Python

CSE 307 – Principles of Programming Languages

Stony Brook University

http://www.cs.stonybrook.edu/~cse307

Python's History

- Created by Guido van Rossum in Netherlands in 1990
- Open source: http://www.python.org

Python 2.7x vs. Python 3.x

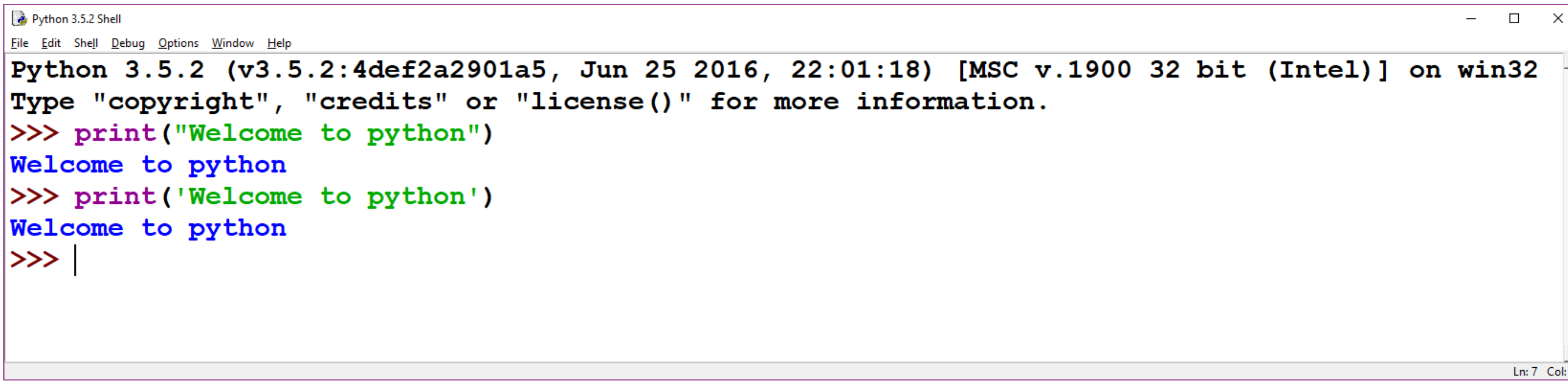
- Python 3.x is a newer version, but it is not backward compatible with Python 2.7x
  - That means if you write a program using Python 2, it may not work on Python 3.x
  - We use Python 3.x for homeworks

Launch Python

Command Prompt - python

```
C:\Users\Paul>python
Python 3.5.2 (v3.5.2:4def2a2901a5, Jun 25 2016, 22:01:18) [MSC v.1900 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> _
```

Launch Python IDLE



Editor, Command line interface, Debugger

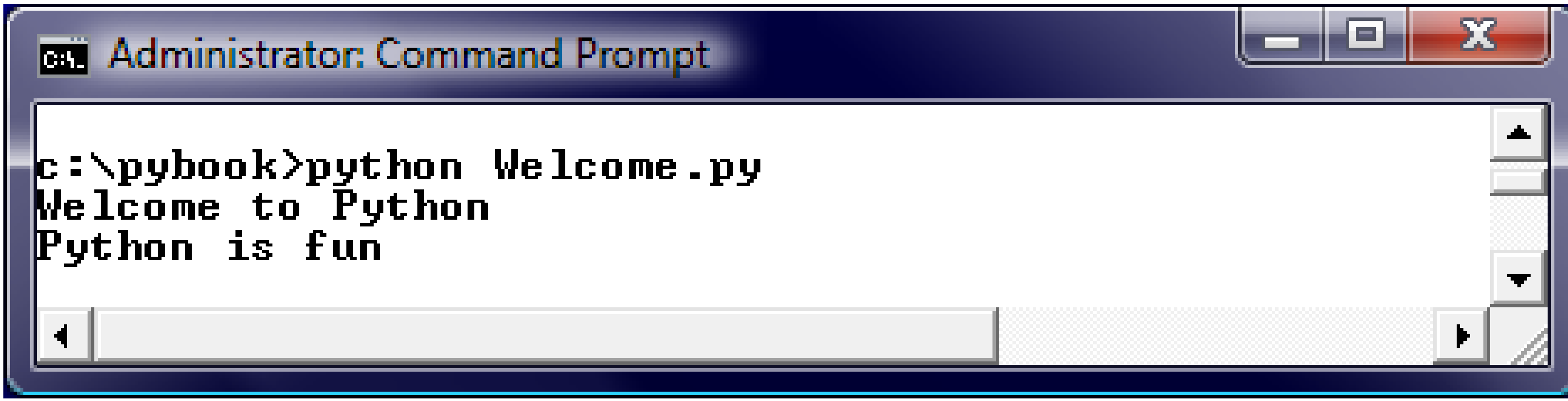
Many other IDEs.

