1 Mutation

1.1 For each row below, fill in the blanks in the output displayed by the interactive Python interpreter when the expression is evaluated. Expressions are evaluated in order, and expressions may affect later expressions.

```python
>>> cats = [1, 2]  
>>> dogs = [cats, cats.append(23), list(cats)]  
>>> cats

[1, 2, 23]

>>> dogs[1] = list(dogs)  
>>> dogs[1]

[[1, 2, 23], None, [1, 2, 23]]

>>> dogs[0].append(2)  
>>> cats

[1, 2, 23, 2]

>>> cats[1::2]

[2, 2]

>>> cats[:3]

[1, 2, 23]

>>> dogs[2].extend([list(cats).pop(0), 3])  
>>> dogs[3]

Index Error

>>> dogs
```
[[1, 2, 23, 2], [[1, 2, 23, 2], None, [1, 2, 23, 1, 3]], [1, 2, 23, 1, 3]]
2 Recursion

2.1 (Adapted from Fall 2013) Fill in the blanks in the implementation of `paths`, which takes as input two positive integers `x` and `y`. It returns a list of paths, where each path is a list containing steps to reach `y` from `x` by repeated incrementing or doubling. For instance, we can reach 9 from 3 by incrementing to 4, doubling to 8, then incrementing again to 9, so one path is `[3, 4, 8, 9]`

```python
def paths(x, y):
    """Return a list of ways to reach y from x by repeated incrementing or doubling.
    >>> paths(3, 5)
    [[3, 4, 5]]
    >>> sorted(paths(3, 6))
    [[3, 4, 5, 6], [3, 6]]
    >>> sorted(paths(3, 9))
    [[3, 4, 5, 6, 7, 8, 9], [3, 4, 8, 9], [3, 6, 7, 8, 9]]
    >>> paths(3, 3) # No calls is a valid path
    [[3]]
    """
    if ________________:
        return ________________________________
    elif ________________:
        return ________________________________
    else:
        a = _________________________________
        b = _________________________________
        return ________________________________
```

```python
def paths(x, y):
    if x > y:
        return []
    elif x == y:
        return [[x]]
    else:
        a = paths(x + 1, y)
        b = paths(x * 2, y)
        return [[x] + subpath for subpath in a + b]
```
3 Trees

3.1 Implement `long_paths`, which returns a list of all paths in a tree with length at least \( n \). A path in a tree is a linked list of node values that starts with the root and ends at a leaf. Each subsequent element must be from a child of the previous value’s node. The length of a path is the number of edges in the path (i.e. one less than the number of nodes in the path). Paths are listed in order from left to right. See the doctests for some examples.

```python
def long_paths(tree, n):
    """Return a list of all paths in tree with length at least n."

    >>> t = Tree(3, [Tree(4), Tree(4), Tree(5)])
    >>> left = Tree(1, [Tree(2), t])
    >>> mid = Tree(6, [Tree(7, [Tree(8)]), Tree(9)])
    >>> right = Tree(11, [Tree(12, [Tree(13, [Tree(14)])])])
    >>> whole = Tree(0, [left, Tree(13), mid, right])
    >>> for path in long_paths(whole, 2):
    ...     print(path)
    ...     print(path)
    ...     print(path)
    ...
    <0 1 2>
    <0 1 3 4>
    <0 1 3 4>
    <0 1 3 5>
    <0 6 7 8>
    <0 6 9>
    <0 11 12 13 14>
    >>> for path in long_paths(whole, 3):
    ...     print(path)
    ...     print(path)
    ...
    <0 1 3 4>
    <0 1 3 4>
    <0 1 3 5>
    <0 6 7 8>
    <0 11 12 13 14>
    >>> long_paths(whole, 4)
    [Link(0, Link(11, Link(12, Link(13, Link(14))))))]
    ""

    paths = []
    if n <= 0 and tree.is_leaf():
        paths.append(Link(tree.label))
    for b in tree.branches:
        for path in long_paths(b, n - 1):
            paths.append(Link(tree.label, path))
    return paths
```

4 Streams

4.1 Write a function merge that takes 2 sorted streams s1 and s2, and returns a new sorted stream which contains all the elements from s1 and s2. Assume that both s1 and s2 have infinite length.

