Python For Engineers II

Where we left off…

- Last workshop, we covered basics of Python.
  - Integer, float objects.
  - Basic strings.
  - Control Flow.
  - Functions.
- In this workshop, we're going to learn:
  - Extra string features.
  - Lists, Tuples, and Dictionaries.
  - Object-Oriented Programming.
  - Libraries and how to use them.

Strings – Formatting with F-Strings

- Python provides many ways to format data and strings.
- F-strings are a fast and convenient way to take multiple, existing data and put it all together in a single string.

```
# structure
# put expression between '{' and '}'
f'characters {<expression>}'
f"characters {<expression>}"
```

```
# f-strings allow you to inline format
# variables into a string without having to
# convert them or use weird specifiers.
a, b, c = 1, 1.0, '1!'
print(f"a = {a}, b = {b}, c = {c}")
pwr = 3
s = f'{(a+a)}^{pwr} = {(a+a)**pwr}'
print(s)
```

Lists I

- Python's way of doing arrays.
    - A container that can hold multiple pieces of data under one name. A table if you will.
- Can hold ***any*** Python object, even lists themselves as lists are also objects.
- Lists can dynamically grow so you can keep adding more and more data onto them as long as your system has enough RAM.
- Since lists can hold multiple objects at once, they are a Sequenced Object.

```
# structure on list creation.
<var name> = [ <comma separated objects> ]

# example
l1 = []  # empty list
l2 = [1] # contains one element.
# lists can hold ANY kind of object.
l3 = [True,l2,99,6e-3]

# lists can be added together
l1 += l2 + l3
print(l1)
```

Lists II

```python
# accessing individual list data
# is done by indexing.
print(l1[2])

# lists can be looped over!
for item in l1:
	print(item)

# print how many objects are in the list
print( len(l1) )

# another way of looping by using 'len' and indexing.
for i in range(len(l1)):
	print(l1[i])

# 'in' expression searches for values.
if 5 in l1:
	print('l1 has a 5!')
```

Tuples

- Similar to Lists but Tuples are not allowed to overwrite their elements.
- You can add tuples like lists.
- Most times you use a tuple is for returning multiple items from a function.

```
# structure of tuple creation
<var name> = ( <comma separated objects> )

# example
point_3D = (1, 5.0, 3)
print(point_3D)

# like lists, tuples can be indexed.
print(f'x axis: {point_3D[0]}')

# like lists, tuples can be looped.
for coord in point_3D:
    print(coord)

# like lists, tuples can be added together
double_point = point_3D + (1.0, 1.0, 10.0)

# tuple of tuples!
line = (point_3D, (2,-10.5,9))

# unlike lists, tuple values CANNOT be changed!
point_3D[2] = 10.0 # ERROR.
```

Slice Expressions

- Sometimes you only want to access a portion of a string, tuple, or list. How can we do that without having to loop through a specific range?
  - Answer: **Slicing**.
- Basic idea: gives you only a portion of a sequenced object that you need.
- Slicing an object gives you the same object type back.
  - IE if you slice a list, the slice expression gives back a list object.

```
name = 'peter griffin'
print(name[1:])        # eter griffin
print(name[:7])        # peter g
print(name[0:10:2]) # ptrgi
```

```
# structure of a slice expression.
# start, stop, and step represent expressions.
<seq-obj> [ <start> : <stop> : <step> ]
<seq-obj> [ <start> : <stop> ]
<seq-obj> [ <start> : ]
<seq-obj> [ <start> :: <step> ]
<seq-obj> [ : <stop> : <step> ]
<seq-obj> [ : <stop> ]
<seq-obj> [ : ]
```

```
nums = [ 1,2,3,4,5,6,7,8,9,10 ]
print(nums[5:])   # slice from index 5 and till end.
print(nums[:5])   # slice from first till index 5.
print(nums[3:5])  # slice from index 3 till index 5.

# print every odd number
print(nums[::2])  # slice from start to end, every 2 indexes.

# print every even number
print(nums[1::2]) # slice from index 1 to end, every 2 indexes.
print(nums[::]) # simply prints whole list
```

