APS106

UNIVERSITY OF TORONTO

writing your own function.

Week 1 | Lecture 2 (1.2.2)

While waiting for class to start:

Download and open the Jupyter Notebook (.ipynb) for Lecture 1.2.2

You may also use this lecture's JupyterHub link instead (although opening it locally is encouraged).

Upcoming:

- Lab 1 released (Gradescope invites coming...)
- Reflection 1 released Friday

- PRA (Lab) on Friday @ 2PM this week

if nothing else, write #cleancode

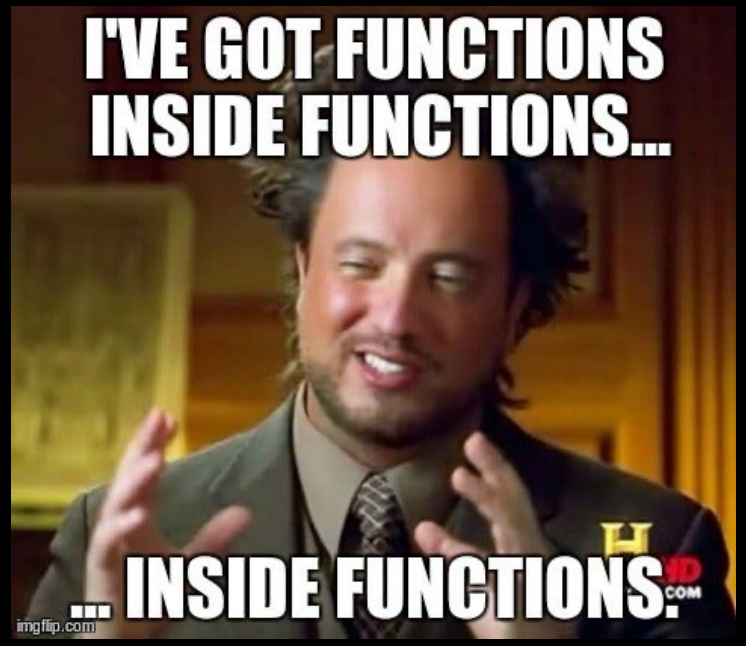
What you'll learn today

Lecture 2.1

- Functions, input & output, importing modules

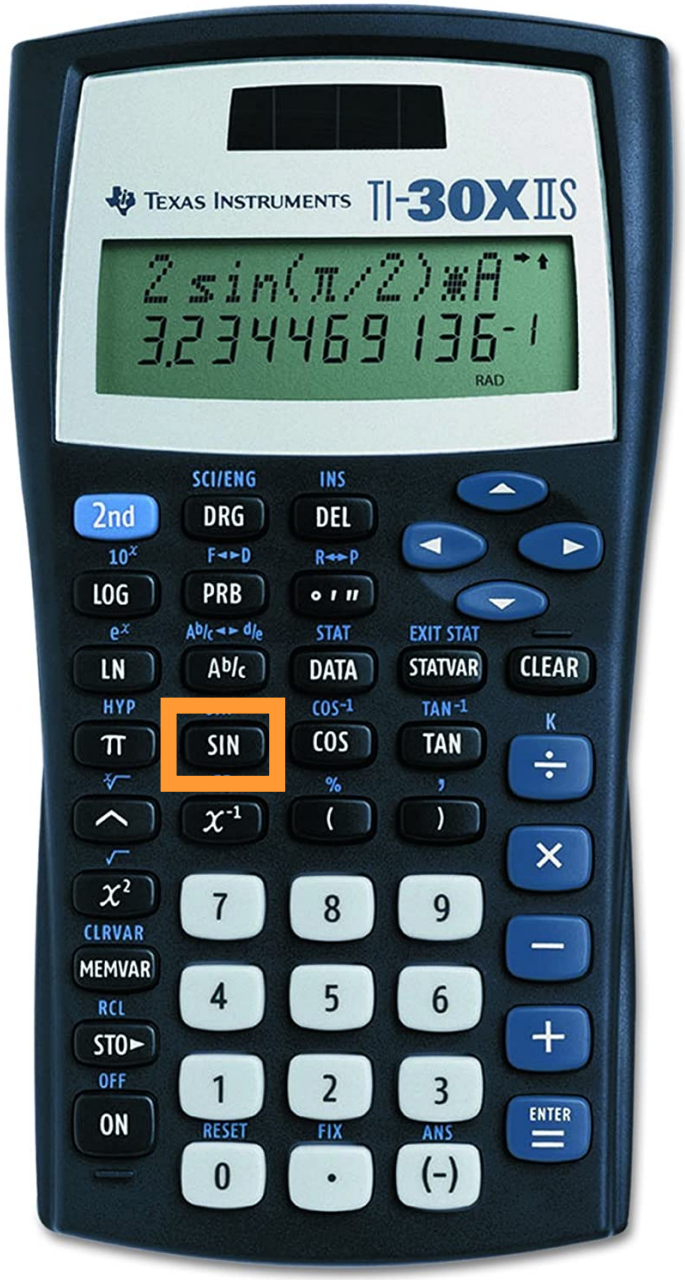
Lecture 2.2

- **Writing your own functions**
  - **Local vs global scope**



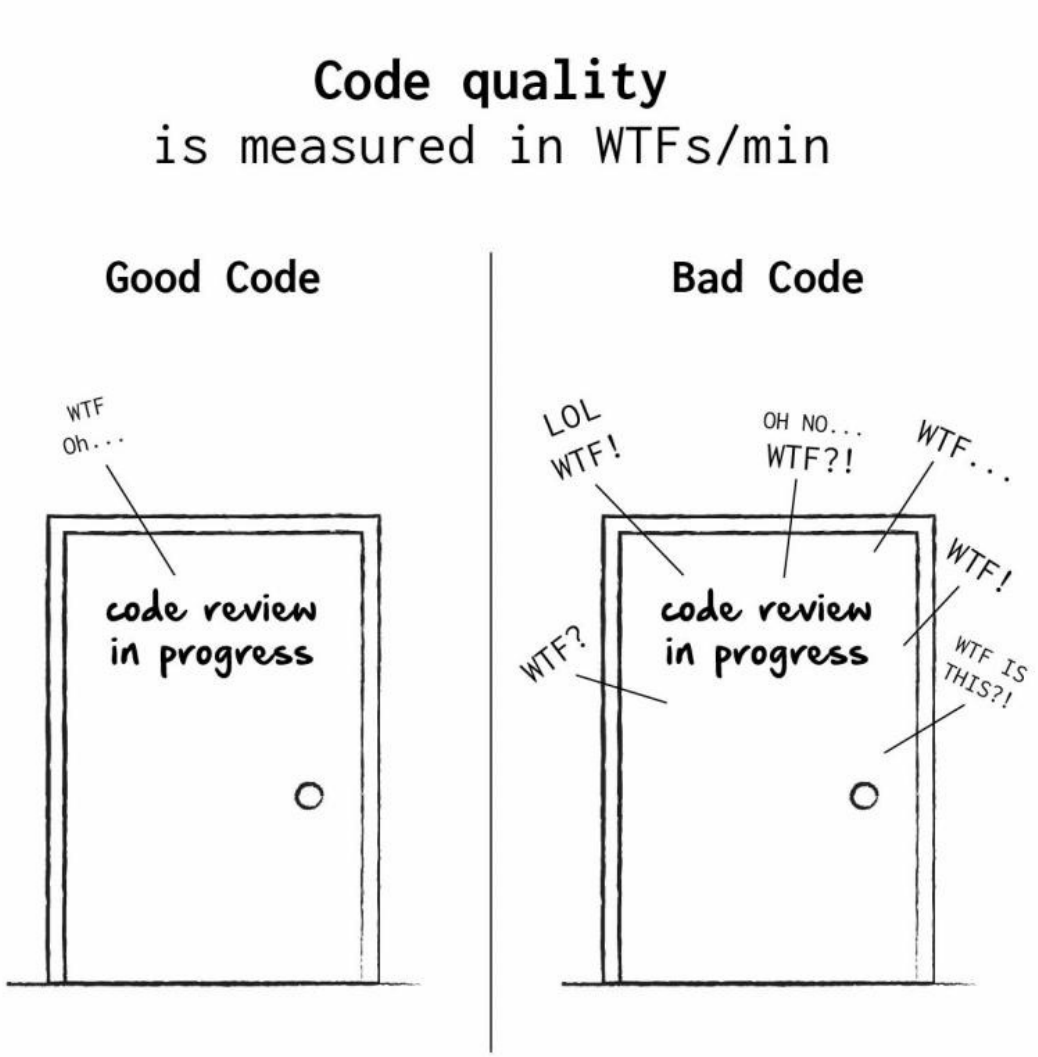
What is a function?

- A function is a piece of code that you can "call" repeatedly to do one thing.
- Think about the **sine** key on your calculator. It takes in an angle, does some calculations and returns the sine of that angle.
- Python has **built-in functions** (today), but programmers can also create their own **user-defined functions** (next lecture).



Defining Your Own Functions

- The real power of functions is in defining your own.
- Good programs typically consist of many small functions that call each other.
- If you have a function that does **only one thing** (like calculate the sine of an angle), it is likely not too large.
- If its not too large, it will be easy to test and maintain.



Function Definitions

(parameter1, parameter2, ...)

