Module 7

class & OBJECTS(1)

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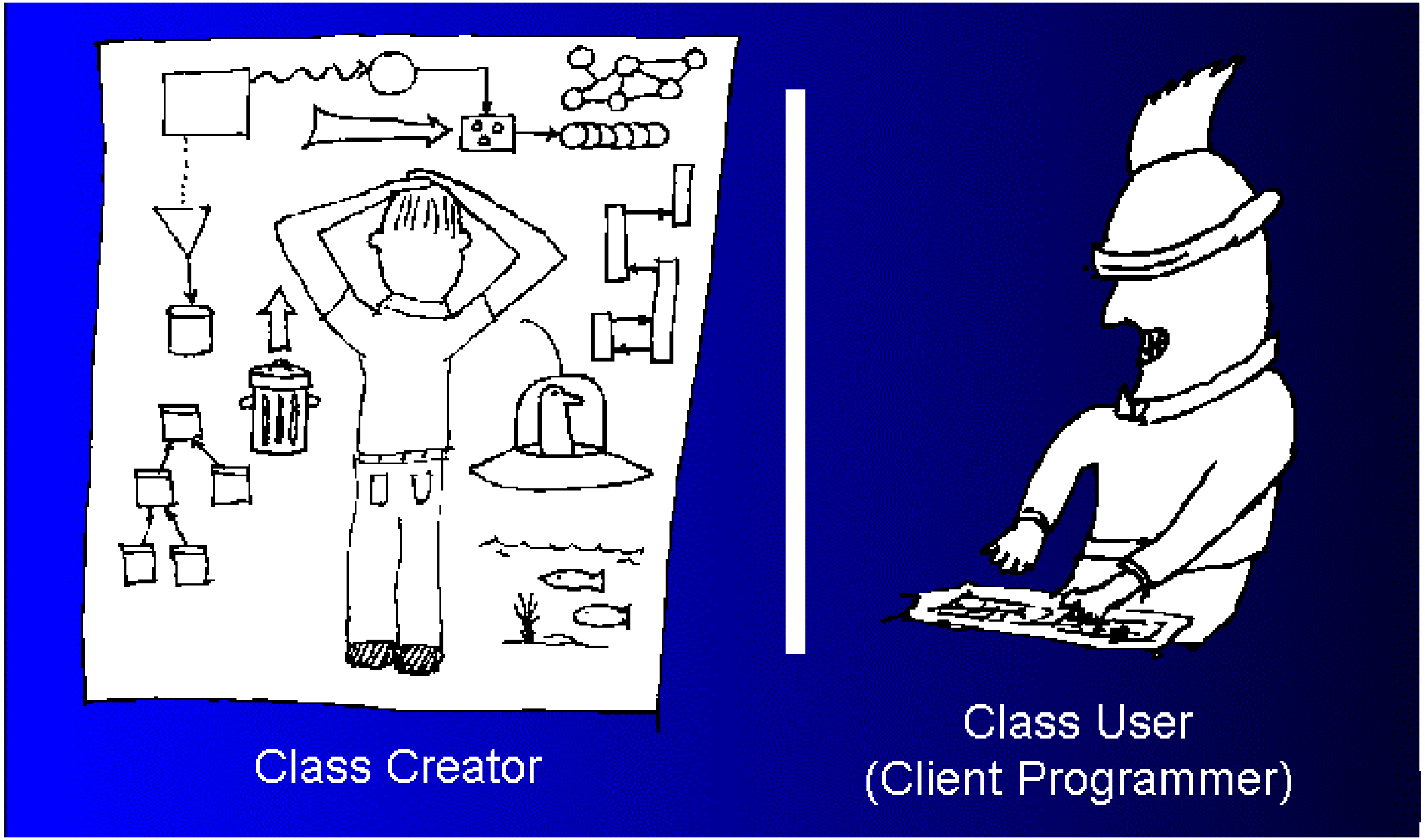
In Python, everything is an object and it is time to create our OWN objects.