A Simple Python Program

```
# Welcome.py
# Display two messages
print("Welcome to Python")
print("Python is fun")

# Comment in Python
```

Run Python Script



Python Example

```
# Assign a radius
radius = 20 # radius is now 20
# Compute area
area = radius * radius * 3.14159
# Display results
print("The area for the circle of radius " +
    str(radius) + " is " + str(area))
```

Reading Input from the Console

1. Use the input function

```
variable = input("Enter a string: ");
```

2. Use the eval function

```
variable = eval("51 + (54 * (3 + 2))");

print(variable);
321
```

Variables

```
# Compute the first area
radius = 1.0
area = radius * radius * 3.14159
print("The area is ", area, " for  radius ", radius)

# Compute the second area
radius = 2.0
area = radius * radius * 3.14159
print("The area is ", area, " for radius ", radius)
```

Expression

```
x = 1              # Assign 1 to variable x
radius = 1.0       # Assign 1.0 to variable radius

# Assign the value of the expression to x
x = 5 * (3 / 2) + 3 * 2
print(x)
           13.5
x = 5 * (3 // 2) + 3 * 2
print(x)
           11
```

Overflow

- When a variable is assigned a value that is too large (in size) to be stored, it causes overflow. For example, executing the following statement causes overflow:

```
>>>245.0 ** 1000000
OverflowError: 'Result too large'
```

Type Conversion and Rounding

- datatype(value) :

  `int(4.5)` => 4

  `float(4)` => 4.0

  `str(4)` => '4'

  `round(4.6)` => 5

  `round(4.5)` => 4

  `round(4.5)` => 4 # in Python 3

  `round(4.5)` => 5 # in Python 2

  https://docs.python.org/2/library/functions.html#round

  https://docs.python.org/3/library/functions.html#round

  Note: 2 vs 3

Built-in Functions and math Module

```
>>> max(2, 3, 4) # Returns a maximum number
4
>>> min(2, 3, 4) # Returns a minimum number
2
>>> round(3.51) # Rounds to its nearest integer
4
>>> round(3.4) # Rounds to its nearest integer
3
>>> abs(-3) # Returns the absolute value
3
>>> pow(2, 3) # Same as 2 ** 3
8
```

Function	Description	Example
fabs(x)	Returns the absolute value of the argument.	fabs(-2) is 2
ceil(x)	Rounds x up to its nearest integer and returns this integer.	ceil(2.1) is 3 ceil(-2.1) is -2
floor(x)	Rounds x down to its nearest integer and returns this integer.	floor(2.1) is 2 floor(-2.1) is -3
exp(x)	Returns the exponential function of x (e^x).	exp(1) is 2.71828
log(x)	Returns the natural logarithm of x.	log(2.71828) is 1.0
log(x, base)	Returns the logarithm of x for the specified base.	log10(10, 10) is 1
sqrt(x)	Returns the square root of x.	sqrt(4.0) is 2.0
sin(x)	Returns the sine of x. x represents an angle in radians.	sin(3.14159 / 2) is 1 sin(3.14159) is 0
asin(x)	Returns the angle in radians for the inverse of sine.	asin(1.0) is 1.57 asin(0.5) is 0.523599
cos(x)	Returns the cosine of x. x represents an angle in radians.	cos(3.14159 / 2) is 0 cos(3.14159) is -1
acos(x)	Returns the angle in radians for the inverse of cosine.	acos(1.0) is 0 acos(0.5) is 1.0472
tan(x)	Returns the tangent of x. x represents an angle in radians.	tan(3.14159 / 4) is 1 tan(0.0) is 0
fmod(x, y)	Returns the remainder of x/y as double.	fmod(2.4, 1.3) is 1.1
degrees(x)	Converts angle x from radians to degrees	degrees(1.57) is 90
radians(x)	Converts angle x from degrees to radians	radians(90) is 1.57

from math import fabs
or
import math

Strings and Characters

A string is a sequence of characters. *String* literals can be enclosed in matching *single quotes* (') or *double quotes* ("). Python does not have a data type for characters. A single-character string represents a character.

```
letter = 'A'      # Same as letter = "A"
numChar = '4'     # Same as numChar = "4"
message = "Good morning"
   # Same as message = 'Good morning'
```

