

Introduction to Python

CSCI 4448/5448: Object-Oriented Analysis & Design

Lecture 9

Learning Objectives

- Students will be able to...
 - Understand why Python is suited to OO designs
 - Find support for their own Python language exploration
 - Use Python for class projects and future designs

Why Python?

- Python: Development Speed
- Python's syntax emphasizes code readability – estimated that 10% of code required for a given application vs. C
- Built-in memory management
- Python has vast library support for UI and M2M/IoT communication protocols
- Python's interactive interpreter allows rapid test of features while programming
- Python has a complete (?) implementation of object-oriented design elements
- IEEE 2018 language survey places Python (#1) above C (#4) [1]
- C++ and Java are #2 and #3

“Pythonic” Code Style

- When working in Python, and looking at examples, you will see the term “Pythonic”
- Pythonic is code that is as simple and readable as possible
- Pythonic code follows the basics of Python code style [4]
- Consider using the pep8 tool to check your code for style issues [5]
- More information on Python style is available [6]

Zen of Python: Tim Peters [7]

- Beautiful is better than ugly.
- Explicit is better than implicit.
- **Simple is better than complex.**
- **Complex is better than complicated.**
- Flat is better than nested.
- Sparse is better than dense.
- **Readability counts.**
- Special cases aren't special enough to break the rules.
- Although practicality beats purity.
- **Errors should never pass silently.**
- Unless explicitly silenced.
- In the face of ambiguity, refuse the temptation to guess.
- There should be one-- and preferably only one --obvious way to do it.
- Although that way may not be obvious at first unless you're Dutch*.
- Now is better than never.
- Although never is often better than *right* now.
- If the implementation is hard to explain, it's a bad idea.
- If the implementation is easy to explain, it may be a good idea.
- Namespaces are one honking great idea -- let's do more of those!

You can see the Zen of Python in a Python interpreter by entering:

```
>>> import this
```

*Dutch – refers to Guido van Rossum, Python's creator, who is Dutch.

Python: Functional, Procedural...

- Functional – Direct evaluation of mathematical functions (like R or Mathematica):

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

```
3
```

- Procedural – Structured programs based on modules and procedure calls (like C):

```
def add_me(x,y):  
    print(x+y)
```

```
add_me(3,4)
```

```
# Output: 7
```

Python: ...and Object-Oriented

Object-oriented – Data operations via objects with defined methods; inheritable classes (like Java and C++):

```
class MyMath:
    input_error = "Bad input"
    def error(self):
        print(self.input_error)
    def adder(x,y,self):
        print(x+y)
```

```
m = MyMath()
print(m.input_error)
# Output: Bad input
print(m.error())
# Output: Bad input
print(m.adder(3,4))
# Output: 7
```

Object-Oriented Python

- Unlike Java, Python can handle multiple inheritance (see code)
- Duplicate method names are parsed based on inheritance order to prevent Diamond issue (linearized inheritance chain)
- Some issues with Python OO:
 - Type safety (dynamic types vs Java static types)
 - Changing objects or attributes at runtime
 - Data privacy/encapsulation
 - `__new__`, `__init__`, `__del__` issues
 - No interfaces (but Python 3 introduced annotations for abstract methods, etc.)

```
# Python example to show working of
# multiple inheritance
class Base1:
    def __init__(self):
        self.str = "I am base 1"
        print("Base1 constructed")

    def util(self):
        print("Do a thing")

class Base2:
    def __init__(self):
        self.str = "I am base 2"
        print("Base2 constructed")

    def util(self):
        print("Do another thing")

class Derived(Base1, Base2):
    def __init__(self):

        # Calling constructors of Base1
        # and Base2 classes
        Base1.__init__(self)
        Base2.__init__(self)
        print("Derived constructed")

d = Derived()      #prints the constructed msgs
d.util()          #prints "Do a thing."
```


Abstract Classes in Python

- Abstract base classes are implemented in Python by importing the abc module
- The abstract base class approach for Python is documented in PEP 3119
<https://www.python.org/dev/peps/pep-3119/>
 - PEP stands for Python Enhancement Proposal
- There is no direct interface equivalent in Python, although you can come close using abc as discussed here:
<https://realpython.com/python-interface/>

```
from abc import ABCMeta, abstractmethod

class A(metaclass=ABCMeta):
    @abstractmethod
    def foo(self): pass

A() # raises TypeError

class B(A):
    pass

B() # raises TypeError

class C(A):
    def foo(self): print(42)

C() # works
```

Common Python Syntax

From the author of Python Crash Course [8]:
A set of Python syntax cheat sheets for most Python coding

Beginner's Python Cheat Sheet

Variables and Strings

Variables are used to store values. A string is a series of characters, surrounded by single or double quotes.

