

## 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.

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

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

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

```
>>> cats[1::2]
```

```
>>> cats[:3]
```

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

```
>>> dogs
```

## 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]`

```
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 _____
```

## 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.

```
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)
    ...
    <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)
    ...
    <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)))))]
    """
```

# 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 -----
      -----
      -----))
```

- 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) % 5 == 0`.

```
(define (cycle start)
```

```
  -----)
```

## 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.

```
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)
```

-----

-----

```
for -----:
```

-----

-----

## 6 Final Review

- 5.2 Write a generator function that yields functions that are repeated applications of a one-argument function  $f$ . The first function yielded should apply  $f$  0 times (the identity function), the second function yielded should apply  $f$  once, etc.

```
def repeated(f):
```

```
    """
```

```
    >>> double = lambda x: 2 * x
    >>> funcs = repeated(double)
    >>> identity = next(funcs)
    >>> double = next(funcs)
    >>> quad = next(funcs)
    >>> oct = next(funcs)
    >>> quad(1)
    4
    >>> oct(1)
    8
    >>> [g(1) for _, g in
    ... zip(range(5), repeated(lambda x: 2 * x))]
    [1, 2, 4, 8, 16]
    """
```

```
g = -----
```

```
while True:
```

```
-----
```

```
-----
```

- 5.3 Ben Bitdiddle proposes the following alternate solution. Does it work?

```
def ben_repeated(f):
```

```
    g = lambda x: x
```

```
    while True:
```

```
        yield g
```

```
        g = lambda x: f(g(x))
```

# 6 SQL

- 6.1 You're starting a new job at an animal shelter, and you've been tasked with keeping track of all the cats that are up for adoption!

We'll start with an empty table:

```
CREATE TABLE cats(name, weight DEFAULT 1, notes DEFAULT "meow");
```

- (a) What would SQL display?

```
sqlite> INSERT INTO cats(name) VALUES ("Tom"), ("Whiskers");
sqlite> SELECT * FROM cats;
```

```
sqlite> INSERT INTO cats VALUES
...> ("Mittens", 2, "Actually likes shoes"),
...> ("Rascal", 4, "Prefers to associate with dogs"),
...> ("Magic", 2, "Expert at card games");
sqlite> SELECT * FROM cats ORDER BY weight, name;
```

```
sqlite> UPDATE cats SET notes = "A cat" WHERE notes = "meow";
sqlite> SELECT name FROM cats WHERE notes = "A cat";
```

- (b) Cats of different weights require different quantities of food. We have the following table:

```
CREATE TABLE food AS
SELECT 1 AS cat_weight, 0.5 AS amount UNION
SELECT 2           , 2.5           UNION
SELECT 3           , 4.0           UNION
SELECT 4           , 4.5;
```

Write a query that calculates the total amount of food required to feed all the cats (this should work for any table of cats, not just the one we created above). In our example, we have two cats of weight 1, two cats of weight 2, and one cat of weight 4. The total food required is  $2 \times 0.5 + 2 \times 2.5 + 1 \times 4.5 = 10.5$ .

```
SELECT -----
FROM -----
WHERE -----;
```

# 7 Macros

7.1 Using macros, let's make a new special form, `when`, that has the following structure:

```
(when <condition>
  (<expr1> <expr2> <expr3> ...))
```

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.

```
(define-macro (when condition exprs)

  (list 'if_____)))
```

(b) Now, implement the macro using quasiquotes.

```
(define-macro (when condition exprs)

  `(if _____)))
```

7.2 Write a macro called `zero-cond` that takes in a list of clauses, where each clause is a two-element list containing two expressions, a predicate and a corresponding result expression. All predicates evaluate to a number. The macro should return the value of the expression corresponding to the first true predicate, *treating 0 as a false value*.

```
scm> (zero-cond
      ((0 'result1)
       ((- 1 1) 'result2)
       ((* 1 1) 'result3)
       (2 'result4)))
result3
```

```
(define-macro (zero-cond clauses)
  (cons 'cond
        (map _____
           _____
           _____)))
```