CS 134:

Classes, Objects, and Inheritance

Announcements & Logistics

- **Lab 8** is a **partner lab:** focuses on using classes
  - **Must attend one lab session with your partner**
  - Mon lab due on Wed, Tue lab due on Thur
  - Try to get through Part 1 before coming to lab
- **Lab 6** feedback will be returned soon
- **HW 7** due Monday (on Glow)
- **CS info session today** (learn about major requirements and courses being offered next year): 2:35 @ Wege (TCL 123)

Do You Have Any Questions?

Last Time

- Built the **Book class** to represents book objects
- Learned about private, protected, public attributes and methods (signal using underscores in Python)
- Explored accessor (getter) and mutator (setter) methods in Python
- Talked about `__init__` (aka constructor) and `__str__` methods

Today's Plan

- Look at another simple example involving classes and methods
- Begin talking about inheritance

Print Representation of an Object

```
In [1]: class A:
            """Test printing of objects."""
            pass

In [2]: a = A()

In [3]: print(a)
<__main__.A object at 0x111e90750>
```

By default, if we print an object, its not helpful

- Special method **`__str__`** is automatically called when we ask to print a class object in Python
- **`__str__`** must always return a string
- We can customize how the object is printed by writing a custom **`__str__`** method for our class
- Very useful for debugging

`__str__` for Book class

- What is a useful string representation of a Book?
  - Something that combines the attributes in a meaningful way
  - The format( ) string method comes in handy here

```
# __str__ is used to generate a meaningful string representation for Book objects
# __str__ is automatically called when we ask to print() a Book object
def __str__(self):
    return "'{}', by {}, in {}".format(self._title, self._author, self._year)
```

  - Now when we ask to print a specific instance of a Book, we get something useful

```
In [21]: print(emma)
```

```
'Emma', by Jane Austen, in 1815
```

Special methods and attributes

- We've seen several "special" methods and attributes in Python:
  - `__name__` special module attribute
  - `__main__` name attribute of scripts
  - `__slots__` list for attributes
  - `__init__` method
  - `__str__` method

Other Special Methods

- There are many other "special" methods in Python.
  - `__len__(self): len(x)`
  - `__contains__(self, item): item in x`
  - `__eq__ (self, other): x == y`
  - `__lt__ (self, other): x < y`
  - `__gt__ (self, other): x > y`
  - `__add__(self, other) : x + y`
  - `__sub__(self, other): x - y`
  - `__mul__(self, other): x * y`
  - `__truediv__(self, other): x / y`
  - `__pow__(self, other): x ** y`
  - There are others!

We'll come back to these in a few weeks!

Another Example: Name Class

- Names of people have certain attributes
    - Almost everyone has a **first and last name**
    - Some people have a **middle name**
- We can create name objects by defining a class to represent these attributes
- Then we can define methods, e.g., getting initials of people's names, etc
- Let's practice some of the concepts using this class
    - **__str__**: how do we want the names to be printed?
    - **initials**: can we define a method that returns the initials of people's names?

Example: Name Class

In [37]:
```
class Name:
    """Class to represent a person's name."""
    __slots__ = ['_f', '_m', '_l']

    def __init__(self, first, last, middle=''):
        self._f = first
        self._m = middle
        self._l = last

    def __str__(self):
        # if the person has a middle name
        if len(self._m):
            return '{}. {}. {}'.format(self._f[0], self._m[0], self._l)
        else:
            return '{}. {}'.format(self._f[0], self._l)
```

In [38]:
```
n1 = Name('Rohit', 'Bhattacharya')
n2 = Name('Jeannie', 'Albrecht', 'Raye')
```

In [39]:
```
print(n1)
print(n2)
```

```
R. Bhattacharya
J. R. Albrecht
```

intials() method

- Suppose we want to write a method that returns the person's initials as a string?
- How would we do that?

