

Lecture 3

Functions & Modules

Labs this Week

- Lab 1 is due at the **beginning** of your lab
 - If it is not yet by then, you cannot get credit
 - Only exception is for students who added late (Those students should talk to me)
- Should spend time *entirely* on Lab 2
 - Getting behind this early is bad
 - We are getting you ready for Assignment 1

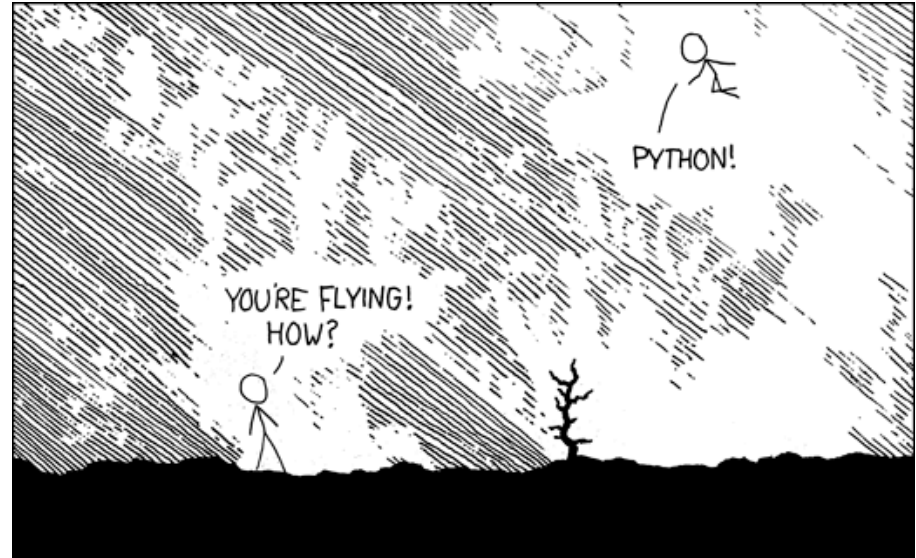
(Optional) Readings

Thursday Reading

- Chapter 3 in the text
 - But can skip section 3.9
- Browse the Python API
 - Will learn what that is today
 - Do not need to read all of it

Next Week

- Sections 8.1, 8.2, 8.5, 8.8



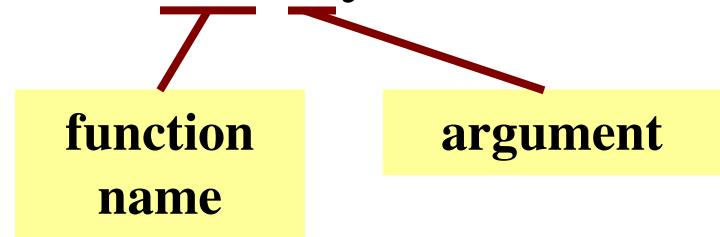
[xkcd.com]

Reminder: AEWs

- Small discussion study group for class
 - Graded on attendance only
 - Can really help if you have no experience
- Enrollment is extremely low right now
 - Each section has room for up to 25 people
 - Recommend it if you have the time
- Recommended to help with exams

Function Calls

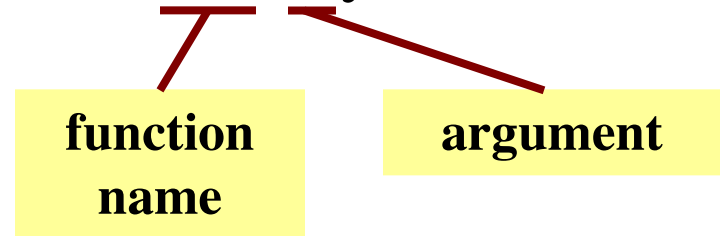
- Python supports expressions with math-like functions
 - A function in an expression is a **function call**
 - Will explain the meaning of this later
- Function expressions have the form **fun**(x,y,...)



- **Examples** (math functions that work in Python):
 - `round(2.34)`
 - `max(a+3,24)`

Function Calls

- Python supports expressions with math-like functions
 - A function in an expression is a **function call**
 - Will explain the meaning of this later
- Function expressions have the form **fun**(x,y,...)