Hello world

```
print("Hello world!")
```

Hello world with a variable

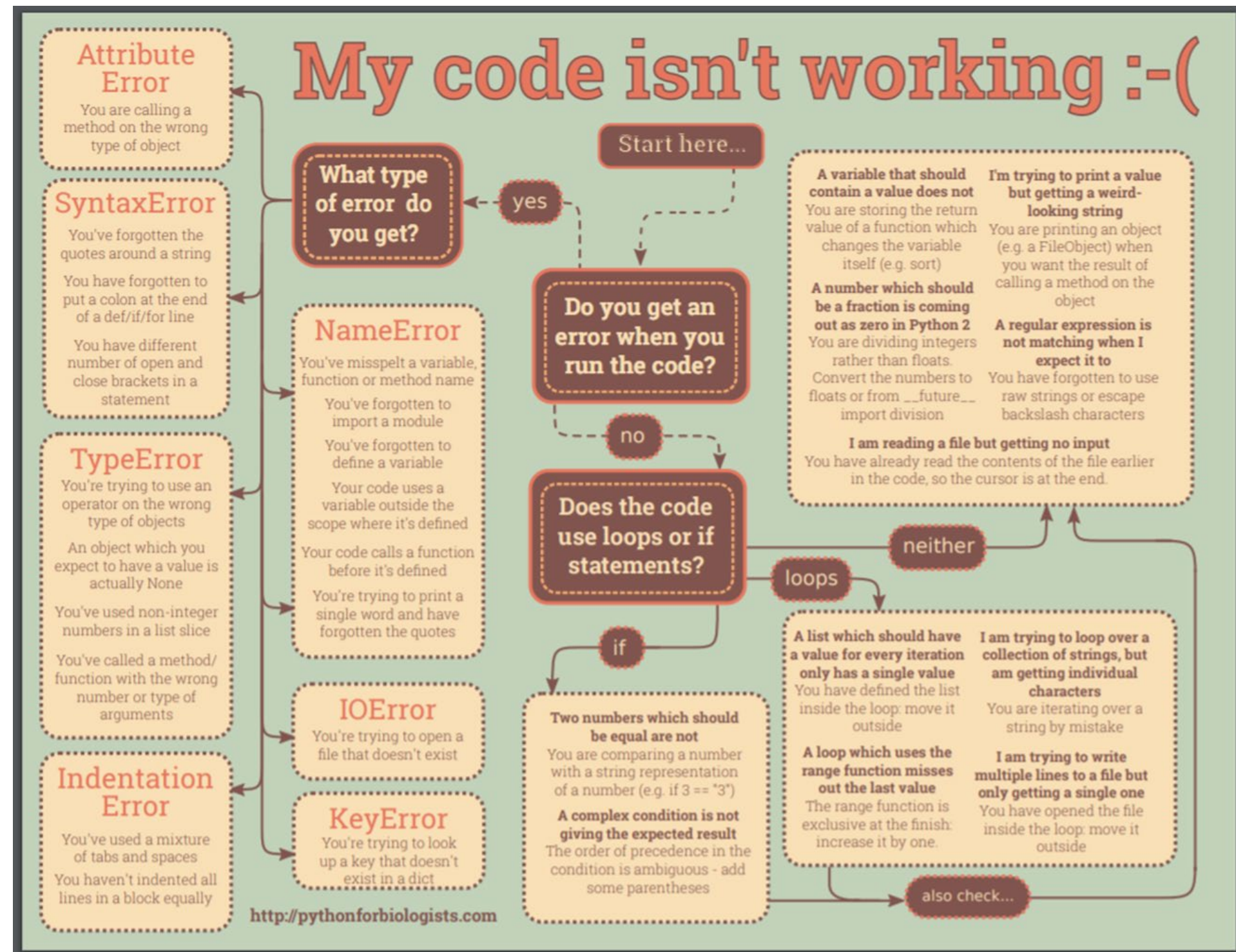
```
msg = "Hello world!"  
print(msg)
```

