

PYTHON CLASSES and INHERITANCE

(download slides and follow along on repl.it!)

COMP100 LECTURE 9

LAST TIME

- abstract data types through classes
- `Coordinate` example
- `Fraction` example

LAST TIME

- abstract data types through classes
- `Coordinate` example
- `Fraction` example

THIS WEEK

- more on classes
 - getters and setters
 - information hiding
 - class variables
- inheritance

IMPLEMENTING THE CLASS

USING THE CLASS

- write code from two different perspectives

implementing a new
object type with a class

- **define** the class
- define **data attributes**
(WHAT IS the object)
- define **methods**
(HOW TO use the object)

IMPLEMENTING THE CLASS

USING vs THE CLASS

- write code from two different perspectives

implementing a new object type with a class

- **define** the class
- define **data attributes** (WHAT IS the object)
- define **methods** (HOW TO use the object)

using the new object type in code

- create **instances** of the object type
- do **operations** with them

CLASS DEFINITION OF AN OBJECT TYPE vs INSTANCE OF A CLASS

- class name is the **type**
`class Coordinate(object)`
- class is defined generically
 - use `self` to refer to some instance while defining the class
`(self.x - self.y)**2`
 - `self` is a parameter to methods in class definition
- class defines data and methods **common across all instances**

CLASS DEFINITION OF AN OBJECT TYPE

INSTANCE OF A CLASS

- class name is the **type**

```
class Coordinate(object)
```
- class is defined generically
 - use `self` to refer to some instance while defining the class

```
(self.x - self.y)**2
```
 - `self` is a parameter to methods in class definition
- class defines data and methods **common across all instances**

- instance is **one specific** object

```
coord = Coordinate(1,2)
```
- data attribute values vary between instances

```
c1 = Coordinate(1,2)  
c2 = Coordinate(3,4)
```

 - `c1` and `c2` have different data attribute values `c1.x` and `c2.x` because they are different objects
- instance has the **structure of the class**

WHY USE OOP AND CLASSES OF OBJECTS?

- mimic real life



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WHY USE OOP AND CLASSES OF OBJECTS?

- mimic real life



Jelly
1 year old
brown



Tiger
2 years old
brown



Bean
0 years old
black



WHY USE OOP AND CLASSES OF OBJECTS?

- mimic real life



Jelly
1 year old
brown



5 years old
brown



Tiger
2 years old
brown



Bean
0 years old
black



2 years old
white



1 year old
b/w

WHY USE OOP AND CLASSES OF OBJECTS?

- mimic real life
- group different objects part of the same type



Jelly
1 year old
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5 years old
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Tiger
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Bean
0 years old
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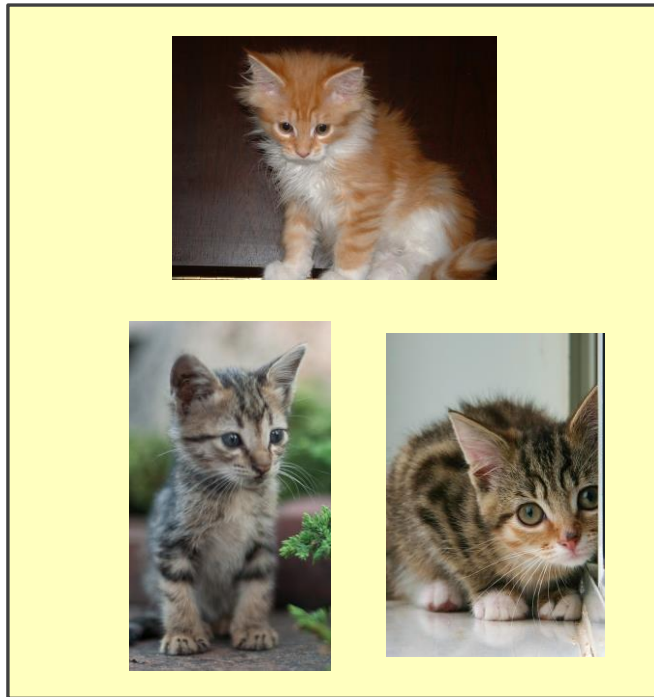
2 years old
white



1 year old
b/w

WHY USE OOP AND CLASSES OF OBJECTS?

