FINAL REVIEW

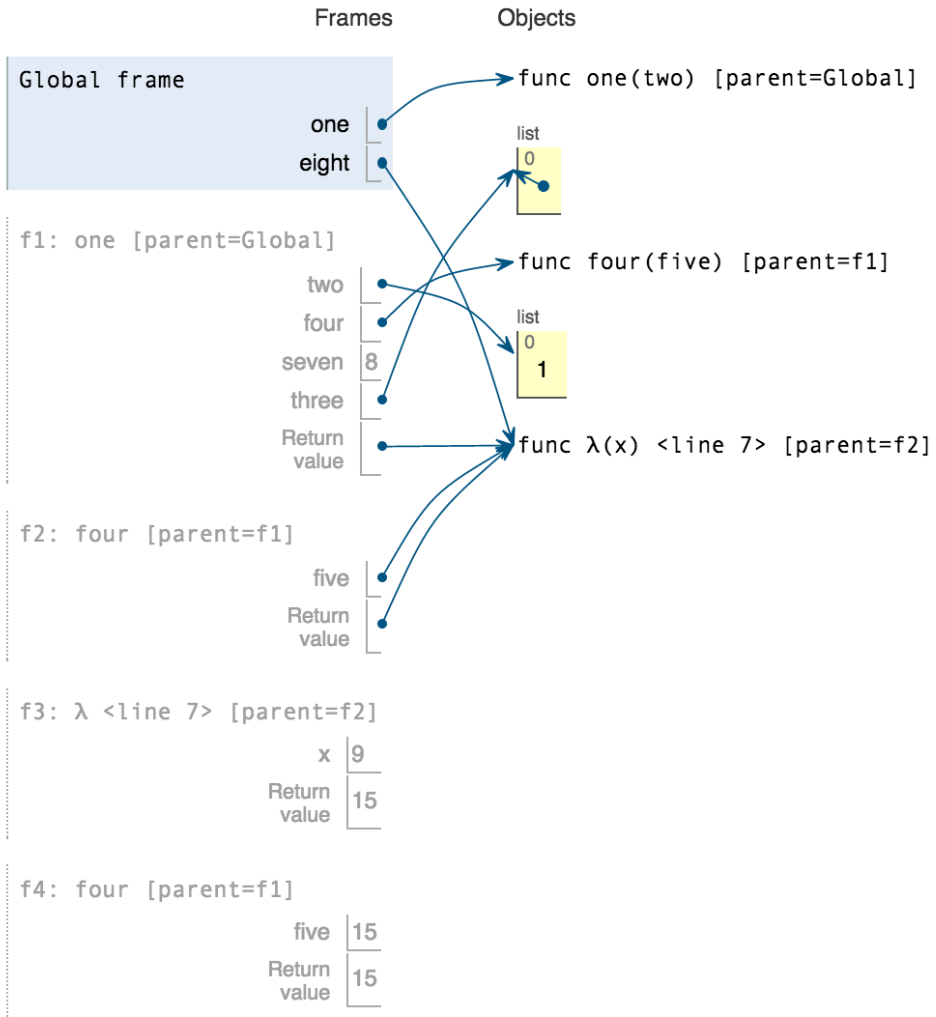
COMPUTER SCIENCE MENTORS 61A

November 28 to December 2, 2016

1 Nonlocal

1. Draw the environment diagram for the following code snippet:

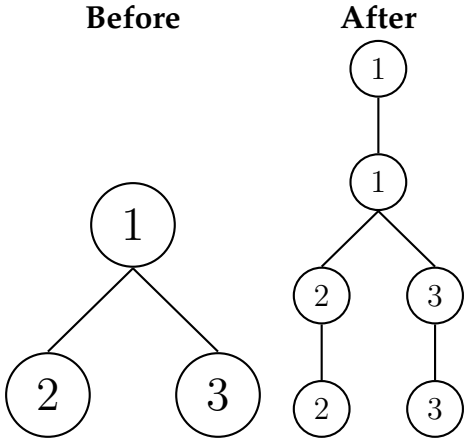
```
def one(two):
    three = two
    def four(five):
        nonlocal three
        if len(three) < 1:
            three += [five]
            five = lambda x: four(x)
        else:
            five = seven + 7
        return five
    two = two + [1]
    seven = 8
    return four(three)

eight = one([])
print(eight(9))
```



