

writing your own function.

Week 2 | Lecture 2 (2.2)

Upcoming

- Lab 0 Due 11:59 pm Friday.
- Lab 1 Released Thursday 6:00 pm.
- Reflection 2 Released Friday 6:00 pm.
- Tutorial and Practical sessions running all week.

if nothing else, write **#cleancode**.

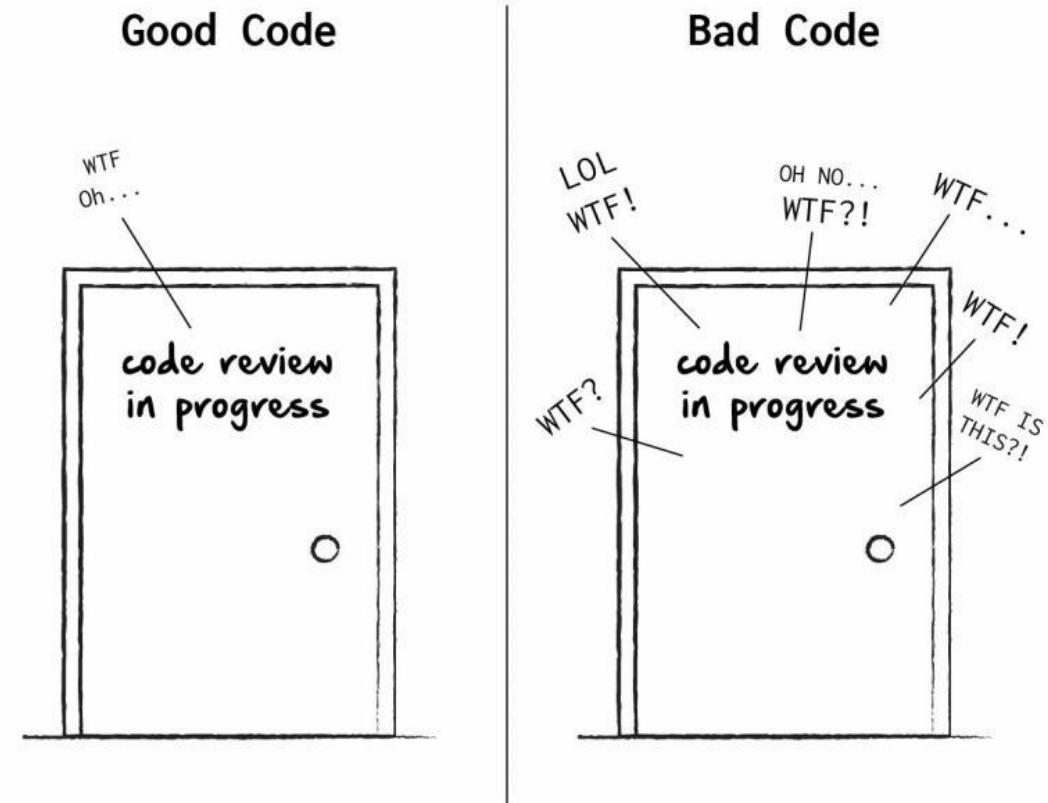
This Week's Content

- **Lecture 2.1**
 - Functions, input & output, importing modules
- **Lecture 2.2**
 - **Defining your own function**
- **Lecture 2.3**
 - Design Problem: Forward Kinematics

