Python for Data Science
4

Welcome!

Welcome to the Python for Data Science class!

About the Program

Four Part Series, Four Hours Each

- **Session 1: Getting Started with Python**
- **Session 2: Applying Python – The Basics**
- **Session 3: Exploring Python Files, Dictionaries, Sets & methods**
- **Session 4: Expanding Python – methods, Error Handling, Importing and OO Classes**

Quick Logistics: Format, Q&A and Follow-On Materials / Hand-Outs

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Today's Agenda: Session 3

Get started with Python! **Learn Object Oriented Programming with Python (and Exceptions).**
We'll also explore some common use cases that are often used in Data Analysis and Data Science.

Topics We'll Explore Today:

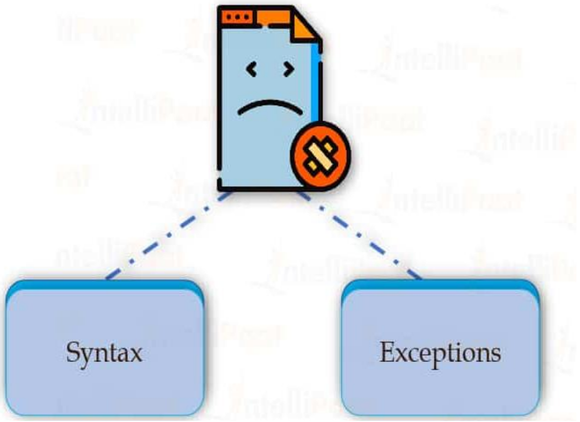
Exception Handling
Object Oriented Programming
Where to from here?
Demo

Exception Handling

Exception Handling

In this lesson, you will learn

- Exceptions
- Catching Exceptions
- Clean-Up Actions



Exceptions

- An example of an exception is IOError, which is raised when you try to open a file that doesn’t exist:

```
>>> open('unicorn.dat')
Traceback (most recent call last):
    File "<pyshell#1>", line 1, in <module>
    open('unicorn.dat')
    File "C:\Python30\lib\io.py", line 284, in __new__
    return open(*args, **kwargs)
    File "C:\Python30\lib\io.py", line 223, in open
    closefd)
IOError: [Errno 2] No such file or directory: 'unicorn.dat'
```

Raising an exception

- As we saw with the open function, Python's built-in functions and library functions usually raise exceptions when something unexpected happens.
- For instance, dividing by zero throws an exception:

```
>>> 1/0
Traceback (most recent call last):
    File "<pyshell#0>", line 1, in <module>
    1/0
ZeroDivisionError: int division or modulo by zero
```

Raising an exception

- Syntax errors can also cause exceptions in Python:

```
>>> x := 5
SyntaxError: invalid syntax (<pyshell#2>, line 1)
>>> print('hello world)
SyntaxError: EOL while scanning string literal (<pyshell#3>, line 1)
```

Raising an exception

- You can also intentionally raise an exception anywhere in your code using the raise statement.

For example:

```
>>> raise IOError('This is a test!')
Traceback (most recent call last):
  File "<pyshell#6>", line 1, in <module>
    raise IOError('This is a test!')
IOError: This is a test!
```

CATCHING EXCEPTIONS

1. Ignore the exception
2. Catch the exception

CATCHING EXCEPTIONS

```
def get_age():
    while True:
        try:
            n = int(input('How old are you? '))
            return n
        except ValueError:
            print('Please enter an integer value.')
```

CATCHING EXCEPTIONS

- If any line of the try block does raise an exception, then the flow of control immediately jumps to the except block, skipping over any statements that have not been executed yet.

- In this example, the return statement will be skipped when an exception is raised.

Try/except blocks

- Try/except blocks work a little bit like if-statements. However, they are different in an important way:

- If statements decide what to do based on the evaluation of Boolean expressions, whereas try/except blocks decide what to do based on whether or not an exception is raised.