- **Examples** (math functions that work in Python):
 - `round(2.34)`
 - `max(a+3,24)`

Arguments can be
any **expression**

Built-In Functions

- You have seen many functions already
 - Type casting functions: `int()`, `float()`, `bool()`
 - Dynamically type an expression: `type()`
 - Help function: `help()`
 - Quit function: `quit()`
- One of the most important functions is `print()`
 - `print(exp)` displays value of `exp` on screen
 - Will see later why this is important

Arguments go in (),
but `name()` refers to
function in general

Built-in Functions vs Modules

- The number of built-in functions is small
 - <http://docs.python.org/3/library/functions.html>
- Missing a lot of functions you would expect
 - **Example:** `cos()`, `sqrt()`
- **Module:** file that contains Python code
 - A way for Python to provide optional functions
 - To access a module, the `import` command
 - Access the functions using module as a *prefix*

Example: Module **math**

```
>>> import math
```

```
>>> math.cos(0)
```

```
1.0
```

```
>>> cos(0)
```

```
Traceback (most recent call last):
```

```
  File "<stdin>", line 1, in <module>
```

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

```
>>> math.pi
```

```
3.141592653589793
```

```
>>> math.cos(math.pi)
```

```
-1.0
```

Example: Module **math**

```
>>> import math
```

To access math functions

```
>>> math.cos(0)
```

```
1.0
```

```
>>> cos(0)
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```
Traceback (most recent call last):
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  File "<stdin>", line 1, in <module>
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Example: Module **math**

```
>>> import math
```

To access math
functions

```
>>> math.cos(0)
```

```
1.0
```

Functions
require math
prefix!

```
>>> cos(0)
```

```
Traceback (most recent call last):
```

```
  File "<stdin>", line 1, in <module>
```

```
NameError: name 'cos' is not defined
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>>> math.pi
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3.141592653589793
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```
-1.0
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Example: Module **math**

```
>>> import math
```

To access math
functions

```
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```
1.0
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Functions
require math
prefix!

```
>>> cos(0)
```

```
Traceback (most recent call last):
```

```
File "<stdin>", line 1, in <module>
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NameError: name 'cos' is not defined
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```
>>> math.pi
```

Module has
variables too!

```
3.141592653589793
```

```
>>> math.cos(math.pi)
```

```
-1.0
```

Example: Module **math**

```
>>> import math
```

To access math functions

```
>>> math.cos(0)
```

```
1.0
```

```
>>> cos(0)
```

Functions require math prefix!

```
Traceback (most recent call last):
```

```
File "<stdin>", line 1, in <module>
```

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

```
>>> math.pi
```

Module has variables too!