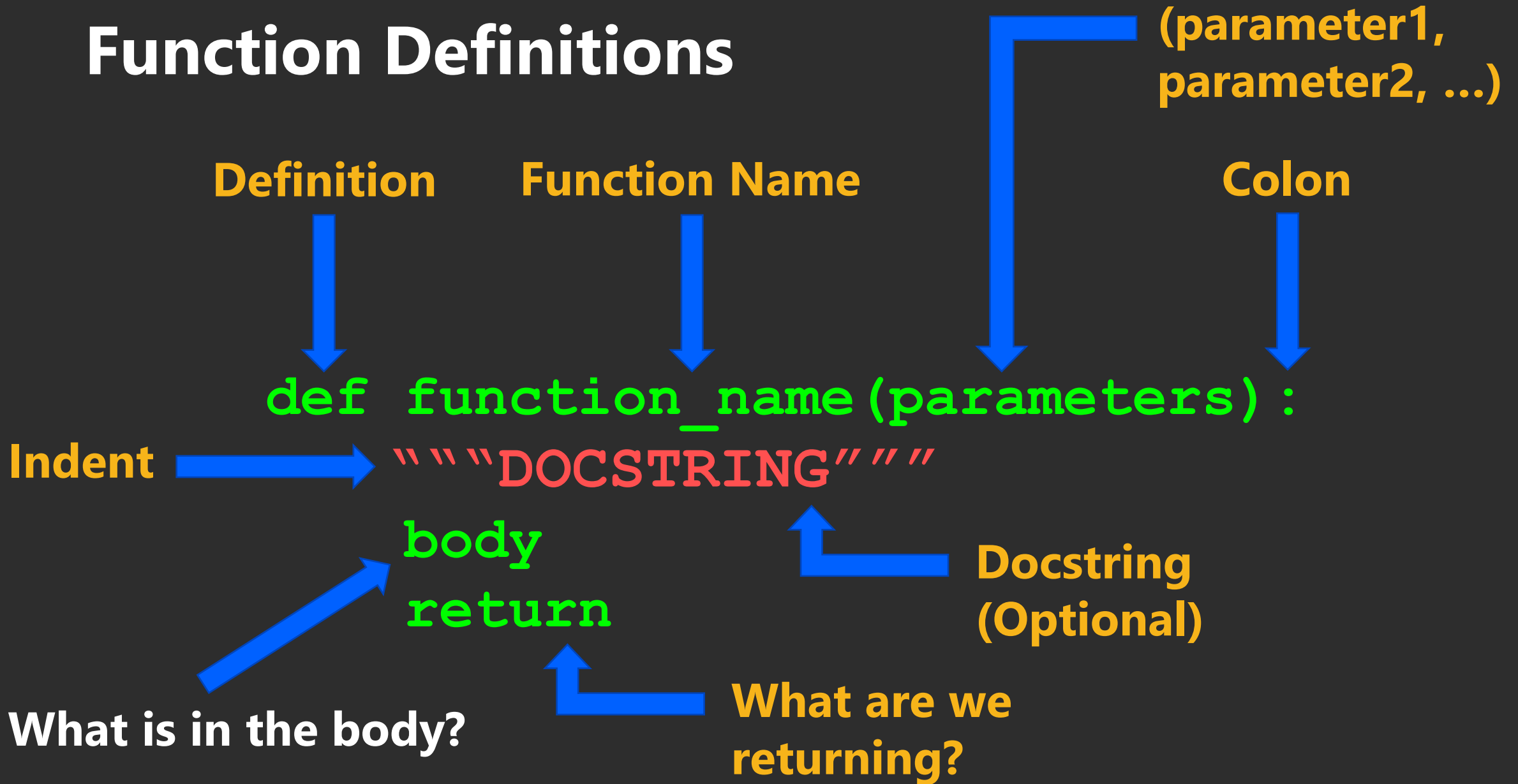
Defining Your Own Functions

- 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.

Code quality
is measured in WTFs/min



Function Definitions



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`

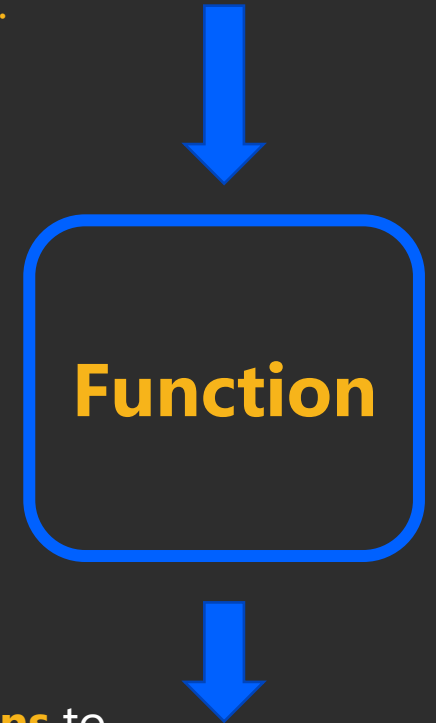
← Would not result in
a function call.

- 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.

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

Call
Function
`()`



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

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`

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**1. Defining Your Own
Functions**

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**

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Click Link:
2. Design Recipe

Docstring

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

```
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
```

This is the
docstring

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

Docstring

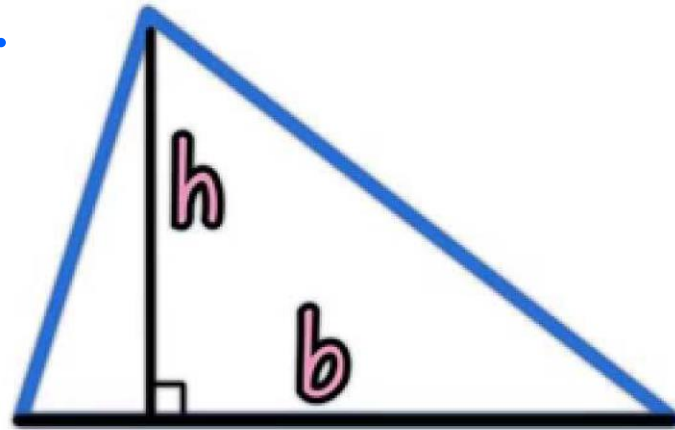
- This can be very valuable:
 - For other programmers to figure out what a function is supposed to do.
 - For you in the future when you have forgotten what you wrote (this happens a lot!).
- You should write a **docstring** for every function!
- Remember good vs bad code review.