- mimic real life
- group different objects part of the same type



GROUPS OF OBJECTS HAVE ATTRIBUTES (RECAP)

■ **data attributes**

- how can you represent your object with data?
- **what it is**
- *for a coordinate: x and y values*
- *for an animal: age, name*

GROUPS OF OBJECTS HAVE ATTRIBUTES (RECAP)

■ **data attributes**

- how can you represent your object with data?
- **what it is**
- *for a coordinate: x and y values*
- *for an animal: age, name*

■ **procedural attributes** (behavior/operations/**methods**)

- how can someone interact with the object?
- **what it does**
- *for a coordinate: find distance between two*
- *for an animal: make a sound*

HOW TO DEFINE A CLASS (RECAP)

class definition

```
class Animal(object):  
    def __init__(self, age):  
        self.age = age  
        self.name = None
```

```
myanimal = Animal(3)
```


HOW TO DEFINE A CLASS (RECAP)

class definition

name

```
class Animal(object):  
    def __init__(self, age):  
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```
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HOW TO DEFINE A CLASS (RECAP)

class definition

name

*class
parent*

```
class Animal(object):
```

```
    def __init__(self, age):
```

```
        self.age = age
```

```
        self.name = None
```

```
myanimal = Animal(3)
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HOW TO DEFINE A CLASS (RECAP)

class definition

name

*class
parent*

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class Animal(object):  
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*special method to
create an instance*

```
myanimal = Animal(3)
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HOW TO DEFINE A CLASS (RECAP)

class definition

```
class Animal(object):
```

name

class parent

variable to refer to an instance of the class

```
    def __init__(self, age):
```

special method to create an instance

```
        self.age = age
        self.name = None
```

```
myanimal = Animal(3)
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HOW TO DEFINE A CLASS (RECAP)

class definition

```
class Animal(object):
```

name

class parent

variable to refer to an instance of the class

```
    def __init__(self, age):
```

special method to create an instance

```
        self.age = age
```

what data initializes an Animal type

```
        self.name = None
```

```
myanimal = Animal(3)
```

HOW TO DEFINE A CLASS (RECAP)

class definition
`class` *name* `Animal` *class parent* `(object)` :

special method to create an instance `def` `__init__` *variable to refer to an instance of the class* `(self, age)` :

`self.age = age`

`self.name = None`

what data initializes an Animal type

name is a data attribute even though an instance is not initialized with it as a param

`myanimal = Animal(3)`

HOW TO DEFINE A CLASS (RECAP)

```
class Animal(object):  
    def __init__(self, age):  
        self.age = age  
        self.name = None  
  
myanimal = Animal(3)
```

class definition

name

class parent

variable to refer to an instance of the class

special method to create an instance

what data initializes an Animal type

name is a data attribute even though an instance is not initialized with it as a param

mapped to self.age in class def

HOW TO DEFINE A CLASS (RECAP)

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class Animal(object):  
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```

class definition

name

class parent

variable to refer to an instance of the class

special method to create an instance

what data initializes an Animal type

name is a data attribute even though an instance is not initialized with it as a param

one instance

mapped to self.age in class def

GETTER AND SETTER METHODS

```
class Animal(object):
    def __init__(self, age):
        self.age = age
        self.name = None
    def get_age(self):
        return self.age
    def get_name(self):
        return self.name
    def set_age(self, newage):
        self.age = newage
    def set_name(self, newname=""):
        self.name = newname
    def __str__(self):
        return "animal:"+str(self.name)+":"+str(self.age)
```

GETTER AND SETTER METHODS

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class Animal(object):
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        self.age = age
        self.name = None

    def get_age(self):
        return self.age
    def get_name(self):
        return self.name

    def set_age(self, newage):
        self.age = newage
    def set_name(self, newname=""):
        self.name = newname

    def __str__(self):
        return "animal:" + str(self.name) + ":" + str(self.age)
```

getter

setter

- **getters and setters** should be used outside of class to access data attributes

AN INSTANCE and DOT NOTATION (RECAP)

- instantiation creates an **instance of an object**

```
a = Animal(3)
```

- **dot notation** used to access attributes (data and methods) though it is better to use getters and setters to access data attributes

```
a.age
```

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- **dot notation** used to access attributes (data and methods) though it is better to use getters and setters to access data attributes