Try/except blocks

```
>>> int('two')
ValueError: invalid literal for int() with base 10: 'two'
>>> int(2, 10)
TypeError: int() can't convert non-string with explicit base
>>> int('2', 1)
ValueError: int() arg 2 must be >= 2 and <= 36
```

So int() raises ValueError for at least two different reasons, and it raises TypeError in at least one other case.

Catching multiple exceptions

- You can write try/except blocks to handle multiple exceptions.
- For example, you can group together multiple exceptions in the except clause:

```
def convert_to_int1(s, base):
    try:
        return int(s, base)
    except (ValueError, TypeError):
        return 'error'
```

Catching multiple exceptions

- Or, if you care about the specific exception that is thrown, you can add extra except clauses:

```
def convert_to_int2(s, base):
    try:
        return int(s, base)
    except ValueError:
        return 'value error'
    except TypeError:
        return 'type error'
```

Catching any exception

- If you write an except clause without any exception name, it will catch any and all exceptions:

```
def convert_to_int3(s, base):
    try:
        return int(s, base)
    except:
        return 'error'
```

CLEAN-UP ACTIONS

- A finally code block can be added to any try/except block to perform clean-up actions. For example:

```
def invert(x):
    try:
        return 1 / x
    except ZeroDivisionError:
        return 'error'
    finally:
        print('invert(%s) done' % x)
```

The with statement

- Python's with statement is another way to ensure that cleanup actions (such as closing a file) are done as soon as possible, even if there is an exception.

The with statement

- For example, consider this code, which prints a file to the screen with numbers for each line:

```
num = 1
f = open(fname)
for line in f:
    print('%04d %s' % (num, line), end = '')
    num = num + 1
    # following code
```

The with statement

- To ensure that the file is closed as soon as it is no longer needed, use a with statement:

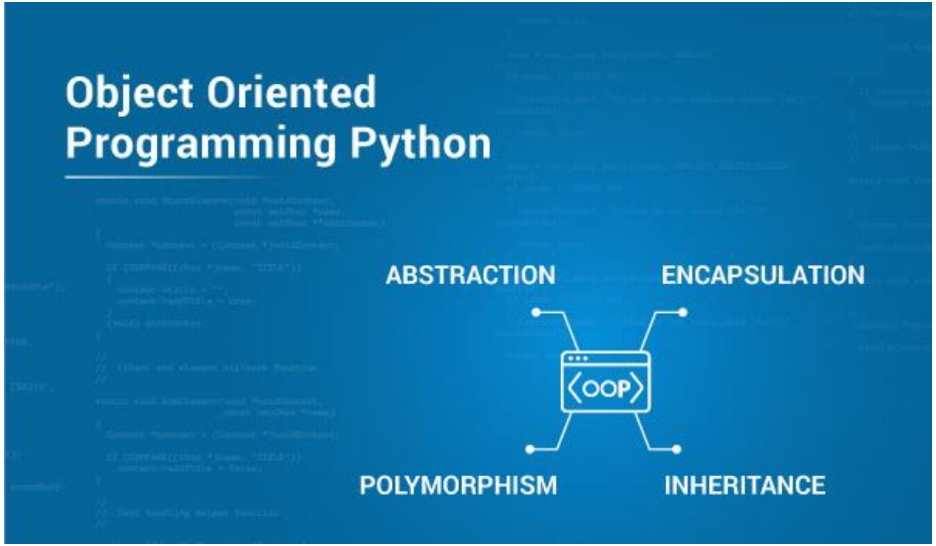
```
num = 1
with open(fname, 'r') as f:
    for line in f:
        print('%04d %s' % (num, line), end = '')
        num = num + 1
```

Object-Oriented Programming

Object-Oriented Programming

In this lesson, you will learn

- Writing a Class
- Displaying Objects
- Flexible Initialization
- Setters and Getters
- Inheritance
- Polymorphism
- Learning More



WRITING A CLASS

- Let's jump right into OOP by creating a simple class to represent a person:

```
# person.py
class Person:
    """ Class to represent a person
    """

    def __init__(self):
        self.name = ''
        self.age = 0
```