Definition

Function Name

Colon

```
def function_name(parameters):
    """DOCSTRING"""
    body
    return
```

Indent

Docstring (Optional)

What is in the body?

What are we returning?

Function Definitions

```
def function_name(parameters):
    body
    return
```

- **def** - is a keyword, standing for "definition". All function definitions must begin with **def**. The **def** statement must end with a colon.
- **function_name** - is the name you will use to call the function (like sin, abs but you need to create your own name).
- **parameters** - are the variables that get values when you call the function. You can have 0 or more parameters, separated by commas. Must be in parenthesis.
- **body** - body is a sequence of commands like we've already seen (assignment, multiplication, function calls).
- **return** – ends the function and returns data (like the sine of an angle.
- Important: all the lines of body must be indented. That is how Python knows that they are part of the function.

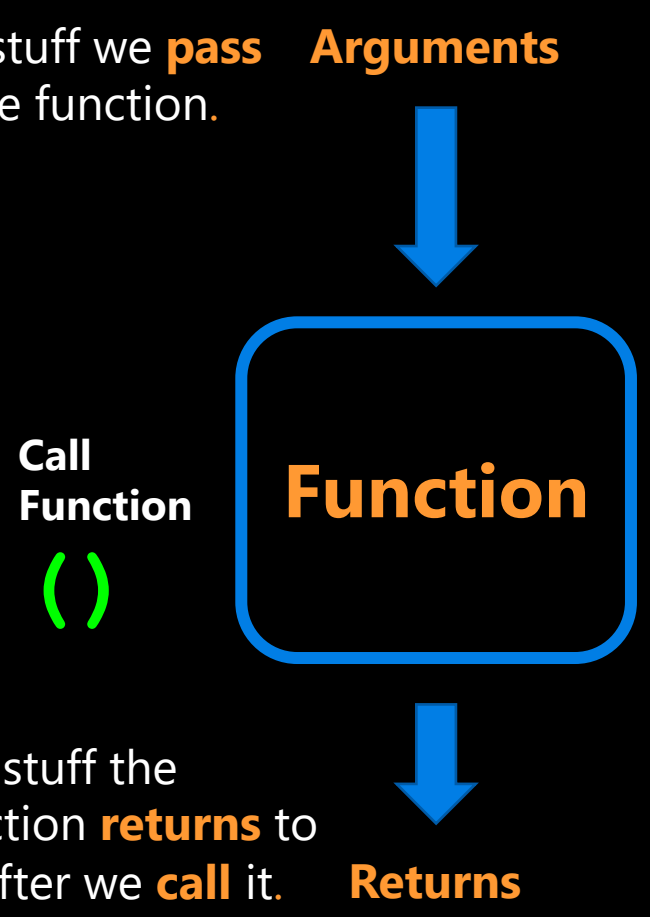
Calling Functions

- The general form of a function call:

```
function_name(arguments)
function_name()
function_name
```

Would not result in a function call.

- Terminology
  - *argument*: a value given to a function.
  - *pass*: to provide an argument to a function.
  - *call*: ask Python to execute a function (by name).
  - *return*: give a value back to where the function was called from.



Function Definitions

```
def function_name(parameters):
    body
    return
```

x is the parameter.

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

Calling Functions

```
function_name(arguments)
```

2 is the argument (data) passed to the **square** function.

```
square(2)
```

Function Definitions

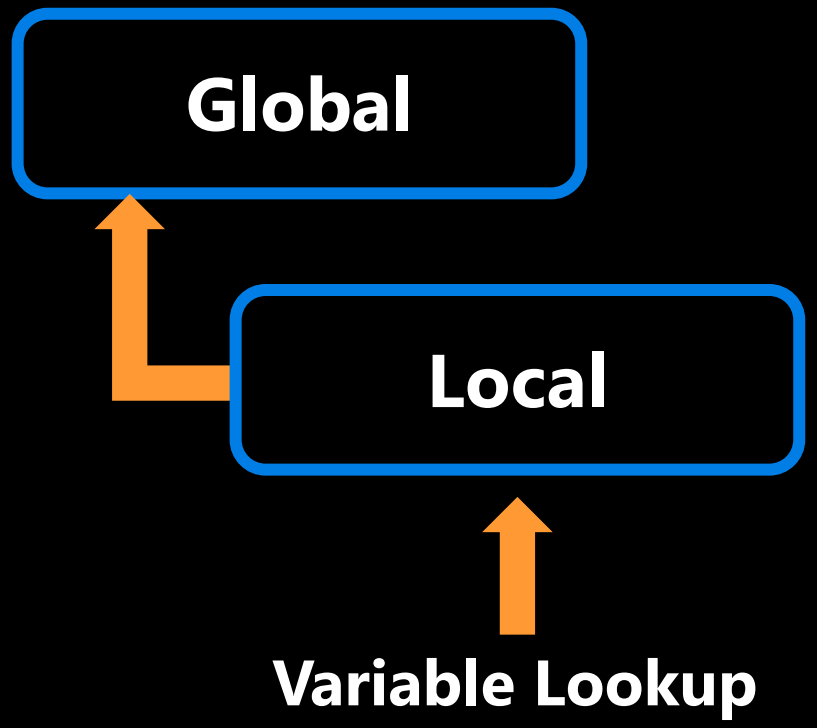
```
def function_name(parameters):
    1. """DOCSTRING""" (optional)
    2. Code that does the thing
    3. return expression
       The return statement is
       optional and if it is not
       included, it's the same as
       writing return None
```