(define (merge s1 s2)

  (if ________________________________________________________________

      ________________________________________________________________

      ________________________________________________________________

      ________________________________________________________________))

(define (merge s1 s2)
  (if (< (car s1) (car s2))
    (cons-stream (car s1) (merge (cdr-stream s1) s2))
    (cons-stream (car s2) (merge s1 (cdr-stream s2)))))

Video walkthrough

4.2 (Adapted from Fall 2014) Implement cycle which returns a stream repeating the digits 1, 3, 0, 2, and 4, forever. Write cons-stream only once in your solution!

**Hint:** \((3+2) \mod 5 = 0\).

(define (cycle start)

  ________________________________________________________________)

(define (cycle start)
  (cons-stream start (cycle (modulo (+ start 2) 5))))

Video walkthrough
5 Generators

5.1 Implement accumulate, which takes in an iterable and a function \( f \) and yields each accumulated value from applying \( f \) to the running total and the next element.

```python
from operator import add, mul

def accumulate(iterable, f):
    """
    >>> list(accumulate([1, 2, 3, 4, 5], add))
    [1, 3, 6, 10, 15]
    >>> list(accumulate([1, 2, 3, 4, 5], mul))
    [1, 2, 6, 24, 120]
    """
    it = iter(iterable)

    total = next(it)
    yield total
    for element in it:
        total = f(total, element)
        yield total
```
5.2 Implement `sum_paths_gen`, which takes in a Tree instance `t` and returns a generator which yields the sum of all the nodes from a path from the root of a tree to a leaf.

You may yield the sums in any order.

```python
def sum_paths_gen(t):
    """
    >>> t1 = Tree(5)
    >>> next(sum_paths_gen(t1))
    5
    >>> t2 = Tree(1, [Tree(2, [Tree(3), Tree(4)]), Tree(9)])
    >>> sorted(sum_paths_gen(t2))
    [6, 7, 10]
    """

    if ____________________________:
        yield ______________________

    for ____________________________:
        for ____________________________:
            yield ______________________

def sum_paths_gen(t):
    if t.is_leaf():
        yield t.label
    for b in t.branches:
        for s in sum_paths_gen(b):
            yield s + t.label
```
6 Macros

6.1 Using macros, let’s make a new special form, when, that has the following structure:

\[
(\text{when } \text{<condition>} \\
(\text{<expr1> } \text{<expr2> } \text{<expr3> } \ldots))
\]

If the condition is not false (a truthy expression), all the subsequent operands are evaluated in order and the value of the last expression is returned. Otherwise, the entire when expression evaluates to okay.

scm> (when (= 1 0) ((/ 1 0) 'error))
okay
scm> (when (= 1 1) ((print 6) (print 1) 'a))
6
1
a

(a) Fill in the skeleton below to implement this without using quasiquotes.

\[
(\text{define-macro } (\text{when } \text{condition exprs}) \\
(\text{if } \text{condition} \ (\text{cons 'begin exprs) 'okay}))
\]

(b) Now, implement the macro using quasiquotes.

\[
(\text{define-macro } (\text{when } \text{condition exprs}) \\
'(\text{if condition (cons 'begin exprs) 'okay}))
\]

6.2 Write a macro that takes in a call expression and strips out every other argument. The first argument is kept, the second is removed, and so on. You may find it helpful to write a helper function.

\[
(\text{define-macro } (\text{prune-expr expr}) \\
(\text{define } (\text{prune lst}) \\
(\text{if } \text{(or (null? lst) (null? (cdr lst))) lst} \\
(\text{cons (car lst) (prune (cdr (cdr lst)))])))
\]

\[
(\text{define-macro } (\text{prune-expr expr}) \\
(\text{cons (car expr) (prune (cdr expr))]))
\]
scm> (prune-expr (+ 10))
10
scm> (prune-expr (+ 10 100))
10
scm> (prune-expr (+ 10 100 1000))
1010
scm> (prune-expr (prune-expr (+ 10 100) 'garbage))
10