Lecture 3: Functions & Modules

(Sections 3.1-3.3)

CS 1110
Introduction to Computing Using Python

Cornell Bowers CIS
Computer Science

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http://www.cs.cornell.edu/courses/cs1110/2022sp

Lecture 3: Functions & Modules

(Sections 3.1-3.3)

Have these ready for today's lecture:
- *Materials for note taking (e.g., lecture slides on paper or pdf)*
- *Terminal or Powershell, ready to start Python*
- *Atom Editor*

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There were many questions about the math module function **`ceil()`**. Since it's not a commonly known function, we've replaced it with **`sqrt()`**, which takes the square root of a number (Recall: $\sqrt{9} = 3$ because 3^2 (or 3x3) = 9).

We hope this is a better example function!

This is not a math class! We just needed an example to work with. ☺

Announcements

Can't see the zoom polls?
- Using zoom in web browser? It doesn't show polls
- It's okay! Please still work out the answer.
- We aren't counting participation, so no credit is lost!

Lab Deadlines
- Lab 1: Feb 2
- Lab 2: Feb 3
- Lab 3: Feb 4
- Lab 4: Feb 7

extensions

New labs this week!

Common Python Gotcha

```
> 1+1
> Command not found: 1+1
>
```

What in the world?!?

Take a step back.
Where am I?
If you don't see **>>>**
you are not in python interactive mode!

```
> python
>>> 1 + 1
2
>>>
```

Ahh, much better.
All is right in the world.

Function Calls

- Function expressions have the form:

```
best_function_ever(x,y,…)
```

function name — argument(s)

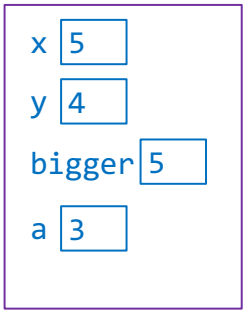
- Arguments
  - Separated by commas
  - Can be any expression

A function might have 0, 1, … or many arguments

Two math functions built into Python

```
>>> x = 5
>>> y = 4
>>> bigger = max(x, y)
>>> bigger
5
>>> a = round(3.14159265)
>>> a
3
```

Visualize the execution!



Play-by-Play of Python interactive mode

```
>>> x = 5
>>> y = 4
>>> bigger = max(x, y)
>>> bigger
5
>>> a = round(3.14159265)
>>> a
3
```

Executes 3 assignment statements

Evaluates the expression and reports

Executes 1 assignment statement

Evaluates the expression and reports

Python interactive mode reports the value to be helpful

Always-available Built-in Functions

- You have seen many functions already
  - Type casting functions: `int()`, `float()`, `bool()`
  - Get type of a value: `type()`
  - Exit function: `exit()`

Empty parens are a human space-saving convention to indicate something is a function.

- Longer list:

http://docs.python.org/3/library/functions.html

Visualizing functions & variables **(1)**

Running Example:

1. Built-in functions

- Available as soon as you start python
- We don't usually draw them, but they are technically there

```
C:\> python
>>>
```

What Python can access directly

```
int()
float()
str()
type()
print()
…
```


Visualizing functions & variables **(2)**

Running Example:

1. Built-in functions

2. Define a new variable

```
C:\> python
>>> x = 7
>>>
```

What Python can access directly

```
int()
float()
str()
type()
print()
…
x 7
```


Modules: libraries and scripts

- Many more functions available via built-in ***modules***
  - "Libraries" of functions and variables
- To access a module in Python, use **`import`** command:

`import` *<module name>*

Can then access functions like this:

<module name>.*<function name>*(*<arguments>*)

Example:

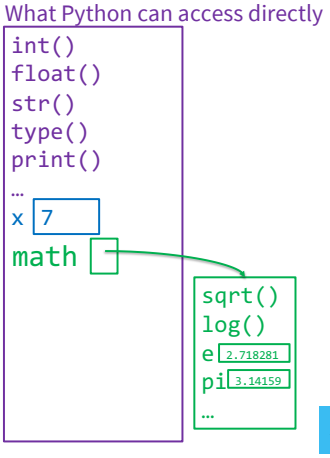
```
>>> import math
>>> p = math.sqrt(9.0)
>>> p
3.0
```

Visualizing functions & variables (3)

Running Example:
1. Built-in functions
2. Define a new variable
3. Import a module

```
C:\> python
>>> x = 7
>>> import math
>>>
```

What Python can access directly



Module Variables

- Modules can have variables, too
- Can access them like this:

  <module name>.<variable name>
- **Example**:

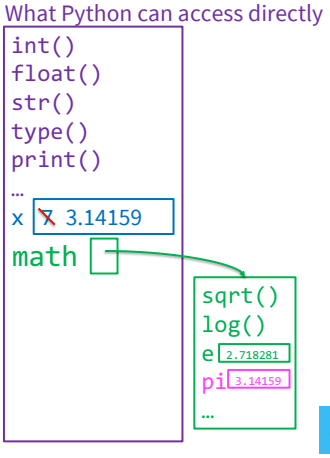
```
>>> import math
>>> math.pi
3.141592653589793
```


Visualizing functions & variables (4)

Running Example:
1. Built-in functions
2. Define a new variable
3. Import a module
4. Use a module variable

```
C:\> python
>>> x = 7
>>> import math
>>> x = math.pi
```

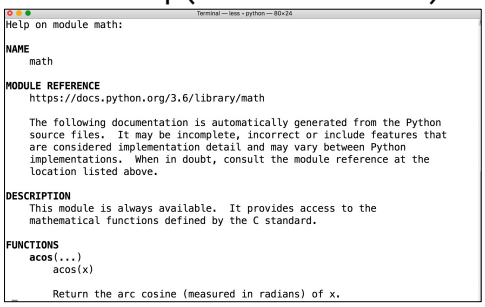
What Python can access directly



module help

After importing a module, see what functions and variables are available:

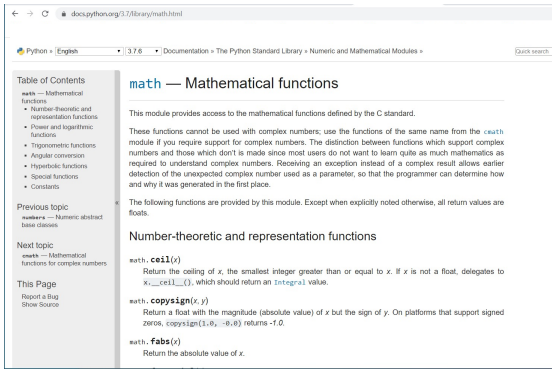
```
>>>  help(<module name>)
```



```
Help on module math:

NAME
    math

MODULE REFERENCE
    https://docs.python.org/3.6/library/math

    The following documentation is automatically generated from the Python
    source files.  It may be incomplete, incorrect or include features that
    are considered implementation detail and may vary between Python
    implementations.  When in doubt, consult the module reference at the
    location listed above.

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

FUNCTIONS
    acos(...)
        acos(x)

        Return the arc cosine (measured in radians) of x.
```

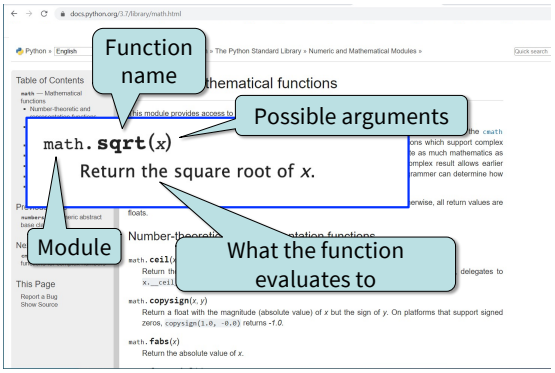

Reading the Python Documentation

https://docs.python.org/3/library/math.html



A Closer Reading of the Documentation

https://docs.python.org/3.7/library/math.html



Other Useful Modules

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

We'll use these many of these this semester.

Make your Own Module!

Why?

Python Interactive Mode:

- Good for scratch work!
  - quickly testing something
- **Not** typically how we'll write programs.

We'll want to write our code in a text file using a text editor.

```
# my_module.py

""" This is a simple module.
It shows how modules work """

x = 1+2
x = 3*x
```

We recommend Atom…
…but any editor will work

Typing in Interactive Mode vs. Writing a Module

Python Interactive Mode

```
[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
>>>
```

- Type python at command line
- Type commands after `>>>`
  - type line-by-line, again and again
- Python executes as you type

Module

```
# my_module.py

""" This is a simple module.
It shows how modules work """

x = 1+2
x = 3*x
```

- Written in text editor
  - write once, go back and edit
  - run repeatedly
- Can load with **`import`**
- Python executes statements when **`import`** is called

Section 2.4 in your textbook discusses a few differences

my_module.py

Module Text File

```
# my_module.py

"""This is a simple module.
It shows how modules work"""

x = 1+2
x = 3*x
```

Single line comment starts with **#** (not executed)

Docstring (note the Triple Quotes) A multi-line comment. Useful for *code documentation.*

Commands Executed on import

What does the docstring do?