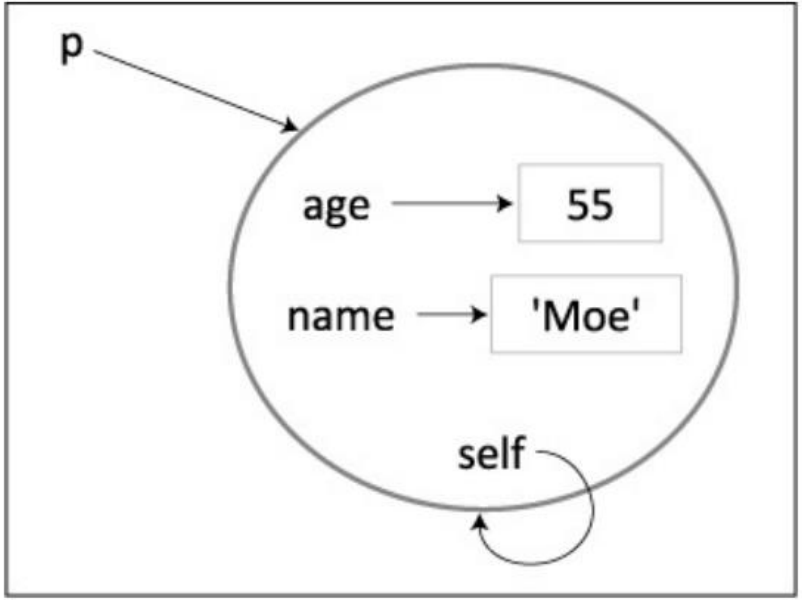
WRITING A CLASS

- We can use Person objects like this:

```
>>> p = Person()
>>> p
<__main__.Person object at 0x00AC3370>
>>> p.age
0
>>> p.name
''
>>> p.age = 55
>>> p.age
55
>>> p.name = 'Moe'
>>> p.name
'Moe'
```

The self parameter

- You’ll notice that we don’t provide any parameters for Person(), but the __init__(self) function expects an input named self.
- That’s because in OOP, self is a variable that refers to the object itself.
- This is a simple idea, but one that trips up many beginners.



DISPLAYING OBJECTS

```
# person.py
class Person:
    """ Class to represent a person
    """
    def __init__(self):
        self.name = ''
        self.age = 0
    def display(self):
        print("Person('%s', age)" % (self.name, self.age))
```

DISPLAYING OBJECTS

- The display method prints the contents of a Person object to the screen in a format useful to a programmer:

```
>>> p = Person()
>>> p.display()
Person('', 0)
>>> p.name = 'Bob'
>>> p.age = 25
>>> p.display()
Person('Bob', 25)
```

DISPLAYING OBJECTS

- For instance, the special __str__ method is used to generate a string representation of an object:

```
# person.py
class Person:
    # __init__ removed for space
    def display(self):
        print("Person('%s', age)" % (self.name, self.age))
    def __str__(self):
        return "Person('%s', age)" % (self.name, self.age)
```

DISPLAYING OBJECTS

- Now we can write code like this:

```
>>> p = Person()
>>> str(p)
"Person('', 0)"
```

DISPLAYING OBJECTS

- We can use str to simplify the display method:

```
# person.py
class Person:
    # __init__ removed for space
    def display(self):
        print(str(self))
    def __str__(self):
        return "Person('%s', age)"  % (self.name, self.age)
```

DISPLAYING OBJECTS

- You can also define a special method named __repr__ that returns the “official” representation of an object.
- For example, the default representation of a Person is not very helpful:

```
>>> p = Person()
>>> p
<__main__.Person object at 0x012C3170>
```

DISPLAYING OBJECTS

- By adding a __repr__ method, we can control the string that is printed here, In most objects, it is the same as the __str__ method:

```
# person.py
class Person:
    # __init__ removed for space
    def display(self):
        print(str(self))
    def __str__(self):
        return "Person('%s', age)" % (self.name, self.age)
    def __repr__(self):
        return str(self)
```

