Introduction to Python

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September 17, 2020

Introduction

Who Am I?

- Charles Daniels
- PhD CS student
- HeRC research group
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- TA for 313, 317, 611

Why Learn Python?

- Easy to write
  - Much less boilerplate than Java
  - No need for manual memory management like C/C++
- Popular
  - Widely used in scientific computing and industry
- Huge, mature library ecosystem
  - Numpy/Scipy
  - Matplotlib
  - PIL
  - many, many more

How Do I Use Python?

I use Python all the time in my work as a graduate student...

- Data processing scripts
  - Convert from one format to another
  - Summarize or gather statistics
- Create figures
- Automate other programs
- Create prototypes for systems to be lowered to C/hardware later

Python Essentials

- Interpreted, not compiled
- Duck-typed
- Object-oriented
- Garbage-collected

The Basics

Want to Follow Along?

- Just open a terminal and run `python3`
- Or use repl.it
- Or use `ipython3` if you feel fancy

Syntax - Variables

Python syntax is different from C and Java...

```
# assign a new variable x
x = 7
y = 3
# print x^y
print("{} to the power of {}={}".format(x, y, x**y))
```

Output:

7 to the power of 3=343

Syntax – Loops

```
x = 2
while x > 0:
  print("x is ", x)
  x -= 1

for y in range(0, 3):
  print("y is ", y)
```

Output:

x is 2

x is 1

y is 0

y is 1

y is 2

Syntax – Functions

Defining a function...

```
def doubleit(x):
  return x * 2

# here, message has a default value
def sayit(x, message="value is: "):
  print(message, x)

print("doubleit(3)=", doubleit(3))
sayit(5)
sayit(5, "different message!")
```

Output:

doubleit(3)= 6

value is: 5

different message! 5

Syntax – Classes 1

Defining a class...

```
class Dog:
  # __init__ is the constructor, the first argument
  # doesn't *have* to be "this", this is just a
  # convention ("self" is also popular)
  #
  # __init__ is defined like any other function, this
  # time we use default values
  def __init__(this, fleas=5, greeting="bark"):
    this.fleas = fleas
    this.greeting = greeting

  def bark(this):
    print(this.greeting)
```

Syntax – Classes 2

Using our class...

```
fido = Dog()
# single quotes are also allowed for strings
spot = Dog(3, 'woof')
doge = Dog(greeting="wow, such class, very types")
```

```
# create a list with the dogs in it
dogs = [fido, spot, doge]

# loop over it
for dog in dogs:
  dog.bark()
```

Output:

bark

woof

wow, such class, very types

Imports

Some functions, such as sin() are in *modules* which we must import before we can use them. sin() lives in the `math` module.

```
import math

print("pi = ", math.pi)
print("sin(1.5*pi) = ", math.sin(1.5*math.pi))

# we can also import specific items from a module
from math import sin
print("sin(2.5*pi) = ", sin(2.5*math.pi))
```

Output:

pi = 3.141592653589793

sin(1.5*pi) = -1.0

sin(2.5*pi) = 1.0

Duck Typing

```
class Duck:
  def quack(this):
    print("Quack quack!")

class Goose:
  def quack(this):
    print("Hong honk!")

duck = Duck()
goose = Goose()
```

```
for bird in [duck, goose]:
  bird.quack()
```

Output:

Quack quack!

Hong honk!

Input – File

```
# open example.txt for reading, the "with" will
# cause the file to be closed automatically when we
# reach the end of the "with" block, so we don't
# have to call f.close()
with open("example.txt", "r") as f:
  lineno = 0
  for line in f:
    print("line", lineno, "is", line)
    lineno += 1
```

Output:

line 0 is line 1

line 1 is line two

line 2 is this is the third line

Input – Standard In

This example shows how to loop over all the lines of standard input...

```
import sys

lineno = 0
for line in sys.stdin:
  print("line", lineno, "is", line)
  lineno += 1
```