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3. Docstring

Breakout Session 1

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



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

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6. Breakout Session 1

More Stuff You Can Do With Functions

▪ Nested Function Calls

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

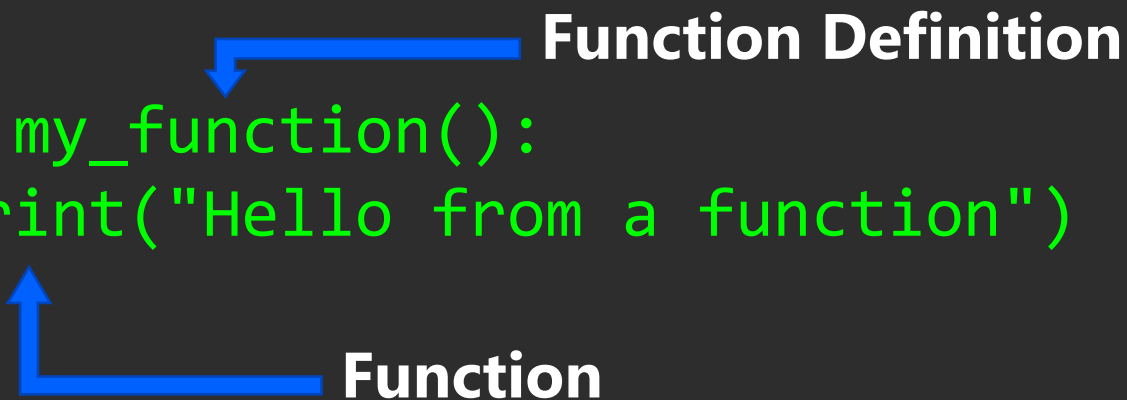


Function

Function

▪ Calling Functions within Functions

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



Function Definition

Function

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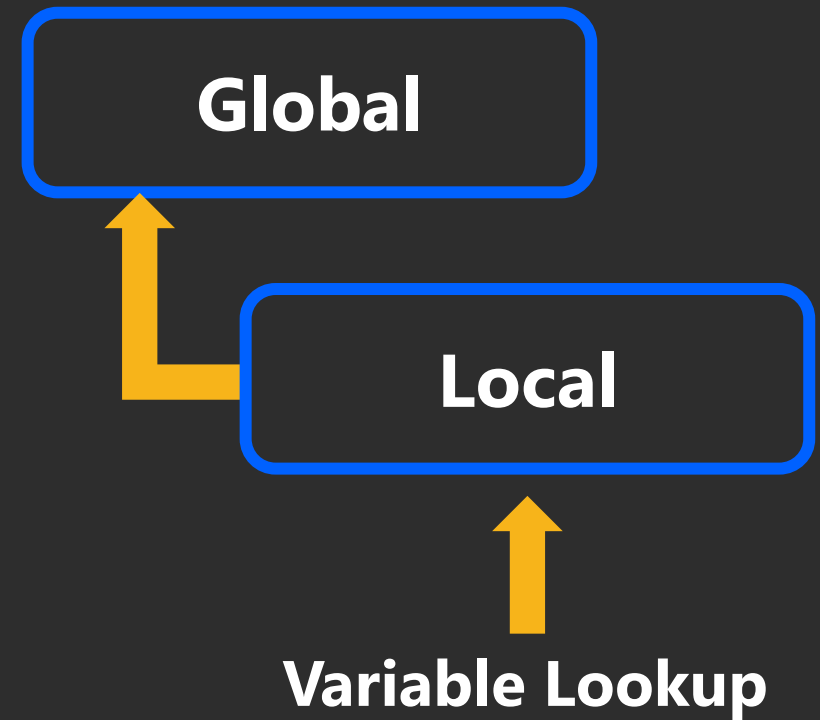
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**4. Nested Function
Calls**

