1 Scope

The **scope** of a variable is the area of the program that can access it. If a variable has **global scope**, it can be accessed from any part of the program. If a variable has **local scope**, it can only be accessed from certain parts (or locales) of the program.

Variables defined inside a function have a local scope that is limited to the body of the function. This program will crash because variable `radius` is not recognized outside the scope of the function body.

```
def circle_area(diameter):
    radius = diameter / 2.0
    return 3.14159 * radius ** 2

circle_area(20)
print radius    # causes NameError: name 'radius' is not defined
```

A function's parameters also have a local scope. If instead of printing radius, we attempt to print diameter, we would get a similar `NameError`.

2 Frames and the frame stack

Given that variables have local scope, consider this example.

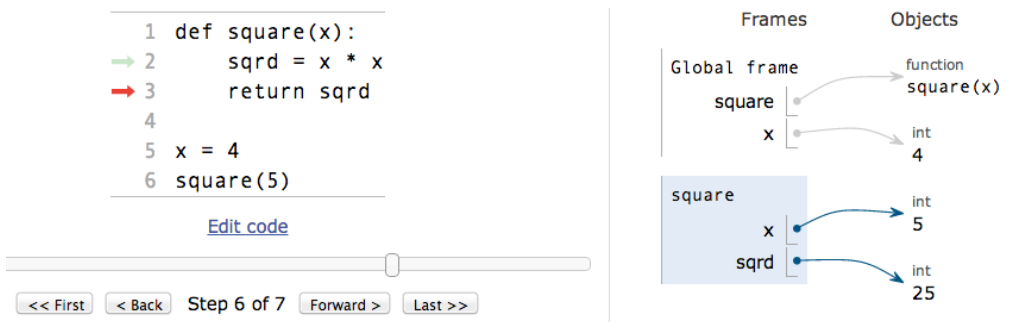
```
def square(x):
    sqrd = x * x
    return sqrd

x = 4
square(5)
```

There are in fact two distinct variables called `x`. In the main program, the variable `x` refers to 4. Inside the function definition, `x` is a parameter. When the function is called, the parameter refers to 5 (because when the function is called, the number 5 is passed in as the argument). So does `x` refer to 4 or 5 or both? How does python make sense of this?

When executing program, python keeps track of information in things called frames. A **frame** keeps track of the mapping between variable names and the data values to which they refer. The **global frame** keeps track of all function names and variables defined in "main" program (outside of any function). When a function is called, a new frame – named a **call frame** – is created. The new frame is stacked on top of existing frames, forming a **stack**. The new call frame keeps track of variables created within the function, including parameters. (Notice the connection with scope: variables with the same *scope* are placed together on the same frame.) When the function finishes and returns to its caller, the call frame is destroyed. (Again, a scope connection: after the function call, the function's local variables are invisible because the frame that held them is gone.)

The python visualizer (see Handout #11) is a great tool for understanding the call stack. Notice that at this moment, there are *two* variables named `x`, one refers to 4 and the other refers to 5.



```
def square(x):
    sqrd = x * x
    return sqrd

x = 4
square(5)
```

3 Can functions modify their arguments?

What does this program print?

```
def abs_value(x):
    if x < 0:
        x = -x
    return x

x = -100
print "abs_value(x) =", abs_value(x)
print "x =", x
```

The function returns 100, so it prints `abs_value(x) = 100`. However, the print statement after the function prints `x = -100`. Huh? The assignment statement inside the function does change what variable `x` refers to. However, there are *two* `x` variables in this program! (Try it in the visualizer.) The assignment statement is affecting *only* the `x` variable whose scope is local to the function.

General rule: if an *immutable* object (such as an `int`, `float`, `str`) is passed in as argument, the function *cannot* change the object. Assignment statements inside the function only affect *local* variables. However, if a *mutable* object is passed in as argument, function may modify it and you may see an effect after the function call is complete. Example: a function that takes an Image object and changes pixel colors... the image will be changed even after the function call completes.

Summary of Key Points

- Variables defined inside a function will not be recognized outside function.
- The same variable name can appear both in- and outside a function. The two variables may refer to different objects! Python uses frames to keep track of variables and objects.
- A variable on the outside and a parameter on the inside can refer to the same object. Immutable objects cannot be changed (assignment only changes which object a variable refers to); but mutable objects can be changed! We will see several examples of this later.