Disc 04

Orders of Growth
Data Abstraction

Orders of Growth Tips

Carefully examine the provided functions. Try running through them with different kinds of input.

Ask yourself: how many iterations will this function go through based on the size of the input?

For recursion it helps to draw out trees instead of actually trying to follow through what happens in each function call

Common orders of Growth

Be able to recall an example of each of the common orders of growth. That way when you are faced with a new function you can compare it to what you already know

O(1)

```
def hello():
    print("hi")
```

O(2^n)

```
def fib(x):
    if x == 0 or x == 1:
        return x
    return fib(x - 1) + fib(x - 2)
```

O(n)

```
def countdown(n):
    if n == 0:
        return
    print(n)
    countdown(n-1)
```

O(n^2)

```
def maze(x, y):
    for i in range(x):
        for j in range(y):
            print(i, j)
```

O(log n)

```
def halve(n):
    if n == 0
        return 1
    else:
    halve(n//2)
```

factorial

What is the order of growth of factorial?

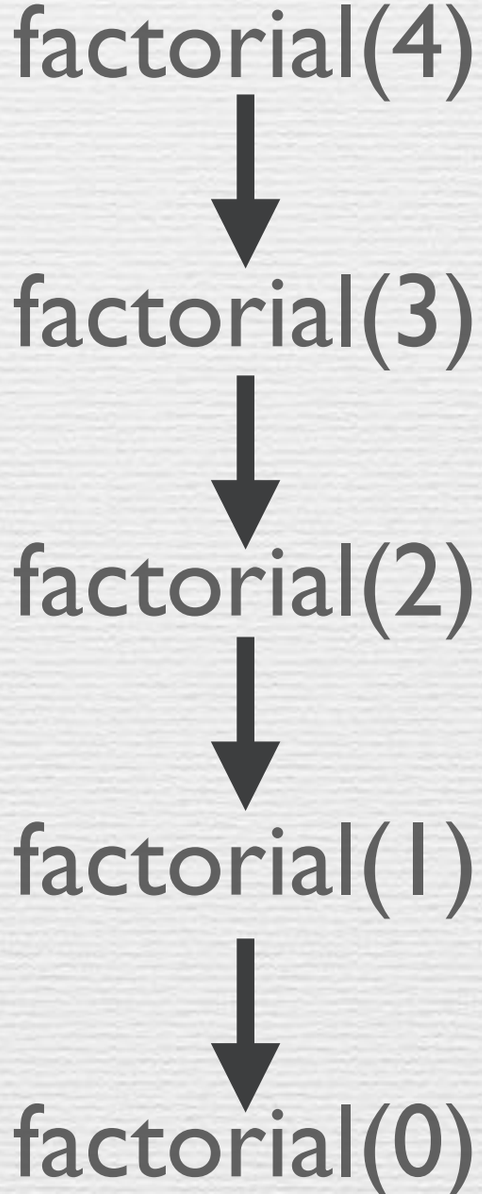
```
def factorial(n):

    if n == 0:

        return 1

    return n * factorial(n - 1)
```

Notice that we have 4 + 1 function calls. So the total amount of calls is one more than the size of the input.

In each function call we do a constant amount of work (multiply two number).

Therefore the order of growth is **linear**

Walk through an example



1.2 #5

What is the order of growth of foo(bar(n))?