Open your notebook

Click Link:
1. Defining Your Own Functions

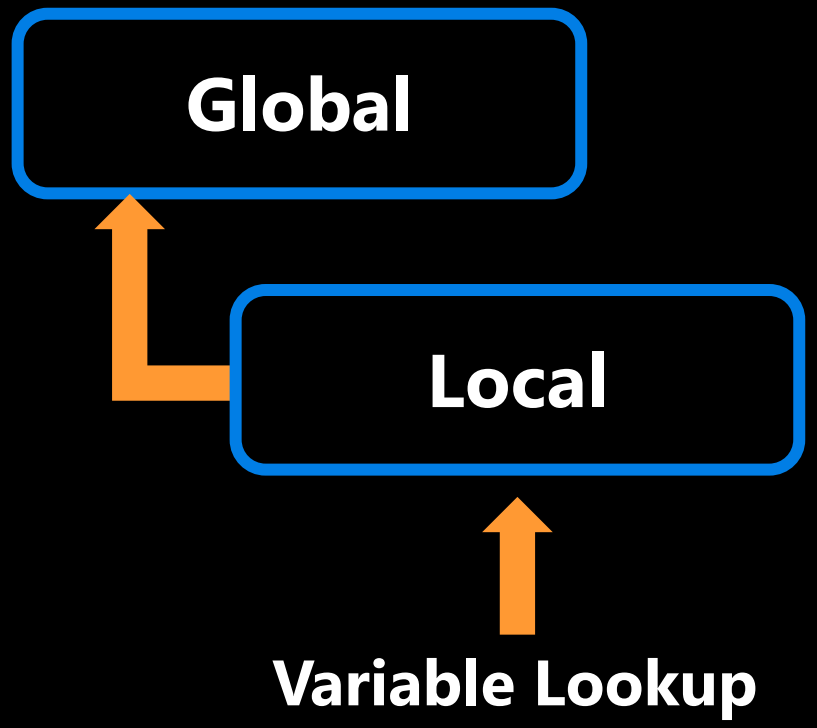
Variable Scope

- A variable is only available from inside the region it is created, which is called the variable's scope.
- Python has four different scopes, and we will discuss the two most important for this course.
- Local Scope
- Global Scope



Variable Scope

- **Local Scope**
- Whenever you define a variable within a function, its scope lies **ONLY** within the function.
- It is accessible from the point at which it is defined until the end of the function and exists for as long as the function is executing.
- This means its value cannot be changed or even accessed from outside the function.



Local Scope

Example 1

```
def my_function():
    name = 'Sebastian'

my_function()

print(name)
```

What will happen when this code is run?

Local Scope

Example 1

```
def my_function():
    name = 'Sebastian'

my_function()

print(name)

>>> Error
```

`name` is local to the function and not accessible outside in the global scope.

Local Scope

Example 1

```
def my_function():
    name = 'Sebastian'

my_function()

print(name)
```

Global

Local Scope

Example 1

```
def my_function():
    name = 'Sebastian'

my_function()

print(name)
```

Global

Local
(my_function)

Local Scope

Example 1

```
def my_function():
    name = 'Sebastian'

my_function()

print(name)
```

Global

Local
(my_function)
name = "Sebastian"