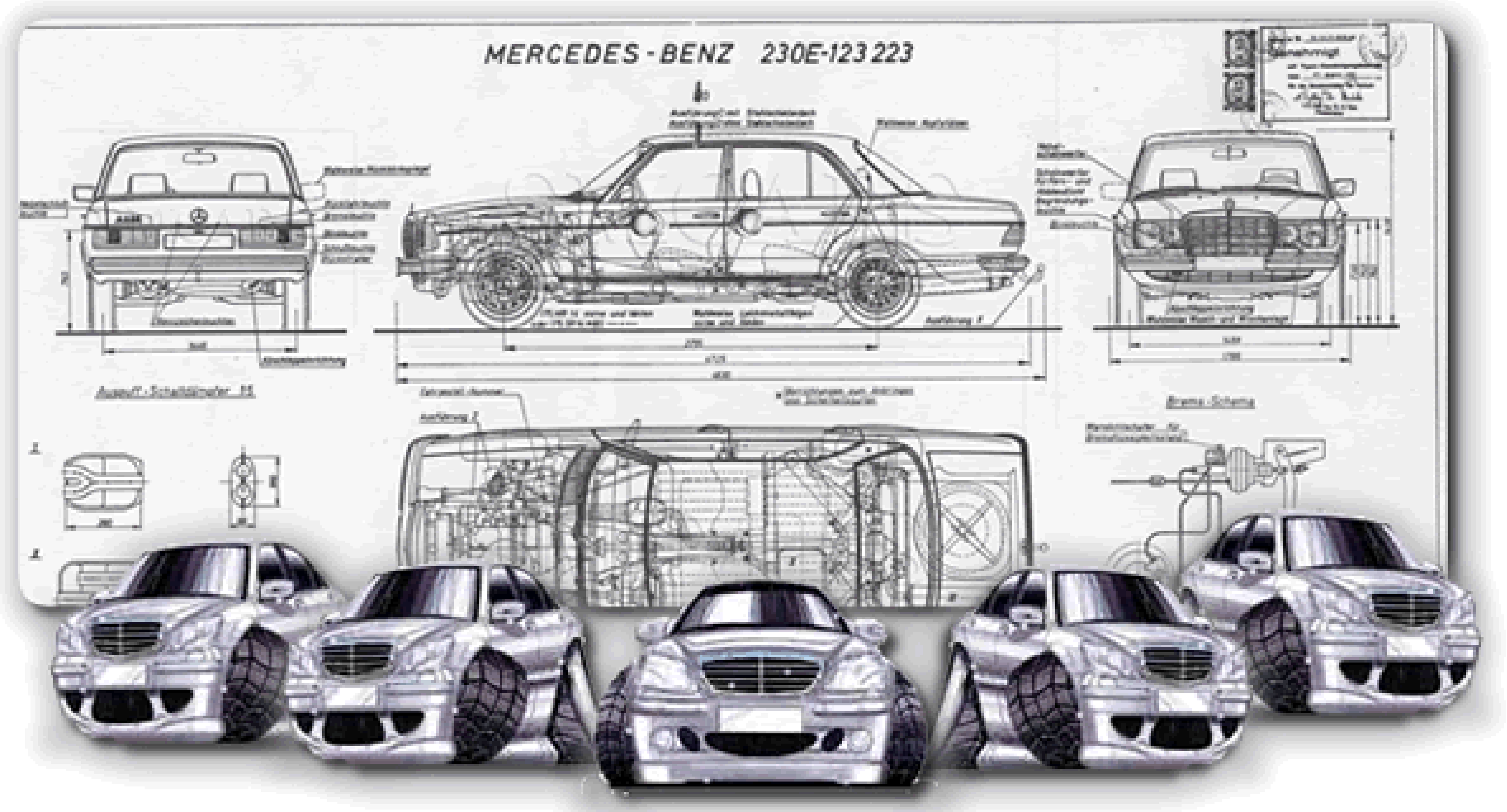
In Python, everything is an object and it is time to create our OWN objects.

```
class list(object):
    """
    list() -> new empty list
    list(iterable) -> new list initializ
    """
    def append(self, p_object): # real s
        """ L.append(object) -> None -- a
        pass

    def clear(self): # real signature un
        """ L.clear() -> None -- remove a
        pass

    def copy(self): # real signature unk
        """ L.copy() -> list -- a shallow
        return []

    def count(self, value): # real signa
```

```
lst = [1, 2, 3, 4]
lst.append(5)
print(f'The list contains: {lst}')
```

