Functions & Scope

- Functions
  - Normal
  - Lambda functions
- Generators
  - What are generators?
  - Why use them?
- Scoping
  - `LEGB` rule
  - Closures

Functions

Functions in Python:

- Are nestable
- Can use closures
- Cannot be overloaded
- Can accept **and** return variable number of arguments

Example: Python function

In [1]:
```
def calculate_salary(position, nyears, is_manager=False):
    """Calculates the salary of an employee given some criteria.

    Args:
        position (string): One of {'engineer', 'accounts', 'marketing'}
        nyears (int): non-negative number of years at company
        is_manager (boolean): if manager (default=False)
    Returns:
        salary (int): how much employee is paid per year
    Raises:
        No exceptions
    """
    salary = 0
    if position == 'engineer':
        salary += 200000
    else:
        salary += 100000

    salary += (1000 * nyears)
    if is_manager:
        salary += 25000
    return salary

help(calculate_salary)
```

```
Help on function calculate_salary in module __main__:

calculate_salary(position, nyears, is_manager=False)
    Calculates the salary of an employee given some criteria.

    Args:
        position (string): One of {'engineer', 'accounts', 'marketing'}
        nyears (int): non-negative number of years at company
        is_manager (boolean): if manager (default=False)
    Returns:
        salary (int): how much employee is paid per year
    Raises:
        No exceptions
```

Return Values

You don't have to return a value, but the default is `None`!

In [15]:
```
def yell():
    print "HEY!"

ret_val = yell()
print ret_val
```

```
HEY!
None
```

Function Arguments

Argument types:

- Positional (fixed & variable)
- Keyword (fixed & variable)

Example: Fixed Positional

In [5]:
```
import math

def distance(x1, y1, x2, y2):
    return math.sqrt((x2 - x1)**2 + (y2 - y1)**2)

# test it out
print distance(0, 0, 4, 4)

# what if we don't give enough arguments?
print distance(0, 0, 2, 3)
```

```
5.65685424949
3.60555127546
```

Example: Fixed Keyword

Only accept a whitelist of keys as variable names, but the order does not matter when calling. Keyword arguments also have default values.

In [10]:
```
def meal(fruit=None, sandwich='baloney'):
    cost = 0
    if not fruit:
        fruit = 'apple'  # handle default

    # handle cost of fruit
    if fruit == 'banana':
        cost += 0.50
    else:
        cost += 0.75

    # handle sandwich cost
    if sandwich == 'baloney':
        cost += 3.50
    else:
        cost += 4.00
    return cost

# try it out
print meal()
print meal(sandwich='baloney', fruit='banana')
print meal('apple', 'baloney')  # don't have to specify keyword! but you
 must order
print meal(fruit='apple')
print meal(fruit='banana')
```

```
4.25
4.0
4.25
4.25
4.0
```

Example: Variable Positional

The order doesn't matter, and we can have as many as we'd like!

In [21]:
```
def add_numbers(*args):
    total = 0
    for arg in args:
        total += arg
    return total

print add_numbers(5)
print add_numbers(1, 2, 3)
print add_numbers(1, 2, 3, 4, 5, 6, 7, 8, 9, 0)
```

```
5
6
45
```

Example: Variable Keyword

The order doesn't matter, and we can have as many as we'd like.

In [11]:
```
def output_key_value_pairs(**kwargs):
    for keyword, value in kwargs.items():
        print keyword, "=>", value

output_key_value_pairs(color='purple', amount='14', total='50')
```

```
color => purple
amount => 14
total => 50
```

Example: Variable Keyword & Positional

In [12]:
```
def do_something(*args, **kwargs):
    total = 0
    for arg in args:
        total += arg
    for key, value in kwargs.items():
        print key, "->", value
    return total

# try it out
do_something(1, 2, 3, color='purple', dwelling='house')
```

```
color -> purple
dwelling -> house
```

Out[12]:
```
6
```

Variable, Fixed, Keyword, *and* Positional ?!

Yes. We. Can.

In [13]:
```
def do_something(fixed1, fixed2, fixed3=None, fixed4=10, *args,
**kwargs):

    print "Fixed positional arguments:", fixed1, fixed2
    print "Fixed keyword arguments:", fixed3, fixed4

    total = 0
    for arg in args:
        total += arg

    for key, value in kwargs.items():
        print key, "->", value
    return total

# try it out
print do_something(1, 2, 3, 4, 5, 6, color='purple', dwelling='house')
# print do_something(1, 2, 3, color='blue')
```

```
Fixed positional arguments: 1 2
Fixed keyword arguments: 3 4
color -> purple
dwelling -> house
11
```

Method overloading in Python

Cannot be explicitly done, must be a single function.

In [ ]:
```
def some_function(switch=None):
    if switch == 'value':
        # ... etc
        pass
    # ... etc
    pass
```

Lambda Functions

Anonymous Python functions created at runtime.

In [1]:
```
# with a single argument
square = lambda x:  x**2
print square(4)
print square(9)
```

```
16
81
```

Lambda Functions with Mutliple Arguments

In [2]:
```
subtract = lambda x, y: x - y
print subtract(10, 3)
```

```
7
```

Why would we want `lambda` functions?

- They are useful in cases where a full-blown function (or series of many) would clutter your module and/or aren't needed outside a function
- When a function is only needed *once*
- For sorting, map, filter, reduce (we'll cover those later!)