```
3.141592653589793
```

```
>>> math.cos(math.pi)
```

```
-1.0
```

Other Modules

- **io**
 - Read/write from files
- **random**
 - Generate random numbers
 - Can pick any distribution
- **string**
 - Useful string functions
- **sys**
 - Information about your OS

Reading the Python Documentation

The screenshot shows the Python Software Foundation documentation page for the `math` module in Python 3.6.2. The browser address bar shows `docs.python.org/3/library/math.html`. The page title is "9.2. `math` — Mathematical functions". The left sidebar contains a "Table Of Contents" with links to various mathematical function categories, and "Previous topic" and "Next topic" links. The main content area starts with a paragraph explaining that the `math` module provides access to mathematical functions defined by the C standard. It then lists several functions: `math.ceil(x)`, `math.copysign(x, y)`, `math.fabs(x)`, `math.factorial(x)`, `math.floor(x)`, and `math.fmod(x, y)`. A red box highlights the URL `http://docs.python.org/library` in the bottom right corner of the page content.

Python Software Foundation docs.python.org/3/library/math.html

Python » English » 3.6.2 » Documentation » The Python Standard Library » 9. Numeric and Mathematical Modules »

Quick search Go | previous | next | modules | index

9.2. `math` — Mathematical functions

This module is always available. It provides access to the mathematical functions defined by the C standard.

These functions cannot be used with complex numbers; use the functions of the same name from the `cmath` module if you require support for complex numbers. The distinction between functions which support complex numbers and those which don't is made since most users do not want to learn quite as much mathematics as required to understand complex numbers. Receiving an exception instead of a complex result allows earlier detection of the unexpected complex number used as a parameter, so that the programmer can determine how and why it was generated in the first place.

The following functions are provided by this module. Except when explicitly noted otherwise, all return values are floats.

9.2.1. Number-theoretic and representation functions

`math.ceil(x)`
Return the ceiling of `x`, the smallest integer greater than or equal to `x`. If `x` is not a float, delegates to `x.__ceil__()`, which should return an [Integral](#) value.

`math.copysign(x, y)`
Return a float with the magnitude (absolute value) of `x` but the sign of `y`. On platforms that support signed zeros, `copysign(1.0, -0.0)` returns `-1.0`.