Functions ord and chr

```
>>> ch = 'a'
>>> ord(ch)
97
>>> chr(98)
'b'
```

The str Function

The str function can be used to convert a number into a string. For example,

```
>>> s = str(3.4) # Convert a float to string
>>> s
'3.4'
>>> s = str(3) # Convert an integer to string
>>> s
'3'
```

The String Concatenation Operator

You can use the + operator add two numbers. The + operator can also be used to concatenate (combine) two strings. Here are some examples:

```
>>> message = "Welcome " + "to " + "Python"
>>> message
'Welcome to Python'
>>> chapterNo = 1
>>> s = "Chapter " + str(chapterNo)
>>> s
'Chapter 1'
>>> s = "Chapter " + chapterNo
TypeError: Can't convert 'int' object to str implicitly
```

Introduction to Objects and Methods

- In Python, all data—including numbers and strings—are actually objects.
- An object is an entity. Each object has an id and a type. Objects of the same kind have the same type. You can use the **id** function and **type** function to get these information for an object.

Object Types and Ids

The **id** and **type** functions are rarely used in programming, but they are good pedagogical tools for understanding objects.

```
>>> n = 3  # n is an integer
>>> id(n)
505408904
>>> type(n)
<class 'int'>
>>> f = 3.0  # f is a float
>>> id(f)
26647120
>>> type(f)
<class 'float'>
```

```
>>> s = "Welcome"
>>> id(s)
36201472
>>> type(s)
<class 'str'>
```

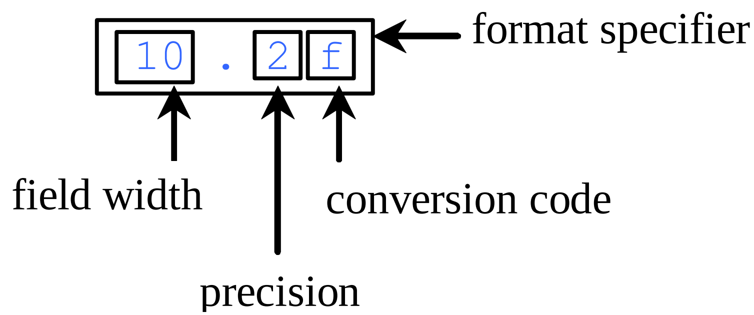
str Object Methods

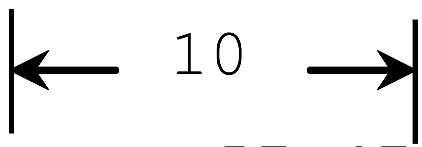
```
>>> s = "Welcome"
>>> s1 = s.lower() # Invoke the lower method
>>> s1
'welcome'

>>> s2 = s.upper() # Invoke the upper method
>>> s2
'WELCOME'
```

Formatting Floating-Point Numbers

```
print(format(57.467657, '10.2f'))
print(format(12345678.923, '10.2f'))
print(format(57.4, '10.2f'))
print(format(57, '10.2f'))
```






```
?????57.47
12345678.9
?????57.40
?????57.00
```

Blocks

- Python 3 uses indentation of 4 spaces for blocks
  - Tabs should be used solely to remain consistent with code that is already indented with tabs

https://www.python.org/dev/peps/pep-0008/#tabs-or-spaces

"*Python 3 disallows mixing the use of tabs and spaces for indentation.*"

if...else Example

```
from math import pi
if radius >= 0:
    area = radius * radius * pi
    print("The area for the ",
        "circle of radius ",
        radius, " is ", area)
else:
    print("Negative input")
```

Multiple Alternative if Statements

```python
if score >= 90.0:
    grade = 'A'
else:
  if score >= 80.0:
      grade = 'B'
  else:
      if score >= 70.0:
          grade = 'C'
      else:
          if score >= 60.0:
              grade = 'D'
          else:
              grade = 'F'
```

(a)

Equivalent

This is better

```python
if score >= 90.0:
    grade = 'A'
elif score >= 80.0:
    grade = 'B'
elif score >= 70.0:
    grade = 'C'
elif score >= 60.0:
    grade = 'D'
else:
    grade = 'F'
```

(b)

Loops

```
# Initialize loop-control variable
i = initialValue
while i < endValue:
      # Loop body
      ...
      i++ # Adjust loop-control variable

for i in range(initialValue, endValue):
      # Loop body
```

range(a, b)

```
for i in range(4, 8):
    print(i)
4
5
6
7
```

range(b)

```
for i in range(4):
    print(i)
0
1
2
3
```

range(a, b, step)

```
for v in range(3, 9, 2):
    print(v)
3
5
7
```

Functions

```
def sum(i1, i2):
    ''' This is the doc '''
    result = 0
    for i in range(i1, i2):
        result += i
    return result
def main():
    print("Sum from 1 to 10 is", sum(1, 10))
    print("Sum from 20 to 37 is", sum(20, 37))
    print("Sum from 35 to 49 is", sum(35, 49))
main() # Call the main function
```