Module Text File

```
# my_module.py

"""This is a simple modul
It shows how modules work

x = 1+2
x = 3*x
```

```
>>> import my_module
>>> help(my_module)
Help on module my_module:

NAME
    my_module

DESCRIPTION
    This is a simple module.
    It shows how modules work

DATA
    x = 9
```

Ways of Executing Python Code

1. running the Python Interactive Shell
2. NEW: importing a module

Importing a module from inside Python (1)

Module Text File

my_module.py

```
# my_module.py

"""This is a simple module.
It shows how modules work"""

x = 1+2
x = 3*x
```

Python Interactive Mode

```
C:\> python
>>> import my_module
```

Needs to be the same name as the file ***without the ".py"***

Importing a module from inside Python (2)

Module Text File

my_module.py

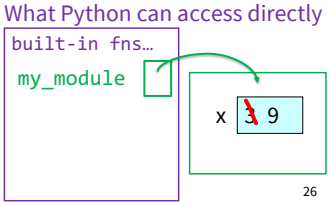
```
# my_module.py

"""This is a simple module.
It shows how modules work"""

x = 1+2
x = 3*x
```

variable x stays "within" the module

Python Interactive Mode

```
C:\> python
>>> import my_module
>>> my_module.x
9
```

What Python can access directly



Clicker Question!

Module Text File

```
# fah2cel.py

"""Convert 32 degrees
Fahrenheit to degrees
Celsius"""

f= 32.0
c= (f-32)*5/9
```

Python Interactive Mode

```
C:\> python
>>> import fah2cel
```

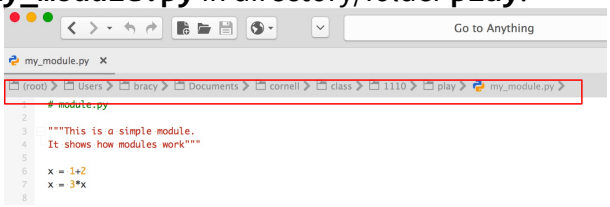
After you hit "Return" here what will python print next?

(A) >>>
(B) 0.0
>>>
(C) an error message
(D) The text of fah2cel.py
(E) Sorry, no clue.

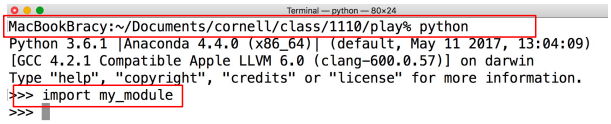
Rule #1: Modules must be in Working Directory*

*the directory where you typed "python"

If **my_module.py** in directory/folder **play**:



Then you must run **python** from the folder **play**:



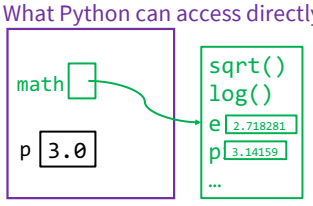
Rule #2: You must **import**

Windows command line (Mac looks different)

With import

```
C:\> python
>>> import math
>>> p = math.sqrt(9.0)
>>> p
3.0
```

What Python can access directly



Without import

```
C:\> python
>>> math.sqrt(9.0)
Traceback (most recent call
last):
  File "<stdin>", line 1,
in <module>
NameError: name 'math' is
not defined
```

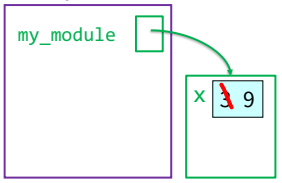
What Python can access directly

Python unaware of what "math" is

Rule #3: You Must Use the Module Name

```
C:\> python
>>> import my_module
>>> my_module.x
9
>>> x
Traceback (most recent call
last):
  File "<stdin>", line 1, in
<module>
NameError: name 'x' is not
defined
```

What Python can access directly



Python unaware of what "x" is (it cannot access it directly)

`from` command (1)

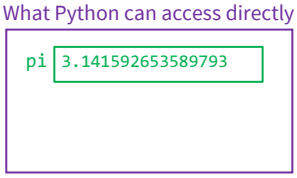
You can also import like this:

`from` <module> `import` <function name>

Example:

```
C:\> python
>>> from math import pi
>>> pi
3.141592653589793
```

What Python can access directly



No longer need the module name!