DISPLAYING OBJECTS

- Now Person objects are easier to work with:

```
>>> p = Person()
>>> p
Person('', 0)
>>> str(p)
"Person('', 0)"
```

FLEXIBLE INITIALIZATION

- If you want to create a Person object with a particular name and age, you must currently do this:

```
>>> p = Person()
>>> p.name = 'Moe'
>>> p.age = 55
>>> p
Person('Moe', 55)
```

FLEXIBLE INITIALIZATION

- A more convenient approach is to pass the name and age to __init__ when the object is constructed. So

- let's rewrite __init__ to allow for this:

```
# person.py
class Person:
    def __init__(self, name = '',
                       age = 0):
        self.name = name
        self.age = age
```

FLEXIBLE INITIALIZATION

- Now initializing a Person is much simpler:

```
>>> p = Person('Moe', 55)
>>> p
Person('Moe', 55)
```

FLEXIBLE INITIALIZATION

- Since the parameters to __init__ have default values, you can even create an “empty” Person:

```
>>> p = Person()
>>> p
Person('', 0)
```

SETTERS AND GETTERS

- As it stands now, we can both read and write the name and age values of a Person object using dot notation

```
>>> p = Person('Moe', 55)
>>> p.age
55
>>> p.name
'Moe'
>>> p.name = 'Joe'
>>> p.name
'Joe'
>>> p
Person('Joe', 55)
```

SETTERS AND GETTERS

- First, let's add a setter method that changes age only if a sensible value is given:

```
def set_age(self, age):
    if 0 < age <= 150:
        self.age = age
```

SETTERS AND GETTERS

- Now we can write code like this:

```
>>> p = Person('Jen', 25)
>>> p
Person('Jen', 25)
>>> p.set_age(30)
>>> p
Person('Jen', 30)
>>> p.set_age(-6)
>>> p
Person('Jen', 30)
```

Property decorators

- Property decorators combine the brevity of variables with the flexibility of functions.

- Decorators indicate that a function or method is special in some way, and here we use them to indicate setters and getters.

Property decorators

- A getter returns the value of a variable, and we indicate this using the @property decorator:

```
@property
def age(self):
    """ Returns this person's age.
    """

    return self._age
```

```python
# person.py
class Person:
    def __init__(self, name = '',
                        age = 0):
        self._name = name
        self._age = age

    @property
    def age(self):
        return self._age

    def set_age(self, age):
        if 0 < age <= 150:
            self._age = age

    def display(self):
        print(self)

    def __str__(self):
        return "Person('%s', %s)" % (self._name, self._age)

    def __repr__(self):
      return str(self)
```

Property decorators

- To create an age setter, we rename the set_age method to age and decorate it with @age.setter:

```
@age.setter
def age(self, age):
    if 0 < age <= 150:
        self._age = age
```

Property decorators

```
>>> p = Person('Lia', 33)
>>> p
Person('Lia', 33)
>>> p.age = 55
>>> p.age
55
>>> p.age = -4
>>> p.age
55
```

- With these changes, we can now write code like this:

Private variables

- It’s still possible to access self._age directly:

```
>>> p._age = -44
>>> p
Person('Lia', -44)
```

Private variables

- To access self.__age directly, you now have to put _Person on the front, like this:

```
>>> p._Person__age = -44
>>> p
Person('Lia', -44)
```

INHERITANCE

- Inheritance is a mechanism for reusing classes.

- Essentially, inheritance allows you to create a brand new class by adding extra variables and methods to a copy of an existing class.

```python
# players.py
class Player:
    def __init__(self, name):
        self._name = name
        self._score = 0
    def reset_score(self):
        self._score = 0
    def incr_score(self):
        self._score = self._score + 1
    def get_name(self):
        return self._name
    def __str__(self):
        return "name = '%s', score = %s" % (self._name, self._score)
    def __repr__(self):
        return 'Player(%s)' % str(self)
```