Example: Name Class

In [40]:
```
class Name:
    """Class to represent a person's name."""
    __slots__ = ['_f', '_m', '_l']

    def __init__(self, first, last, middle=''):
        self._f = first
        self._m = middle
        self._l = last

    def initials(self):
        if len(self._m):
            return '{}. {}. {}.'.format(self._f[0], self._m[0], self._l[0]).upper()
        else:
            return '{}. {}.'.format(self._f[0], self._l[0]).upper()

    def __str__(self):
        # if the person has a middle name
        if len(self._m):
            return '{}. {}. {}'.format(self._f[0], self._m[0], self._l)
        else:
            return '{}. {}'.format(self._f[0], self._l)
```

In [41]:
```
n1 = Name('Steve', 'Freund', 'N')
```

In [42]:
```
n1.initials()
```

Out[42]:
```
'S. N. F.'
```

In [43]:
```
n2 = Name('Lida', 'Doret', 'P')
```

In [44]:
```
n2.initials()
```

Out[44]:
```
'L. P. D.'
```

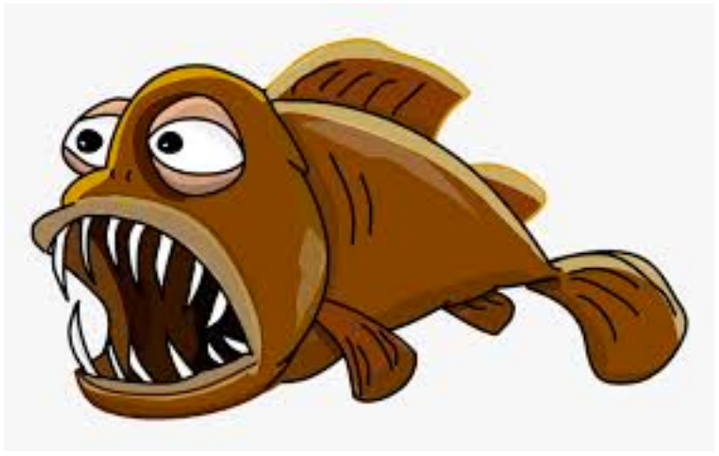
Inheritance

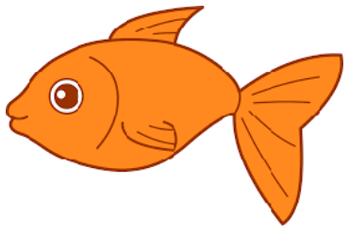
Introduction to Inheritance

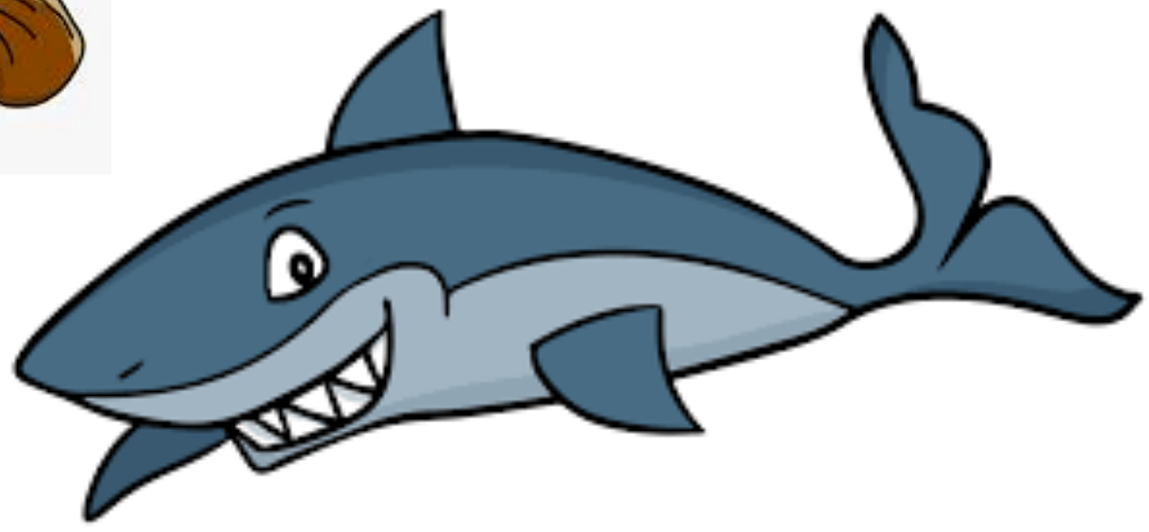
- **Inheritance** is the capability of one class to derive or ***inherit*** the properties from another class
- The benefits of inheritance are:
    - Often represents real-world relationships well
    - Provides **reusability of code**, so we don't have to write the same code again and again
    - Allows us to add more features to a class without modifying it
- Inheritance is **transitive** in nature, which means that if class B inherits from class A, then all the subclasses of B would also automatically inherit from class A
- When a class inherits from another class, all methods and attributes are accessible to subclass, ***except private attributes*** (indicated with __)