```
a.age
```

- access data attribute
- allowed, but not recommended

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a = Animal(3)
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- **dot notation** used to access attributes (data and methods) though it is better to use getters and setters to access data attributes

```
a.age
```

```
a.get_age()
```

- access data attribute
- allowed, but not recommended

AN INSTANCE and DOT NOTATION (RECAP)

- instantiation creates an **instance of an object**

```
a = Animal(3)
```

- **dot notation** used to access attributes (data and methods) though it is better to use getters and setters to access data attributes

```
a.age
```

```
a.get_age()
```

- access method
- best to use getters
and setters

- access data attribute
- allowed, but not recommended

INFORMATION HIDING

- author of class definition may **change data attribute** variable names

```
class Animal(object):  
    def __init__(self, age):  
        self.years = age  
    def get_age(self):  
        return self.years
```

INFORMATION HIDING

- author of class definition may **change data attribute** variable names

*replaced age data
attribute by years*

```
class Animal(object):  
    def __init__(self, age):  
        self.years = age  
    def get_age(self):  
        return self.years
```


INFORMATION HIDING

- author of class definition may **change data attribute** variable names

replaced age data attribute by years

```
class Animal(object):  
    def __init__(self, age):  
        self.years = age  
    def get_age(self):  
        return self.years
```

- if you are **accessing data attributes** outside the class and class **definition changes**, may get errors
- outside of class, use getters and setters instead
use `a.get_age()` NOT `a.age`
 - good style
 - easy to maintain code
 - prevents bugs

PYTHON NOT GREAT AT INFORMATION HIDING

- allows you to **access data** from outside class definition
`print(a.age)`

PYTHON NOT GREAT AT INFORMATION HIDING

- allows you to **access data** from outside class definition
`print(a.age)`
- allows you to **write to data** from outside class definition
`a.age = 'infinite'`

PYTHON NOT GREAT AT INFORMATION HIDING

- allows you to **access data** from outside class definition
`print(a.age)`
- allows you to **write to data** from outside class definition
`a.age = 'infinite'`
- allows you to **create data attributes** for an instance from outside class definition
`a.size = "tiny"`

PYTHON NOT GREAT AT INFORMATION HIDING

- allows you to **access data** from outside class definition
`print(a.age)`
- allows you to **write to data** from outside class definition
`a.age = 'infinite'`
- allows you to **create data attributes** for an instance from outside class definition
`a.size = "tiny"`
- it's **not good style** to do any of these!

DEFAULT ARGUMENTS

- **default arguments** for formal parameters are used if no actual argument is given

```
def set_name(self, newname="") :  
    self.name = newname
```

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```
def set_name(self, newname="") :  
    self.name = newname
```

- default argument used here

```
a = Animal(3)  
a.set_name()  
print(a.get_name())
```

DEFAULT ARGUMENTS

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```
def set_name(self, newname="") :  
    self.name = newname
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```
a = Animal(3)
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```
a.set_name()
```

```
print(a.get_name())
```

prints ""

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def set_name(self, newname="") :  
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```
a.set_name()
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```
print(a.get_name())
```

prints ""

- argument passed in is used here

```
a = Animal(3)
```

```
a.set_name("fluffy")
```

```
print(a.get_name())
```

DEFAULT ARGUMENTS

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def set_name(self, newname="") :  
    self.name = newname
```

- default argument used here

