Discussion 11: HOFs, Lambda Functions, Tree Recursion

Lambda Functions

1. Write a lambda function called f that takes in a number and outputs that number squared.

\[ f = \lambda x. x + x \]

2. Now, use a list comprehension and your lambda function f to return a list the squares of all numbers between 1-5, inclusive.

Functions as Data

1. What would the Python interpreter display for the following lines of code? If you believe a line errors, just write “Error.” Assume that the lines are executed independently, not sequentially.

```
>>> f1 = lambda x: x + x
>>> f2 = lambda x: x > 9
>>> [f(10) for f in [f1, f2]]
```

```
>>> f = lambda x: lambda: x + x
>>> f(2)
```

```
>>> y = 3
>>> f = lambda x: lambda: x + y
>>> f(2)()
```

```
>>> g = lambda y: x + y
>>> g(2)
```

2. Now, continue the exercise, instead assuming that the lines are executed sequentially.

```
>>> def make_adder(x):
...     def inner(y):
...         return x + y
...     return inner
>>> make_adder(5)
```

```
>>> make_adder(5)(6)
```
functions = [lambda x: x, lambda x: x * x, lambda x: x * 3]
functions[2](3)

def returnMax():
    return max
returnMax()

returnMax()(2, 3)

max = min
max(5, 4)

returnMax()

returnMax()(2, 3)

3. Write a function called functionList that takes in a list of functions, functions, and a number, n, and returns a list of the results of calling each function on n.

>>> functionList([lambda x: x + x, lambda x: x * x], 4)
[8, 16]

4. Write a recursive function called recursiveSum that takes in a function func and a number n, and returns the summed results of func applied from 1 to n.

>>> recursiveSum(lambda x: x * x, 3)
14 # 3*3 + 2*2 + 1*1
Tree Recursion

1. The Fibonacci sequence is a sequence of numbers where each number is the sum of the previous two. Here is the start of the Fibonacci sequence: 1, 1, 2, 3, 5, 8, 13, ...

In the space below, write the function `fib(n)` that returns the nth Fibonacci number in the sequence, assuming the first one is \( n = 0 \).

What is the runtime of this function? _______________________________________________________

2. We find ourselves at the bottom of a staircase with `num_steps` steps. We can either climb the stairs one at a time or two at a time (or a mix of the two). Fill in the function below to return the number of ways you can climb the staircase.

```python
def climb_staircase(num_steps):
    if num_steps == 0:
        return _______________________________________________________
    elif num_steps < 0:
        return _______________________________________________________
    else:
        return _______________________________________________________
```

3. Now, when we are climbing the staircase, we can take any from 1 to `max_steps` number of steps at a time (not just 1 or 2). Fill in the blanks below to rewrite `climb_staircase` to return the number of ways you can now climb the staircase.

```python
def climb_staircase(num_steps, max_steps):
    if num_steps == 0:
        return _______________________________________________________
    elif num_steps < 0:
        return _______________________________________________________
    else:
        return _______________________________________________________
```