Local Scope

Example 1

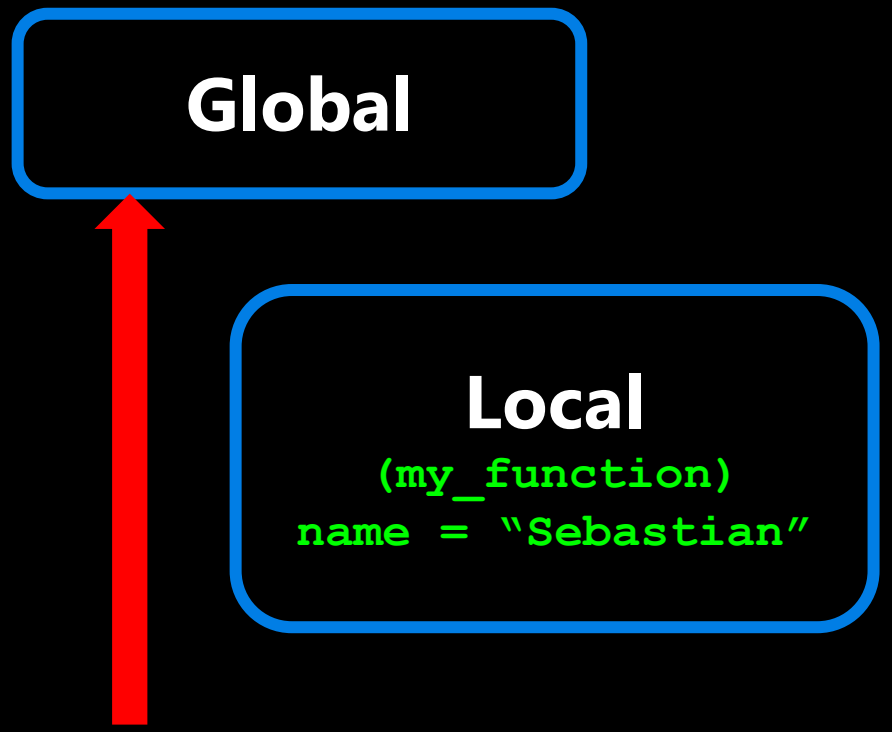
```
def my_function():
    name = 'Sebastian'

my_function()

print(name)

>>> Error
```

Error: builtins.NameError: name 'name' is not defined



Variable Lookup

- Is `name` in global?
- No (Done)

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)
```

What will happen when this code is run?

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)

>>> Ben
```

What will happen when this code is run?

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)
```

Global

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)
```

Global

Local
(my_function)

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)
```

Global

Local
(my_function)
name = "Sebastian"

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)
```

Global

name = "Ben"

Local

(my_function)

name = "Sebastian"

Local Scope

Example 2

```
def my_function():
    name = 'Sebastian'

my_function()

name = 'Ben'
print(name)

>>> Ben
```

Global
`name = "Ben"`

Local
`(my_function)`
`name = "Sebastian"`

Variable Lookup
- Is `name` in global?
- Yes (Done)

Variable Scope

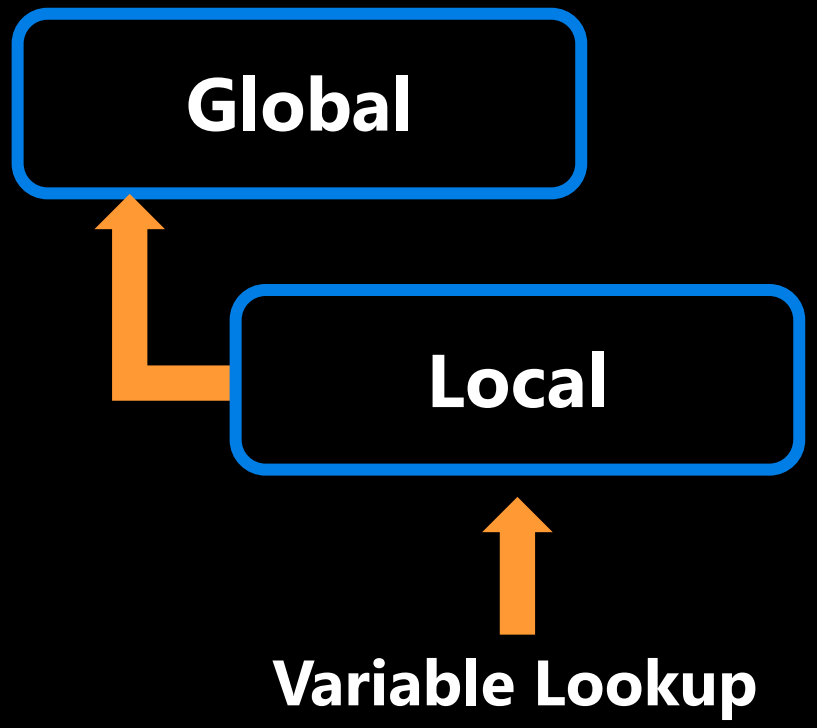
- **Local Scope**
- Whenever you define a variable within a function, its scope lies **ONLY** within the function.
- It is accessible from the point at which it is defined until the end of the function and exists for as long as the function is executing.
- This means its value cannot be changed or even accessed from outside the function.

Open your notebook

Click Link:
2. Local Scope

Variable Scope

- **Global Scope**
- Whenever a variable is defined outside any function, it becomes a global variable, and its scope is anywhere within the program.
- This means that variables and functions defined outside of a function are accessible inside of a function.