Sequence Repeating

- We saw last workshop that strings can be repeated by multiplying them with an integer number.
- You can also do the same for other sequencing objects like lists and tuples!

```
# useful in presizing a list but with initial values
nums = [ 1,2,3,4,5,6,7,8,9,10 ] * 3
print(nums)

num_players = int( input('how many players?: ') )
scores = [0] * num_players  # start everybody off with 0 points.
print(scores)

cheer = 'sis boom bah! '
print(cheer * 4)
```

Dictionaries I

- Allows us to map keys* (as objects) to values (also as objects).
- Mostly used to map string keys or other sequential data to other data in such that it establishes a relationship as a key-value pair.
- One of the most valuable object types in the software world.

***lists can’t be used as keys, tuples are allowed.**

```
# structure of dictionary creation.
# expr is short for expression.
<var name> = { <key expr> : <value expr> }
<var name> = {
    <key expr1> : <value expr1> ,
    ...
    <key exprN> : <value exprN> ,
}

# example
empty_dict = {}

spouses = {
    'peter griffin': 'lois pewterschmidt',
    'homer simpson': 'marge bouvie',
    'stan smith': 'francine "ling" dawson',
    'bob belcher': 'linda genarro',
}

# adding a new entry.
spouses['phillip j fry'] = 'turanga leela'

# oops, we mispelled marge's maiden name! let's fix it.
spouses['homer simpson'] = 'marge bouvier'

# remove entries.
del spouses['phillip j fry']
```

Dictionaries II

```
# check if an entry exists.
print('peter griffin' in spouses)

# dictionaries can be looped over.
# loop gives the key, not value.
for guy in spouses:
    print(f'{guy} is married to {spouses[guy]}')

# dictionaries have a length as well.
print(len(spouses))
```

Lambda Functions

- Useful when you need a small function that only returns a singular expression!
- No need for a return statement!
- Creates a direct, <u>unnamed</u> function object.
- Lambdas are technically expressions.

```
# structure
lambda <parameter names> : <expression>

# example
sqr = lambda x: x**2
print(sqr(9))    # prints 81

pwrize = lambda a,b: a**b * a
print(pwrize(2,3))  # prints 16
```

Object-Oriented Programming Overview

- Everything in Python is an object.
- Object-oriented is when:
  - Objects are paired with special functions that provide actions for a type of object. These special functions are called **methods**.
  - The programmer can create custom object types with their own custom methods.
- Custom object types must be modelled by a constructo known as a **class**.
- Named, individual pieces of data that custom objects hold are called **fields, members, or properties**.
  - Python usually calls them ***attributes***.
  - Ex: the `real` and `imag` in – `1j.real` & `1j.imag`
- Each unique object holds their own independent copy of the properties defined by the class they model.
- *Think of a class like a blueprint describing an object type, where properties describe the data of the objects and methods describe the actions that you can do with that data.*

Object Oriented Programming – Structure of Classes

- **<u>Important to know</u>**: `self` in class methods ALWAYS refers to the object that's using/calling the method.

```
# structure
class <name>:
    <optional named props & their expressions>

    # constructor method. optional but usually necessary
    # for custom property initializing.
    def __init__(self, <parameters>):
        self.<prop1> = <param1>
        ...
        self.<propN> = <paramN>

    # a class can have as many methods or none.
    def <method nameN>(self, <parameters>):
        <statements>
```

Object Oriented Programming – Class Example I

```
class Dog:
    kind = 'canine' # property shared by all objects of this class.

    def __init__(self, name):
        self.name = name  # property unique to each independent object.

d = Dog('Scooby Doo') # this is calling '__init__' in Dog
e = Dog('Air Bud')
print(d.kind, d.name)
print(e.kind, e.name)
```

Object Oriented Programming – Class Example II: Objects & Methods

```python
class Dog:
    kind = 'canine'
    def __init__(self, name):
        self.name = name
    
    # method that defines an action for the object type.
    # in this case, Dogs bark.
    def bark(self):
        print(f'{self.name}: "woof!"')

fiddo = Dog('fido')

# Calling a method is the combination of
# a function call and accessing properties.
fiddo.bark()
```

