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
Solution:
[1, 2, 23]

>>> dogs[1] = list(dogs)
>>> dogs[1]
Solution:
[[1, 2, 23], None, [1, 2, 23]]

>>> dogs[0].append(2)
>>> cats
Solution:
[1, 2, 23, 2]

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

Solution:
Index Error

>>> dogs

Solution:
[[1, 2, 23, 2], [1, 2, 23, 2], None, [1, 2, 23, 1, 3]],
[1, 2, 23, 1, 3]]
1. (Fall 2012) Draw the environment diagram.

```python
def box(a):
    def box(b):
        def box(c):
            nonlocal a
            a = a + c
            return (a, b)
        return box
    gift = box(1)
    return (gift(2), gift(3))
box(4)
```

Solution: [http://goo.gl/myL8Qq](http://goo.gl/myL8Qq)
3 Object-Oriented Programming

1. Assume these commands are entered in order. What would Python output?

```python
>>> class Foo:
...     def __init__(self, a):
...         self.a = a
...     def garply(self):
...         return self.baz(self.a)
>>> class Bar(Foo):
...     a = 1
...     def baz(self, val):
...         return val
>>> f = Foo(4)
>>> b = Bar(3)
>>> f.a
Solution: 4

>>> b.a
Solution: 3

>>> f.garply()
Solution: AttributeError: 'Foo' object has no attribute 'baz'

>>> b.garply()
Solution: 3

>>> b.a = 9
>>> b.garply()
Solution: 9

>>> f.baz = lambda val: val * val
>>> f.garply()
```
Solution: 16
Mutable Linked Lists and Trees

1. 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)))))
    ""
    if lnk == Link.empty or lnk.rest == Link.empty:
        return
    lnk.first, lnk.rest.first = lnk.rest.first, lnk.first
    flip_two(lnk.rest.rest)
```

2. Write a function `flatten` that given a Tree `t`, will return a linked list of the elements of `t`, ordered by level. Entries on the same level should be ordered from left to right. For example, the following tree will return the linked list `<1 2 3 4 5 6 7>`.

```python
def flatten(t):
    def flatten_helper(queue):
        if not queue:
            return
        curr = queue.pop(0)
        for b in curr.branches:
            queue.append(b)
        return queue
    return flatten_helper(make_queue(t))
```
queue.append(b)

    return Link(curr.label, flatten_helper(queue))

    return flatten_helper([t])
1. Consider the following Scheme tree data abstraction.

```
(define (make-tree label branches) (cons label branches))
(define (label tree) (car tree))
(define (branches tree) (cdr tree))
(define tree 'below-example)
```

```
   +--------+--------+
   |       |       |
   6      7      2
   |       |       |
   +--+--+ | +--+--+
   | | | | | | |
   9 8 1 6 4
   | |
   |
   3
```

Write a procedure `tree-sums` that takes a tree of numbers (like the one above) and outputs a list of sums from following each possible path from label to leaf.

**Hint**: You may find the `flatten` procedure helpful.

```
(define flatten lst)
  (cond ((null? lst) nil)
        ((list? (car lst)) (append (flatten (car lst)) (flatten (cdr lst))))
        (else (cons (car lst) (flatten (cdr lst))))))
```

```
(define (flatten '(0 (1) ((2)) (3 ((4)))))
(0 1 2 3 4)
```

```
(scm> (flatten '(0 (1) ((2)) (3 ((4)))))
(0 1 2 3 4)
scm> (tree-sums tree)
(20 19 13 16 11)
```
### Solution:

(define (tree-sums tree)
  (if (null? (branches tree))
      (list (label tree))
      (map (lambda (x) (+ x (label tree)))
           (flatten (map tree-sums (branches tree))))))

```
6 Streams

1. (Summer 2012 Final) What are the first five values in the following stream?

```python
def my_stream():
    def compute_rest():
        return add_streams(filter_stream(lambda x: x % 2 == 0, my_stream()), map_stream(lambda x: x + 2, my_stream()))
    return Stream(2, compute_rest)
```

Solution: 2, 6, 14, 30, 62

2. (Fall 2014) Define `cycle` that returns a Stream repeating the digits 1, 3, 0, 2, and 4. Hint: \((3+2) \mod 5\) equals 0.

```python
def cycle(start=1):
    """Return a stream repeating 1, 3, 0, 2, 4 forever."
    >>> first_k(cycle(), 12) # Return the first 12 elements as a list
    [1, 3, 0, 2, 4, 1, 3, 0, 2, 4, 1, 3]
    """
    def compute_rest():
        return ___________________________

    return Stream(________________________, __________________________)
```

Solution:
```python
def cycle(start=1):
    def compute_rest():
        return cycle((start + 2) % 5)
    return Stream(start, compute_rest)
```
Generators

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):
    ""
    >>> [g(1) for _, g in ...
        ... zip(range(5), repeated(double))]
    [1, 2, 4, 8, 16]
    """
    g = ______________________________

    while True:
        ____________________________
        ____________________________

    Solution:
def repeated(f):
    g = lambda x: x
    while True:
        yield g
    g = (lambda g: lambda x: f(g(x)))(g)
```

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))
```

Solution: This solution does not work. The value \( g \) changes with each iteration so the bodies of the lambdas yielded change as well.
1. You’re trying to re-organize your music library! The table `tracks` below contains song titles and the corresponding album. Create another table `tracklist` with two columns: the album and a comma-separated list of all songs from that album in alphabetical.

```sql
create table tracks as
select "Human" as title, "The Definition" as album union
select "Simple and Sweet", "The Definition" union
select "Paper Planes", "Translations Through Speakers";

create table tracklist as
with
    songs(album, total) as ( ( )
),
    ( ) as ( ( )
    )
select ( )
where ( );
```

**Solution:**
create table tracklist as
with
    songs(album, total) as ( ( select album, count(*) from tracks group by album )
),
listing(album, songs_so_far, last_song, num_songs_so_far) as (  
  select album, title, title, 1 from tracks union  
  select l.album, songs_so_far || ', ' || title, title,  
    num_songs_so_far + 1  
  from tracks as t, listing as l  
  where l.album = t.album and title > last_song  
)  
select l.album, l.songs_so_far  
from songs as s, listing as l  
where s.album = l.album and total = num_songs_so_far;  

sqlite3> select * from tracklist order by album;
The Definition|Human, Simple and Sweet
Translations Through Speakers|Paper Planes