1 Recursion

1.1 (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 _____________________________________________
```
1.2 We will now write one of the faster sorting algorithms commonly used, known as `merge sort`. Merge sort works like this:

1. If there is only one (or zero) item(s) in the sequence, it is already sorted!

2. If there are more than one item, then we can split the sequence in half, sort each half recursively, then merge the results, using the `merge` procedure described below. The result will be a sorted sequence.

Using the algorithm described, write a function `mergesort(seq)` that takes an unsorted sequence and sorts it.

Recall the `merge` procedure is as follows:

```python
def merge(s1, s2):
    # Merges two sorted lists
    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:])

def mergesort(seq):
```

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

2.1 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 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)])]), Tree(9)])
    >>> 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)))))]
    """
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
Write a function that takes a `Tree` object and returns the elements at the depth with the most elements.

In this problem, you may find it helpful to use the second optional argument to `sum`, which provides a starting value. All items in the sequence to be summed will be concatenated to the starting value. By default, start will default to 0, which allows you to sum a sequence of numbers. We provide an example of sum starting with a list, which allows you to concatenate items in a list.

```python
def widest_level(t):
    """
    >>> sum([[1], [2]], [])
    [1, 2]
    >>> t = Tree(3, [Tree(1, [Tree(1), Tree(5)]),
    ...       Tree(4, [Tree(9, [Tree(2)])])])
    >>> widest_level(t)
    [1, 5, 9]
    """
    levels = []
    x = [t]

    while ________________:
        ________________
        _______ = sum(_________________________ , [])

    return max(levels, key=____________________)
```

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3 Mutation

3.1 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
```

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

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

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

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

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

```python
>>> dogs
```
4.1 Fill in the classes `Emotion`, `Joy`, and `Sadness` below so that you get the following output from the Python interpreter.

```python
>>> Emotion.num
0
>>> joy = Joy()
>>> sadness = Sadness()
>>> Emotion.num # number of Emotion instances created
2
>>> joy.power
5
>>> joy.catchphrase() # Print Joy's catchphrase
Think positive thoughts
>>> sadness.catchphrase() # Print Sad's catchphrase
I'm positive you will get lost
>>> sadness.power
5
>>> joy.feeling(sadness) # When both Emotions have same power value, print "Together"
Together
>>> sadness.feeling(joy)
Together
>>> joy.power = 7
>>> joy.feeling(sadness) # Print the catchphrase of the more powerful feeling before the less powerful feeling
Think positive thoughts
I'm positive you will get lost
>>> sadness.feeling(joy)
Think positive thoughts
I'm positive you will get lost
```
class Emotion(_______):

def __init__(self):

def feeling(self, other):

class Joy(_______):

def catchphrase(self):

class Sadness(_______):

def catchphrase(self):

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
5. Write a recursive function `flip_two` that takes as input a linked list `lnk` and mutates `lnk` so that every pair is flipped.

```python
def flip_two(lnk):
    
    >>> one_lnk = Link(1)
    >>> flip_two(one_lnk)
    >>> one_lnk
    Link(1)
    >>> lnk = Link(1, Link(2, Link(3, Link(4, Link(5))))))
    >>> flip_two(lnk)
    >>> lnk
    Link(2, Link(1, Link(4, Link(3, Link(5))))))
    
    #
```
6 Generators

6.1 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:
        ______________________________________________________________________
        ______________________________________________________________________
        ______________________________________________________________________

    g = ______________________________________________________________________

    while True:
        ______________________________________________________________________
        ______________________________________________________________________
        ______________________________________________________________________
```

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

```python
def ben_repeated(f):
    g = lambda x: x
    while True:
        yield g
        g = lambda x: f(g(x))
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
6.3 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)
    while True:
        try:
            x = next(it)
            yield reduce(f, itertools.accumulate([x] + [next(it)]))
        except StopIteration:
            break
    
    for it in accumulate([1, 2, 3, 4, 5], lambda x, y: x + y):
        print(it)
    
    for it in accumulate([1, 2, 3, 4, 5], lambda x, y: x * y):
        print(it)
```

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7 Scheme

7.1 Implement the `append-stream` procedure, which takes in two streams and returns a
stream with the two streams concatenated. (Note that if the first stream is infinite,
the result will not contain any elements from the second stream.)