```
a = Animal(3)  
a.set_name()
```

```
print(a.get_name())
```

prints ""

- argument passed in is used here

```
a = Animal(3)  
a.set_name("fluffy")
```

```
print(a.get_name())
```

prints "fluffy"

HIERARCHIES

Animal

People



Student

Cat

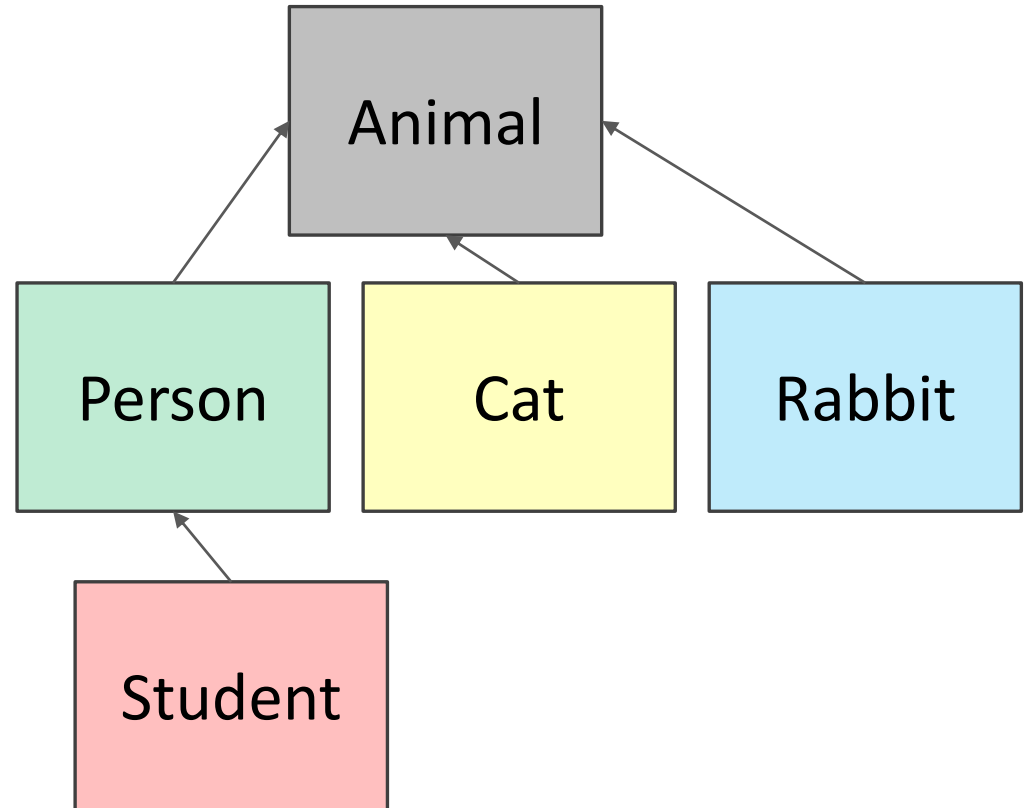


Rabbit



HIERARCHIES

- **parent class**
(superclass)
- **child class**
(subclass)
 - **inherits** all data and behaviors of parent class
 - **add** more **info**
 - **add** more **behavior**
 - **override** behavior



INHERITANCE: PARENT CLASS

```
class Animal(object):
    def __init__(self, age):
        self.age = age
        self.name = None
    def get_age(self):
        return self.age
    def get_name(self):
        return self.name
    def set_age(self, newage):
        self.age = newage
    def set_name(self, newname=""):
        self.name = newname
    def __str__(self):
        return "animal:"+str(self.name)+":"+str(self.age)
```

INHERITANCE: PARENT CLASS

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class Animal(object):  
    def __init__(self, age):  
        self.age = age  
        self.name = None  
    def get_age(self):  
        return self.age  
    def get_name(self):  
        return self.name  
    def set_age(self, newage):  
        self.age = newage  
    def set_name(self, newname=""):  
        self.name = newname  
    def __str__(self):  
        return "animal:" + str(self.name) + ":" + str(self.age)
```

- everything is an object
- class object
implements basic
operations in Python, like
binding variables, etc

INHERITANCE: SUBCLASS

```
class Cat(Animal):  
    def speak(self):  
        print("meow")  
    def __str__(self):  
        return "cat:"+str(self.name)+":"+str(self.age)
```

- add new functionality with `speak()`
 - instance of type `Cat` can be called with new methods
 - instance of type `Animal` throws error if called with `Cat`'s new method
- `__init__` is not missing, uses the `Animal` version

INHERITANCE: SUBCLASS

inherits all attributes of Animal:

*__init__()
age, name
get_age(), get_name()
set_age(), set_name()
__str__()*

```
class Cat(Animal):  
    def speak(self):  
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    def __str__(self):  
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class Cat(Animal):
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```
        print("meow")
```

```
    def __str__(self):
```

```
        return "cat:" + str(self.name) + ":" + str(self.age)
```

*add new
functionality via
speak method*

- add new functionality with `speak()`
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INHERITANCE: SUBCLASS

inherits all attributes of Animal:

*__init__()
age, name
get_age(), get_name()
set_age(), set_name()
__str__()*

```
class Cat(Animal):
```

```
    def speak(self):
```

```
        print("meow")
```

```
    def __str__(self):
```

```
        return "cat:" + str(self.name) + ":" + str(self.age)
```

*add new
functionality via
speak method*

overrides __str__

- add new functionality with `speak()`
 - instance of type `Cat` can be called with new methods
 - instance of type `Animal` throws error if called with `Cat`'s new method
- `__init__` is not missing, uses the `Animal` version

WHICH METHOD TO USE?