`math.fabs(x)`
Return the absolute value of `x`.

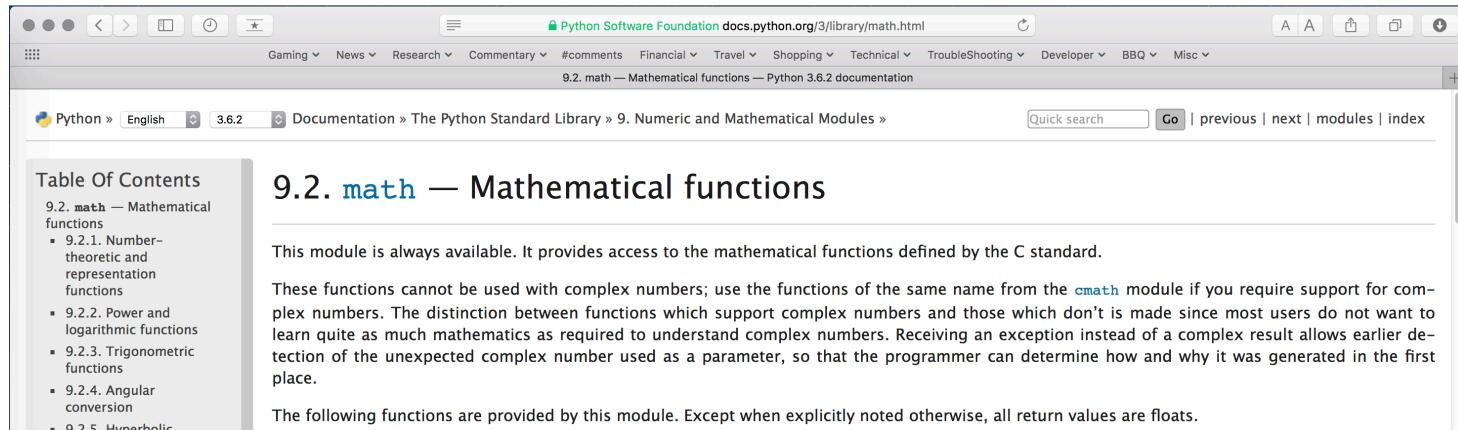
`math.factorial(x)`
Return `x` factorial. Raises `ValueError` if `x` is not integral or is negative.

`math.floor(x)`
Return the floor of `x`, the largest integer less than or equal to `x`. If `x` is not a float, delegates to `x.__floor__()`, which should return an [Integral](#) value.

`math.fmod(x, y)`
Return `fmod(x, y)`, as defined by the platform C library. Note that the C standard is that `fmod(x, y)` be exactly (mathematically; to infinite precision) equal to `x - n*y` for some integer `n` such that the result has the same sign as `x` and magnitude less than `abs(y)`. Python's `x % y` returns a result with the sign of `y` instead, and may not be exactly computable for float arguments. For example, `fmod(-1e-100, 1e100)` is `-1e-100`, but the result of Python's `-1e-100 % 1e100` is `1e100-1e-100`, which cannot be

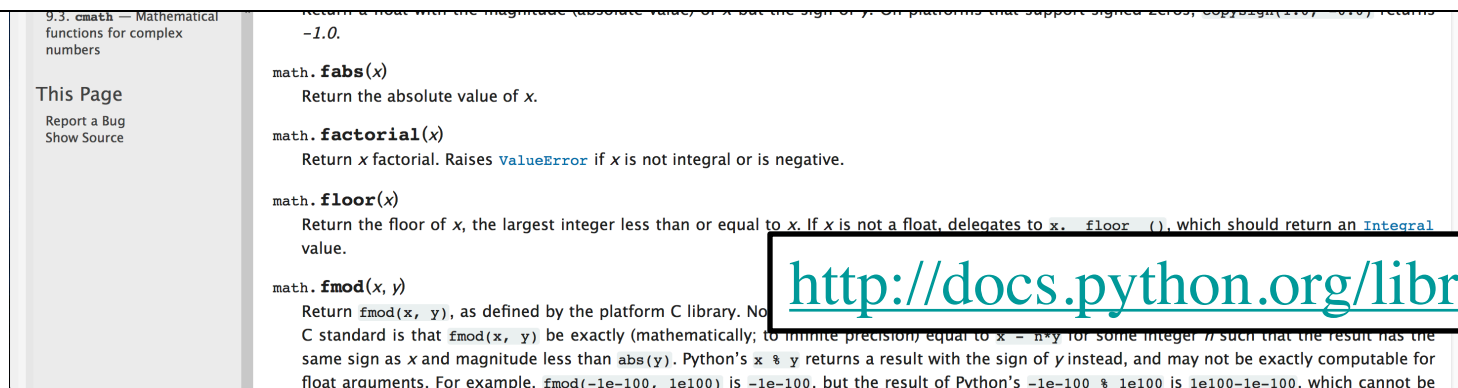
<http://docs.python.org/library>

Reading the Python Documentation



`math.ceil(x)`

Return the ceiling of `x` as a float, the smallest integer value greater than or equal to `x`.



<http://docs.python.org/library>

Reading the Python Documentation

The screenshot shows the Python documentation page for the `math` module. The browser address bar shows `docs.python.org/3/library/math.html`. The page title is "9.2. `math` — Mathematical functions". The left sidebar contains a "Table Of Contents" with links to "9.2. `math` — Mathematical" and "9.2.4. Angular conversion". The main content area starts with "This module is always available. It provides access to the mathematical functions defined by the C standard." followed by a paragraph about complex numbers and a list of functions. A callout bubble labeled "Function name" points to `math.ceil(x)`. Another callout labeled "Possible arguments" points to the parameter `x` in `math.ceil(x)`. A third callout labeled "Module" points to the `math` module name in the function signature. A fourth callout labeled "What the function evaluates to" points to the description "Return the ceiling of `x` as a float, the smallest integer value greater than or equal to `x`." A fifth callout labeled "http://docs.python.org/library" points to the URL in the bottom right corner.

Function name

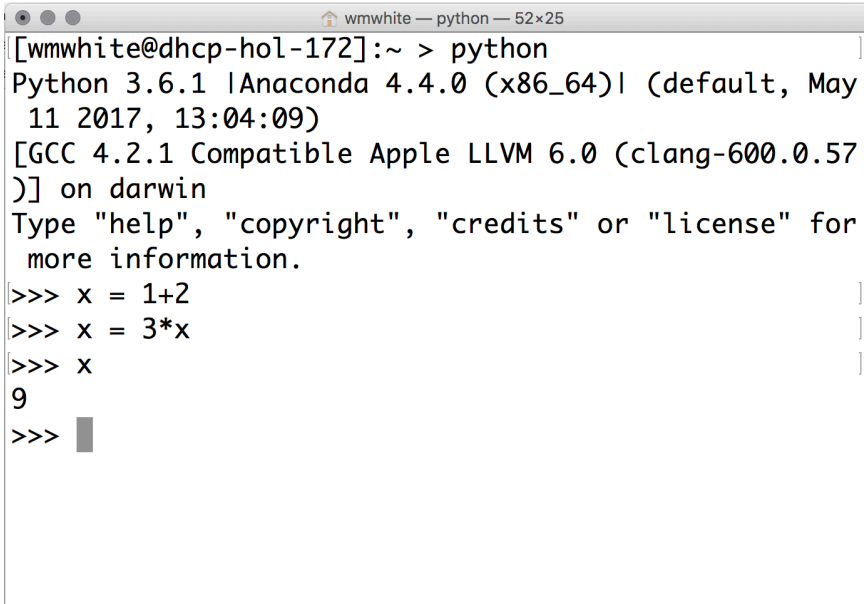
Possible arguments

Module

What the function evaluates to

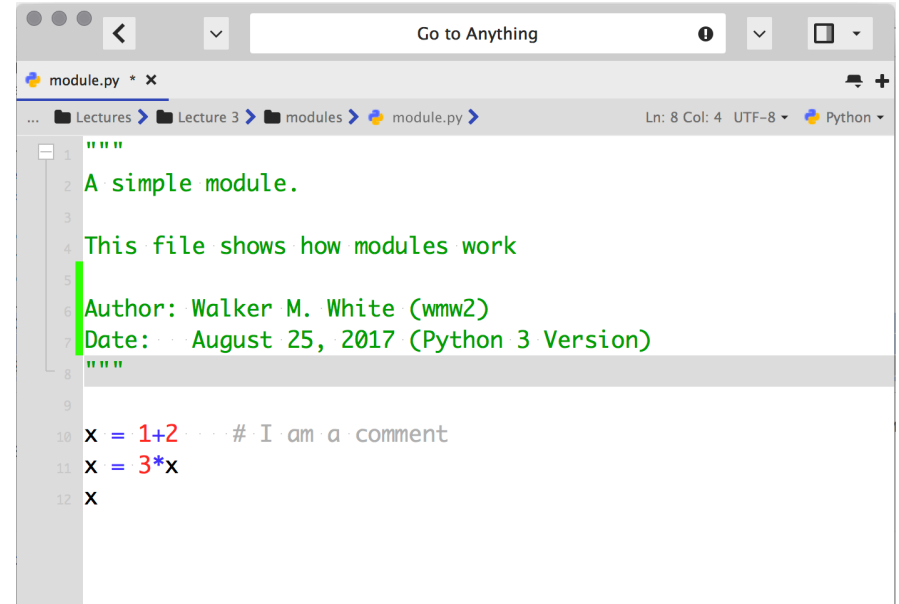
<http://docs.python.org/library>

Interactive Shell vs. Modules