Global Scope

Example 1

```
def my_function():
    print(name)


name = 'Sebastian'

my_function()
```

What will happen when this code is run?

Global Scope

Notice that **name** is not defined anywhere in the function.

Example 1

```
def my_function():
    print(name)


name = 'Sebastian'

my_function()

>>> Sebastian
```

What will happen when this code is run?

name is in the global scope and is accessible inside the function.

Global Scope

Example 1

```
def my_function():
    print(name)


name = 'Sebastian'

my_function()
```

Global

Global Scope

Example 1

```
def my_function():
    print(name)

name = 'Sebastian'

my_function()
```

Global

Local
(my_function)

Global Scope

Example 1

```
def my_function():
    print(name)

name = 'Sebastian'

my_function()
```

Global

`name = "Sebastian"`

Local

`(my_function)`

Global Scope

Example 1

```
def my_function():
    print(name)

name = 'Sebastian'

my_function()
```

Global

`name = "Sebastian"`

Local

`(my_function)`

Variable Lookup

- Is `name` in local?
- No

Global Scope

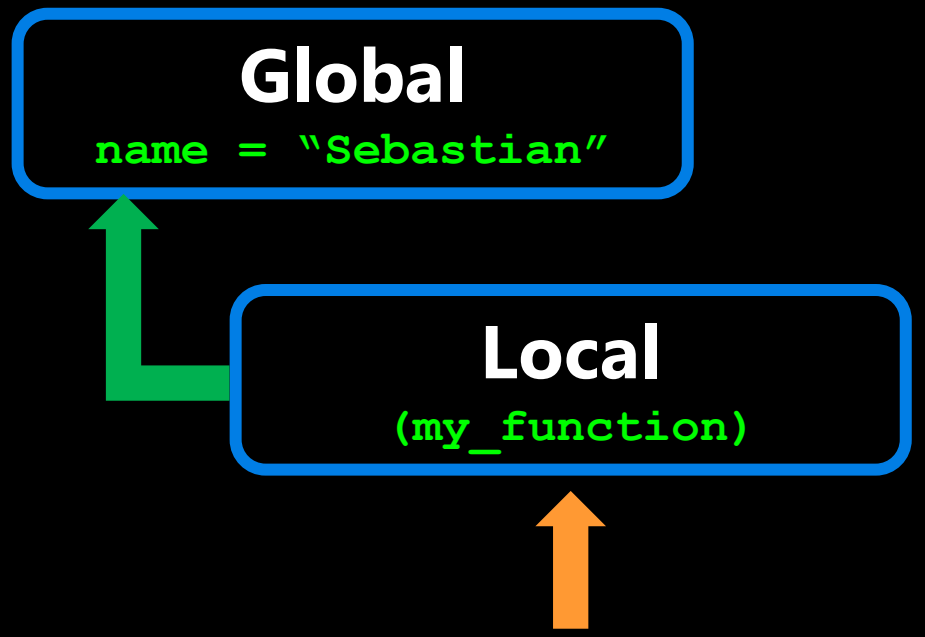
Example 1

```
def my_function():
    print(name)


name = 'Sebastian'

my_function()

>>> Sebastian
```



Variable Lookup

- Is **name** in local?
- No
- Is **name** in global?
- Yes (Done)

Global Scope

Example 2

```
def my_function():
    name = 'Ben'
    print(name)

name = 'Sebastian'

my_function()
```

What will happen when this code is run?

Global Scope

Example 2

```
def my_function():
    name = 'Ben'
    print(name)

name = 'Sebastian'

my_function()

>>> Ben
```

What will happen when this code is run?

`name` is in the local and global scope. Python will use the local version.

Global Scope

Example 2

```
def my_function():
    name = 'Ben'
    print(name)

name = 'Sebastian'

my_function()
```

Global

Global Scope

Example 2

```
def my_function():
    name = 'Ben'
    print(name)

name = 'Sebastian'

my_function()
```

Global

Local
my_function

Global Scope

Example 2

```
def my_function():
    name = 'Ben'
    print(name)

name = 'Sebastian'

my_function()
```

Global

`name = 'Sebastian'`

Local

`my_function`

Global Scope

Example 2

```
def my_function():
    name = 'Ben'
    print(name)

name = 'Sebastian'

my_function()

>>> Ben
```

Global

```
name = 'Sebastian'
```

Local

```
my_function
name = 'Ben'
```

Variable Lookup

- Is name in local?
- Yes (Done)

Global Scope

Example 3

```
def my_function():
    print(name)

my_function()
```

What will happen when this code is run?

Global Scope

Example 3

```
def my_function():
    print(name)

my_function()

>>> Error
```

What will happen when this code is run?