Concatenation (combining strings)

```
first_name = 'albert'  
last_name = 'einstein'  
full_name = first_name + ' ' + last_name  
print(full_name)
```


Common Python Errors

From Python for Biologists [9]:
A nice site for an introductory Python tutorial as well



Useful Python Libraries

- One of the best things about Python is the richness of the available libraries
- Requests – “HTTP for Humans”, eases messaging via HTTP packets [10]
- Pillow – a fork of the PIL image manipulation library [11]
- BeautifulSoup – parser for XML and HTML [12]
- Twisted – event-driven networking and web server [13]
- NumPy, SciPy, SymPy – math/scientific libraries [14][15][16]
- Matplotlib – 2D plotting library [17]
- Python Rule of Thumb – There’s already a library for it.
- More suggestions at 20 Python Libraries You Can’t Live Without [18]

Pip

- Pip is a tool for installing and managing Python packages, such as those found in the Python Package Index (aka PyPI [19])
- Typically, pip is used to install packages into a python environment:
- Pip can also be used to create packages you want to provide to the larger Python community
- Wheels (distribution packages) are relatively new to Python, replacing older “eggs” [20]
 - <https://packaging.python.org/discussions/wheel-vs-egg/>
- Most Python packages have been converted to Wheels [21]

Usage: pip [options]

Commands:

install	Install packages.
uninstall	Uninstall packages.
freeze	Output installed packages in requirements format.
list	List installed packages.
show	Show information about installed packages.
search	Search PyPI for packages.
wheel	Build Wheel archives for your requirements and dependencies.
help	Show help for commands.

Python Test Frameworks

- One accepted approach to professional software development is test-first (sometimes test-with) programming
- The goal is to create suites of unit test cases that can be run against code whenever it changes to ensure issues are not introduced
- In a continuous development environment, using a tool such as Jenkins, such unit tests are included in each build execution to ensure project health
- Python supports several test frameworks, including:
 - pytest, nose, and unittest
- For more information and other test frameworks, including for GUIs, see [22]

PyTest Example

- In this example, a test case is defined for func at a value of 3
- The assert clause is checked by the PyTest run, which fails because the assert = 4, not 5 as specified
- Such testing can be performed for function bounds and abnormal values
- The creation of effective unit tests is a skill
- TDD is common in many professional development environments, we'll discuss it further for your project work

```
# content of test_sample.py
def func(x):
    return x + 1
def test_answer():
    assert func(3) == 5
```

```
$ pytest
===== test session starts =====
platform linux -- Python 3.x.y, pytest-
3.x.y, py-1.x.y, pluggy-0.x.y
rootdir: $REGENDOC_TMPDIR, inifile:
collected 1 item

test_sample.py F

===== FAILURES =====
_____ test_answer _____

def test_answer():
> assert func(3) == 5
E assert 4 == 5
E + where 4 = func(3)

test_sample.py:5: AssertionError
===== 1 failed in 0.12 seconds =====
```

