Python 101

Functions

Announcements

quiz: `quiz05` due Thurs 09/26

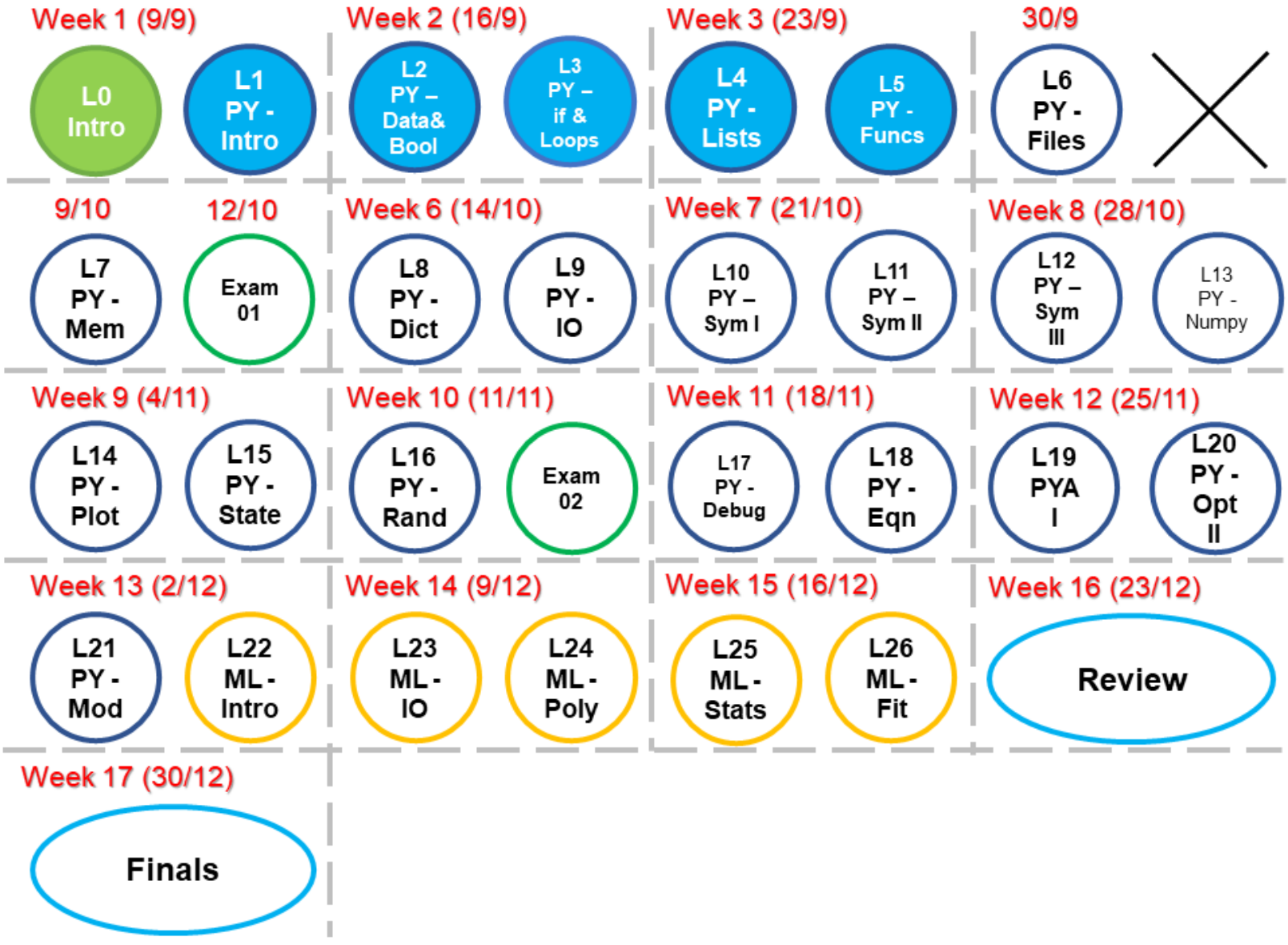
lab: `lab02` on Fri 09/27

lab: `lab03` on Sun 09/29

hw: `hw03` due Mon 09/30

exam01: `lec01 - lec05, hw01 - hw03, quiz01 - quiz05, lab01 - lab03`

Roadmap


Week 1 (9/9)
L0 Intro
L1 PY - Intro
Week 2 (16/9)
L2 PY – Data& Bool
L3 PY – if & Loops
Week 3 (23/9)
L4 PY - Lists
L5 PY - Funcs
30/9
L6 PY - Files
9/10
L7 PY - Mem
12/10
Exam 01
Week 6 (14/10)
L8 PY - Dict
L9 PY - IO
Week 7 (21/10)
L10 PY – Sym I
L11 PY – Sym II
Week 8 (28/10)
L12 PY – Sym III
L13 PY - Numpy
Week 9 (4/11)
L14 PY - Plot
L15 PY - State
Week 10 (11/11)
L16 PY - Rand
Exam 02
Week 11 (18/11)
L17 PY - Debug
L18 PY - Eqn
Week 12 (25/11)
L19 PYA I
L20 PY - Opt II
Week 13 (2/12)
L21 PY - Mod
L22 ML - Intro
Week 14 (9/12)
L23 ML - IO
L24 ML - Poly
Week 15 (16/12)
L25 ML - Stats
L26 ML - Fit
Week 16 (23/12)
Review
Week 17 (30/12)
Finals

Objectives

A. Write a simple `function` to implement a mathematical formula.
B. Use `function` to modularize code.
C. Explain how `variable scope` impacts what the program ”sees”.
D. Understand the difference between *returning a value* and *printing a value*.
E. Use default values of `(keyword arguments)` in functions.

Recap on List

Question 1

```
s = 'ABcd'
if not s[0:2].isupper():
    if s[0] == s[2]:
        print( s[0] )
    else:
        print( s[1] )
else:
    if s[1] != s[2]:
        print( s[-1] )
    else:
        print( s[-2] )
```

Question 1

```
s = 'ABcd'
if not s[0:2].isupper():
    if s[0] == s[2]:
        print( s[0] )
    else:
        print( s[1] )
else:
    if s[1] != s[2]:
        print( s[-1] )   ★★★
    else:
        print( s[-2] )
```

```