INHERITANCE

- We can use Player objects this way:

```
>>> p = Player('Moe')
>>> p
Player(name = 'Moe', score = 0)
>>> p.incr_score()
>>> p
Player(name = 'Moe', score = 1)
>>> p.reset_score()
>>> p
Player(name = 'Moe', score = 0)
```

INHERITANCE

- We can define the Human class to inherit all the variables and methods from the Player class so that we don't have to rewrite them:

```
class Human(Player):
    pass
```

INHERITANCE

```
>>> h = Human('Jerry')
>>> h
Player(name = 'Jerry', score = 0)
>>> h.incr_score()
>>> h
Player(name = 'Jerry', score = 1)
>>> h.reset_score()
>>> h
Player(name = 'Jerry', score = 0)
```

Overriding methods

- One small wart is that the string representation of h says Player when it would be more accurate for it to say Human.
- We can fix that by giving Human its own __repr__ method:

```
class Human(Player):
    def __repr__(self):
        return 'Human(%s)' % str(self)
```

Overriding methods

- Now we get this:

```
>>> h = Human('Jerry')
>>> h
Human(name = 'Jerry', score = 0)
```

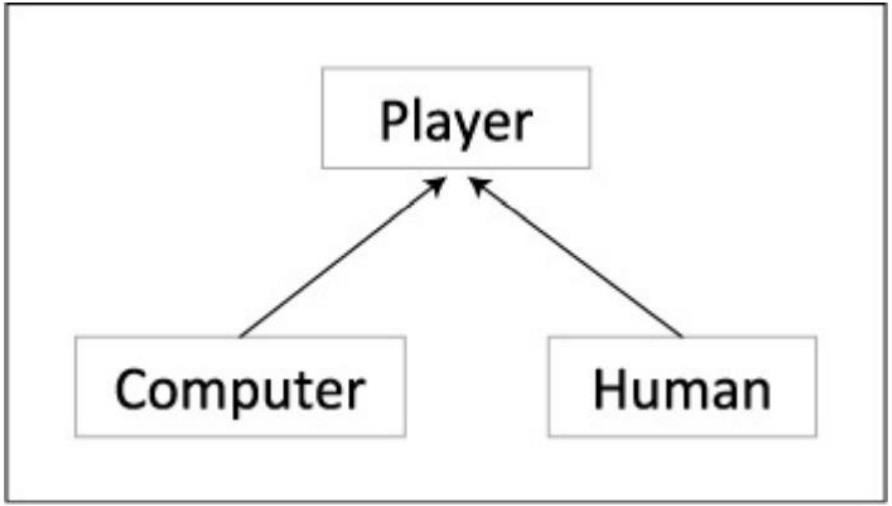
Overriding methods

- Now it’s easy to write a similar Computer class to represent computer moves:

```
class Computer(Player):
    def __repr__(self):
        return Computer(%s)' % str(self)
```

Overriding methods

- These three classes form a small class hierarchy, as shown in the class diagram.
- The Player class is called the base class, and the other two classes are derived, or extended, classes.



POLYMORPHISM

- To demonstrate the power of OOP, let’s implement a simple game called Undercut.
- In Undercut, two players simultaneously pick an integer from 1 to 10 (inclusive).
- If a player picks a number one less than the other player

POLYMORPHISM

- Here’s a function for playing one game of Undercut:

```
def play_undercut(p1, p2):
    p1.reset_score()
    p2.reset_score()
    m1 = p1.get_move()
    m2 = p2.get_move()
    print("%s move: %s" % (p1.get_name(), m1))
    print("%s move: %s" % (p2.get_name(), m2))
    if m1 == m2 - 1:
        p1.incr_score()
        return p1, p2, '%s wins!' % p1.get_name()
    elif m2 == m1 - 1:
        p2.incr_score()
        return p1, p2, '%s wins!' % p2.get_name()
    else:
        return p1, p2, 'draw: no winner'
```

Implementing the move functions

- Even though moves in Undercut are just numbers from 1 to 10, humans and computers determine their moves in very different ways.

