

Introduction to Programming for Public Policy Week 2

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Functions

Function composition

```
>>> math.exp(math.log(5))  
5.0
```

Adding new functions

Define a new function using the `def` keyword:

```
def hello():  
    print('Hello, World')  
  
hello()
```

Parameters

The inputs to a function are called *parameters*. For example:

```
math.sqrt(2)
```

2 is a parameter

Arguments

To define a function that “takes” parameters:

```
def hello(name):  
    print('Hello, ' + name)  
  
hello('John')
```

- The variable `name` is called an *argument* to the function.
- The parameter `'John'` gets assigned to the argument `name`.

Parameters are local

Argument and variable names used inside a function stay inside that function:

```
def hello(name):
    print('Hello, ' + name)

hello('Jane')
print(name)
```

```
NameError: name 'name' is not defined
```

Multiple arguments

Functions can have multiple arguments, separated by commas:

```
def hello(greeting, name):  
    print(greeting + ', ' + name)  
  
hello('Bonjour', 'Jean')
```


Return values

- Math functions like `exp`, `log`, etc. all produce an output/result.
- This is called a return value and your functions can return using the keyword `return`:

```
def hello(name):  
    return 'Hello, ' + name  
  
hello_john = hello('John')
```

Default return value

- Note that if a function does not explicitly return a value, it returns a special value `None`:

```
def hello():
    print('Hello, World')

hello_return = hello()
print(hello_return)
```

Why functions?

- Functions are a part of “good code”
- They make your code more clear
- They also make it more “modular”

Pythagorean theorem

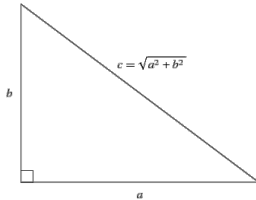


Figure 1: <http://mathworld.wolfram.com/PythagoreanTheorem.html>

Calculate the length of the hypotenuse of a triangle:

```
import math

math.sqrt(3**2 + 4**2)
math.sqrt(1**2 + 1**2)
math.sqrt(5**2 + 12**2)
```

Pythagorean theorem refactored

```
import math

def hypotenuse(a, b):
    return math.sqrt(a**2 + b**2)

hypotenuse(3,4)
hypotenuse(1,1)
hypotenuse(5,12)
```

Input

Keyboard input

Use the `input` function to read text input in your program:

```
# hello_input.py
name = input()
print('Hello, ' + name)
```

```
$ python hello_input.py
Eric
Hello, Eric
```

Keyboard input prompt

The input function takes one *optional* prompt parameter:

```
# hello_prompt.py  
name = input("Name: ")  
print('Hello, ' + name)
```

```
$ python hello_prompt.py  
Name: Eric  
Hello, Eric  
$
```


Incremental Development

Introduction

- *Incremental development* is a process for dealing with complex code
 - Add only a small amount of code at a time
 - That way you can test it bit-by-bit
- A related concept is a “minimum working example”
- Reference: Think Python, Chapter 6

Example: distance function

Let's implement the formula for calculating the distance between two points in the plane:

$$distance = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

Step 1: Define the function

- The function should take four arguments: x_1, y_1, x_2, y_2
- The function should return a floating-point (decimal) value

```
def distance(x1, y1, x2, y2):  
    return 0.0
```

Testing function definition

```
>>> distance(1,2,4,6)  
0.0
```

- The function call and return are working
- But the answer is obviously wrong (correct answer is 5)

Step 2: Calculate differences

```
def distance(x1, y1, x2, y2):
    dx = x2 - x1
    dy = y2 - y1

    print('dx is', dx)
    print('dy is', dy)

    return 0.0
```

```
>>> distance(1,2,4,6)
dx is 3
dy is 4
0.0
```

Step 3: Sum of squares

```
def distance(x1, y1, x2, y2):  
    dx = x2 - x1  
    dy = y2 - y1  
  
    dsquared = dx**2 + dy**2  
    print('dsquared is', dsquared)  
  
    return 0.0
```

Step 4: Distance

```
import math

def distance(x1, y1, x2, y2):
    dx = x2 - x1
    dy = y2 - y1

    dsquared = dx**2 + dy**2
    return math.sqrt(dsquared)
```


Conditions

Booleans

- Consider the python expression `x > 0`.
- This has a type called “boolean” and can take only two values: True or False.
- Other boolean operators include:
 - Equals (`==`), as in `1 == 1`
 - Not equals (`!=`) as in `'a' != 'b'`

Conditions: if

Boolean logic can be used to control program execution through the `if` statement:

```
if (x < 0):  
    print('Negative')
```

Conditions: else

Use else to execute code when the condition is False:

```
if (x < 0):  
    print('Negative')  
else:  
    print('Non-negative')
```

Conditions: elif

```
if (x < 0):  
    print('Negative')  
elif (x == 0):  
    print('Zero')  
else:  
    print('Positive')
```

Modulo

Another related operator is modulo (%). This operator returns the remainder when one number is divided by another:

$a \% b$ is the remainder when a is divided by b

For example:

- $5 \% 3 = 2$, because 5 divided by 3 is 1 with remainder 2
- $10 \% 3 = 1$, because 10 divided by 3 is 3 with remainder 1
- $4 \% 2 = 0$, because 4 divided by 2 is 2 with remainder 0

Even-odd

We can use modulo (%) to determine whether a number is even or odd by checking whether it is divisible by 2:

```
if (x % 2 == 0):  
    print('Even')  
else:  
    print('Odd')
```

Boolean operators

We often want to combine booleans. For example, we might ask of a person:

- Do they speak English *and* Russian?
- Do they speak French *or* Chinese?
- Do they speak *not* speak Spanish?

Boolean operators in Python

Those are the three basic boolean operators:

- `and`: True if both parameters are True
 - `a and b` where `a` and `b` are booleans
- `or`: True if at least one parameter is True
 - `a or b`
 - Note that it's not "either-or", i.e. `True or True` is `True`
- `not`: the opposite of the argument
 - `not a`

Boolean logic

- Boolean logic (and, or, not) is fundamental to how computers work.
- In fact, all operations (e.g. arithmetic) on a computer can be expressed in boolean logic.

More string functions

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- `substring in string`: does string contain substring?
- `string.find(substring)`: what is the (first!) index of substring in string? (or -1 if substring not in string)

Raising errors

- You can trigger your own errors using the `raise` keyword
- The most common type of error is a `ValueError`:

```
price = input('Price: ')  
if price <= 0:  
    raise ValueError('price must be non-negative!')
```

String parsing

The process of reading through a string to break it down or interpret it is called *parsing*.

- Command line programs do this in order to interpret options and arguments
- Python does this to execute your code
- Google does it to execute a search query
- Etc.

String parsing example

```
city_state = 'Chicago, IL'

if ',' not in city_state: # substring
    raise ValueError('no comma')

comma_index = city_state.find(',')
city = city_state[:comma_index]
state = city_state[comma_index+2:]

if len(state) != 2:
    raise ValueError('invalid state abbrev: ' + state)

print('City:', city)
print('State:', state)
```

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- Complex programs are easier to read and write using functions
- Use the `input` function to make interactive programs
- Incremental development makes debugging easier
- Use the `if` statement to execute code under certain conditions
- Use boolean logic to express those conditions