Object Oriented Programming – Inheritance

- What happens if we want to model objects that have shared as well as distinct qualities?
- The answer: <u>**Inheritance**</u>
- Create a class(es) that contains all the qualities the objects have in common.
- Create the class(es) that model the differences.

```
# structure of class inheritance
# single inheritance.
class <name> (<class_name>):
    ... <remaining_class_structure>

# multiple inheritance
class <name> (<class_name1>, ..., <class_nameN>):
    ... <remaining_class_structure>
```

Object Oriented Programming – Inheritance Example I

- Classes that inherit from other classes gain their methods and properties.

```
class Weapon:
    # the var names in params are NOT
    # the same var for self.<var name>
    def __init__(self, power, weight):
        self.damage = power
        self.weight = weight

# class Bow & Sword inherit from Weapon
class Bow(Weapon):
    def __init__(self, power, weight, wood_type):
        # 'super' sets up call to __init__
        # of the class   we inherit from.
        super().__init__(power, weight)
        self.material = wood_type

class Sword(Weapon):
    def __init__(self, power, weight, two_handed):
        super().__init__(power, weight)
        self.hold_type = two_handed
```

Object Oriented Programming – Inheritance Example II

- This is an example where a class is derived from two existing classes.
- Multi-inheritance is typically not recommended due to complexity and maintainability of the code.
- Use it only if necessary.
- When you have single inheritance, use **`super()`**.
- For multi-inheritance, you must manually call constructors

```python
class Weapon:
    def __init__(self, power, weight):
        self.damage = power
        self.weight = weight

class Magic:
    def __init__(self, magic_power):
        self.magic_power = magic_power

    def cast(self, multiplier, intercept):
        return (self.magic_power * multiplier) + intercept

class MagicStaff(Weapon, Magic):
    def __init__(self, pwr, weight, magic_pwr):
        # for multi-inheriting, use manual constructor calls.
        Weapon.__init__(self, pwr, weight)
        Magic.__init__(self, magic_pwr)

staff = MagicStaff(10, 2, 3.5)
print(f'with this staff, I cast a spell and do {staff.cast(staff.damage, 35)} damage!')
```

Object Oriented Programming – Polymorphism I

- What do you do when you have to model objects that not only have shared qualities but actions as well? Answer: **Polymorphism**.
- There's two kinds of polymorphism.
  - Method overriding – Change the code of an existing method for a derived class.
  - Duck Typing – Run code based on the ***type*** of the object.
- The example to the right is an example of method overriding.
- Method Overriding is best when you only need polymorphism for custom objects.
- Duck Typing is best when you have to model objects that have shared actions but little-to-no shared qualities.

```python
class Dog:
	kind = 'canine'
	def __init__(self, name):
		self.name = name
	
	def bark(self):
		print(f'{self.name}: "woof!"')

class StBernard(Dog):
	def __init__(self, name):
		super().__init__(name)
	
	# override 'bark' from 'Dog' class.
	def bark(self):
		print(f'{self.name}: "ruff!"')

class Chihuahua(Dog):
	def __init__(self, name):
		super().__init__(name)
	
	def bark(self):
		print(f'{self.name}: "arff!"')

Dog('fido').bark()
StBernard('beethoven').bark()
Chihuahua('eevee').bark()
```