- Human players enter a number from 1 to 10 at the keyboard, whereas computer players use a function to generate their moves.

```
class Human(Player):
    def __repr__(self):
        return 'Human(%s)' % str(self)

    def get_move(self):
        while True:
            try:
                n = int(input('%s move (1 - 10): ' % self.get_name()))
                if 1 <= n <= 10:
                    return n
                else:
                    print('Oops!')
            except:
                print(Oops!')
```

Implementing the move functions

```
import random


class Computer(Player):
    def __repr__(self):
        return 'Computer(%s)' % str(self)

    def get_move(self):
        return random.randint(1, 10)
```

LEARNING VOYAGE

Playing Undercut

- With all the pieces in place, we can now start playing Undercut.
- Let’s try a game between a human and a computer:

```
>>> c = Computer('Hal Bot')
>>> h = Human('Lia')
>>> play_undercut(c, h)
Lia move (1 - 10): 7
Hal Bot move: 10
Lia move: 7
(Computer(name = 'Hal Bot', score = 0), Human(name = 'Lia', score = 0), '
```

Playing Undercut

- It’s possible to pass two computer players to play_undercut:

```
>>> c1 = Computer('Hal Bot')
>>> c2 = Computer('MCP Bot')
>>> play_undercut(c1, c2)
Hal Bot move: 8
MCP Bot move: 7
(Computer(name = 'Hal Bot', score = 0), Computer(name = 'MCP Bot', sco
```

Playing Undercut

- We can also pass in two human players:

```
>>> h1 = Human('Bea')
>>> h2 = Human('Dee')
>>> play_undercut(h1, h2)
Bea move (1 - 10): 5
Dee move (1 - 10): 4
Bea move: 5
Dee move: 4
(Human(name = 'Bea', score = 0), Human(name = 'Dee', score = 1), 'Dee w
```

LEARNING MORE

- This lesson introduced a few of the essentials of OOP.
- Python has many more OOP features you can learn about by reading the online documentation.
- Creating good object-oriented designs is a major topic.
- Using objects well is much harder than merely using them.

Case Study Text Statistics

Case Study Text Statistics

In this lesson, you will learn

- Problem Description
- Keeping the Letters We Want
- Testing the Code on a Large Data File
- Finding the Most Frequent Words
- Converting a String to a Frequency Dictionary
- Putting It All Together
- Exercises
- The Final Program

PROBLEM DESCRIPTION

- When asked to write a program that solves some non-trivial problem, beginning programmers often don’t know where to start.

- At a high level at least, the answer is simple: You start writing a big program by first understanding the problem you want to solve.

PROBLEM DESCRIPTION

Let's look at an example using a short piece of text:

- A long time ago, in a galaxy far, far away ...

We can see that it contains:

- One line of text. We assume that the return-line character, \n, is used to indicate the end of a line, and that every text file (that is not empty!) is at least one line long.

PROBLEM DESCRIPTION

- A useful thing to do in Python is to play with examples in the interpreter.

For example:

```
>>> s = 'A long time ago, in a galaxy far, far away ...'
>>> len(s)
46
>>> s.split()
['A', 'long', 'time', 'ago,', 'in', 'a', 'galaxy', 'far,', 'far', 'away', '...']
```

PROBLEM DESCRIPTION

We will ignore non-letters (e.g., digits and punctuation), and convert uppercase letters to lowercase. So our sentence becomes this:

- Original: A long time ago, in a galaxy far, far away ...
- Modified: a long time ago in a galaxy far away

PROBLEM DESCRIPTION

- Splitting the modified sentence into words now gives more accurate results:

```
>>> t = 'a long time ago in a galaxy far far away'
>>> t.split()
['a', 'long', 'time', 'ago', 'in', 'a', 'galaxy', 'far', 'far', 'away']
>>> len(t.split())
10
```

PROBLEM DESCRIPTION

- We can count the number of unique words by converting the list to a set (recall that a set never stores duplicates):

```
>>> set(t.split())
{'a', 'ago', 'far', 'away', 'time', 'long', 'in', 'galaxy'}
>>> len(set(t.split()))
8
```

KEEPING THE LETTERS, WE WANT

- Next, let's think about how to automatically convert a string to the format we want.

