CS 257: Non-Imperative Programming: Scheme!
Homework 5 (Spring ’07)

Part I

1. Exercises 7.2, 7.3, 7.6, 7.7, 7.8

2. Consider the following definition of unary-map:

   (define unary-map
     (lambda (proc ls)
       (if (null? ls)
           ()
           (cons (proc (car ls))
                 (unary-map proc (cdr ls))))))

Rewrite unary-map so that it is tail recursive. Hint: Look at the tail recursive definition of append.

3. Write a function, disjunction2, which takes two predicates as arguments and returns the predicate which returns #t if either predicate does not return #f. For example:

   > ((disjunction2 symbol? procedure?) +)
   #t
   > ((disjunction2 symbol? procedure?) (quote +))
   #t
   > (filter (disjunction2 even? (lambda (x) (< x 4))) (iota 8))
   (1 2 3 4 6 8)
   >

4. Now write disjunction, which takes an arbitrary number (> 0) of predicates as arguments.

5. A matrix, \[
\begin{bmatrix}
1 & 2 \\
3 & 4
\end{bmatrix}
\], can be represented in Scheme as a list of lists: ((1 2) (3 4)). Without using recursion, write a function, matrix-map, which takes a function, f, and a matrix, A, as arguments and returns the matrix, B, consisting of f applied to the elements of A, i.e., \[B_{ij} = f(A_{ij}).\]

   > (matrix-map (lambda (x) (* x x)) (1 2) (3 4))
   (((1 4) (9 16))

6. Using the function, iterate, and without using recursion, give a definition for the function, iota.
Part II

Using the functions, apply, select, map, filter, outer-product and iota, and without using recursion, give definitions for the following functions:

1. length - returns the length of a list.
2. sum-of-squares - returns the sum of the squares of its arguments.
3. avg - returns the average of its arguments.
4. avg-odd - returns the average of its odd arguments.
5. shortest - returns the shortest of its list arguments.
6. avg-fact - returns the average of the factorials of its arguments.
7. tally - takes a predicate and a list and returns the number of list elements which satisfy the predicate.
8. assoc - takes a key and a list of pairs and returns the pair with car equal to the key.
9. list-ref - takes a list and an integer, n, and returns the n-th element of the list.