`from` command (2)

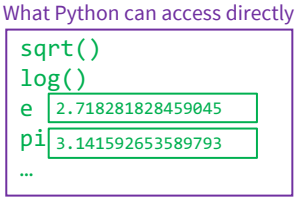
You can also import *everything* from a module:

`from` <module> `import *`

Example:

```
C:\> python
>>> from math import *
>>> pi
3.141592653589793
>>> sqrt(pi)
1.7724538509055159
```

What Python can access directly



Module functions now behave like built-in functions

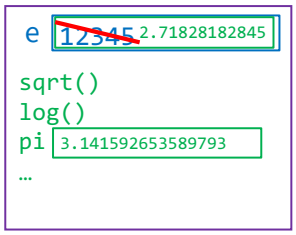
Dangers of Importing Everything

Example:

e was overwritten!

```
C:\> python
>>> e = 12345
>>> from math import *
>>> e
2.71828182845
```

What Python can access directly



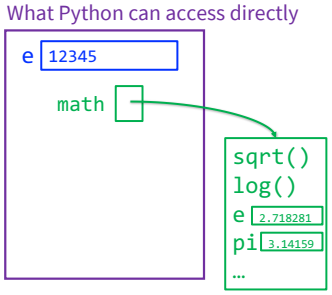
Do you know every mathematical constant? Might not want to import them all.

Avoiding `from` keeps variables separate

Example:

```
C:\> python
>>> e = 12345
>>> import math
>>> math.e
2.718281828459045
>>> e
12345
```

What Python can access directly



Ways of Executing Python Code

1. running the Python Interactive Shell
2. importing a module
3. NEW: running a script (a different kind of module)

This is as far as we got in the Lecture on 2/1/22.

The following slides will be useful for and covered in this week's lab.

Running a Script

- From the command line, type:

  `python <script filename>`

From the command line, use **full** filename, *with* ".py"

- Example:

  C:\> python my_module.py

Common Command shell Gotcha

```
>>> python last_task.py
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'python' is not defined
>>>
```

Rule #1 of running a script from the command line is making sure you are in the command line!
If you see **>>>** *you are in* ***python interactive mode****,*
But you wanted to be ***outside*** *of Python!*

```
>>> exit()
C:\> python last_task.py
[..some output…]
```


Running a Script

- From the command line, type:
  `python <script filename>`

From the command line, use **full** filename, *with* ".py"

- Example:
  C:\> python my_module.py
  C:\>
  looks like nothing happened!
- Actually, something did happen
  - Python executed all of my_module.py

Clicker Question

Module Text File

```
# my_module.py

"""This is a simple module.
It shows how modules work"""

x = 1+2
x = 3*x
```

Command Line

```
C:\> python my_module.py
C:\> my_module.x
```

After you hit "Return" here what will be printed next?

(A) >>>
(B) 9
>>>
(C) an error message
(D) The text of my_module.py
(E) Sorry, no clue.

Running my_module.py as a script

Module Text File

```
# my_module.py

"""This is a simple module.
It shows how modules work"""

x = 1+2
x = 3*x
```

Command Line

```
C:\> python my_module.py
C:\>
```

What Python can access directly

x ~~3~~ 9

When the script ends:

- All memory used by `my_module.py` is deleted
  - Includes all variables
- There is no evidence that the script ran!

Creating Evidence that the Script Ran

- New (very useful!) command: `print`

  `print (<expression>)`

- **`print`** evaluates the `<expression>` and writes the value to the console

`my_module.py` vs. `script.py`

my_module.py

```
# my_module.py

"""This is a simple module.
It shows how modules work"""

x = 1+2
x = 3*x
```

script.py

```
# script.py

"""A simple script.
Shows why we use print"""

x = 1+2
x = 3*x
print(x)
```

Only difference!

Running script.py as a script

script.py

```
# script.py
"""A simple script.
Shows why we use print"""

x = 1+2
x = 3*x
print(x)
```

Command Line

```
C:\> python script.py
9
C:\>
```

What Python can access directly

x 9

When the script ends:

- All memory used by `script.py` is deleted
  - Includes all variables
- But the print statement leaves evidence that it ran

Interactive mode **evaluates & reports**
Script mode only **evaluates**

Python Interactive Mode

```
C:\> python
>>> x = 1+2
>>> x = 3*x
>>> x
9
>>>
```

Executes 2 assignment statements

Evaluates the expression and reports

No output!

script2.py

```
# script2.py

"""A simple script.
Shows why we use print"""

x = 1+2
x = 3*x
x
```

Executes 2 assignment statements

Evaluates the expression

Command Line

```
C:\> python script2.py
C:\>
```


Modules: Libraries vs. Scripts

Library

- Provides functions, variables
- **`import`** it into Python shell, don't include ".py"
- Within Python shell you have access to the functions and variables of the imported module

Script

- Behaves like an application
- At command line prompt, Tell python to run the file (use full filename, including ".py")
- After running the app you're back at the command line

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