**5. Calling Functions
within Functions**

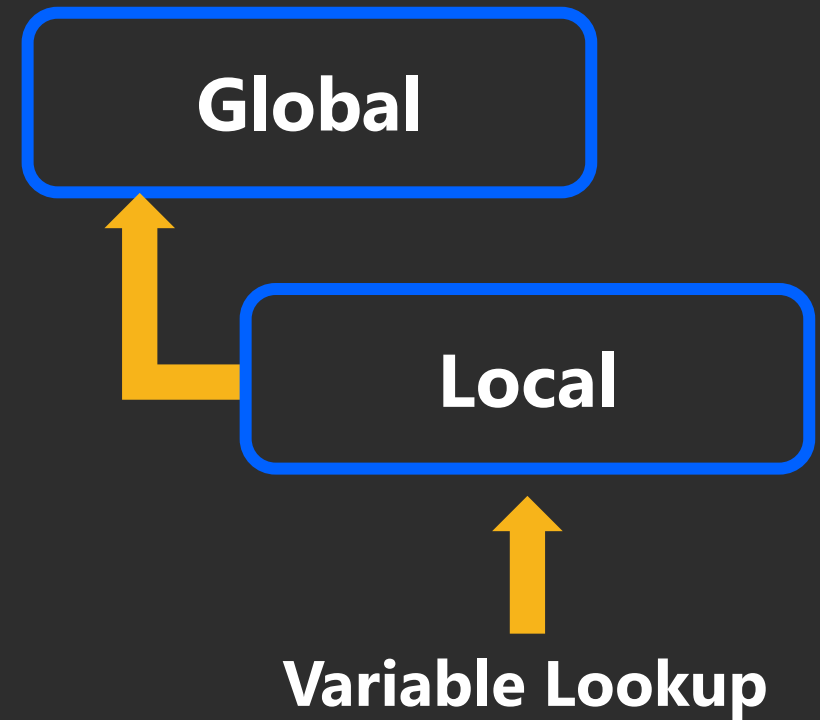
Variable Scope

- 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



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

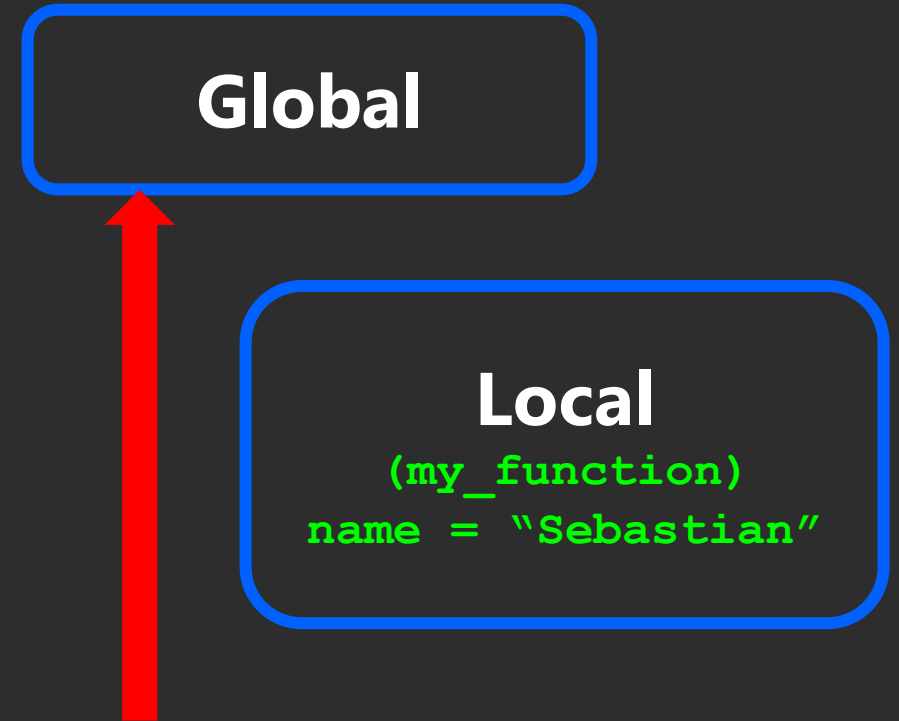
```
def my_function():  
    name = 'Sebastian'
```

```
my_function()
```