```scheme
(define s (cons-stream 1 (cons-stream 2 nil)))
s
(define a (append-stream s s))
a
(car a)
1
(car (cdr-stream a))
2
(car (cdr-stream (cdr-stream a)))
1
(car (cdr-stream (cdr-stream (cdr-stream a))))
2
```

```scheme
(define (append-stream s1 s2)
  ...)
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
Now implement `subset-stream`, which takes in a normal Scheme list and returns a stream with every possible subset of that Scheme list.

It might help to use `map-stream`, which we've defined for you:

```scheme
(define (map-stream f s)
  (if (null? s)
      nil
      (cons-stream (f (car s)) (map-stream f (cdr-stream s)))))
```

```scheme
scm> (define a (subset-stream '(1 2 3 4 5)))

```

```scheme
a
```

```scheme
scm> (car a)

```

```scheme
(1 2 3 4 5)
```

```scheme
scm> (car (cdr-stream a))

```

```scheme
(1 2 3 4)
```

```scheme
scm> (car (cdr-stream (cdr-stream a)))

```

```scheme
(1 2 3 5)
```

```scheme
scm> (car (cdr-stream (cdr-stream (cdr-stream a))))

```

```scheme
(1 2 3)
```

```scheme
(define (subset-stream lst)
```

---

*Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.*
7.3 Write a function that takes a procedure and applies to every element in a given nested list.

The result should be a nested list with the same structure as the input list, but with each element replaced by the result of applying the procedure to that element.

Use the built-in list? procedure to detect whether a value is a list.

\[
\text{(define (deep-map fn lst)}
\]

\[
\text{scm> (deep-map (lambda (x) (* x x)) '(1 2 3))}
\]
(1 4 9)

\[
\text{scm> (deep-map (lambda (x) (* x x)) '(1 ((4) 5) 9))}
\]
(1 ((16) 25) 81)

7.4 Write a tail recursive function that takes in a Scheme list and returns the numerical sum of all values in the list. You can assume that the list contains only numbers (no nested lists).

\[
\text{(define (sum lst)}
\]

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

(Adapted from Fall 2019) The scoring table has three columns, a player column of strings, a points column of integers, and a quarter column of integers. The players table has two columns, a name column of strings and a team column of strings. Complete the SQL statements below so that they would compute the correct result even if the rows in these tables were different than those shown. Important: You may write anything in the blanks including keywords such as WHERE or ORDER BY. Use the following table called courses for the questions below:

CREATE TABLE scoring AS
SELECT "Donald Stewart" AS player, 7 AS points, 1 AS quarter UNION
SELECT "Christopher Brown Jr." , 7, 1 UNION
SELECT "Ryan Sanborn", 3, 2 UNION
SELECT "Greg Thomas", 3, 2 UNION
SELECT "Cameron Scarlett", 7, 3 UNION
SELECT "Nikko Remigio", 7, 4 UNION
SELECT "Ryan Sanborn", 3, 4 UNION
SELECT "Chase Garbers", 7, 4;

CREATE TABLE players AS
SELECT "Ryan Sanborn" AS name, "Stanford" AS team UNION
SELECT "Donald Stewart", "Stanford" UNION
SELECT "Cameron Scarlett", "Stanford" UNION
SELECT "Christopher Brown Jr.", "Cal" UNION
SELECT "Greg Thomas", "Cal" UNION
SELECT "Nikko Remigio", "Cal" UNION
SELECT "Chase Garbers", "Cal";

8.1 Write a SQL statement to select a one-column table of quarters in which more than 10 total points were scored.

8.2 Write a SQL statement to select a two-column table of the points scored by each team. Assume that no two players have the same name.

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