`name` is not defined in the local or global scope.

Global Scope

```
def my_function():
    print(name)

my_function()
```

Global

Global Scope

```
def my_function():
    print(name)

my_function()
```

Global

Local
`my_function`

Global Scope

```
def my_function():
    print(name)

my_function()
```

Global

Local
`my_function`

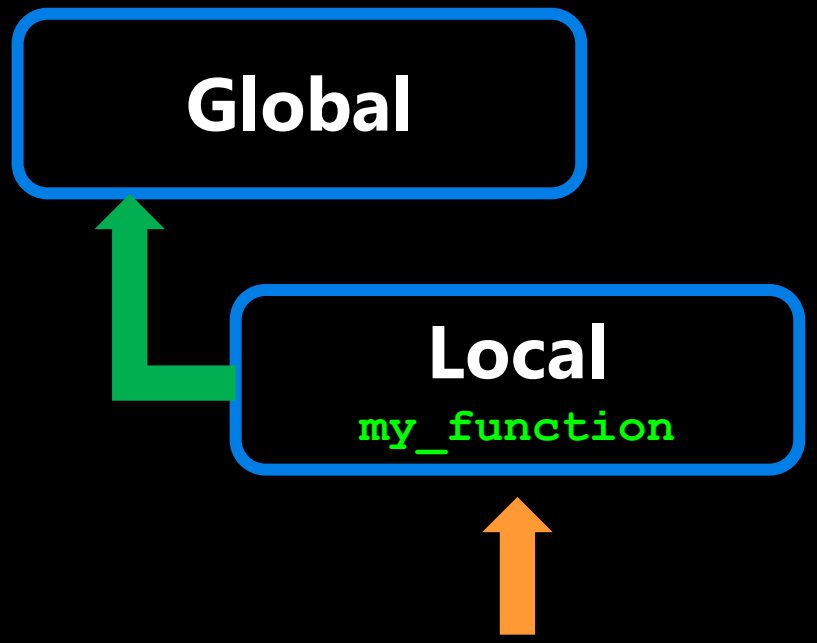
Variable Lookup
- Is `name` in local?
- No

Global Scope

```
def my_function():
    print(name)

my_function()

>>> Error
```



Variable Lookup

- Is `name` in local?
- No
- Is name in global?
- No

Variable Scope

- **Global Scope**
- Whenever a variable is defined outside any function, it becomes a global variable, and its scope is anywhere within the program.
- This means that variables and functions defined outside of a function are accessible inside of a function.

Open your notebook

Click Link:
3. Global Scope

Design Recipe

- How do we go about writing a function?
- You should follow these six steps.

1. **Examples** (What do you want your function calls to look like?)
2. **Type Contract** (Specify the type(s) of parameters and return values)
3. **Header** (Decide on the name of the function)
4. **Description** (Write a short description of what the function does)
5. **Body** (Write the code that actually does the thing that you want)
6. **Test** (Verify the function using examples)

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

1. **Examples** (What do you want your function calls to look like?)

```
celsius = convert_to_celsius(32)

celsius = convert_to_celsius(212)

celsius = convert_to_celsius(98.6)
```

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

2. Type Contract (Specify the type(s) of parameters and return values)

```
def convert_to_celsius(degrees_f):
    """
    ...
    """

    ... Do something

    return degrees_c
```

What types are passed in?

What types are returned?

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

2. Type Contract (Specify the type(s) of parameters and return values)

```
def convert_to_celsius(degrees_f):
    """
    (number) -> number
    """

    ... Do something

    return degrees_c
```

What types are passed in? Number

What types are returned? Number

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

3. Header (Decide on the name of the function and parameters)

```
def convert_to_celsius(degrees_f):
    """
    (number) -> number
    """

    ... Do something

    return degrees_c
```

(you probably already did this in step 1)

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

4. Description (Write a short description of what the function does)

```
def convert_to_celsius(degrees_f):
    """
    (number) -> number
    Return the temperature in degrees Celsius corresponding to
    the degrees Fahrenheit passed in.
    """

    ... Do something

    return degrees_c
```

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

5. Body (Write the code that actually does the thing that you want)

```
def convert_to_celsius(degrees_f):
    """
    (number) -> number
    Return the temperature in degrees Celsius corresponding to
    the degrees Fahrenheit passed in.
    """

    degrees_c = (degrees_f - 32) * 5 / 9

    return degrees_c
```

Design Recipe

- **Write a function that converts from Fahrenheit to Celsius.**

6. **Test** (Verify the function using examples)
   - Run all the examples that you created in Step 1.
   - Testing is so important.
   - In industry, you'll be expected to provide tests for everything.

```
celsius = convert_to_celsius(32) # celsius should be 0

celsius = convert_to_celsius(212) # celsius should be 100

celsius = convert_to_celsius(98.6) # celsius should be 37.0
```

Design Recipe

- How do we do about writing a function?
- You should follow these six steps.

