APS106

UNIVERSITY OF TORONTO

writing your own function.

Week 2 | Lecture 2 (2.2)

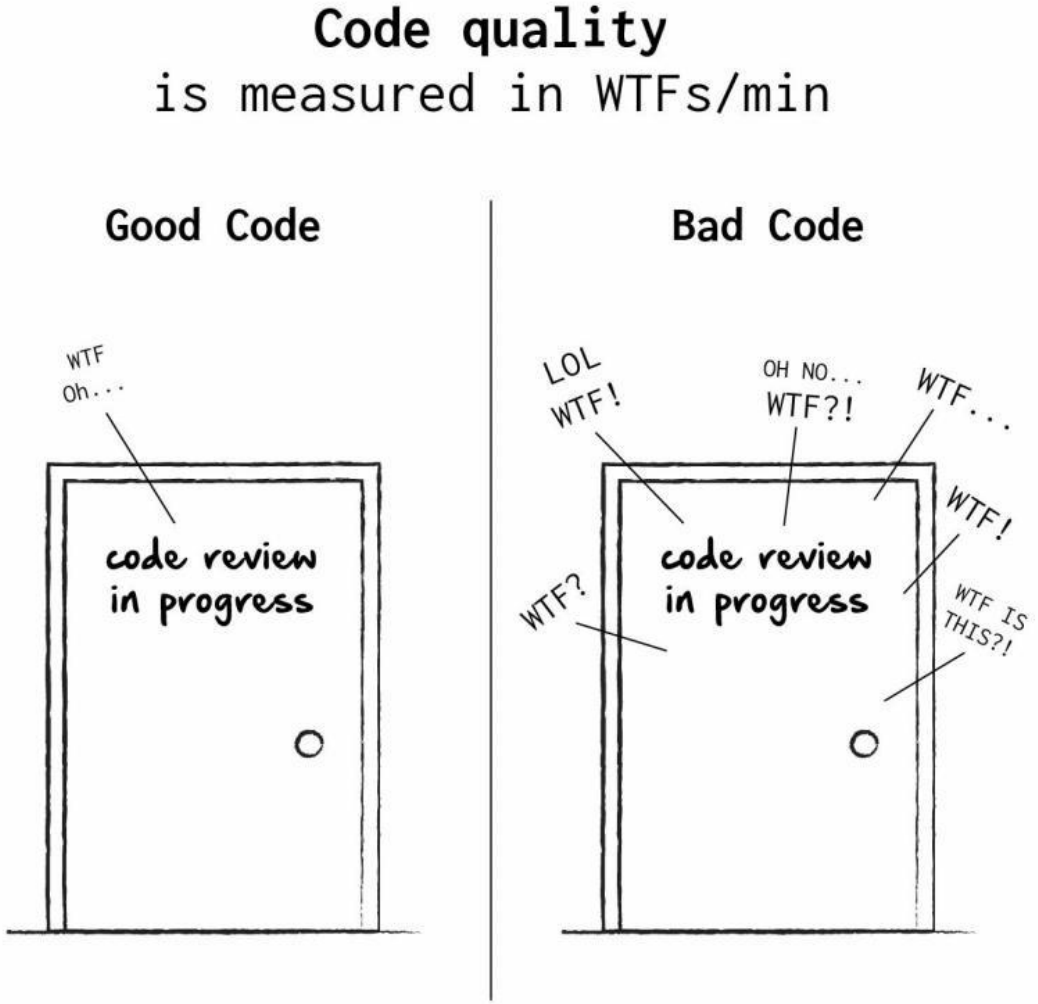
if nothing else, write #cleancode

This Week's Content

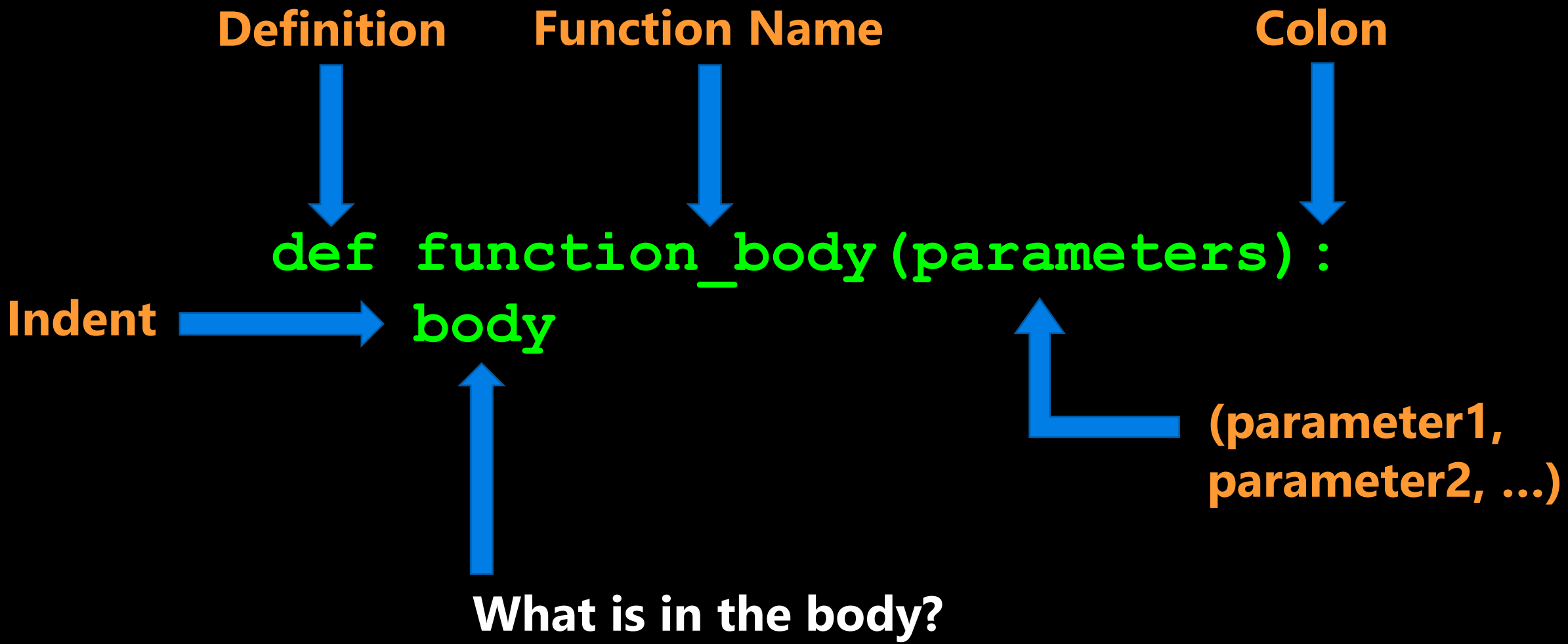
- **Lecture 2.1**
  - Functions, input & output, importing modules
  - Reading: Chapter 3
- **Lecture 2.2**
  - **Defining your own function**
  - **Reading: Chapter 3**
- **Lecture 2.3**
  - Engineering design
  - Design Problem: Forward Kinematics

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.



Function Definitions



Function Definitions

```