'd'
```

Question 2

```
s = 'abcd'
if not s.isalpha():
    print( s[0] )
elif s.isupper():
    print( s[-1] )
elif 'ab' in s:
    print( s[-2] )
else:
    print( s[1] )
```

Question 2

```
s = 'abcd'
if not s.isalpha():
    print( s[0] )
elif s.isupper():
    print( s[-1] )
elif 'ab' in s:
    print( s[-2] )   ★★★
else:
    print( s[1] )
```

```
'c'
```

String Methods

```
tryI = input( ”Give me a password:  ” )
```

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```
tryI = input( ”Give me a password:  ” )

if len( tryI ) < 8:
    # must be 8 characters at a minimum
    print( ’Invalid password’ )
elif tryI.isupper() or tryI.islower():
    # must have both upper- and lower-case letters
    print( ’Invalid password’ )
elif tryI.isalpha() or tryI.isdigit():
    # must have letters and numbers
    print( ’Invalid password’ )
else:
    print( ’Password OK’ )
```

String Methods

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tryI = input( ”Give me a password:  ” )

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    # must have letters and numbers
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```

But ’ !@#$%&* ’ will also be ok!

String Methods

So??? How to make sure that there are numbers as well as letters from the alphabet?

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So??? How to make sure that there are numbers as well as letters from the alphabet?
Add some more conditions!
M1.

```
if any(s in tryI.lower() for s
            in 'abcdefghijklmnopqrstuvwxyz'):
   # must have any of the letters from the alphabet
   if any(s in tryI for s in '0123456789'):
   # must have any numbers
      print( 'Password OK' )
```

No

String Methods

M2.

