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]

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

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>>> dogs

[[1, 2, 23, 2], [[1, 2, 23, 2], None, [1, 2, 23, 1, 3]], [1, 2, 23, 1, 3]]
2 Recursion

2.1 Write a procedure `merge(s1, s2)` which takes two sorted (smallest value first) lists and returns a single list with all of the elements of the two lists, in ascending order. Use recursion.

**Hint:** If you can figure out which list has the smallest element out of both, then we know that the resulting merged list will have that smallest element, followed by the merge of the two lists with the smallest item removed. Don’t forget to handle the case where one list is empty!

```python
def merge(s1, s2):
    """ Merges two sorted lists
    >>> merge([1, 3], [2, 4])
    [1, 2, 3, 4]
    >>> merge([1, 2], [])
    [1, 2]
    """
    if ________________________________________________________________________:
        return s2
    elif ________________________________________________________________________:
        return s1
    elif ________________________________________________________________________:
        return _____________________________________________________________________
    else:
        return _____________________________________________________________________

    if len(s1) == 0:
        return s2
    elif len(s2) == 0:
        return s1
    elif s1[0] < s2[0]:
        return [s1[0]] + merge(s1[1:], s2)
    else:
```
return [s2[0]] + merge(s1, s2[1:])

2.2 Implement a function to solve the subset sum problem: you are given a list of integers and a number k. Is there a subset of the list that adds up to k?

def subset_sum(lst, k):
    
    if k == 0:
        return True
    elif lst == []:
        return False
    else:
        return subset_sum(lst[1:], k - lst[0]) or 
             subset_sum(lst[1:], k)
3 Streams

3.1 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

3.2 (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
4 Generators

4.1 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
```
4.2 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.

```python
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:
    __________________________________________________________________________
    __________________________________________________________________________
    __________________________________________________________________________

```
This solution does not work. The value $g$ changes with each iteration so the bodies of the lambdas yielded change as well.
5 SQL

5.1 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;

Tom|1|meow
Whiskers|1|meow
```

```
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;

Tom|1|meow
Whiskers|1|meow
Magic|2|Expert at card games
Mittens|2|Actually likes shoes
Rascal|4|Prefers to associate with dogs
```

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

Tom
Whiskers
```

(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 $2 \times 0.5 + 2 \times 2.5 + 1 \times 4.5 = 10.5$. 
Specifying the table name in the WHERE clause here is not necessary and was added just for clarity.

```sql
SELECT SUM(amount) FROM cats, food WHERE cats.weight = food.cat_weight;
```

### 6 Macros

6.1 Write the `let` special form as a macro called `let-macro`. Recall that `let` takes in a list of bindings and a body expression. It creates a temporary frame containing the given bindings, and returns the result of evaluating the body in this temporary frame. Do not use the `let` special form in your solution.

You may use the provided `cadr` procedure in your solution.

*Hint:* The built-in `map` procedure takes in a one-argument function and a list and returns the result of mapping the function to every element in the list.

```scheme
(define-macro (let-macro bindings body)
  (cons `(lambda ,bindings ,body) `(map cadr bindings))
)
```

```scheme
(define (cadr lst) (car (cdr lst)))
```

```scheme
scm> (define x 3)
x
scm> (let-macro ((x 1) (y 2)) (+ x y))
3
scm> (let-macro ((x 2) (y x)) (* x y))
6
```