Why *wouldn't we*?

- Cannot be serialzed
- Cannot be reused

Scoping & Closures

What is `foo`? What is the value of `A()`?

To answer these questions we'll have to talk about how Python handles scope, and how that allows us to use function closures.

In [4]:
```
foo = 0

# a convoluted class
def A():
    foo = 1
    def B():
        foo = 2
        def C():
            return foo
        return C()
    return B()

# print A()  # ?
# print foo  # ?
```

Not in Kansas Anymore

In [58]:
```
# defining things at module level! ouch
for i in range(10):
    variable = 'apple'

# not in Java or C land anymore...
print i
print variable
```

```
9
apple
```

Generators

Generators in Python are a powerful way to create lazily-evaluated (ie: only "do" the work as it's requested, rather than upfront) iterables.

In [5]:
```
def odd_generator(n):
    for i in range(n):
        if i % 2 == 0:
            continue
        else:
            yield i

generator = odd_generator(10)
print next(generator)
print next(generator)
```

```
1
3
```

A Silly Example

In [8]:
```
def my_generator():
    yield 1
    yield 2
    yield 3

g = my_generator()

print next(g)
print next(g)
print next(g)
print next(g)
```

```
1
2
3

---------------------------------------------------------------------------
StopIteration                             Traceback (most recent call l
ast)
<ipython-input-8-0dbd887f82b1> in <module>()
      9 print next(g)
     10 print next(g)
---> 11 print next(g)

StopIteration:
```

A Silly Example (con't)

In [11]:
```
def my_generator():
    yield 1
    yield 2
    yield 3

g = my_generator()

for element in g:
    print element
```

```
1
2
3
```

Describing "Infinite Streams"

In [13]:
```
def fib():
    a, b = 0, 1
    while True:
        yield a
        a, b = b, a + b

f = fib()  # create our generator

for i in xrange(10):  # and here I snuck in another generator...can you
 spot it?
    print next(f)
```

```
0
1
1
2
3
5
8
13
21
34
```

Ok, but when is this practically useful?

In [12]:
```
with open('really_gigantic_40gb_file.csv', 'r') as rbf:

    lines = rbf.readlines()  # <--- this is a generator!

    for line in lines:
        # no problem! we only have a single line in memory at a time
        continue
```

```
---------------------------------------------------------------------
----
IOError                                   Traceback (most recent call l
ast)
<ipython-input-12-fe0b93ab5cf0> in <module>()
----> 1 with open('really_gigantic_40gb_file.csv', 'r') as rbf:
      2     lines = rbf.readlines()
      3     for line in lines:
      4         # ... do something
      5         pass

IOError: [Errno 2] No such file or directory: 'really_gigantic_40gb_fil
e.csv'
```

Next level generators & iterables!

The famous Python itertools (https://docs.python.org/2/library/itertools.html). One of the best reasons to use Python.

Scoping in Python: `LEGB` rules

Python follows the LEGB rule for scoping (http://www.amazon.com/dp/0596513984), which means when Python encounters a name, the search is conducted as follows in order:

1. **L**ocal
   A. Names assigned in a `def`, and not declared `global`
2. **E**nclosing function locals
   A. Name in scope of any (and all) enclosing functions
   B. Goes inner to outer
3. **G**lobal (module)
   A. Names at top level of module file
   B. a global declaration in a `def`
4. **B**uilt-in (Python)
   A. `open`
   B. `for`
   C. etc

Back to the Question!

Take two minutes individually and come up with your answer. Don't code it out - try to think through it.

In [19]:
```
foo = 0

#########################################################
# Remember: 1) Local,  then 2) Enclosing functions,
#      then 3) Global, then 4) Built-in
#########################################################
def A():
    foo = 1
    def B():
        foo = 2
        def C():
            return foo
        return C()
    return B()

print A()  # ?
print foo  # ?
```

```
2
0
```

Closures

Because we've seen that functions can remember variables that were in their scope, we can create closures in Python.

Closures in any language allow us to create function "factories" - functions inside of functions.

(Insert Inception joke here)

Example: Closure

What does this code do? What variable & `LEGB` rule enables this closure?

In [25]:
```
def adder_factory(base):
    def inner(x):
        return base + x
    return inner

adder = adder_factory(10)
print adder(1)
print adder(1)
```

```
11
11
```

Example: Closure with Lambda

We're still returning an inner function which keeps `base` in its scope.

In [27]:
```
def adder_factory_lambda(base):
    return lambda x: base + x

adder = adder_factory_lambda(7)
print adder(2)
```

```
9
```

So, yes, you can do this...

In [49]:
```
inception = lambda base: \
                lambda x: \
                    base + x

# try it out
add = inception(100)
print add(5)
print add(7)
```

```
105
107
```

But **don't**!

Lab: Coding Excercises

Fill in the method definitions in the file `excercises/functions.py`.

Make sure you can pass tests with:

```
$ py.test tests/test_functions.py::FunctionExcercises::<function_name>  # te
st single function
$ py.test tests/test_functions.py::FunctionExcercises                   # te
st all at once
```

Wrap-Up

- **Functions**
  - Normal
    - Fixed & Variable
    - Positional & Keyword
  - `lambda` functions
- **Scoping**
  - `LEGB` rule
  - Closures
    - Usage
    - Using `lambda`s