Object Oriented Programming – Polymorphism II: Duck Typing

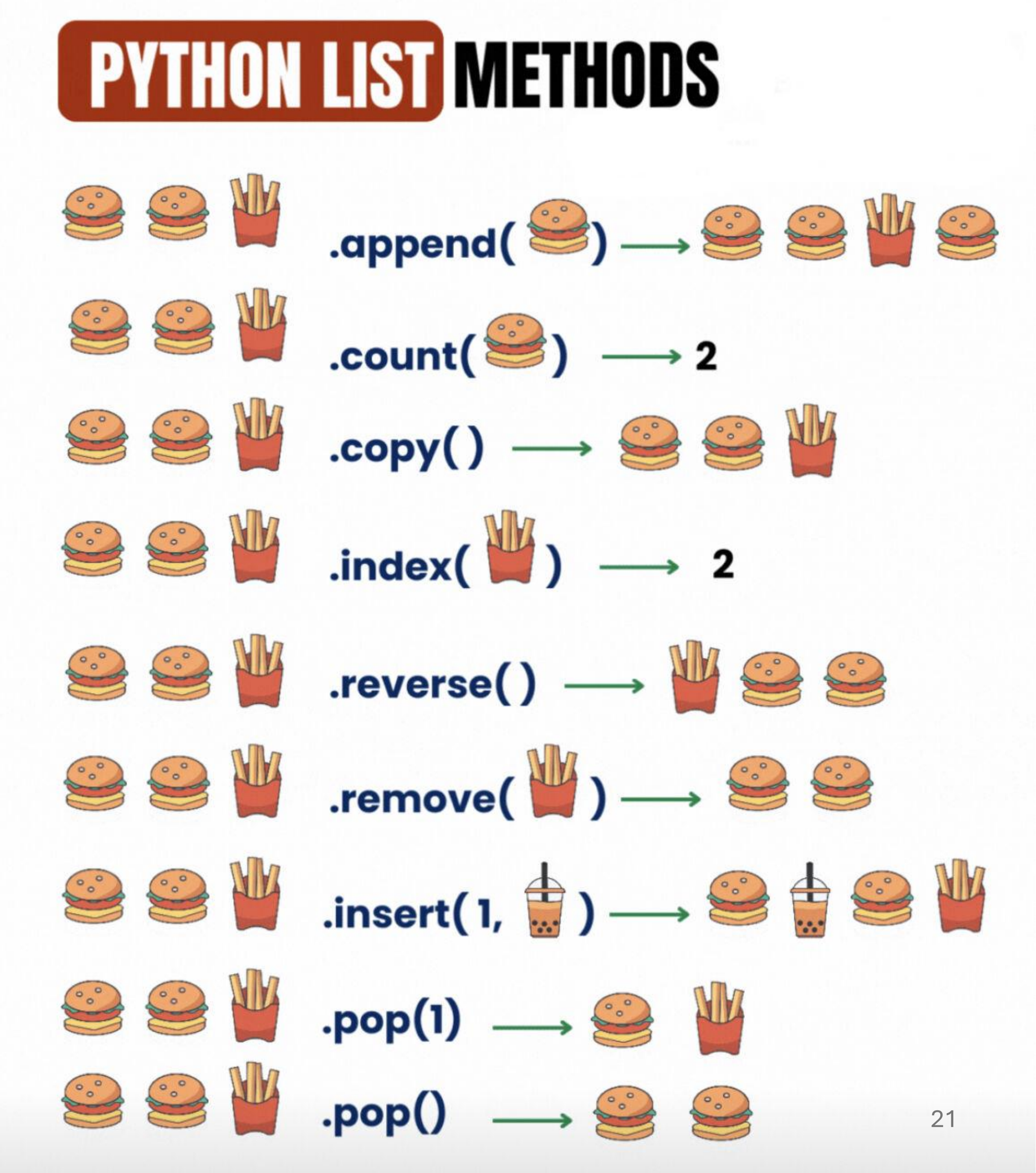
```python
class Car:
    def __init__(self):
        self.gas = 100.0

    def drive(self):
        if self.gas <= 0.0:
            return
        # drain gas when we drive
        self.gas -= 10.0
        print('vroom')

class Airplane:
    def __init__(self):
        self.gas = 100.0

    def fly(self):
        if self.gas <= 0.0:
            return
        self.gas -= 10.0
        print('phwee')
```

```python
# two ways to do duck typing: check type or check properties/attributes
# better to just check by type unless you're doing something special.
def move1(vehicle):
    if isinstance(vehicle, Car):
        vehicle.drive()
    elif isinstance(vehicle, Airplane):
        vehicle.fly()

def move2(vehicle):
    if hasattr(vehicle, 'drive'):
        vehicle.drive()
    elif hasattr(vehicle, 'fly'):
        vehicle.fly()

move1(Car())
move1(Airplane())
```

```python
def product(obj):
    if isinstance(obj, int):
        return obj * 2
    elif isinstance(obj, float|complex):
        return obj * 3
    elif isinstance(obj, str):
        return obj * 4
    elif isinstance(obj, list|tuple):
        return sum(obj) * 10

print( product(1) )
print( product(2j) )
print( product('h') )
print( product([1,2,3]) )
print( product((2,4,6)) )
```