Solution:

2 Recursive Data Structures

2. DoubleTree hired you to architect one of their hotel expansions! As you might expect, their floor plan can be modeled as a tree and the expansion plan requires doubling each node (the patented double tree floor plan). Here's what some sample expansions look like:



Fill in the implementation for `double_tree`.

```
def double_tree(t):
    """
    Given a tree, return a new tree where entries appear
    twice.
    >>> double_tree(Tree(1))
    Tree(1, [Tree(1)])
    >>> double_tree(Tree(1, [Tree(2), Tree(3)]))
    Tree(1, [Tree(1, [Tree(2, [Tree(2)]),
                      Tree(3, [Tree(3)])
                     ])
            ])
    """
```

Solution:

```
    if t.is_leaf():
        return Tree(t.label, [Tree(t.label)])
    else:
        dbl_children = [double_tree(c) for c in t.children]
        return Tree(t.label, [Tree(t.label, dbl_children)])
```

3. Fill in the implementation of `double_link`.

```
def double_link(lst):
    """
    Using mutation, replaces the second in each pair of items
    with the first. The first of each pair stays as is.
    >>> double_link(Link(1, Link(2, Link(3, Link(4)))))
    Link(1, Link(1, Link(3, Link(3))))
    >>> double_link(
            Link('c', Link('s', Link(6, Link(1, Link('a'))))))
        )
    Link('c', Link('c', Link(6, Link(6, Link('a')))))
    """
    if _____________________________________________:
        return _____________________________________
    _____________________________________________
    _____________________________________________
    return _____________________________________
```

Solution:

```
if lst is Link.empty or lst.rest is Link.empty:
    return lst
lst.rest.first = lst.first
double_link(lst.rest.rest)
return lst
```

4. Fill in the implementation of `shuffle`.

```
def shuffle(lst):
    """
    Swaps each pair of items in a linked list.
    >>> shuffle(Link(1, Link(2, Link(3, Link(4)))))
    Link(2, Link(1, Link(4, Link(3))))
    >>> shuffle(
            Link('s', Link('c', Link(1, Link(6, Link('a'))))))
        )
    Link('c', Link('s', Link(6, Link(1, Link('a')))))
    """
    if _____________________________________________
        return _____________________________________
    new_head = lst.rest
    lst.rest = _________________________________
    _____________________________________________
```

```
    return _____________________________________________
```

Solution:

```
    if lst == Link.empty or lst.rest == Link.empty:
        return lst
    new_head = lst.rest
    lst.rest = shuffle(new_head.rest)
    new_head.rest = lst
    return new_head
```

3 Scheme

5. Write a Scheme function insert that creates a new list that would result from inserting an item into an existing list at the given index. Assume that the given index is between 0 and the length of the original list, inclusive.
Extra: Write this as a tail recursive function. Assume append is tail recursive.

```
(define (insert lst item index)
```

Solution:

```
(define (insert lst item index)
  (if (= index 0)
    (cons item lst)
    (cons (car lst) (insert (cdr lst) item (- index 1))))
)
```

Solution:

```
; Tail recursive
(define (insert lst item index)
  (define (helper lst index so-far)
    (if (or (null? lst) (= index 0))
      (append so-far (cons item lst))
      (helper (cdr lst) (- index 1)
              (append so-far (list (car lst))))
    )
  )
  (helper lst index nil)
)
```

4 Interpreters

6. Circle the number of calls to `scheme_eval` and `scheme_apply` for the code below.

```
(define (square x) (* x x))
(+ (square 3) (- 3 2))
```

Calls to `scheme_eval` (circle one)	2	5	14	24
Calls to `scheme_apply` (circle one)	1	2	3	4

Solution: 14 for eval, 4 for apply.