- Converting a string to lowercase is easy:

```
>>> s = "I'd like a copy!"
>>> s.lower()
"i'd like a copy!"
```

KEEPING THE LETTERS WE WANT

- Getting rid of characters, we don’t want is a bit trickier. One way to do it is to use the string replace function to replace individual characters with nothing; for example:

```
>>> s = "I'd like a copy!"
>>> s.replace('!', '')
"I'd like a copy"
```

- A better approach is to keep the letters we want.

For example:

```
# Set of all characters to keep
keep = {'a', 'b', 'c', 'd', 'e',
    'f', 'g', 'h', 'i', 'j',
    'k', 'l', 'm', 'n', 'o',
    'p', 'q', 'r', 's', 't',
    'u', 'v', 'w', 'x', 'y',
    'z',
    ' ', '-', "'"}

    def normalize(s):
    """Convert s to a normalized string.
    """
    result = ''
    for c in s.lower():
        if c in keep:
            result += c
    return result
```

TESTING THE CODE ON A LARGE DATA FILE

- We’ve written only a small amount of code, but it is enough to do some useful experiments.
- In the examples that follow, we’ll use a file called bill.txt.
- It is a 5.4 megabyte text file containing the complete works of Shakespeare (which are free on the Project Gutenberg site, www.gutenberg.org).

TESTING THE CODE ON A LARGE DATA FILE

- One way to process a text file is to read the entire thing into memory as a string.
- Let’s try this by hand in the interpreter:

```
>>> bill = open('bill.txt', 'r').read()
>>> len(bill)
5465395
>>> bill.count('\n')
124796
>>> len(bill.split())
904087
>>> len(normalize(bill).split())
897610
```

- Now let’s automate this by putting all the code in a function:

```
def file_stats(fname):
    """Print statistics for the given
    file.
    """
    s = open(fname, 'r').read()
    num_chars = len(s)
    num_lines = s.count('\n')
    num_words = len(normalize(s).split())

    print("The file '%s' has: " % fname)
    print("   %s characters" % num_chars)
    print("   %s lines" % num_lines)
    print("   %s words" % num_words)
```

TESTING THE CODE ON A LARGE DATA FILE

- Calling file_stats prints this:

```
>>> file_stats('bill.txt')
The file 'bill.txt' has:
    5465395 characters
    124796 lines
    897610 words
```

FINDING THE MOST FREQUENT WORDS

- Let's consider the problem of finding the most frequently occurring words in a text file.
- The basic idea will be to use a dictionary whose keys are words and whose values are the counts of the words in the file.
- For example, consider our original example text (in normalized form):

a long time ago in a galaxy far away

FINDING THE MOST FREQUENT WORDS

We can make a count of all the words like this:
a: 2
long: 1
time: 1
ago: 1
in: 1
galaxy: 1
far: 2
away: 1

FINDING THE MOST FREQUENT WORDS

```
d = {
        'a': 2,
     'long': 1,
     'time': 1,
      'ago': 1,
       'in': 1,
   'galaxy': 1,
      'far': 2,
     'away': 1
   }
```

- If we convert this to a Python dictionary, it looks like this:

```
lst = []
for k in d:
    pair = (d[k], k)
    lst.append(pair)
#
# [(2, 'a'), (1, 'ago'),
#  (1, 'galaxy'), (1, 'time'),
#  (2, 'far'), ...]
lst.sort()
#
# [(1, 'ago'), (1, 'away'),
#  (1, 'galaxy'), (1, 'in'),
#  (1, 'long'), ...]
lst.reverse()
#
# [(2, 'far'), (2, 'a'),
#  (1, 'time'), (1, 'long'),
#  (1, 'in'), ...]
```

FINDING THE MOST FREQUENT WORDS

- With lst ordered from most frequent word to least frequent word, we can use slicing to access, say, the top three most frequent words on the list:

```
print(lst[:3])
#
# [(2, 'far'), (2, 'a'),
#  (1, 'time')]
```