```
numE, lettE = 0, 0
for number in range(10):
    #find numbers, .find() returns -1 if not found
    if tryI.find(str(number)) != -1:
        numE = 1
        break
tryI = tryI.lower()
for letter in "abcdefghijklmnopqrstuvwxyz":
    if tryI.find(letter) != -1:
        lettE = 1
        break
if lettE == 1 and numE == 1:
    print("Password OK")
else:
     print( 'Invalid password' )
```

No

String Methods

M3

```
lettE = 0
lettCap = 0
lengthS = len(tryI)
for letter in tryI:
    if letter in 'abcdefghijklmnopqrstuvwxyz
                  ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789':
        lettE += 1
if not (tryI.isupper() or tryI.islower()):
        lettCap = 1
if lettE == lengthS and lengthS >= 8
                                    and lettCap > 0:
    print("Password OK")
else:
    print( 'Invalid password' )
```

OK

String comparison methods

These produce Boolean output.

`isdigit()`	Does a string contain only numbers?
`isalpha()`	Does a string contain only text?
`isalnum()`	what does this do?
`islower()`	Are **all the letters in a string** lower-case?
`isupper()`	Are **all the letters in a string** upper-case?

List Methods

```
Sort small to big (ascending order)
- x.sort()
Sort big to small (descending order)
- x.reverse()
```

List casting

```
list(range(5))
```

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```

= [0, 1, 2, 3, 4]

```
list('I am Happy')
```

List casting

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```
list('I am Happy')
```

= ['I', ' ', 'a', 'm', ' ', 'H', 'a', 'p', 'p', 'y']

Function, Method, Attribute

Function e.g., `print()` etc

a piece of code that is called by name.
belongs to a library or your own code

Method e.g., `.isupper()` etc

also a function but special!
belongs to a data type

Attribute e.g., `.isupper(), .real` etc

property of the data type
can be a function or a value

Functions

Code blocks

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    # must have letters and numbers
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```

Define a function

```
def validate_password( try ):
    if len( try ) < 8:
        # must be 8 characters at a minimum
        return False
    if try.isupper() or try.islower():
        # must have both upper- and lower-case lett
        return False
    if try.isalpha() or try.isdigit():
        # must have letters and numbers
        return False
    return True  # password is OK
```

Code blocks become...

```
try = input( ”Give me a password:  ” )
ans = validate_password( try )
```

Use or Call a Function

```
output** = function ( input )
```

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Analogy: If operators are verbs, functions are 'complex' verbs.

Also called subroutine or procedure.

```
output** is the return value of the function
but it is optional
input is also called argument(s)
```

Function calls

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for me to score 100% !' )
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```

Many functions come built-in to Python or in the standard library.

Others we will create when needed.

Arguments

```
x = len('Exam is so exciting! I cannot breathe!')
```

Arguments are the input to functions.

Here, *argument* is `'Exam is so...'`

Functions can return a value.

Here, `x = len( )` returns a value of `38`

Return values are the output of a function. Here `x` stores the return value

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Examples:

`x = len('Yong Chun')`, Which is the `return` value? Which is the argument?

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Examples:

`x = len('Yong Chun')`, Which is the `return` value? Which is the argument?

`y = print('-123')`, y = ? (Any return value?)

Arguments

A function can accept **zero to many arguments**.

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```
print()
len('My String')
```

Multiple arguments are **separated by commas**:

```
min( 1,4,5 )
max( 1,4,5 )
```

Example: Type conversion

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str( 3 - 15j )
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```
float( ”0.13” )
str( 3 - 15j )
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```

Be careful of nonsense:

```
int( ”Data” )
int( 0.37 + 2j )
```

Composing Functions

Example: Defining functions

```
def pow( a,b ):
    y = a ** b
    return y
```

Defining functions

We define a new function with the following:

- the keyword `def`
- the name of the function
- a pair of parentheses
- a **block** of code
- a `return` statement (optional)

```
def pow( a,b ):
    y = a ** b
    return y
```

Parameters/Argument

Functions can accept values as arguments.

These variables are declared in the function header.
e.g.,

```
def print_message( msg ):
```

Multiple parameters are separated by commas.

```
def print_message( msg1, msg2, msg3 ):
    print( 'I say:', str(msg1)+str(msg2)+str(msg3))
```

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Functions can return values with the keyword `return`.

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def three():
    return 3
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def zero():
  return 0
  print('The answer is 0')
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What happens to `print('The answer is 0')`?

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Functions can return values with the keyword `return`.