Inheritance Example

- Suppose we have a base class `Fish`
- `Fish` defines several methods that are common to all fish:
  - `eat()`, `swim()`
- `Fish` also defines several attributes with default values:
  - `_length`, `_weight`, `_lifespan`

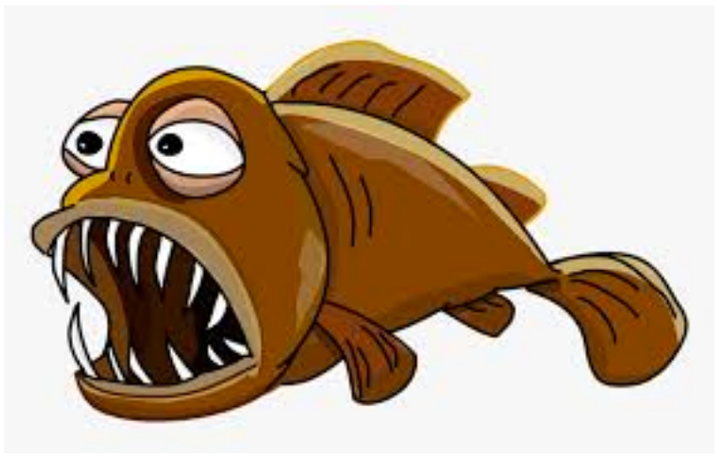


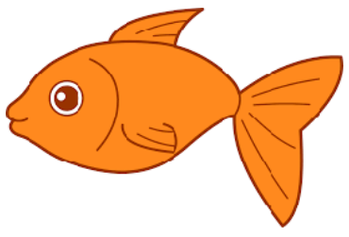




Inheritance Example

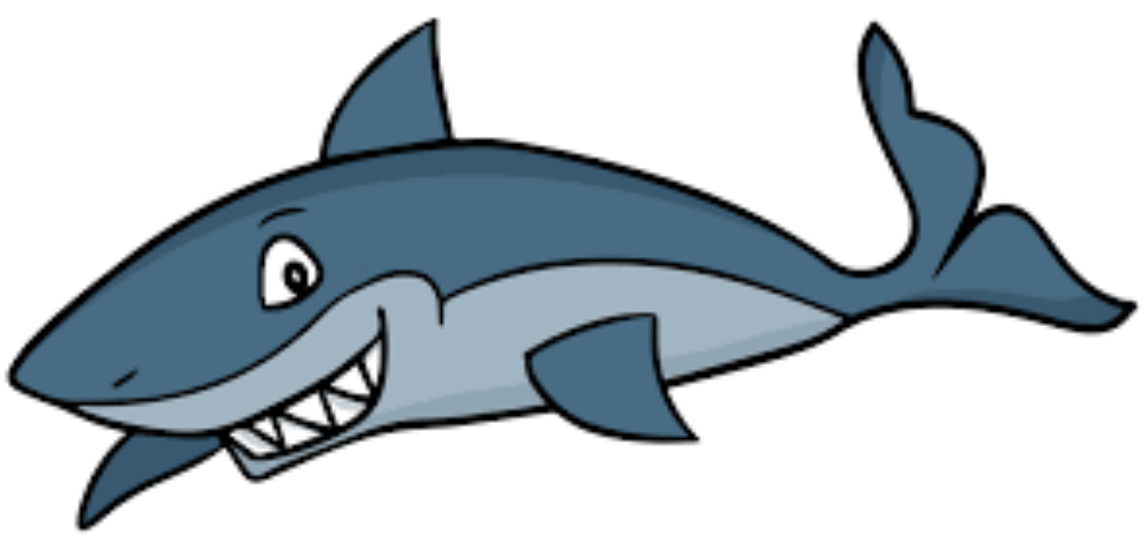
- All fish have some features in common
    - But not all fish are the same!
- Each `Fish` instance will specify different values for attributes (`_length`, `_weight`, `_lifespan`)
- Some fish may still need extra functionality!