- subclass can have **methods with same name** as superclass
- for an instance of a class, look for a method name in **current class definition**
- if not found, look for method name **up the hierarchy** (in parent, then grandparent, and so on)
- use first method up the hierarchy that you found with that method name

```
class Person(Animal):
    def __init__(self, name, age):
        Animal.__init__(self, age)
        self.set_name(name)
        self.friends = []
    def get_friends(self):
        return self.friends
    def add_friend(self, fname):
        if fname not in self.friends:
            self.friends.append(fname)
    def speak(self):
        print("hello")
    def age_diff(self, other):
        diff = self.age - other.age
        print(abs(diff), "year difference")
    def __str__(self):
        return "person:" + str(self.name) + ":" + str(self.age)
```

```
class Person(Animal):
```

parent class is Animal

```
    def __init__(self, name, age):
```

```
        Animal.__init__(self, age)
```

```
        self.set_name(name)
```

```
        self.friends = []
```

```
    def get_friends(self):
```

```
        return self.friends
```

```
    def add_friend(self, fname):
```

```
        if fname not in self.friends:
```

```
            self.friends.append(fname)
```

```
    def speak(self):
```

```
        print("hello")
```

```
    def age_diff(self, other):
```

```
        diff = self.age - other.age
```

```
        print(abs(diff), "year difference")
```

```
    def __str__(self):
```

```
        return "person:" + str(self.name) + ":" + str(self.age)
```

```
class Person(Animal):
```

```
    def __init__(self, name, age):
```

```
        Animal.__init__(self, age)
```

```
        self.set_name(name)
```

```
        self.friends = []
```

```
    def get_friends(self):
```

```
        return self.friends
```

```
    def add_friend(self, fname):
```

```
        if fname not in self.friends:
```

```
            self.friends.append(fname)
```

```
    def speak(self):
```

```
        print("hello")
```

```
    def age_diff(self, other):
```

```
        diff = self.age - other.age
```

```
        print(abs(diff), "year difference")
```

```
    def __str__(self):
```

```
        return "person:" + str(self.name) + ":" + str(self.age)
```

parent class is Animal

call Animal constructor

```
class Person(Animal):
```

```
    def __init__(self, name, age):
```

```
        Animal.__init__(self, age)
```

```
        self.set_name(name)
```

```
        self.friends = []
```

```
    def get_friends(self):
```

```
        return self.friends
```

```
    def add_friend(self, fname):
```

```
        if fname not in self.friends:
```

```
            self.friends.append(fname)
```

```
    def speak(self):
```

```
        print("hello")
```

```
    def age_diff(self, other):
```

```
        diff = self.age - other.age
```

```
        print(abs(diff), "year difference")
```

```
    def __str__(self):
```

```
        return "person:"+str(self.name)+":"+str(self.age)
```

parent class is Animal

call Animal constructor
call Animal's method

```
class Person(Animal):
```

```
    def __init__(self, name, age):
```

```
        Animal.__init__(self, age)
```

```
        self.set_name(name)
```

```
        self.friends = []
```

```
    def get_friends(self):
```

```
        return self.friends
```

```
    def add_friend(self, fname):
```

```
        if fname not in self.friends:
```

```
            self.friends.append(fname)
```

```
    def speak(self):
```

```
        print("hello")
```

```
    def age_diff(self, other):
```

```
        diff = self.age - other.age
```

```
        print(abs(diff), "year difference")
```

```
    def __str__(self):
```

```
        return "person:" + str(self.name) + ":" + str(self.age)
```