5 Recursive Select in SQL

7. Create a `mod_seven` table that has two columns, a number from 0 to 100 and then its value mod 7.
Hint: You can create a table first with all of the initial data you will build from, and then build the `mod_seven` table.

Solution:

```
with
    base(n) as (
        select 0 union
        select n+1 from base where n+1<7
    ),
    mod_seven (n, value) as (
        select n, n from base union
        select n+7, value from mod_seven where n+7<=100
    )
select * from mod_seven;

ALTERNATIVE SOLUTION WITH MODULO OPERATOR
with
    mod_seven (n, value) as (
        select 0, 0 union
        select n+1, (n+1)%7 from mod_seven where n<100
     )
select * from mod_seven;

ALTERNATIVE SOLUTION WITH ONE TABLE
(This could be a pre-step to approaching the original
   solution.)
with
    mod_seven (n, value) as (
        select 0, 0 union
        select 1, 1 union
        select 2, 2 union
        select 3, 3 union
```

```
        select 4, 4 union
        select 5, 5 union
        select 6, 6 union
        select n+7, value from mod_seven where n+7 <= 100
    )
select * from mod_seven;
```

6 Iterators, Generators, and Streams

8. What Would Python Output?

```
class SkipMachine:
    skip = 1
    def __init__(self, n=2):
        self.skip = n + SkipMachine.skip

    def generate(self):
        current = SkipMachine.skip
        while True:
            yield current
            current += self.skip
            SkipMachine.skip += 1
    p = SkipMachine()
    twos = p.generate()
    SkipMachine.skip += 1
    twos = p.generate()
    threes = SkipMachine(3).generate()
```

Expression	Interactive Output
`next(twos)`	**Solution:** 2
`next(threes)`	**Solution:** 2
`next(twos)`	**Solution:** 5
`next(twos)`	**Solution:** 8
`next(threes)`	**Solution:** 7
`next(twos2)`	**Solution:** 5

9. Write a generator that will take in two iterators and will compare the first element of each iterator and yield the smaller of the two values.

```
def interleave(iter1, iter2):
    """
    >>> gen = interleave(iter([1, 3, 5, 7, 9]),
                         iter([2, 4, 6, 8, 10]))
    >>> for elem in gen:
    ...     print(elem)
    ...
    1
    2
    3
    4
    5
    6
    7
    8
    9
    """
```

Solution:

```
t1, t2 = next(iter1), next(iter2)
while True:
    if t1 > t2:
        yield t2
        t2 = next(iter2)
    else:
        yield t1
        t1 = next(iter1)
```

10. **Food Planning Scheme**

(a) You and your 61A friends are cons. You cdr'd just studied for the final, but instead you scheme to drive away across a stream in a car during dead week. Of course, you would like a variety of food to eat on your roadtrip.

Write an infinite stream that takes in a list of foods and loops back to the first food in the list when the list is exhausted.
Bonus: Count all the puns in this question!

```
(define (food-stream foods)
```

Solution: We counted **6 puns**.

1. Scheme in the question title.
2. "cons", first sentence.
3. "cdr" vs. could've, second sentence.
4. "scheme" to drive away, second sentence.
5. "stream", second sentence.
6. "car", second sentence.

```
(define (food-stream foods)
  (cons-stream (car foods)
               (food-stream (append (cdr foods)
                                    (list (car foods))))
  )
)
```

(b) We discover that some of our food is stale! Every other food that we go through is stale, so put it into a new stale food stream. Assume `is-stale` starts off at 0.

```
(define (stale-stream foods is-stale)
```

Solution:

```
(define (stale-stream foods is-stale)
  (cond ((null? foods) nil)
        ((= is-stale 1)
          (cons-stream (car foods)
                       (stale-stream (cdr foods) 0)))
        (else (stale-stream (cdr foods) 1))
  )
)
```