FINDING THE MOST FREQUENT WORDS

Or, if we want neater formatting, we can do this:

```
for count, word in lst:
    print('%4s %s' % (count, word))
```

FINDING THE MOST FREQUENT WORDS

- Which prints:

2 far
2 a
1 time
1 long
1 in
1 galaxy
1 away
1 ago

CONVERTING ASTRING TO A FREQUENCY DICTIONARY

```
def make_freq_dict(s):
    """Returns a dictionary whose keys
       are the words of s, and whose
       values are the counts of those
       words.
    """
    s = normalize(s)
    words = s.split()
    d = {}
    for w in words:
        if w in d:    # seen w before?
            d[w] += 1
        else:
            d[w] = 1
    return d
```

PUTTING IT ALL TOGETHER

```
def print_file_stats(fname):
    """Print statistics for the given file.
    """
    s = open(fname, 'r').read()
    num_chars = len(s)              # count characters before normalizing s
    num_lines = s.count('\n')        # count lines before normalizing s
```

```
d = make_freq_dict(s)
num_words = sum(d[w] for w in d)  # count number of words in s
# create list of (count, pair) words ordered from
# most frequent to least frequent
lst = [(d[w], w) for w in d]
lst.sort()
lst.reverse()
# print the results to the screen
print("The file '%s' has: " % fname)
print("   %s characters" % num_chars)
print("   %s lines" % num_lines)
print("   %s words" % num_words)
print("\nThe top 10 most frequent words are:")
i = 1   # i is the number of the list item
for count, word in lst[:10]:
    print('%2s. %4s %s' % (i, count, word))
    i += 1
```

The file 'bill.txt' has:

5465395 characters

124796 lines

897610 words

The top 10 most frequent words are:

1. 27568 the
2. 26705 and
3. 20115 i
4. 19211 to
5. 18263 of
6. 14391 a
7. 13606 you
8. 12460 my
9. 11107 that
10. 11001 in

EXERCISES

1. Modify print_file_stats so that it also prints the total number of unique words in the file.

2. Modify print_file_stats so that it prints the average length of the words in the file

THE FINAL PROGRAM

```
# wordstats.py
# Set of all allowable characters.
keep = {'a', 'b', 'c', 'd', 'e',
        'f', 'g', 'h', 'i', 'j',
        'k', 'l', 'm', 'n', 'o',
        'p', 'q', 'r', 's', 't',
        'u', 'v', 'w', 'x', 'y',
        'z',
        ' ', '-', "'"}

def normalize(s):
    """Convert s to a normalized string.
    """
    result = ''
    for c in s.lower():
        if c in keep:
            result += c
    return result

def make_freq_dict(s):
    """Returns a dictionary whose keys are the words of s, and whose va
```

```
    are the counts of those words.
    """
    s = normalize(s)
    words = s.split()
    d = {}
    for w in words:
        if w in d:    # add 1 to its count if w has been seen before
            d[w] += 1
        else:
            d[w] = 1    # initialize to 1 if this is the first time w has been seen
    return d

def print_file_stats(fname):
    """Print statistics for the given file.
    """
    s = open(fname, 'r').read()

    num_chars = len(s)              # count characters before normalizing s
    num_lines = s.count('\n')       # count lines before normalizing s

    d = make_freq_dict(s)
    num_words = sum(d[w] for w in d)  # count number of words in s
```

```
# create list of (count, pair) words ordered from
# most frequent to least frequent
lst = [(d[w], w) for w in d]
lst.sort()
lst.reverse()

# print the results to the screen
print("The file '%s' has: " % fname)
print("   %s characters" % num_chars)
print("   %s lines" % num_lines)
print("   %s words" % num_words)

print("\nThe top 10 most frequent words are:")
i = 1   # i is the number of the list item
for count, word in lst[:10]:
    print('%2s. %4s %s' % (i, count, word))
```

THE FINAL PROGRAM

```
        i += 1


def main():
    print_file_stats('bill.txt')


if __name__ == '__main__':
    main()
```

Demo