Classes

```
import math
class Circle:
    # Construct a circle object
    def __init__(self, radius = 1):
        self.radius = radius
    def getPerimeter(self):
        return 2 * self.radius * math.pi
    def getArea(self):
        return self.radius * self.radius * math.pi
    def setRadius(self, radius):
        self.radius = radius
    def __str__(self):
        return "Circle: radius=" + str(radius)
```

```
from Circle import Circle

def main():
    # Create a circle with radius 1
    circle1 = Circle()
    print("The area of the circle of radius", circle1.radius,
        "is", circle1.getArea())
    # Create a circle with radius 25
    circle2 = Circle(25)
    print("The area of the circle of radius", circle2.radius,
        "is", circle2.getArea())
    # Create a circle with radius 125
    circle3 = Circle(125)
    print("The area of the circle of radius", circle3.radius,
        "is", circle3.getArea())
    # Modify circle radius
    circle2.radius = 100
    print("The area of the circle of radius", circle2.radius,
        "is", circle2.getArea())

main() # Call the main function
```

Inheritance

```
from GeometricObject import GeometricObject
import math
class Circle(GeometricObject):
    def __init__(self, radius):
        super().__init__()
        self.__radius = radius
    def getRadius(self):
        return self.__radius
    def setRadius(self, radius):
        self.__radius = radius
    def getArea(self):
        return self.__radius * self.__radius * math.pi
    def getDiameter(self):
        return 2 * self.__radius
    def getPerimeter(self):
        return 2 * self.__radius * math.pi
    def printCircle(self):
        print(self.__str__() + " radius: " +
            str(self.__radius))
```

Adding fields to Objects dynamically

```
class Employee:
    pass

# Create an empty employee record
john = Employee()

# Add the fields of the record
john.name = 'John Doe'
john.dept = 'computer lab'
john.salary = 1000
```

Exceptions

```
from GeometricObject import GeometricObject
import math
class Circle(GeometricObject):
    def __init__(self, radius):
        super().__init__()
        self.setRadius(radius)
    def setRadius(self, radius):
        if radius < 0:
            raise RuntimeError("Negative radius")
        else:
            self.__radius = radius
```

The str Class

Creating Strings

```
s1 = str()          # Create an empty string
s2 = str("Welcome") # Create a string Welcome
```

Python provides a simple syntax for creating string using a string literal. For example,

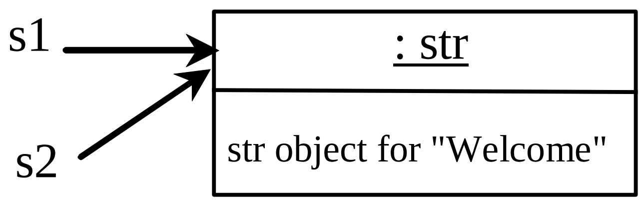
```
s1 = ""             # Same as s1 = str()
s2 = "Welcome"      # Same as s2 = str("Welcome")
```

Strings are Immutable

A string object is immutable. Once it is created, its contents cannot be changed. To optimize performance, Python uses one object for strings with the same contents.

- both s1 and s2 refer to the same string object.

```
>>> s1 = "Welcome"
>>> s2 = "Welcome"
>>> id(s1)
505408902
>>> id(s2)
505408902
```



Functions for str

```
>>> s = "Welcome"
>>> len(s)
7
>>> max(s)
o
>>> min(s)
W
```

The +, *, [:], and in Operators

```
>>> s1 = "Welcome"
>>> s2 = "Python"
>>> s3 = s1 + " to " + s2
>>> s3
'Welcome to Python'
>>> s4 = 2 * s1
>>> s4
'WelcomeWelcome'
>>> s1[3 : 6]
'com'
>>> 'W' in s1
True
>>> 'X' in s1
False
```

Negative Index

```
>>> s1 = "Welcome"
>>> s1[-1]
'e'
>>> s1[-3 : -1]
'om'
```

The in and not in Operators

```
>>> s1 = "Welcome"
>>> "come" in s1
True
>>> "come" not in s1
False
>>>
```

Foreach Loops

```
for ch in string:
    print(ch)


for i in range(0, len(s), 2):
    print(s[i])
```