```
wmwhite@dhcp-hol-172]:~ > python
Python 3.6.1 |Anaconda 4.4.0 (x86_64)| (default, May
 11 2017, 13:04:09)
[GCC 4.2.1 Compatible Apple LLVM 6.0 (clang-600.0.57
)] on darwin
Type "help", "copyright", "credits" or "license" for
more information.
>>> x = 1+2
>>> x = 3*x
>>> x
9
>>>
```

- Launch in command line
- Type each line separately
- Python executes as you type



```
module.py * x
... Lectures > Lecture 3 > modules > module.py >
Ln: 8 Col: 4 UTF-8 Python
1 """
2 A simple module.
3
4 This file shows how modules work
5
6 Author: Walker M. White (wmw2)
7 Date: August 25, 2017 (Python 3 Version)
8 """
9
10 x = 1+2 # I am a comment
11 x = 3*x
12 x
```

- **Write in a text editor**
 - We use Komodo Edit
 - But anything will work
- Load module with import

Using a Module

Module Contents

```
""" A simple module.
```

```
This file shows how modules work
```

```
"""
```

```
# This is a comment
```

```
x = 1+2
```

```
x = 3*x
```

```
x
```

Using a Module

Module Contents

```
""" A simple module.
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```
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```
# This is a comment
```

Single line comment
(not executed)

```
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Docstring (note the Triple Quotes)
Acts as a multiple-line comment
Useful for *code documentation*

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x
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Commands
Executed on import

Using a Module

Module Contents

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```

Single line comment
(not executed)

```
x = 1+2
```

```
x = 3*x
```

Commands
Executed on import

```
x
```

Not a command.
`import` **ignores this**

Using a Module

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x = 1+2
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```
x
```

Python Shell

```
>>> import module
```

```
>>> x
```

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```
Traceback (most recent call last):
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```
  File "<stdin>", line 1, in <module>
```

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

“**Module data**” must be
prefixed by module name

Python Shell

```
>>> import module
```

```
>>> x
```

```
Traceback (most recent call last):
```

```
File "<stdin>", line 1, in <module>
```

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

```
>>> module.x
```

```
9
```

Using a Module

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```
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```

```
x = 3*x
```

```
x
```

“**Module data**” must be
prefixed by module name

Prints **docstring** and
module contents

Python Shell

```
>>> import module
```

```
>>> x
```

```
Traceback (most recent call last):
```

```
File "<stdin>", line 1, in <module>
```

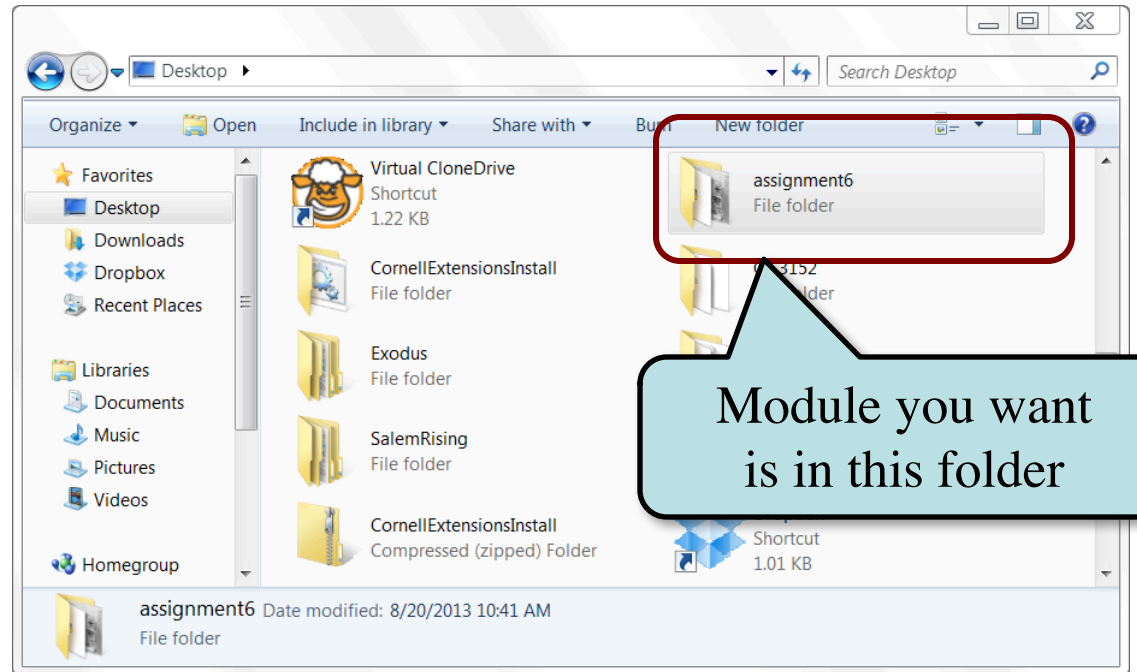
```
NameError: name 'x' is not defined
```

```
>>> module.x
```

```
9
```

```
>>> help(module)
```

Modules Must be in Working Directory!



Modules Must be in Working Directory!