parent class is Animal

call Animal constructor

call Animal's method

add a new data attribute


```
class Person(Animal):
```

```
    def __init__(self, name, age):
```

```
        Animal.__init__(self, age)
```

```
        self.set_name(name)
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```
        self.friends = []
```

```
    def get_friends(self):
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```
        return self.friends
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    def add_friend(self, fname):
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```
        if fname not in self.friends:
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```
            self.friends.append(fname)
```

```
    def speak(self):
```

```
        print("hello")
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```
    def age_diff(self, other):
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```
        diff = self.age - other.age
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```
        print(abs(diff), "year difference")
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```
    def __str__(self):
```

```
        return "person:" + str(self.name) + ":" + str(self.age)
```

parent class is Animal

*call Animal constructor
call Animal's method
add a new data attribute*

new methods

```
class Person(Animal):
```

```
    def __init__(self, name, age):
```

```
        Animal.__init__(self, age)
```

```
        self.set_name(name)
```

```
        self.friends = []
```

```
    def get_friends(self):
```

```
        return self.friends
```

```
    def add_friend(self, fname):
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```
        if fname not in self.friends:
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```
    def speak(self):
```

```
        print("hello")
```

```
    def age_diff(self, other):
```

```
        diff = self.age - other.age
```

```
        print(abs(diff), "year difference")
```

```
    def __str__(self):
```

```
        return "person:" + str(self.name) + ":" + str(self.age)
```

parent class is Animal

*call Animal constructor
call Animal's method
add a new data attribute*

new methods

*override Animal's
__str__ method*

```
import random

class Student(Person):
    def __init__(self, name, age, major=None):
        Person.__init__(self, name, age)
        self.major = major
    def change_major(self, major):
        self.major = major
    def speak(self):
        r = random.random()
        if r < 0.25:
            print("i have homework")
        elif 0.25 <= r < 0.5:
            print("i need sleep")
        elif 0.5 <= r < 0.75:
            print("i should eat")
        else:
            print("i am watching tv")
    def __str__(self):
        return "student:" + str(self.name) + ":" + str(self.age) + ":" + str(self.major)
```

```
import random
```

```
class Student(Person):  
    def __init__(self, name, age, major=None):  
        Person.__init__(self, name, age)  
        self.major = major  
    def change_major(self, major):  
        self.major = major  
    def speak(self):  
        r = random.random()  
        if r < 0.25:  
            print("i have homework")  
        elif 0.25 <= r < 0.5:  
            print("i need sleep")  
        elif 0.5 <= r < 0.75:  
            print("i should eat")  
        else:  
            print("i am watching tv")  
    def __str__(self):  
        return "student:" + str(self.name) + ":" + str(self.age) + ":" + str(self.major)
```

*inherits Person and
Animal attributes*

```
import random
```

```
class Student(Person):
```

```
    def __init__(self, name, age, major=None):
```

```
        Person.__init__(self, name, age)
```

```
        self.major = major
```

```
    def change_major(self, major):
```

```
        self.major = major
```

```
    def speak(self):
```

```
        r = random.random()
```

```
        if r < 0.25:
```

```
            print("i have homework")
```

```
        elif 0.25 <= r < 0.5:
```

```
            print("i need sleep")
```

```
        elif 0.5 <= r < 0.75:
```

```
            print("i should eat")
```

```
        else:
```

```
            print("i am watching tv")
```

```
    def __str__(self):
```

```
        return "student:" + str(self.name) + ":" + str(self.age) + ":" + str(self.major)
```

*inherits Person and
Animal attributes
adds new data*

```
import random
```

```
class Student(Person):
```

```
    def __init__(self, name, age, major=None):
```

```
        Person.__init__(self, name, age)
```

```
        self.major = major
```

```
    def change_major(self, major):
```

```
        self.major = major
```

```
    def speak(self):
```

```
        r = random.random()
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```
    def __str__(self):
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        return "student:" + str(self.name) + ":" + str(self.age) + ":" + str(self.major)
```

bring in methods
from random class

inherits Person and
Animal attributes

adds new data

- I looked up how to use the
random class in the python docs
- random() method gives back
float in [0, 1)

CLASS VARIABLES AND THE Rabbit SUBCLASS

- **class variables** and their values are shared between all instances of a class

```
class Rabbit(Animal):  
    tag = 1  
  
    def __init__(self, age, parent1=None, parent2=None):  
        Animal.__init__(self, age)  
        self.parent1 = parent1  
        self.parent2 = parent2  
        self.rid = Rabbit.tag  
        Rabbit.tag += 1
```