Comparing Strings

```
>>> s1 = "green"
>>> s2 = "glow"
>>> s1 == s2
False
>>> s1 != s2
True
>>> s1 > s2
True
>>> s1 >= s2
True
>>> s1 < s2
False
>>> s1 <= s2
False
```

Testing Characters in a String

str	
isalnum(): bool	Return True if all characters in this string are alphanumeric and there is at least one character.
isalpha(): bool	Return True if all characters in this string are alphabetic and there is at least one character.
isdigit(): bool	Return True if this string contains only number characters.
isidentifier(): bool	Return True if this string is a Python identifier.
islower(): bool	Return True if all characters in this string are lowercase letters and there is at least one character.
isupper(): bool	Return True if all characters in this string are uppercase letters and there is at least one character.
isspace(): bool	Return True if this string contains only whitespace characters.

Searching for Substrings

str	
endswith(s1: str): bool	Returns True if the string ends with the substring s1.
startswith(s1: str): bool	Returns True if the string starts with the substring s1.
find(s1): int	Returns the lowest index where s1 starts in this string, or -1 if s1 is not found in this string.
rfind(s1): int	Returns the highest index where s1 starts in this string, or -1 if s1 is not found in this string.
count(subtring): int	Returns the number of non-overlapping occurrences of this substring.

Converting Strings

str	
capitalize(): str	Returns a copy of this string with only the first character capitalized.
lower(): str	Returns a copy of this string with all characters converted to lowercase.
upper(): str	Returns a copy of this string with all characters converted to uppercase.
title(): str	Returns a copy of this string with the first letter capitalized in each word.
swapcase(): str	Returns a copy of this string in which lowercase letters are converted to uppercase and uppercase to lowercase.
replace(old, new): str	Returns a new string that replaces all the occurrence of the old string with a new string.

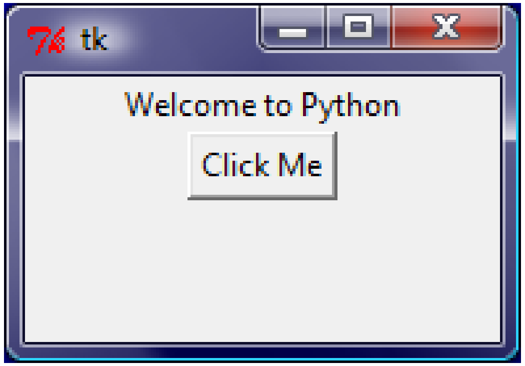
Stripping Whitespace Characters

str	
lstrip(): str	Returns a string with the leading whitespace characters removed.
rstrip(): str	Returns a string with the trailing whitespace characters removed.
strip(): str	Returns a string with the starting and trailing whitespace characters removed.

Formatting Strings

str	
center(width): str	Returns a copy of this string centered in a field of the given width.
ljust(width): str	Returns a string left justified in a field of the given width.
rjust(width): str	Returns a string right justified in a field of the given width.

Python GUIs with tkinter




```
from tkinter import * # Import tkinter

root = Tk() # Create a root window

# Create a label
label = Label(root, text = "Welcome to Python")

# Create a button
button = Button(root, text = "Click Me")

label.pack() # Display the label in the window
button.pack() # Display the button in the window

root.mainloop() # Create an event loop
```

Creating Lists

Creating list using the list class

```
list1 = list() # Create an empty list
list2 = list([2, 3, 4]) # Create a list with elements 2, 3, 4
list3 = list(["red", "green", "blue"]) # Create a list with strings
list4 = list(range(3, 6)) # Create a list with elements 3, 4, 5
list5 = list("abcd") # Create a list with characters a, b, c, d
```

For convenience, you may create a list using the following syntax:

```
list1 = [] # Same as list()
list2 = [2, 3, 4] # Same as list([2, 3, 4])
list3 = ["red", "green"] # Same as list(["red", "green"])
```

list Methods

list	
append(x: object): None	Add an item x to the end of the list.
insert(index: int, x: object): None	Insert an item x at a given index. Note that the first element in the list has index 0.
remove(x: object): None	Remove the first occurrence of the item x from the list.
index(x: object): int	Return the index of the item x in the list.
count(x: object): int	Return the number of times item x appears in the list.
sort(): None	Sort the items in the list.
reverse(): None	Reverse the items in the list.
extend(l: list): None	Append all the items in L to the list.
pop([i]): object	Remove the item at the given position and return it. The square bracket denotes that parameter is optional. If no index is specified, list.pop() removes and returns the last item in the list.