→

```
print(name)
```

```
>>> Error
```



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

Global

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

```
my_function()
```

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

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

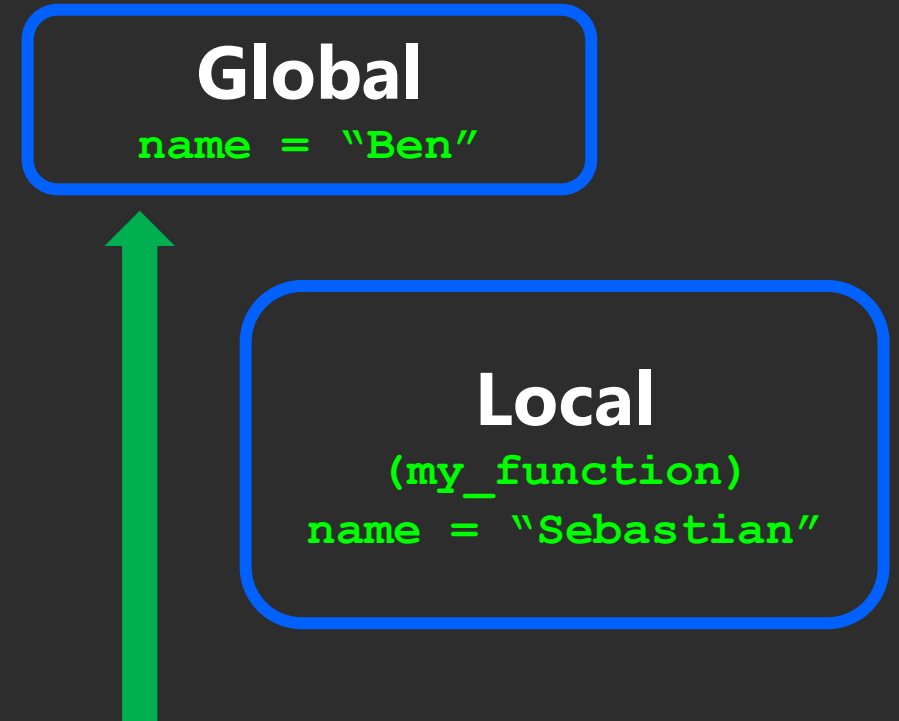
```
def my_function():  
    name = 'Sebastian'
```

```
my_function()
```

```
name = 'Ben'
```

```
→ print(name)
```

```
>>> Ben
```



Variable Lookup

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

Local Scope

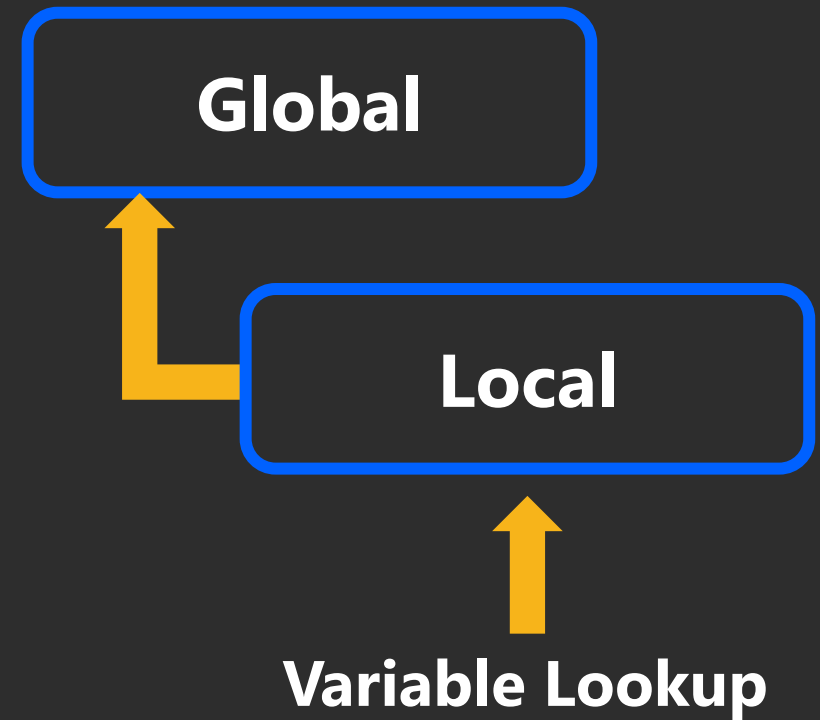
- Whenever you define a variable within a function, its scope lies **ONLY** within the function.
- It is accessible from the point at which it is defined until the end of the function and exists for as long as the function is executing.
- This means its value cannot be changed or even accessed from outside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