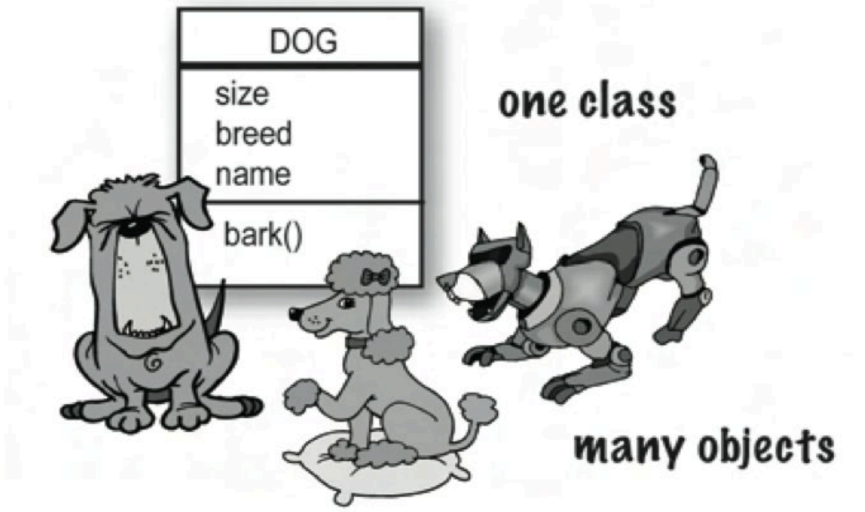
```
The list contains: [1, 2, 3, 4, 5]
```

We use the class mechanism to specify our own objects



Classes vs. Instances

- **Class: code that specifies the data attributes and methods of a particular type of object**
  - Similar to a blueprint of a house
- **Instance: an object created from a class**
  - Similar to a specific house built according to the blueprint
  - There can be many instances of one class



How to Define a Class

- All class definitions start with the class keyword followed by the name of class and a colon
  - `class Class_name:`
    - Class names often start with uppercase letter
    - Any code indented below the class definition is part of class body

```
class Dog:
    pass
```

- The body of the Dog class consists of a single statement: the pass keyword.
- pass is often used as a placeholder indicating where code will eventually go. It allows you to run this code without Python throwing an error.

Instantiate Objects

- **Creating a new object from a class is called instantiating an object.**

[1]You can instantiate a new Dog object by typing the name of the class followed by parentheses.

[2] You now have a new Dog object at 0x7fee58403d50. This funny-looking string of letters and numbers is a memory address that indicates where the Dog object is stored in your computer's memory.

[3] If you instantiate a second object, it will be stored at different memory address.

[4] When you compare a and b using the == operator, the result is False because they represent two distinct objects in memory.

```
[1]: class Dog:
         pass

[2]: Dog()

[2]: <__main__.Dog at 0x7fee58403d50>

[3]: Dog()

[3]: <__main__.Dog at 0x7fee702fc410>

[4]: a = Dog()
     b = Dog()
     a == b

[4]: False
```

In Python, everything is an object and it is time to create our OWN objects.

```python
class Dog:
    pass
```

```python
Dog()
```

```
<__main__.Dog at 0x7fee58403d50>
```

```python
Dog()
```

```
<__main__.Dog at 0x7fee702fc410>
```

```python
a = Dog()
b = Dog()
a == b
```

```
False
```

__init__() method

Define a Class with __init__ method

- The attributes of all objects must have are defined in a method called __init__()
- When a new object is created, __init__() sets the initial state of the object by assigning the values of the object's attributes.

```python
class Dog:
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

In the body of __init__(), there are two statements using the self variable:

- **self.name = name** creates an attribute called name and assigns to it the value of the name parameter.
- **self.age = age** creates an attribute called age and assigns to it the value of the age parameter.
- You can give __init__() any number of parameters, but the first parameter will always be a variable called self.
- When a new class instance is created, the instance is automatically passed to the self parameter in __init__() so that new attributes can be defined on the object.

Instance Attributes and Class Attributes

- Attributes created in __init__() are called instance attributes or object attributes.
  - An instance attribute is specified to a particular object of a class.
  - For example, all Dog objects have a name and an age, but the values for the name and age attributes will vary depending on the Dog object.
- Class attributes are attributes that have the same value for all objects.
  - You can define a class attribute by assigning a value to a variable name outside of __init__().