Functions for lists

```
>>> list1 = [2, 3, 4, 1, 32]
>>> len(list1)
5
>>> max(list1)
32
>>> min(list1)
1
>>> sum(list1)
42
>>> import random
>>> random.shuffle(list1) # Shuffle the items in the list
>>> list1
[4, 1, 2, 32, 3]
```

The +, *, [:], and in Operators

```
>>> list1 = [2, 3]
>>> list2 = [1, 9]
>>> list3 = list1 + list2
>>> list3
[2, 3, 1, 9]
>>> list3 = 2 * list1
>>> list3
[2, 3, 2, 3]
>>> list4 = list3[2 : 4]
>>> list4
[2, 3]
```

The +, *, [:], and in Operators

```
>>> list1 = [2, 3, 5, 2, 33, 21]
>>> list1[-1]
21
>>> list1[-3]
2
>>> list1 = [2, 3, 5, 2, 33, 21]
>>> 2 in list1
True
>>> list1 = [2, 3, 5, 2, 33, 21]
>>> 2.5 in list1
False
```

Comparing Lists

```
>>>list1 = ["green", "red", "blue"]
>>>list2 = ["red", "blue", "green"]
>>>list2 == list1
False
>>>list2 != list1
True
>>>list2 >= list1
True
>>>list2 > list1
True
>>>list2 < list1
False
>>>list2 <= list1
False
```

Splitting a String to a List

```
items = "Welcome to CSE307".split()
print(items)
['Welcome', 'to', 'CSE307']

items = "34#13#78#45".split("#")
print(items)
['34', '13', '78', '45']
```

Pass-by-Value Example

```
def main():
    x = 1 # x represents an int value
    y = [1, 2, 3] # y represents a list
    m(x, y) # Invoke f with arguments x and y
    print("x is " + str(x))
    print("y[0] is " + str(y[0]))
def m(number, numbers):
    number = 1001 # Assign a new value to number
    numbers[0] = 5555 # Assign a new value to numbers[0]
main()
```

Binary Search

```
# Use binary search to find the key in the list
def binarySearch(lst, key):
    low = 0
    high = len(lst) - 1
    while high >= low:
        mid = (low + high) // 2
        if key < lst[mid]:
            high = mid - 1
        elif key == lst[mid]:
            return mid
        else:
            low = mid + 1
    # Now high < low, key not found
    return -low - 1
```

Selection Sort

```
def selectionSort(lst):
    for i in range(0, len(lst) - 1):
        # Find the minimum in the lst[i..len(lst)-1]
        currentMin = lst[i]
        currentMinIndex = i
        for j in range(i + 1, len(lst)):
            if currentMin > lst[j]:
                currentMin = lst[j]
                currentMinIndex = j
        # Swap lst[i] with lst[currentMinIndex] if necessary
        if currentMinIndex != i:
            lst[currentMinIndex] = lst[i]
            lst[i] = currentMin
    return lst
```

Write to a File

```
outfile = open("test.txt", "w")
outfile.write("Welcome to Python")
```

file	
read([number: int]): str	Returns the specified number of characters from the file. If the argument is omitted, the entire remaining contents are read.
readline(): str	Returns the next line of file as a string.
readlines(): list	Returns a list of the remaining lines in the file.
write(s: str): None	Writes the string to the file.
close(): None	Closes the file.

Testing File Existence

```
import os.path
if os.path.isfile("Presidents.txt"):
    print("Presidents.txt exists")
```

Write/Read in/from File

```
def main():
    # write
    w = open("a.txt", "w")
    w.write("de")
    w.close()
    # read
    r = open("a.txt", "r")
    for line in r:
        print(line)
    r.close()
main()
```

Tuples

`t1 = ()` # Create an empty tuple

`t2=(1,3,5)` # Create a set with three elements

Create a tuple from a list

`t3 = tuple([2*x for x in range(1,5)])`

Create a tuple from a string

`t4 = tuple("abac")` # t4 is ['a', 'b', 'a', 'c']

- Tuples vs. lists: you cannot modify a tuple!

List Comprehensions

- List comprehensions are a concise way to create lists

```
>> squares = [x**2 for x in range(10)]
>>> squares
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

same with:

```
>>> squares = []
>>> for x in range(10):
...      squares.append(x**2)
```

but shorter

List Comprehensions

```
>>> vec = [-4, -2, 0, 2, 4]
# create a new list with the values doubled
>>> [x*2 for x in vec]
[-8, -4, 0, 4, 8]
# filter the list to exclude negative numbers
>>> [x for x in vec if x >= 0]
[0, 2, 4]
# apply a function to all the elements
>>> [abs(x) for x in vec]
[4, 2, 0, 2, 4]
```

List Comprehensions

- A list comprehension consists of brackets containing an expression followed by a **`for`** clause, then zero or more **`for`** or **`if`** clauses
  - the result will be a new list resulting from evaluating the expression in the context of the **`for`** and **`if`** clauses which follow it
  - example: combines the elements of two lists if they are not equal