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7. Local 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
```

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

What will happen when this code is run?

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)`

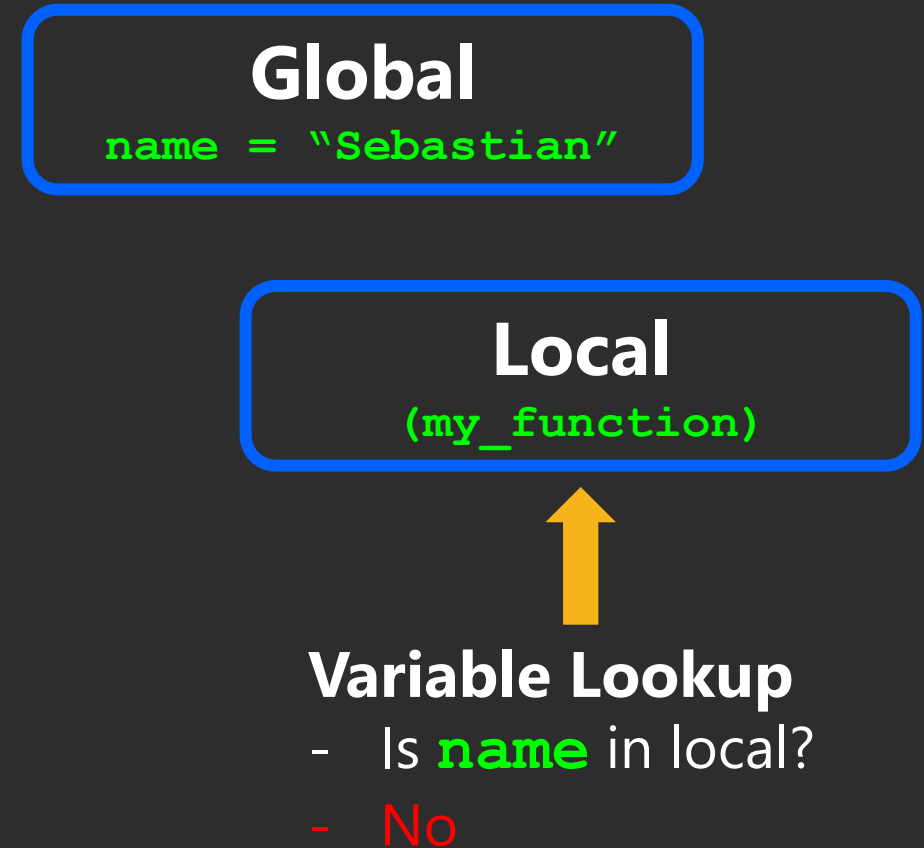
Global Scope

Example 1

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

```
name = 'Sebastian'
```

→ `my_function()`



Global Scope

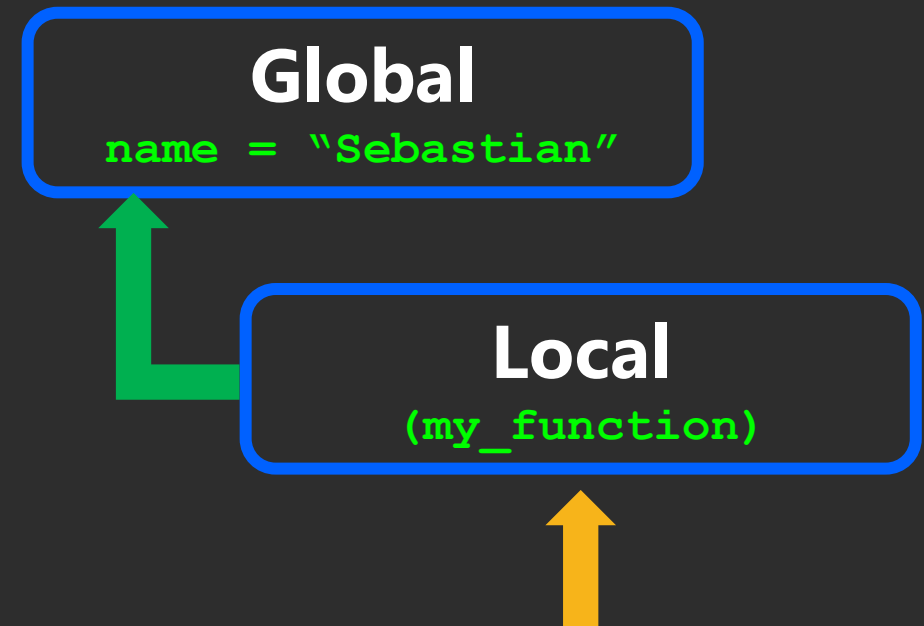
Example 1