```python
class Dog:
    # Class attribute
    species = "Canis familiaris"
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

- Use class attributes to define attributes that should have the same value for every object.
- Use instance attributes for attributes that vary from one object to another.

```
[1]: class Dog:
         # Class attribute
         species = "Canis familiaris"
         def __init__(self, name, age):
             self.name = name
             self.age = age
```

```
[2]: Dog()
```

```
---------------------------------------------------
TypeError                                       Trac
<ipython-input-2-2dced99f65a6> in <module>
----> 1 Dog()

TypeError: __init__() missing 2 required posit
```

```
[3]: buddy = Dog("Buddy", 9)
```

```
[4]: miles = Dog("Miles", 4)
```

```
[5]: buddy.name
[5]: 'Buddy'
```

```
[6]: miles.age
[6]: 4
```

```
[7]: Dog.species
[7]: 'Canis familiaris'
```

```
[8]: buddy.species
[8]: 'Canis familiaris'
```

Instantiate Objects

- [1] We now define a Dog class with __init__ method.
- [1] Instance attributes are initialized in the __init__ method while class attribute is assigned before the method.
- [2] Every Dog object MUST instantiate from __init__. To instantiate objects of this Dog class, you need to provide values for the name and age. If you don't, then Python raises a TypeError.
- [3], [4] You can create two new Dog objects.
- [5] – [6] You can access the object attributes via object as usual.
- [7] – [8] You can access the class attributes via class or object.

In Python, everything is an object and it is time to create our OWN objects.

```
class Dog:
    # Class attribute
    species = "Canis familiaris"
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

L1_Dog.ipynb

```
[3]: buddy = Dog("Buddy", 9)

[4]: miles = Dog("Miles", 4)

[5]: buddy.name

[5]: 'Buddy'

[6]: miles.age

[6]: 4

[7]: Dog.species

[7]: 'Canis familiaris'

[8]: buddy.species

[8]: 'Canis familiaris'
```

Example: Point class

- In two dimensions, a point has two coordinates x and y.
- Define a Point class so we can instantiate a Point object with given values of x and y. If x and y are not provided, treat the point as the origin.
- Use the following client codes to test your class implementation.

```
p = Point(4, 2)
```

```
r = Point()
```

```
print(f'Point p: x = {p.x} and y = {p.y}')
```

```
Point p: x = 4 and y = 2
```

```
print(f'Point r: x = {r.x} and y = {r.y}')
```

```
Point r: x = 0 and y = 0
```

Example: Point class (Ans)

- In two dimensions, a point has two coordinates x and y.
- Define a Point class so we can instantiate a Point object with given values of x and y. If x and y are not provided, treat the point as the origin.
- Use the following client codes to test your class implementation.

[1]:
```
class Point:
    """ Point class represents and manipulates
    x,y coords. """

    def __init__(self, x=0, y=0):
        """ Create a new point at x, y """
        self.x = x
        self.y = y
```

[2]:
```
p = Point(4, 2)
```

[3]:
```
r = Point()
```

[4]:
```
print(f'Point p: x = {p.x} and y = {p.y}')
```

```
Point p: x = 4 and y = 2
```

[5]:
```
print(f'Point r: x = {r.x} and y = {r.y}')
```

```
Point r: x = 0 and y = 0
```

L1_Point_Init.ipynb

Instance methods

Instantiate Objects

- Instance methods are functions that are defined inside a class and can only be called from an object of that class.
- Just like __init__(), an instance method's first parameter is always self.

```
class Dog:
    species = "Canis familiaris"
    def __init__(self, name, age):
        self.name = name
        self.age = age
    # Instance method
    def description(self):
        return f"{self.name} is {self.age} years old"
    # Another instance method
    def speak(self, sound):
        return f"{self.name} says {sound}"
```

- description() returns a string displaying the name and age of the dog.
- speak() has one parameter called sound and returns a string containing the dog's name and the sound the dog makes.

Instantiate Objects

```
[1]: class Dog:
         species = "Canis familiaris"
         def __init__(self, name, age):
             self.name = name
             self.age = age
         # Instance method
         def description(self):
             return f"{self.name} is {self.age} years old"
         # Another instance method
         def speak(self, sound):
             return f"{self.name} says {sound}"
```

```
[2]: miles = Dog("Miles", 4)
```

```
[3]: miles.description()
```

```
[3]: 'Miles is 4 years old'
```

```
[4]: miles.speak('Woof Woof')
```

```
[4]: 'Miles says Woof Woof'
```

```
[5]: miles.speak('Bow Wow')
```

```
[5]: 'Miles says Bow Wow'
```

L1_Dog.ipynb

Example: Point class

- Define a Point class so we can instantiate a Point object with given values of x and y. If x and y are not provided, treat the point as the origin.
- Add a distance method to return the distance of the point from the origin. Use the following client codes to test your class implementation.