- tag used to give **unique id** to each new rabbit instance

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parent class

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class variable

instance variable

access class variable

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parent class

class variable

instance variable

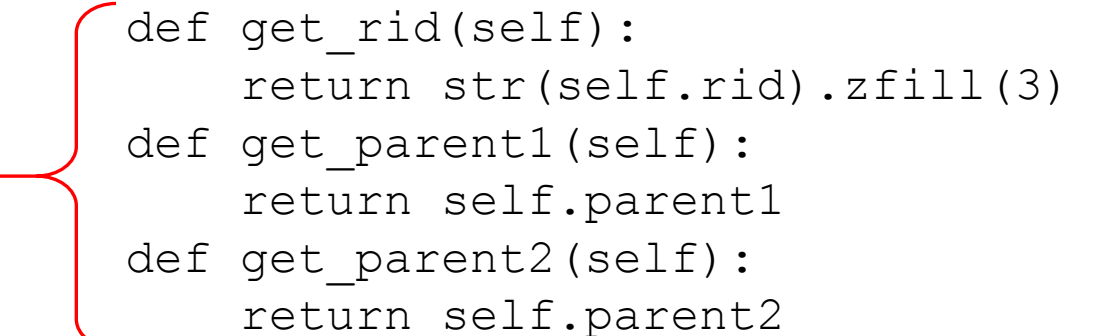
access class variable

incrementing class variable changes it for all instances that may reference it

- tag used to give **unique id** to each new rabbit instance

Rabbit GETTER METHODS

```
class Rabbit(Animal):
    tag = 1
    def __init__(self, age, parent1=None, parent2=None):
        Animal.__init__(self, age)
        self.parent1 = parent1
        self.parent2 = parent2
        self.rid = Rabbit.tag
        Rabbit.tag += 1
    def get_rid(self):
        return str(self.rid).zfill(3)
    def get_parent1(self):
        return self.parent1
    def get_parent2(self):
        return self.parent2
```



- getter methods specific
for a Rabbit class
- there are also getters
get_name and get_age
inherited from Animal

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```

method on a string to pad
the beginning with zeros
for example, 001 not 1

- getter methods specific
for a Rabbit class
- there are also getters
get_name and get_age
inherited from Animal

WORKING WITH YOUR OWN TYPES

```
def __add__(self, other):  
    # returning object of same type as this class  
    return Rabbit(0, self, other)
```

- define **+ operator** between two `Rabbit` instances
 - define what something like this does: `r4 = r1 + r2`
where `r1` and `r2` are `Rabbit` instances
 - `r4` is a new `Rabbit` instance with age 0
 - `r4` has `self` as one parent and `other` as the other parent
 - in `__init__`, **parent1 and parent2 are of type `Rabbit`**

WORKING WITH YOUR OWN TYPES

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    # returning object of same type as this class  
    return Rabbit(0, self, other)
```

recall Rabbit's `__init__(self, age, parent1=None, parent2=None)`

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where `r1` and `r2` are `Rabbit` instances
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 - in `__init__`, **parent1 and parent2 are of type `Rabbit`**

SPECIAL METHOD TO COMPARE TWO Rabbits

- decide that two rabbits are equal if they have the **same two parents**

```
def __eq__(self, other):  
    parents_same = self.parent1.rid == other.parent1.rid \  
                    and self.parent2.rid == other.parent2.rid  
    parents_opposite = self.parent2.rid == other.parent1.rid \  
                       and self.parent1.rid == other.parent2.rid  
    return parents_same or parents_opposite
```


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booleans

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                      and self.parent1.rid == other.parent2.rid  
    return parents_same or parents_opposite
```

- compare ids of parents since **ids are unique** (due to class var)
- note you can't compare objects directly
 - for ex. with `self.parent1 == other.parent1`
 - this calls the `__eq__` method over and over until call it on `None` and gives an `AttributeError` when it tries to do `None.parent1`

OBJECT ORIENTED PROGRAMMING

- create your own **collections of data**
- **organize** information
- **division** of work
- access information in a **consistent** manner
- add **layers** of complexity
- like functions, classes are a mechanism for **decomposition** and **abstraction** in programming