Have to navigate to folder **BEFORE** running Python

Module you want is in this folder

Using the from Keyword

```
>>> import math
```

```
>>> math.pi
```

Must prefix with
module name

```
3.141592653589793
```

```
>>> from math import pi
```

```
>>> pi
```

No prefix needed
for variable pi

```
3.141592653589793
```

```
>>> from math import *
```

```
>>> cos(pi)
```

```
-1.0
```

No prefix needed
for anything in math

- Be careful using from!
- Using import is *safer*
 - Modules might conflict (functions w/ same name)
 - What if import both?
- **Example:** Turtles
 - Used in Assignment 4
 - 2 modules: turtle, tkturtle
 - Both have func. Turtle()

Modules vs. Scripts

Module

- Provides functions, variables
 - **Example:** temp.py
- import it into Python shell

```
>>> import temp
>>> temp.to_fahrenheit(100)
212.0
>>>
```

Script

- Behaves like an application
 - **Example:** helloApp.py
- Run it from command line:

```
python helloApp.py
```



Modules vs. Scripts

Module

- Provides functions, variables
 - **Example:** temp.py
- import it into Python shell

```
>>> import temp
>>> temp.to_fahrenheit(100)
212.0
>>>
```

Script

- Behaves like an application
 - **Example:** helloApp.py
- Run it from command line:

```
python helloApp.py
```



Files look the same. Difference is how you use them.

Scripts and Print Statements

module.py

```
""" A simple module.
```

```
This file shows how modules work  
"""
```

```
# This is a comment
```

```
x = 1+2
```

```
x = 3*x
```

```
x
```

script.py

```
""" A simple script.
```

```
This file shows why we use print  
"""
```

```
# This is a comment
```

```
x = 1+2
```

```
x = 3*x
```

```
print(x)
```


Scripts and Print Statements

module.py

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x
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script.py

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This file shows why we use print  
"""
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```
# This is a comment
```

```
x = 1+2
```

```
x = 3*x
```

```
print(x)
```



Only difference

Scripts and Print Statements

module.py

```
modules — -bash — 62x24
[wmwhite@Ryleh]:modules > python module.py
[wmwhite@Ryleh]:modules > █
```

- Looks like nothing happens
- Python did the following:
 - Executed the **assignments**
 - Skipped the last line
(‘x’ is not a statement)

script.py

```
modules — -bash — 62x24
[wmwhite@Ryleh]:modules > python script.py
9
[wmwhite@Ryleh]:modules > █
```

- We see something this time!
- Python did the following:
 - Executed the **assignments**
 - Executed the last line
(Prints the contents of x)

Scripts and Print Statements

module.py

script.py

```
modules — -bash — 62x24
[wmwhite@Ryleh]:modules > python module.py
[wmwhite@Ryleh]:modules > █
```

```
modules — -bash — 62x24
[wmwhite@Ryleh]:modules > python script.py
9
[wmwhite@Ryleh]:modules > █
```

When you run a script,
only statements are executed

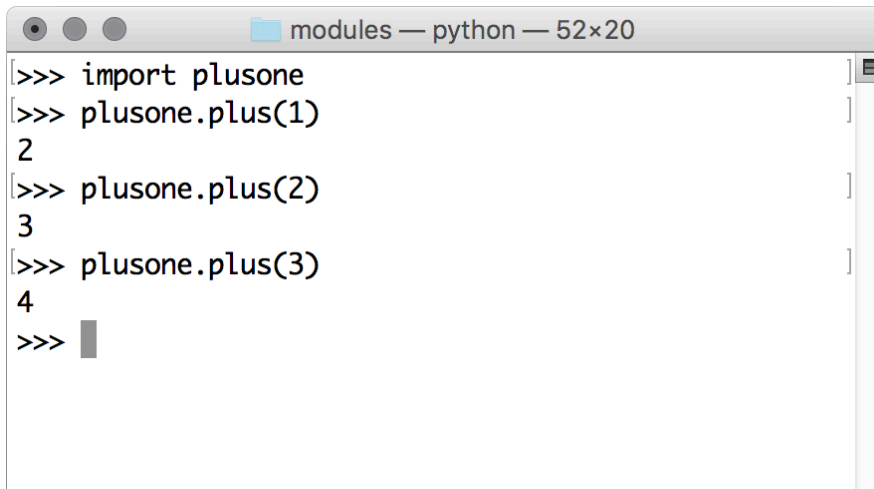
- Looks like this time!
- Python executed the following:
 - Executed the assignments
 - Skipped the last line ('x' is not a statement)

- Executed the assignments
- Executed the last line (Prints the contents of x)

Next Time: Defining Functions

Function Call

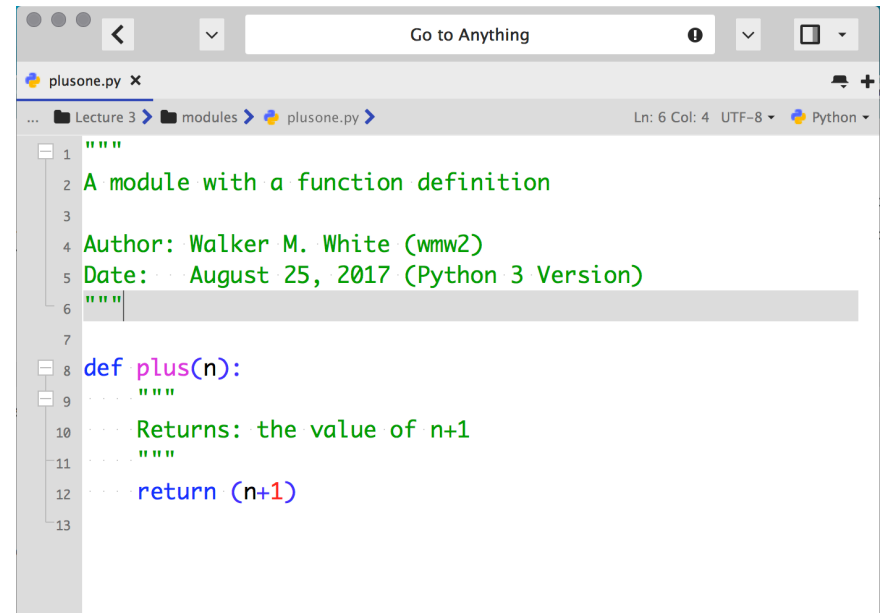
- Command to **do** the function
- Can put it anywhere
 - In the Python shell
 - Inside another module