def function_body(parameters):
    body
```

- **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).
- Important: all the lines of body must be indented. That is how Python knows that they are part of the function.

Function Definitions

```
def function_body(parameters):
```

1. """DOCSTRING""" (optional)
2. Code that does the thing
3. return [expression]
   The return statement is options and if it is not included, it's the same as writing return None

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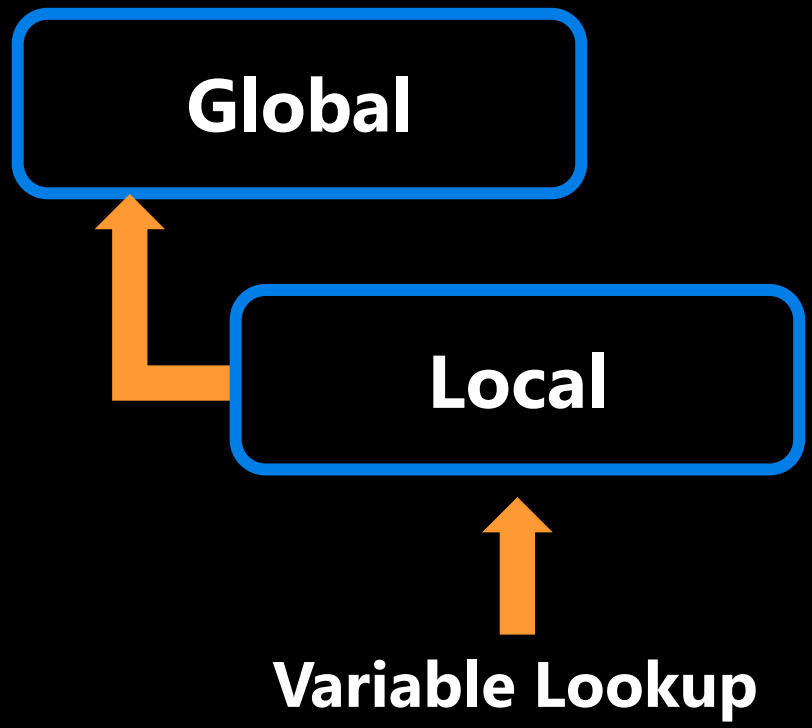
Click Link:
1. Defining Your Own Functions