```
>>> [(x, y) for x in [1,2,3] for y in [3,1,4] if x != y]
[(1, 3), (1, 4), (2, 3), (2, 1), (2, 4), (3, 1), (3, 4)]
```

List Comprehensions

```
>>> [(x, y) for x in [1,2,3] for y in [3,1,4] if x != y]
[(1, 3), (1, 4), (2, 3), (2, 1), (2, 4), (3, 1), (3, 4)]
```

is the same with:

```
>>> combs = []
>>> for x in [1,2,3]:
...     for y in [3,1,4]:
...         if x != y:
...             combs.append((x, y))
```

List Comprehensions

```
# create a list of 2-tuples like (number, square)
>>> [(x, x**2) for x in range(6)]
[(0, 0), (1, 1), (2, 4), (3, 9), (4, 16), (5, 25)]

# flatten a list using a listcomp with two 'for'
>>> vec = [[1,2,3], [4,5,6], [7,8,9]]
>>> [num for elem in vec for num in elem]
[1, 2, 3, 4, 5, 6, 7, 8, 9]
```

List Comprehensions

```
# Nested List Comprehensions
>>> matrix = [
...     [1, 2, 3, 4],
...     [5, 6, 7, 8],
...     [9, 10, 11, 12],
... ]
>>> [ [row[i] for row in matrix]
              for i in range(len(matrix[0]))]
[[1, 5, 9], [2, 6, 10], [3, 7, 11], [4, 8, 12]]
```

all and any

- **`all(iterable)`** returns True if all elements of the iterable are true (or if the iterable is empty)
  - The internal implementation:

```
def all(iterable):
    for element in iterable:
        if not element:
            return False
    return True
```

all and any

- **`any(iterable)`** returns True if any element of the iterable is true. If the iterable is empty, return False.
  - The internal implementation:

```
def any(iterable):
    for element in iterable:
        if element:
            return True
    return False
```

all and any

- **`all`** and **`any`** will short-circuit the execution the moment they know the result.
  - that is, the entire iterable need not be consumed

all and any Example

```
def is_prime(element):
    if element == 2:
        return True
    elif element <= 1 or element % 2 == 0:
        return False
    else:
        return all(element%i for i
                          in range(3,element,2))

myList = [4, 5, 9, 12]
if not any(is_prime(x) for x in myList):
    print("The list did not contain a prime")
else:
    print("The list contains a prime")
```

Sets

```
s1 = set() # Create an empty set

s2 = {1, 3, 5} # Create a set with three elements

s3 = set([1, 3, 5]) # Create a set from a list

# Create a set from a list
s4 = set([x * 2 for x in range(1, 10)])

# Create a set from a string
s5 = set("abac") # s5 is {'a', 'b', 'c'}
```

Manipulating and Accessing Sets

```
>>> s1 = {1, 2, 4}
>>> s1.add(6)
>>> s1
{1, 2, 4, 6}
>>> len(s1)
4
>>> max(s1)
6
>>> min(s1)
1
>>> sum(s1)
13
>>> 3 in s1
False
>>> s1.remove(4)
>>> s1
{1, 2, 6}
>>>
```

Subset and Superset

```
>>> s1 = {1, 2, 4}
>>> s2 = {1, 4, 5, 2, 6}
>>> s1.issubset(s2) # s1 is a subset of s2
True
>>>

>>> s2.issuperset(s1) #s2 is a superset of s1
True
>>>
```

Equality Test

```
>>> s1 = {1, 2, 4}
>>> s2 = {1, 4, 2}
>>> s1 == s2
True
>>> s1 != s2
False
>>>
```

Comparison Operators

Note that it makes no sense to compare the sets using the conventional comparison operators (>, >=, <=, <), because the elements in a set are not ordered. However, these operators have special meaning when used for sets.

s1 > s2 returns true is s1 is a proper superset of s2.

s1 >= s2 returns true is s1 is a superset of s2.

s1 < s2 returns true is s1 is a proper subset of s2.

s1 <= s2 returns true is s1 is a subset of s2.

Set Operations (union, |)

```
>>> s1 = {1, 2, 4}
>>> s2 = {1, 3, 5}
>>> s1.union(s2)
{1, 2, 3, 4, 5}

>>> s1 | s2
{1, 2, 3, 4, 5}
```

Set Operations (intersection, &)