1. Type
2. Contract
3. Header
4. Description
5. Body
6. Test

Open your notebook

Click Link:
4. Design Recipe

Docstring

- A Python documentation string, commonly known as **docstring**, helps you understand the capabilities of a function (or module, class).

This is the docstring

```
def convert_to_celsius(degrees_f):
    """
    (number) -> number
    Return the temperature in degrees Celsius corresponding to
    the degrees Fahrenheit passed in.
    """

    degrees_c = (degrees_f - 32) * 5 / 9

    return degrees_c
```

Docstring

- As we saw before, `help()` prints information about a function.
- The help function actually prints out the **"docstring"** that we write as part of a function definition.
- For the function we just wrote, we could type:

```
help(convert_to_celsius)

>>>
Help on function convert_to_celsius in module __main__:

convert_to_celsius(degrees_f)
    (number) -> number
    Return the temperature in degrees Celsius corresponding to the degrees
    Fahrenheit passed in
```

Docstring

- These are the most popular Docstrings format available.

Formatting Type	Description
NumPy/SciPy docstrings	Combination of reStructured and GoogleDocstrings and supported by Sphinx
PyDoc	Standard documentation module for Python and supported by Sphinx
EpyDoc	Render Epytext as series of HTML documents and a tool for generating API documentation for Python modules based on their Docstrings
Google Docstrings	Google's Style

Docstring

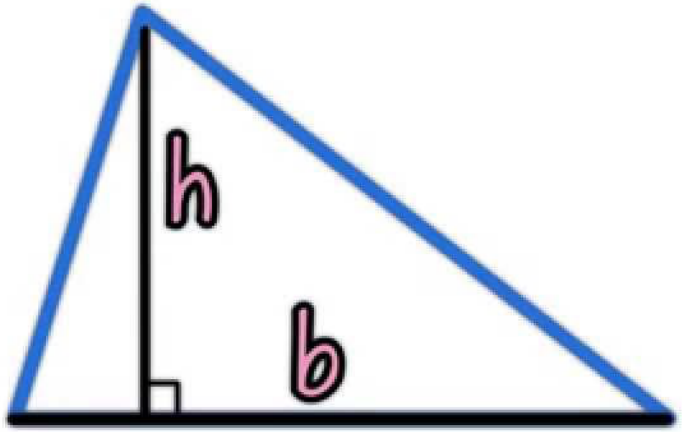
- This can be very valuable:
  - For other programmers to figure out what a function is supposed to do.
  - For you in the future when you have forgotten what you wrote (this happens a lot!).
- You should write a **docstring** for every function!
- Remember good vs bad code review.

Open your notebook

Click Link:
5. Docstring

Breakout Session 1

- Following the Design Recipe, write a function to calculate the area of a triangle.



$$\text{Area} = \frac{1}{2} \times b \times h = \frac{bh}{2}$$

Open your notebook

Click Link:
6. Breakout Session 1

More Stuff You Can Do With Functions

- **Nested Function Calls**

```
print(3 + 7 + abs(-5))
```

Function

Function

- **Calling Functions within Functions**

Function Definition

```
def my_function():
    print("Hello from a function")
```

Function

Open your notebook

Click Link:

7. Nested Function Calls

8. Calling Functions within Functions

`print` v.s. `return`

- The difference between print and return is a point of confusion year after year.
- So, let's be proactive and address this.

Are we the same?

`return`

Eww, no.

`print`

`print`

Use cases

- Debugging.
- Displaying messages to users.

`return`

Use cases

- Used to end the execution of the function call and "return" the result.
  - Sends a function's result back to where it was called
  - The entire function call evaluates to whatever is returned

print

```
def square(x):
    output = x * x
    print(output)
```

```
>>> square(2)
4
```

return

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

```
>>> square(2)
4
```

print

The stuff we **pass** to the function.

Arguments: 2

```
def square(x):
    output = x * x
    print(output)
```

Function
square

The stuff the function **returns** to us after we **call** it.

Returns: `None`

return

The stuff we **pass** to the function.

Arguments: 2

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

Function
square

The stuff the function **returns** to us after we **call** it.

Returns: 4

print v.s. return

```
def square(x):
    output = x * x
    print(output)
```

```
def square(x):
    output = x * x
    print(output)
    return None
```

These two functions return the same thing.

Open your notebook

Click Link:
9. print v.s. return

APS106

UNIVERSITY OF TORONTO

writing your own function.

Week 1 | Lecture 2 (1.2.2)

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