```
[2]: p = Point(4, 2)
```

```
[3]: r = Point()
```

```
[4]: print(f'Point p: x = {p.x} and y = {p.y}')
```

```
Point p: x = 4 and y = 2
```

```
[5]: print(f'Distane of point p from the origin is {p.distance():.2f}')
```

```
Distane of point p from the origin is 4.47
```

```
[6]: print(f'Point r: x = {r.x} and y = {r.y}')
```

```
Point r: x = 0 and y = 0
```

```
[7]: print(f'Distane of point r from the origin is {r.distance():.2f}')
```

```
Distane of point r from the origin is 0.00
```

Example: Point class (Ans)

```
[1]: class Point:
         """ Point class represents and manipulates
         x,y coords. """

         def __init__(self, x=0, y=0):
             """ Create a new point at x, y """
             self.x = x
             self.y = y

         def distance(self):
             return (self.x**2 + self.y**2)**0.5
```

```
[2]: p = Point(4, 2)
```

```
[3]: r = Point()
```

```
[4]: print(f'Point p: x = {p.x} and y = {p.y}')
```

```
Point p: x = 4 and y = 2
```

```
[5]: print(f'Distane of point p from the origin is {p.distance():.2f}')
```

```
Distane of point p from the origin is 4.47
```

```
[6]: print(f'Point r: x = {r.x} and y = {r.y}')
```

```
Point r: x = 0 and y = 0
```

```
[7]: print(f'Distane of point r from the origin is {r.distance():.2f}')
```

```
Distane of point r from the origin is 0.00
```

L1_Point_Distance.ipynb

__str__() method

__str__(): motivation

- When you create a list object, you can use print() to display a string that looks like the list:

```
[1]: names = ['David', 'Homer', 'Jay', 'Mikasa']
```

```
[2]: print(names)
```

```
['David', 'Homer', 'Jay', 'Mikasa']
```

- Let us see what happens when you print the Dog object

```
[4]: miles = Dog("Miles", 4)
```

```
[5]: print(miles)
```

```
<__main__.Dog object at 0x7fb01012ab90>
```

- This is not very helpful and you can change what gets printed by defining a special instance method called __str__().

__str__() method

```
[1]: class Dog:
         species = "Canis familiaris"
         def __init__(self, name, age):
             self.name = name
             self.age = age
         # An instance method
         def speak(self, sound):
             return f"{self.name} says {sound}"
         # Replace description() with __str__()
         def __str__(self):
             return f"{self.name} is {self.age} years old"
```

```
[2]: miles = Dog("Miles", 4)
```

```
[3]: print(miles)
```

```
Miles is 4 years old
```

L1_Dog.ipynb

Example: Car class

- Create a Car class with two instance attributes: color, which stores the name of the car's color as a string, and mileage, which stores the number of miles on the car as an integer.
- Implement an instance method called drive(), which takes a number as an argument and adds that number to the mileage attribute.
- Implement __str__() method
- Use the following client codes to test your class implementation

```
[2]: c1 = Car("blue", 100)
     c2 = Car("red", 200)
     cars = [c1, c2]
```

```
[3]: for c in cars:
         print(c)
```

```
The blue car has 100 miles
The red car has 200 miles
```

```
[4]: c1.drive(500)
```

```
[5]: for c in cars:
         print(c)
```

```
The blue car has 600 miles
The red car has 200 miles
```

Example: Car class (Ans)

[1]:
```python
class Car:
    def __init__(self, color, mileage):
        self.color = color
        self.mileage = mileage

    def drive(self, miles):
        self.mileage = self.mileage + miles

    def __str__(self):
        return f'The {self.color} car has {self.mileage} miles'
```

[2]:
```python
c1 = Car("blue", 100)
c2 = Car("red", 200)
cars = [c1, c2]
```

[3]:
```python
for c in cars:
    print(c)
```

```
The blue car has 100 miles
The red car has 200 miles
```

[4]:
```python
c1.drive(500)
```

[5]:
```python
for c in cars:
    print(c)
```