```
>>> s1 = {1, 2, 4}
>>> s2 = {1, 3, 5}
>>> s1.intersection(s2)
{1}

>>> s1 & s2
{1}
```

Set Operations (difference, -)

```
>>> s1 = {1, 2, 4}
>>> s2 = {1, 3, 5}
>>> s1.difference(s2)
{2, 4}

>>> s1 - s2
{2, 4}
```

Creating a Dictionary

```
# Create an empty dictionary
dictionary = {}
# Create a dictionary
dictionary = {"john":40, "peter":45}
```

Looping Entries

```
for key in dictionary:
    print(key + ":" +
        str(dictionary[key]))
```

Lambda Expressions

- Small anonymous functions
  - a function can return a function

```
>>> def make_incrementor(n):
...       return lambda x: x + n
...
>>> f = make_incrementor(42)
>>> f(0)
42
>>> f(1)
43
```

Standard Library

- Operating System Interface:

```
>>> import os

# Return the current working directory
>>> os.getcwd()
'C:\\Python35'

# Run the command mkdir
>>> os.system('mkdir today')
0
```

Standard Library

- Operating System Interface:

```
>>> import shutil

>>> shutil.copyfile('data.db', 'archive.db')
'archive.db'

>>> shutil.move('/build/executables', 'installdir')
'installdir'
```

Standard Library

- String Pattern Matching Interface:

```
>>> import re

>>> re.findall(r'\bf[a-z]*',
     'which foot or hand fell fastest')

['foot', 'fell', 'fastest']
```

Standard Library

- Mathematics:

```
>>> import random
>>> random.choice(['apple', 'pear', 'banana'])
'apple'

# sampling without replacement
>>> random.sample(range(100), 10)
[30, 83, 16, 4, 8, 81, 41, 50, 18, 33]

>>> random.random()    # random float
0.17970987693706186
```

Standard Library

- Mathematics:

```
>>> import statistics

>>> data = [2.75, 1.75, 1.25, 0.25, 0.5, 1.25, 3.5]
>>> statistics.mean(data)
1.6071428571428572

>>> statistics.median(data)
1.25

>>> statistics.variance(data)
1.3720238095238095
```

Standard Library

- Internet Access:

```
>>> from urllib.request import urlopen

>>> with urlopen('http://www.cs.stonybrook.edu') as response:
    for line in response:
        print(line)
```

Standard Library

- Dates and Times:

```
>>> from datetime import date

>>> now = date.today()
>>> now

>>> birthday = date(2000, 5, 23)

>>> age = now - birthday

>>> age.days
```

Standard Library

- Data Compression:

```
>>> import zlib
>>> s = b'data archiving and compression'
# A prefix of 'b' means that the chars are encoded in byte type
# may only contain ASCII characters

>>> t = zlib.compress(s)
>>> zlib.decompress(t)
b'data archiving and compression'
>>> zlib.crc32(s)
3701065259
```

Standard Library

- Testing:
  - doctest: scans a module and validate tests embedded in a program's docstrings

```
def average(values):
    """Computes the arithmetic mean of a list of numbers.
    >>> print(average([20, 30, 70]))
    40.0
    """
    return sum(values) / len(values)

import doctest
doctest.testmod()   # automatically validate the embedded tests
```

Standard Library

- Testing:
  - unittest: comprehensive set of tests to be maintained in a separate file

```
import unittest
class TestStatisticalFunctions(unittest.TestCase):
    def test_average(self):
        self.assertEqual(average([20, 30, 70]), 40.0)
        self.assertEqual(round(average([1, 5, 7]), 1), 4.3)
        with self.assertRaises(ZeroDivisionError):
            average([])
        with self.assertRaises(TypeError):
            average(20, 30, 70)

unittest.main() # Calling from the command line invokes all tests
```

Standard Library

- Logging:

```
import logging
logging.debug('Debugging information')
logging.info('Informational message')
logging.warning('Warning:config file %s not found', 'server.conf')
logging.error('Error occurred')
logging.critical('Critical error -- shutting down')
logging.getLogger().setLevel('INFO')
```

  - by default, informational and debugging messages are suppressed:

Level	Numeric value
CRITICAL	50
ERROR	40
WARNING	30
INFO	20
DEBUG	10
NOTSET	0

What else?

- Lots:
  - The Python Standard Library: built-in functions, collections, and many modules: https://docs.python.org/3/library/index.html#library-index
  - Installing Python Modules: pip, virtual environments https://docs.python.org/3/installing/index.html#installing-index
  - The Python Language Reference: the syntax and "core semantics" https://docs.python.org/3/reference/index.html#reference-index