Output – File

```
with open("output.txt", "w") as f:
  for i in range(5):
    f.write("line #{}\n".format(i))
with open("output.txt", "r") as f:
  for line in f:
    print(line)
```

Output:

line #0

line #1

line #2

line #3

line #4

Getting Fancy

List Comprehensions (Map)

For a list L, apply a function f to each item, creating a new list L' such that $L'[i] = f(L[i]) \forall i$.

```
numbers = [1, 2, 3, 4]
squared = [x*x for x in numbers]
print("squared=", squared)

# convert a string to a list of it's ASCII codes
s = "Hello!"
print("characters=", [ord(c) for c in s])
```

Output:

squared= [1, 4, 9, 16]

characters= [72, 101, 108, 108, 111, 33]

Setting up to Plot

Code taken from matplotlib.org.

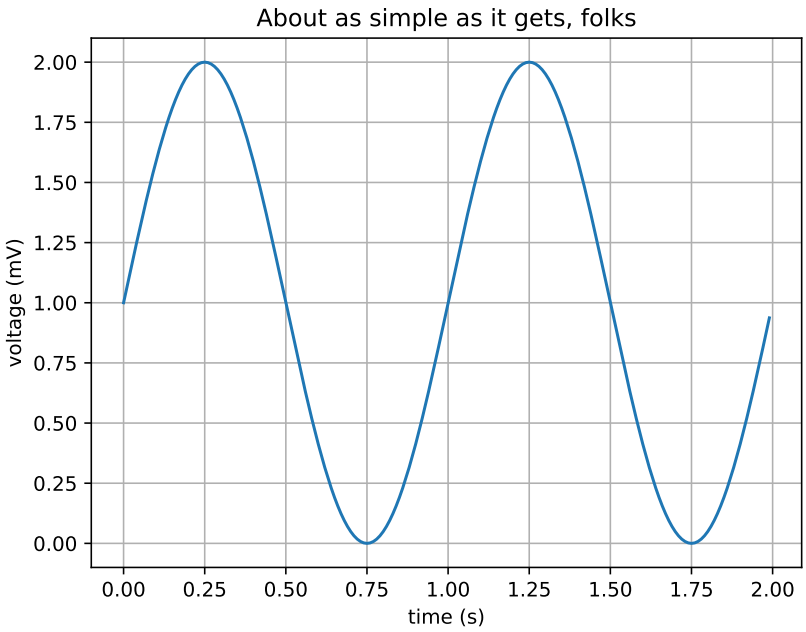
```
import matplotlib
import matplotlib.pyplot as plt
import numpy as np


# Data for plotting
t = np.arange(0.0, 2.0, 0.01)
s = 1 + np.sin(2 * np.pi * t)
```

Plot the Data

```
fig, ax = plt.subplots()

ax.plot(t, s)
```

```
ax.set(xlabel='time (s)', ylabel='voltage (mV)',
       title='About as simple as it gets, folks')
ax.grid()

# un-comment to save out to a file
# fig.savefig("test.png")

# un-comment to show GUI plot window
# plt.show()
```

The Result...



Attributes Aren't Pre-Declared

Remember our `class Dog` from earlier? This technique is great for annotating objects you didn't instantiate (but be careful to avoid name collisions)

```
fido = Dog()
fido.name = "Fido"
fido.bark()
print(fido.name)
```

Output:

bark

Fido

What Next?

Libraries

- Numerical computing
  - NumPy
  - SciPy
- Plots
  - matplotlib
- GUIs
  - tkinter
    - shameless plug
- Argument Parsing
  - argarse

How to Install Them

- `pip` will let you install Python modules from the internet.
  - Official docs on python.org
- Search packages: `pip3 search searchterm`
- Install a package `pip3 install --user packagename`
  - Don't install globally with `sudo pip install` unless you know what you are doing.
- Find packages on pypi.org.
  - Also try awesome-python.com

Questions?

End.

Thanks

- This slideshow was written using `pandoc` with caiofcm/filter_pandoc_run_py used to execute in-line Python code and embed the output.
- Thanks to Josh for copyediting.