```
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
```

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

What will
happen when
this code is
run?

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

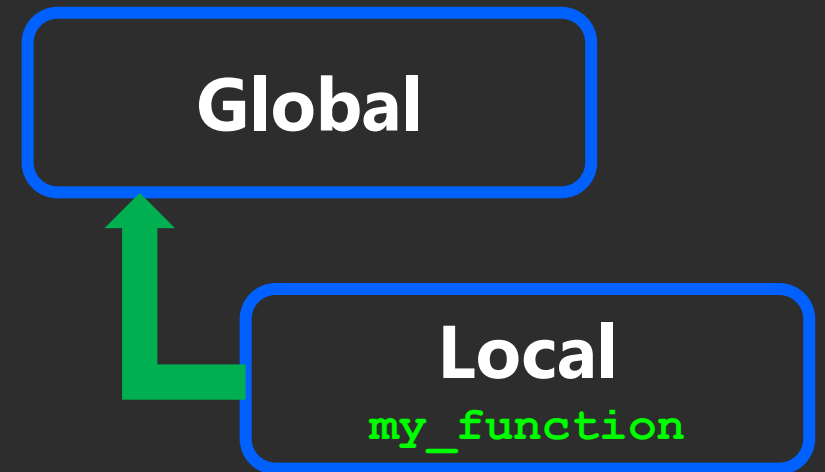
- Is `name` in local?
- No

Global Scope

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

→ `my_function()`

>>> **Error**



Variable Lookup

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

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.


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8. Global Scope

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.

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** **Arguments: 2**
to the function.



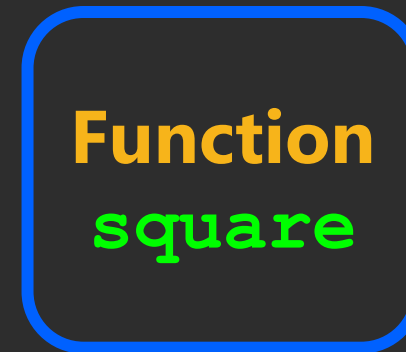
```
def square(x):  
    output = x * x  
    print(output)
```



The stuff the
function **returns** to
us after we **call** it. **Returns: None**

return

The stuff we **pass** **Arguments: 2**
to the function.



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



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.

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9. print v.s. return

From Functions to Programs

- The recipe we discussed earlier highlights a few of the realities about programming whether for individual functions or for large pieces of software.
- 1. A formal design process (or even a recipe) can help.
 - Especially when you are writing a large program with many programmers, it is easy to get lost.
 - In fact, it is more often impossible to hold the entire program in your head.
 - Having a process helps you to figure out where you are and what you should do next.

From Functions to Programs

- The recipe we discussed earlier highlights a few of the realities about programming whether for individual functions or for large pieces of software.
- 2. Functions can be written and then their insides can be forgotten about.
 - Do you know how Python calculates **sin()**?
 - Do you care?
 - You can successfully use functions without knowing how they are implemented if you know what they take in and what they return.
 - This is very important for large projects.

From Functions to Programs

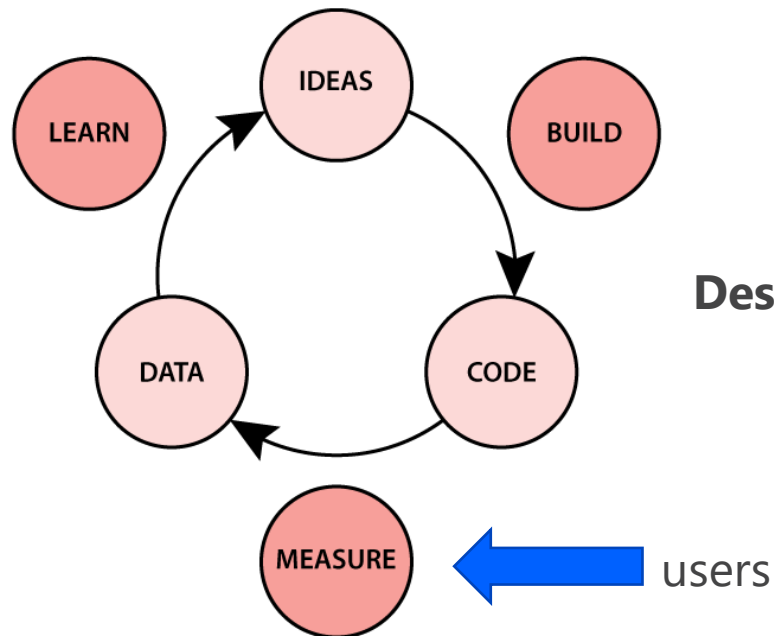
- The recipe we discussed earlier highlights a few of the realities about programming whether for individual functions or for large pieces of software.
- 3. Start with examples.
 - This helps in communication with the client, helps (a lot) to figure out what the problem really is, and is the core for testing your code.

A Design Process for Programming

- APS111/112, a key part of engineering is the design of objects, processes, and systems.