```
The blue car has 600 miles
The red car has 200 miles
```

L1_Car.ipynb

Other Double UNDERscore (Dunder) or magic methods

Magic Methods

- Special methods which add "magic" to your class.

- Magic methods are not meant to be invoked directly by you, but the invocation happens internally from the class on a certain action.

- For example, when you add two numbers using the + operator, internally, the `__add__()` method will be called.

Magic Methods for Comparison

Method	Description
__eq__(*self*, *other*)	*self* == *other*
__ne__(*self*, *other*)	*self* != *other*
__lt__(*self*, *other*)	*self* < *other*
__gt__(*self*, *other*)	*self* > *other*
__le__(*self*, *other*)	*self* <= *other*
__ge__(*self*, *other*)	*self* >= *other*

Magic Methods for Math

Method	Description
__add__(*self*, *other*)	*self* + *other*
__sub__(*self*, *other*)	*self* - *other*
__mul__(*self*, *other*)	*self* * *other*
__floordiv__(*self*, *other*)	*self* // *other*
__truediv__(*self*, *other*)	*self* / *other*
__mod__(*self*, *other*)	*self* % *other*
__pow__(*self*, *other*)	*self* ** *other*

Magic Methods for Comparison

```
[1]: class Word:
         def __init__(self, text):
             self.text = text
         def __eq__(self, word2):
             return self.text.lower() == word2.text.lower()
```

```
[2]: first = Word('ha')
```

```
[3]: second = Word('HA')
```

```
[4]: third = Word('Ha Ha')
```

```
[5]: first == second
```

```
[5]: True
```

```
[6]: first == third
```

```
[6]: False
```

- [1] We define a Word class with __init__ and __eq__ methods.
- [1] __eq__ now does customized == comparison by ignoring case.
- [2-6] The client codes to test our class implementation

Other Useful Magic Methods

Two Display Methods

- __str__ is tried first for the print operation and the str built-in function (the internal equivalent of which print runs). It generally should return a user-friendly display.

- __repr__ is used in all other contexts: for interactive echoes, the repr function, and nested appearances, as well as by print and str if no __str__ is present. It should generally return an as-code string that could be used to re-create the object, or a detailed display for developers.

Method	Description
`__str__`(*self*)	`str`(*self*)
`__repr__`(*self*)	`repr`(*self*)
`__len__`(*self*)	`len`(*self*)

Magic Methods for Display

```
[7]: class Word2:
         def __init__(self, text):
             self.text = text
         def __eq__(self, word2):
             return self.text.lower() == word2.text.lower()
         def __str__(self):
             return self.text
         def __repr__(self):
             return('Word("'+ self.text + '")')
```

```
[8]: first = Word2('Ha Ha Ha')
```

```
[9]: first
```

```
[9]: Word("Ha Ha Ha")
```

```
[10]: print(first)
```

```
Ha Ha Ha
```

- [1] We define a Word2 class with __init__, __eq__, __str__, and __repr__ methods.
- [9-10] The client codes that call __repr__ and __str__ methods.

L1_MagicMethods.ipynb

Example: Number Class Using Magic Methods

- Implement a Number class that supports the operators specified by the client codes.

```
[1]:

[2]: a = Number(20)

[3]: a

[3]: Number: 20

[4]: b = Number(10)

[5]: b

[5]: Number: 10

[6]: c = Number(5)

[7]: print(a + b)

30

[8]: print(a + b + c)

35
```

Example: Number Class Using Magic Methods (Ans)

- Implement a Number class that supports the operators specified by the client codes.

L1_Number.ipynb

```
[1]: class Number:
         def __init__(self, num):
             self._num = num
         def __add__(self, num):
             return Number(self._num + num._num)
         def __repr__(self):
             return f'Number: {self._num}'
         def __str__(self):
             return f'{self._num}'

[2]: a = Number(20)

[3]: a

[3]: Number: 20

[4]: b = Number(10)

[5]: b

[5]: Number: 10

[6]: c = Number(5)

[7]: print(a + b)

     30

[8]: print(a + b + c)

     35
```

Food for Thought: Managing Complexity

- **Programming is about managing complexity.**

- **There are two powerful mechanisms, to accomplish this: decomposition and abstraction.**

- **Decomposition creates structure.**
  - It allows us to break a program into parts that are self-contained.
  - **Functions** are the major facilitator.

- **Abstraction hides details.**
  - It allows us to use a piece of code as if it were a black box. For example, **lists**.
  - **Abstract data types** are the major facilitator.
  - **Class** allows us to create abstract data types of our own.

Summary

- This module covered:
  - The `class` keyword
  - The `self` parameter
  - `__init__` (constructor)
  - Instance and class attributes
  - Instance methods
  - `__str__`
  - Comparison magic methods, math magic methods, display magic methods

To be continued…