 6 7 8))
;;; ((3 4) (5 6) (7 8))
;;; scm> (pair-up '(3 4 5 6 7 8 9))
;;; ((3 4) (5 6) (7 8 9))
(define (pair-up s)
    (if (<= (length s) 3)
        (list s)
        (cons (list (car s) (car (cdr s))) (pair-up (cdr (cdr s))))
    ))

(expect (pair-up '(3 4 5 6 7 8)) ((3 4) (5 6) (7 8)) )
(expect (pair-up '(3 4 5 6 7 8 9)) ((3 4) (5 6) (7 8 9)) )
```

`pair-up` takes a list (of numbers) and returns a list of lists, so when `(length s)` is less than or equal to 3, return a list containing the list `s`. For example, `(pair-up (list 2 3 4))` should return `((2 3 4))`.

Use `(cons _ (pair-up _))` to create the result, where the first argument to `cons` is a list with two elements: the `(car s)` and the `(car (cdr s))`. The argument to `pair-up` is everything after the first two elements.

Discussion: What's the longest list `s` for which `(pair-up (pair-up s))` will return a list with only one element? (Don't just guess and check; discuss!)

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.

Document the Occasion

Please all fill out the attendance form (one submission per person per week).