- **Programming** is the design, implementation, testing, and documentation of a piece of software that solves a particular problem.
- The software might be part of a larger system (e.g., the avionics software of an aircraft, the accounting or human resources software of a business), but it represents the solution to a design problem (or part of a design problem).

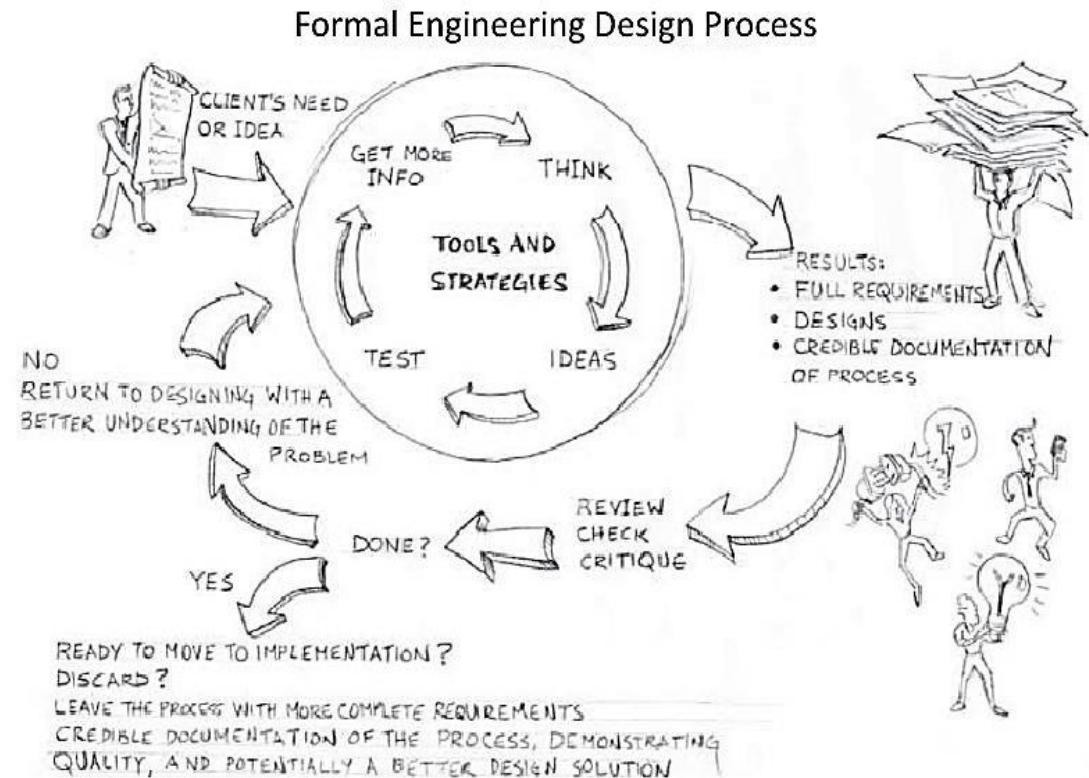
A Design Process for Programming

- We will approach programming as an engineering design process and adapt the process you have already seen in APS111/112.



Design is iterative.

Taken from: [Designing Engineers: An Introductory Text](#)



A Design Process for Programming

- In the next lecture, we are going to talk about a detailed design process for programming, based on the engineering design processes that are key to any engineering.
- The steps are as follows:
- **Define the Problem.**
- **Define Test Cases.**
- **Generate Multiple Solutions.**
- **Select a Solution.**
- **Implement the Solution.**
- **Perform Final Testing.**

A Design Process for Programming

- **Define the Problem.**
- Write down what the problem actually is.

A Design Process for Programming

- **Define Test Cases.**
- Create some examples that reflect your code solving the problem: input and output.

A Design Process for Programming

- **Generate Multiple Solutions.**
- At this point a "solution" consists of an algorithm plan (the high-level sequence steps defining what your algorithm will do) and a programming plan (the high-level sequence of steps that you will take to code the algorithm).

A Design Process for Programming

- **Select a Solution.**
- Based on the different algorithm and programming plans, decide which is the most promising.

A Design Process for Programming

- **Implement the Solution.**
- Start to execute your programming plan.
- Test as you go!
- You may realize that your algorithm plan doesn't solve the problem, or even that you do not understand the problem.
- If so, go back to earlier steps.

A Design Process for Programming

- **Perform Final Testing.**
- Make sure that your original test cases as well as any others that you have thought up work.

A Design Process for Programming

- It is critical to realize that programming is:
 - Iterative: you will go back and change your algorithm/programming plan. You will write some code during Step 3: you might not be able to define a solution without writing some code to solve part of the problem. You will move back-and-forth in this process.
 - This process is a lot about finding your own mistakes: even for good programmers, most of their time is spent testing and debugging!

PRACTICE!

writing your own function.

Week 2 | Lecture 2 (2.2)

if nothing else, write **#cleancode**.