Practical Python Issues

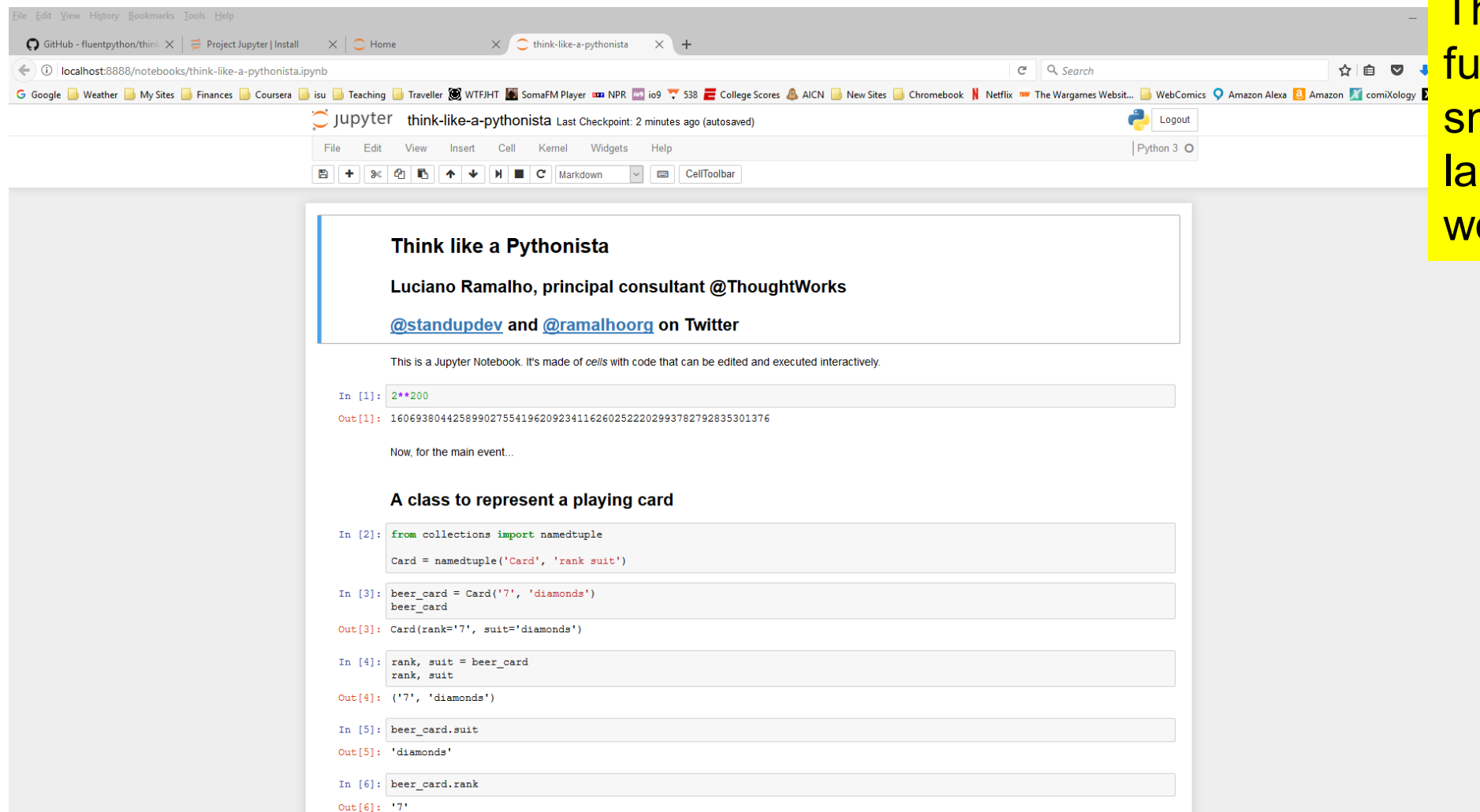
- Good practice on Linux to include a shebang as the first line in a Python program to run it directly from a Linux shell
- `#!/usr/bin/env python3`
- Now the program can be made executable to run directly from the shell
- `$./program.py`
- Use Python docstrings, keywords like `__author__` and `__copyright__`, and comments to document your code for yourself and others
- Examples will be found in homework and projects
- You'll see references to both Python 3.x and 2.x environments
- Simple answer now: Use Python 3.x, differences from 2.7 are minor
 - Python is up to 3.10, but generally any 3.x should be fine

If you haven't used Python...

- Python is NOT required for OOAD, I will show some code examples in it
- Past this introduction, I will not teach Python coding in class
- If you know other languages, learning Python will likely be easy for you
- Many available environments and distributions for Python
- I recommend two Python tools for your laptop in particular
 - Anaconda – A Python distribution with many standard libraries pre-loaded (including Jupyter below) [23]
 - Jupyter Notebooks – An interactive notebook style editor for executing code snippets in development [24]

Jupyter – Python IDE in a browser

The Jupyter environment is fun for running small Python snippets as you learn the language. Jupyter saves your workspace into .ipynb files.