Builtin List Methods

- Special methods exclusively for the List object.
- Example works by starting out every list with two burgers and a box of fries.
- The food items represent different possible objects.
- ***Notice what some of the methods return***.
- Tuples only have **`count`** and **`index`** for builtin methods, so no special slide for tuple methods.



Builtin Dictionary Methods

```python
student_gpas = {
    'ahmed smithy': 3.6,
    'austin powers': 2.3,
    'johanne rodriguez': 3.5,
    'simon jarrett': 2.9,
    'lisa simpson': 5.0,
    'minerva baskil': 3.33,
}

# removes all keys and values.
student_gpas.clear()

# makes a copy of the dictionary values.
print(student_gpas.copy())

# 'fromkeys(keys)' or 'fromkeys(keys, value)'
# creates a dictionary from existing data.
# class method as opposed to object method.
staff = dict.fromkeys(('edna krabapple', 'armin tamzarian', 'groundskeeper willy'), 4.0)
print(staff)

# get(keyname, value)
# 'value' parameter is optional.
# It's for giving a default value if key isn't found.
print(student_gpas.get('lisa simpson', 2.0))

# this gets a viewing object of the dictionary's keys and values.
# the viewing object is convertible to a list/tuple.
print(list(student_gpas.keys()))
print(list(student_gpas.values()))
```

Scoping – Visibility of Objects

- An object only exists from inside the region it is created. This is called the **scope** [of that object].
- Objects created inside a function have Local scope.
- **<u>Python's Scoping rules are complex</u>**.
- If-statements, loops **<u>do not</u>** have their own scopes.
- Classes do have their own scope.

```
times_f_called = 0

def f(a):
    # to access a global variable.
    # you need 'global' keyword.
    global times_f_called
    times_f_called += 1
    return a * 2

f(10)
print(times_f_called) # prints 1
```

```
# objects created here are called 'global variables'.
# they have global scope, meaning they can be used in any lower or equivalent scope.
a = 1

# functions have their own scope.
def f(a):
    a *= 2  # this 'a' is separate from 'a' outside the function.

f(a)
print(a) # prints 1
```

Exceptions – Structure

```
# structure of a try-except statement
try:
    <statements>
except (<optional exception types>):
    <statements that handle error>
else: # optional part
    <statements when no error happens>
finally: # also optional part
    <statements when try-except block finishes>

# raising an exception
raise Exception('message')
```

- Sometimes you need to run code with the possibility of an error happening.
- We sometimes need to handle that error when it occurs.
- **Try-Exception** Statements do the job.
- When we also need, we can raise our own exceptions back to the user!

Exceptions - Example

```
data = input('enter a number: ')
try:
    i = int(data)
except ValueError:
    print(f'{data} can"t be converted to int.')
else:
    if i < 0:
        raise ValueError('no negative numbers.')
    print(i)
```

Libraries & Importing Library Modules – Importing Structure

- Libraries are a set of ready-to-use Python code that is packaged under a name.
- Accessing these libraries requires a special action called ***importing***.

```
# structure of importing libraries.
import <library name>
import <library name1 , ... , library nameN>

from <library name> import <object_name>
from <library name> import <object_name1 , ... , object_nameN>

# structure of accessing objects within a library.
<library name> . <object_name>
```

Libraries & Importing Library Modules – Importing Example

```python
# example
import os
# print out the current, working directory.
print(os.getcwd())

# alternate equivalent
from os import getcwd
print(getcwd())
```

End of
Python For Engineers II

- Thank you for attending.
- Next week: **Python for Engineers III**.
  - List 1.