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



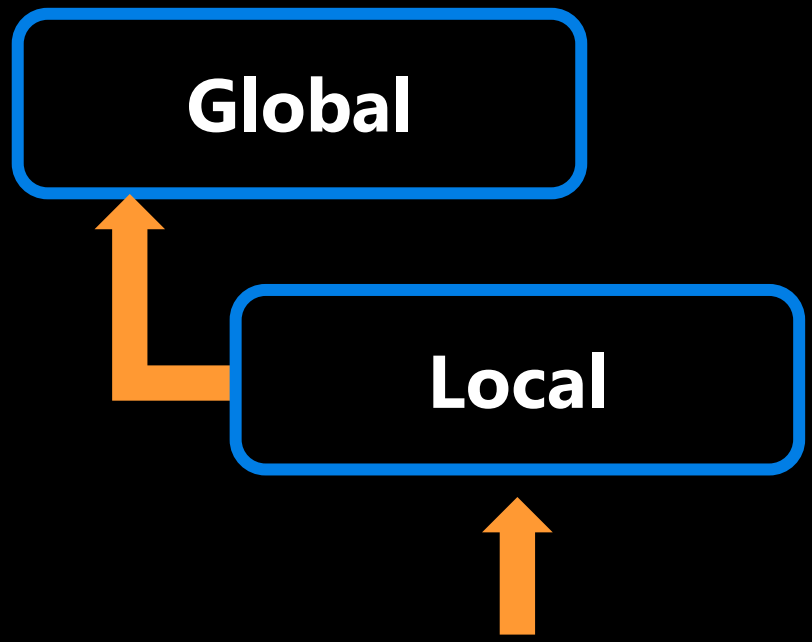
Variable Scope

- **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.

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

print(name)
```

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



Variable Lookup

- Is name in local?
- 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.

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

print(name)
```

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

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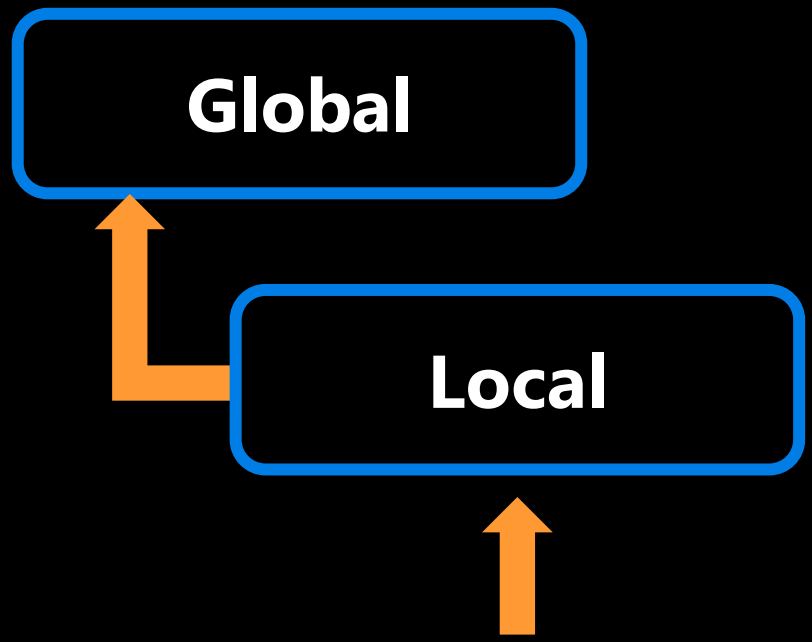
Click Link:
2. Local Scope

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.



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

```
name = 'Sebastian'

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

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

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.

```
name = 'Sebastian'

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

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

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Click Link:
3. Global Scope

Design Recipe

- How do we do 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:
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.

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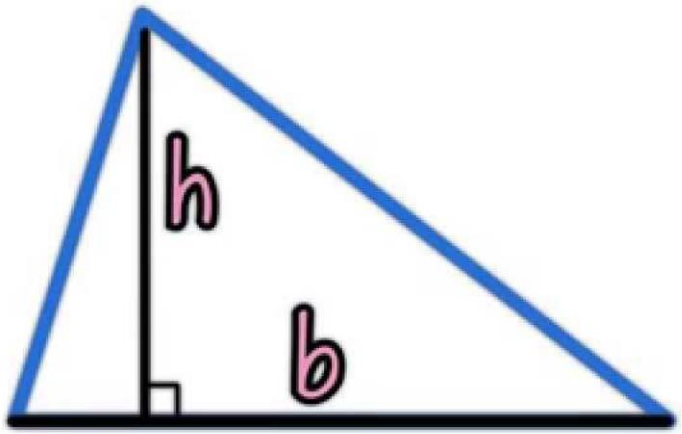
Click Link:
5. Docstring

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

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.