```
def three():
    return 3
```

`return` immediately exits a function.

```
def zero():
  return 0
  print('The answer is 0')
```

What happens to `print('The answer is 0')`?
Ignored!

Scope

Variables defined inside of a block are *independent* of variables outside of the block.

Variables inside a block *do not exist* outside of the block.

Example: Defining functions

```
def pendulum( L ):
    import math
    g = 9.8  # m/s^2
    T = 2 * math.pi * math.sqrt( L / g )
    return T
time = pendulum( 1.0 )
print(g)
```

1. What is the value of `time`?
2. What will be shown on the screen?

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ans:

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1. value of `T` is approximately 2.0

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print(g)
```

1. What is the value of `time`?
2. What will be shown on the screen?

ans:

1. value of `T` is approximately 2.0
2. Error

Example: Defining functions

```
a = 5
b = 6

def foo( c ):
    a = c
    b = c ** 2
    return a + b

print( foo( 6 ) )
print( a,b )
```

What will be printed?

Example: Defining functions

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42

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print( a,b )
```

What will be printed?

42

5 6

Example

```
def fun(a):
    return a+2

x = fun(2) * fun(3)
```

What is the value of `x`?

A `6`

B `8`

C `24`

D None of the above.

Example

```
def fun(a):
    return a+2

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```

Example

```
def fun(a):
    return a+2

x = fun(2) * fun(3)
```

```
x = 4 * fun(3)
```

Example

```
def fun(a):
    return a+2

x = fun(2) * fun(3)
x = 4 * fun(3)
x = 4 * 5
```

Example

```
def fun(a):
    return a+2

x = fun(2) * fun(3)
x = 4 * fun(3)
x = 4 * 5
x = 20
```

Example

```
def fun(a):
    return a+2

x = fun(2) * fun(3)
```

What is the value of `x`?

A `6`

B `8`

C `24`

D None of the above. ⋆ (`20`)

Example

```
def spacer(m):
    return m + ' '

x = spacer( "abb") + spacer( "acab" )
```

What is the value of `x`?

A `'abb acab '`

B `'abb acab'`

C `'abbacab'`

D None of the above (error)

Example

```
def spacer(m):
    return m + ' '

x = spacer( "abb") + spacer( "acab" )
```

What is the value of `x`?

A `'abb acab ' *` (note the space!)

B `'abb acab'`

C `'abbacab'`

D None of the above (error)

Default Arguments

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If these are present, you can use the function in several ways:

```
def my_default_value( a=5 ):
    print( 'I have the value %i.' % a )

1. my_default_value()
2. my_default_value( 6 )
3. my_default_value( a=6 )  #Less used;
Note: variable used in 3. is the same
                        as defined in the function()
```

Exercise

Write a function `isclose` which assesses whether two float values `a` and `b` are sufficiently near each other to be consider ”equal”. It is equal if its relatve tolerance is less than or equal to 0.001.
(The relative tolerance is defined as $\frac{|a-b|}{\min(|a|,|b|)}$.)

Exercise

Write a function `isclose` which assesses whether two float values `a` and `b` are sufficiently near each other to be consider ”equal”. It is equal if its relatve tolerance is less than or equal to 0.001.
(The relative tolerance is defined as $\frac{|a-b|}{\min(|a|,|b|)}$.)

```
def isclose( a, b, rtol=1e-3 ):
    return ( abs( a-b ) / min( abs(a), abs(b ) )
                                        <= rtol
```

Fun time

```
def runningSum( a ):
    if a == 0:
        return 0
    f = a + runningSum(a-1)
    return f
tt = runningSum( 6 )
```

ans:

Fun time

```
def runningSum( a ):
    if a == 0:
        return 0
    f = a + runningSum(a-1)
    return f
tt = runningSum( 6 )
```

ans:
tt = 21!
This is called a recursive function

Summary

Summary

1. `function` can be `import` from library or written on your own
2. `Def .... ( arg1, arg2 ...):`
3. `return`
4. `Default value`
5. variable scope
6. `isclose()`