```
>>> import plusone
>>> plusone.plus(1)
2
>>> plusone.plus(2)
3
>>> plusone.plus(3)
4
>>>
```

Function Definition

- Command to **do** the function
- Belongs inside a module

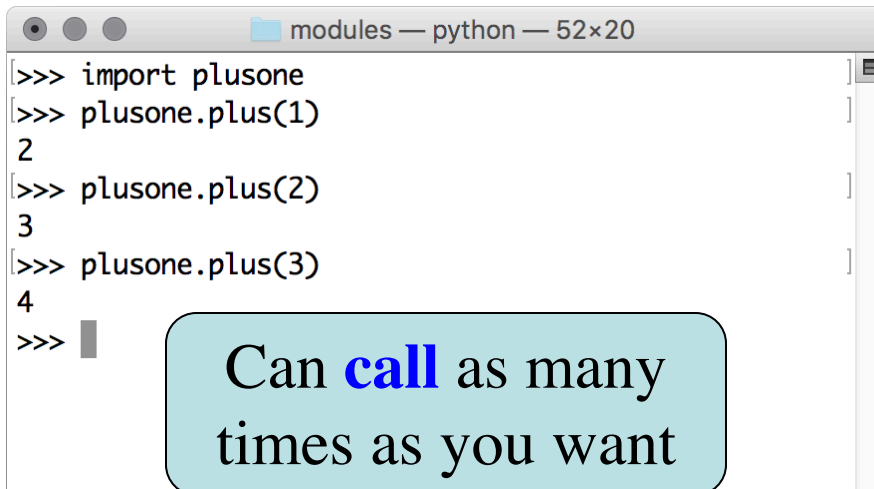


```
1 """
2 A module with a function definition
3
4 Author: Walker M. White (wmw2)
5 Date: August 25, 2017 (Python 3 Version)
6 """
7
8 def plus(n):
9     """
10     Returns: the value of n+1
11     """
12     return (n+1)
13
```

Next Time: Defining Functions

Function Call

- Command to **do** the function
- Can put it anywhere
 - In the Python shell
 - Inside another module

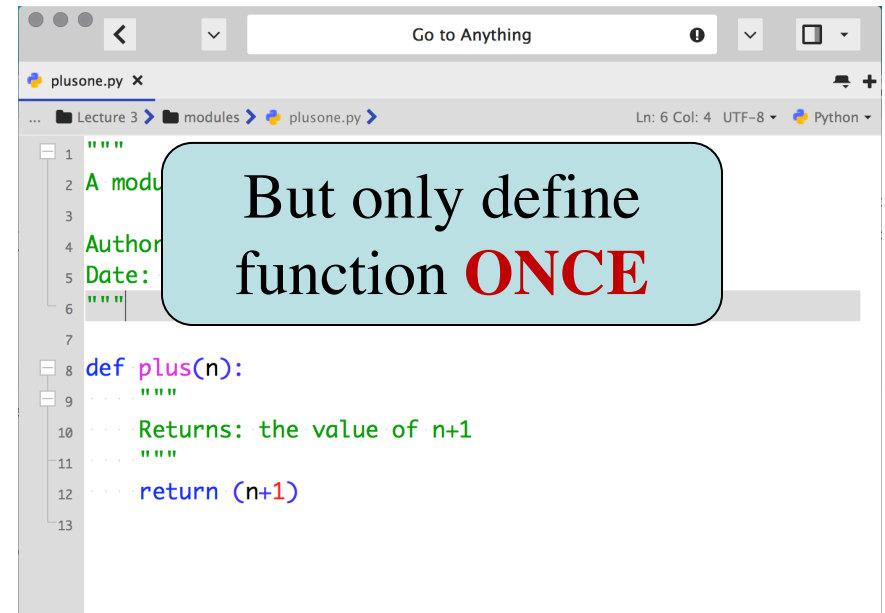