The screenshot shows a Jupyter Notebook running in a web browser. The browser's address bar shows the URL `localhost:8888/notebooks/think-like-a-pythonista.ipynb`. The notebook's title bar includes the Jupyter logo, the title "think-like-a-pythonista", and a "Last Checkpoint: 2 minutes ago (autosaved)" status. The interface features a menu bar (File, Edit, View, Insert, Cell, Kernel, Widgets, Help) and a toolbar with icons for file operations and cell execution. The notebook content includes a title "Think like a Pythonista", the author "Luciano Ramalho, principal consultant @ThoughtWorks", and Twitter handles "@standupdev" and "@ramalhoorg". A descriptive paragraph states: "This is a Jupyter Notebook. It's made of cells with code that can be edited and executed interactively." The code cells are as follows:

```
In [1]: 2**200
Out[1]: 160693804425899027554196209234116260252202993782792835301376

Now, for the main event...

A class to represent a playing card

In [2]: from collections import namedtuple
        Card = namedtuple('Card', 'rank suit')

In [3]: beer_card = Card('7', 'diamonds')
        beer_card
Out[3]: Card(rank='7', suit='diamonds')

In [4]: rank, suit = beer_card
        rank, suit
Out[4]: ('7', 'diamonds')

In [5]: beer_card.suit
Out[5]: 'diamonds'

In [6]: beer_card.rank
Out[6]: '7'
```

Python References

Python can get very complex and obscure:
The book, *Fluent Python* by Ramalho, goes into some very esoteric language elements [11]

- <http://dowell.colorado.edu/education-python.html>
 - A CU-based Python tutorial
- Dan Bader's tutorials
 - <https://dbader.org/>
- Google's Python class
 - <https://developers.google.com/edu/python/>
- OO in Python
 - <https://realpython.com/python3-object-oriented-programming/>
- Many others...
- If you haven't used Python before, take the opportunity to write a little code and get used to the language... It's fun!

Next Steps

All staff now providing office hours:
Office hours are posted in Canvas
Announcements and Piazza posts

- Latest
 - At this point you should be ok writing Java and have resources for doing UML diagrams – we'll do both in project work coming up
 - Put some work in on Project 2, you'll be using the code and UML for two more projects...
- Assignments
 - New Piazza participation topic this week, keep up to get those 100 points!
 - Project 2 is up on Canvas – for your two-person team!
 - Part 1 (UML and OO questions) is due this Wed 9/14
 - Part 2 (code submission) is due after that on Wed 9/21
 - No active Quiz this week, Quiz 3 opens on Sat 9/17
 - Graduate Research Project team topics are due on Fri 9/16
- Stay Engaged
 - Make sure you sign up for Piazza and Canvas notifications
 - Make sure you can access the Head First Design Patterns textbook – no readings yet
 - Consider tutorials/resources for Git and Java especially, if you need them
- Coming up
 - Next up: the tools – Test & TDD, then into the Patterns and related lectures
 - Readings from the book will start with the first Patterns talk, lecture 11 – you can read before or after the lecture, or use the book to fill in blanks as you need it
- Please come find us for any help you need or questions you have!

References

- [1] <https://spectrum.ieee.org/at-work/innovation/the-2018-top-programming-languages> (2-3 not used)
- [4] <https://docs.python.org/3/tutorial/controlflow.html#intermezzo-coding-style>
- [5] <https://www.python.org/dev/peps/pep-0008/>
- [6] <http://docs.python-guide.org/en/latest/writing/style/>
- [7] <https://www.python.org/dev/peps/pep-0020/>
- [8] https://github.com/ehmatthes/pcc/releases/download/v1.0.0/beginners_python_cheat_sheet_pcc.pdf
- [9] <https://pythonforbiologists.com/29-common-beginner-errors-on-one-page/>
- [10] <http://www.python-requests.org/en/master/>
- [11] <https://github.com/python-pillow/Pillow>
- [12] <https://www.crummy.com/software/BeautifulSoup/>
- [13] <https://twistedmatrix.com/trac/>
- [14] <http://www.numpy.org/>
- [15] <https://www.scipy.org/>
- [16] <https://www.sympy.org/en/index.html>
- [17] <https://matplotlib.org/>
- [18] <https://pythontips.com/2013/07/30/20-python-libraries-you-cant-live-without/>
- [19] <https://pypi.python.org/pypi>
- [20] <https://wheel.readthedocs.io/en/latest/>
- [21] <https://pythonwheels.com/>
- [22] https://wiki.python.org/moin/PythonTestingToolsTaxonomy#GUI_Testing_Tools
- [23] <https://www.anaconda.com/download/>
- [24] <http://jupyter.org/install.html>
- [25] <https://github.com/fluentpython>