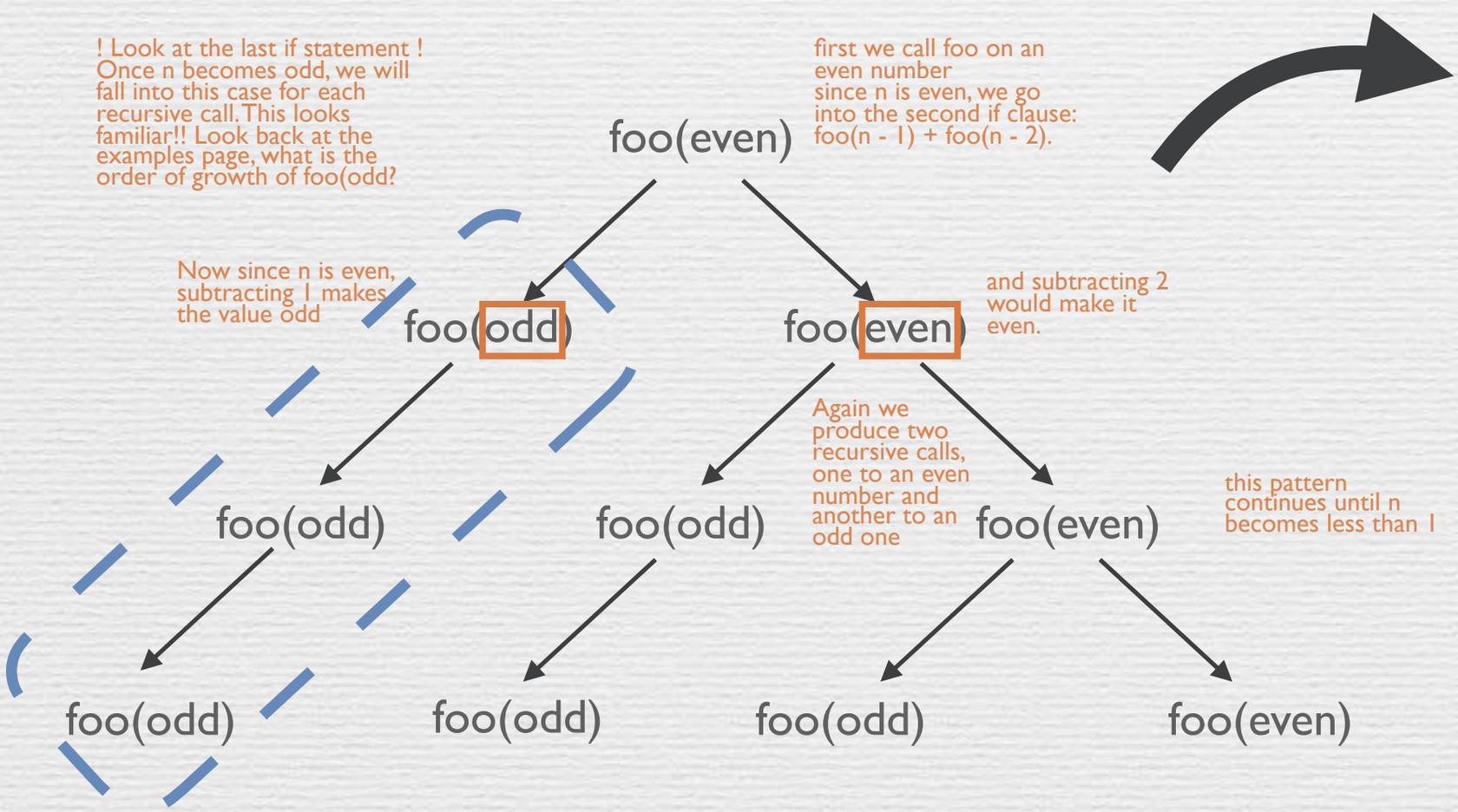
```
def bar(n):
    if n % 2 == 1:
        return n + 1
    return n

def foo(n):
    if n < 1:
        return 2
    if n % 2 == 0:
        return foo(n - 1) \
               + foo(n - 2)
    return 1 + foo(n - 2)
```

This problem is a bit tricky!
Lets draw out the function calls

Before we even go into foo, it is important to know that bar will always return an even number. So our first input to foo will be even.

! Look at the last if statement ! Once n becomes odd, we will fall into this case for each recursive call. This looks familiar!! Look back at the examples page, what is the order of growth of foo(odd?

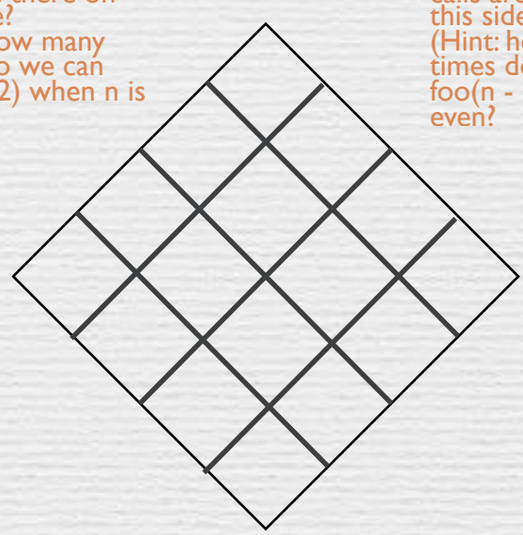
first we call foo on an even number since n is even, we go into the second if clause: foo(n - 1) + foo(n - 2).



Try to visualize the number of recursive calls as a grid. Each recursive call is represented by the intersection of two lines

How many recursive calls are there on this side? (Hint: how many times do we can foo(n - 2) when n is odd?

How many recursive calls are there on this side? (Hint: how many times do we call foo(n - 2) when n is even?



On the left since we decrement n by 2 each time, it would be something like n / 2 calls to foo until n becomes less than 1. The same can be said for the right How many intersection points are there total?

(n / 2) * (n / 2) = n^2/4 = **O(n^2)**

Data Abstraction

Don't assume you know how something works.

Abstraction is all around us; to turn on your computer you just press the power button. You don't have to understand what signals are transferred through the wires on the inside of the computer.

The same is with data abstraction. To access the root of a tree, I don't have to know if we used a list, or a string, or anything else to build it. I can just call a function that knows about this internal structure and happily use whatever it returns.