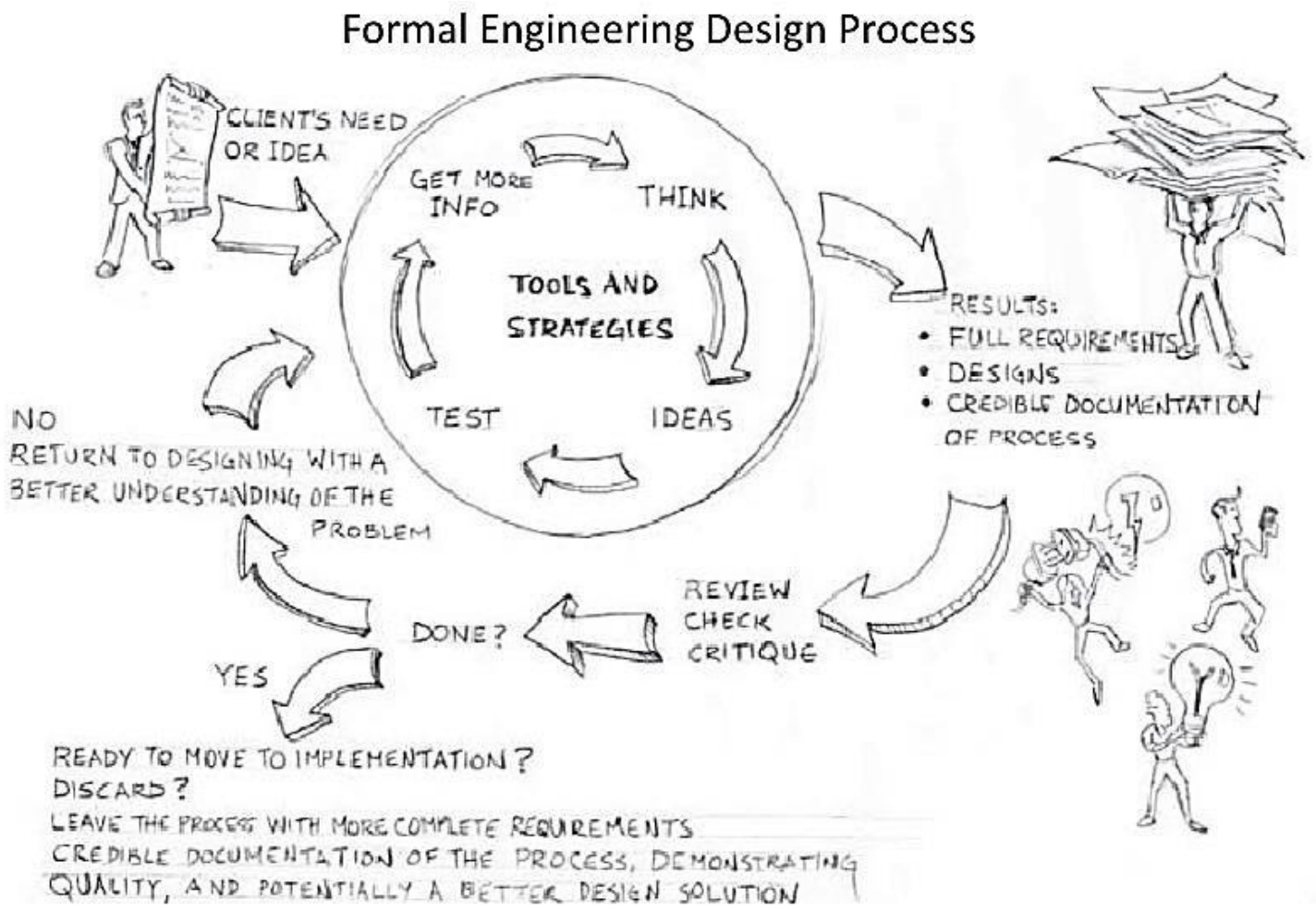
A Design Process for Programming

- 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 programing as an engineering design process and adapt the process you have already seen in APS111/112.

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).
- These two plans are not the same thing!
- If the hardest part of your algorithm plan is late in the sequence, you may still choose to code it first to figure out how to do it. (Figuring it out may change other parts of your algorithm plan!).

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.
  - A lot about finding your own mistakes: even for good programmers, most of their time is spent testing and debugging!

Lecture Recap

Practice!

- The syntax of function definitions.
- A design recipe for writing functions.
- Nested function calls.
- Calling functions from within functions.
- An Engineering Design Process for Programming.

- See Chapter 3 of the textbook.

- More on engineering design next lecture!

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