```
>>> import plusone
>>> plusone.plus(1)
2
>>> plusone.plus(2)
3
>>> plusone.plus(3)
4
>>>
```

Can **call** as many times as you want

Function Definition

- Command to **do** the function
- Belongs inside a module



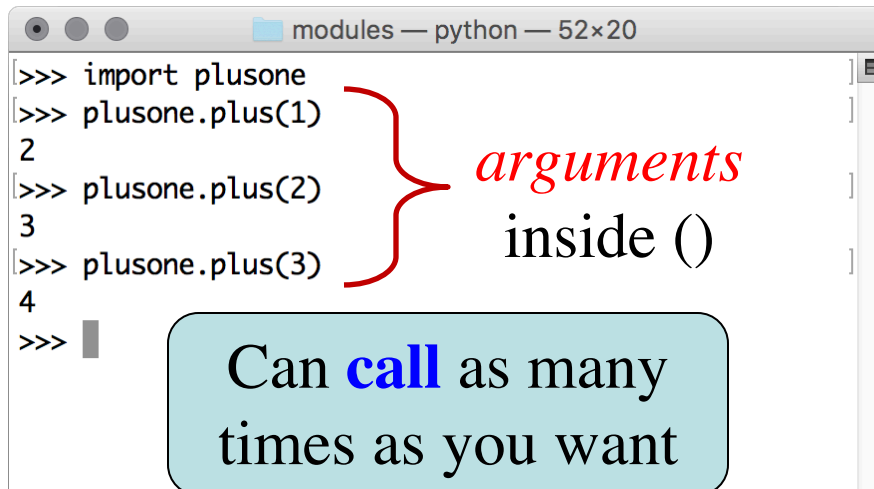
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1 """
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8 def plus(n):
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```

But only define function **ONCE**

Next Time: Defining Functions

Function Call

- Command to **do** the function
- Can put it anywhere
 - In the Python shell
 - Inside another module



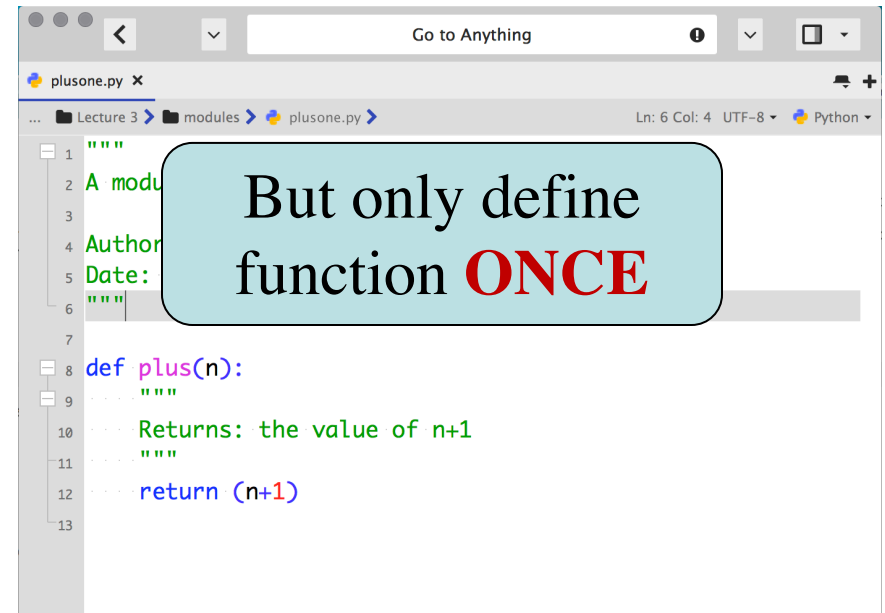
```
>>> import plusone
>>> plusone.plus(1)
2
>>> plusone.plus(2)
3
>>> plusone.plus(3)
4
>>>
```

arguments
inside ()

Can **call** as many times as you want

Function Definition

- Command to **do** the function
- Belongs inside a module



```
1 """
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```

But only define function **ONCE**

Functions and Modules

- Purpose of modules is **function definitions**
 - Function definitions are written in module file
 - Import the module to call the functions
- Your Python workflow (right now) is

1. Write a function in a module (a .py file)
2. Open up the Terminal/Command Prompt
3. Move to the directory with this file
4. Start Python (type python)
5. Import the module
6. Try out the function