Inheritance Example

- For example, Sharks might need an `attack()` method
- Pufferfish might need a `puff()` method
- We might even want to ***override*** an existing method with a different (more specialized) implementation
    - Inheritance allows for all of this!



Inheritance

- When defining **super/parent** classes, think about the common features and methods that all subclasses will have
- In subclasses, inherit as much as possible from parent class, and add and/or override attributes and methods as necessary
- Consider an simple example:
  - **Person** class: defines common attributes for all people on campus
  - **Student** subclass: inherits from `Person` and adds additional attributes for student's ***major*** and ***year***
  - **Faculty** subclass: inherits from `Person` and adds additional attributes for ***department*** and ***office***
  - **Staff** subclass: inherits from `Person` and adds additional attributes for type/status of employee (***full-time, part-time***)

Person Class

```
class Person:
    __slots__ = ['_name']

    def __init__(self, name):
        self._name = name

    def getName(self):
        return self._name

    def __str__(self):
        return self._name
```

Student Class

Our Student class inherits from Person

Notice this does not include the inherited attribute '_name' since that is already provided in Person

```
class Student(Person):
    __slots__ = ['_year', '_major']

    def __init__(self, name, year, major):
        # call __init__ of Person (the super class)
        super().__init__(name)
        self._year = year
        self._major = major

    def getYear(self):
        return self._year

    def getMajor(self):
        return self._major

    def setMajor(self, major):
        self._major = major
```

This calls the __init__ method of Person

Using the Student Class

```
In [49]: jane = Student("Jane", 2024, "CS")
```

```
In [50]: # inherited from Person
         jane.getName()
```

```
Out[50]: 'Jane'
```

```
In [51]: # defined in Student
         jane.getMajor()
```

```
Out[51]: 'CS'
```

```
In [52]: jane.setMajor("Math")
```

```
In [53]: jane.getMajor()
```

```
Out[53]: 'Math'
```

Faculty Class

```
class Faculty(Person):
    __slots__ = ['_dept', '_office']

    def __init__(self, name, dept, office):
        # call __init__ of Person (the super class)
        super().__init__(name)
        self._dept = dept
        self._office = office

    def getDept(self):
        return self._dept

    def getOffice(self):
        return self._office
```

Using the Faculty Class

```
In [54]: rohit = Faculty("Rohit", "CS", "TBL 309B")

In [55]: rohit.getName()
Out[55]: 'Rohit'

In [56]: rohit.getDept()
Out[56]: 'CS'

In [57]: print(rohit)
         Rohit

In [58]: # this doesn't work since instances of Faculty do
         # not have a major attribute
         rohit.getMajor()
         ---------------------------------------------------------------------------
         AttributeError                            Traceback (most recent call last)
         <ipython-input-58-19bd647b2008> in <module>
               1 # this doesn't work since instances of Faculty do
               2 # not have a major attribute
         ----> 3 rohit.getMajor()

         AttributeError: 'Faculty' object has no attribute 'getMajor'
```

Using the Faculty Class

```
In [54]: rohit = Faculty("Rohit", "CS", "TBL 309B")

In [55]: rohit.getName()
Out[55]: 'Rohit'

In [56]: rohit.getDept()
Out[56]: 'CS'

In [57]: print(rohit)
         Rohit

In [58]: # this doesn't work since instances of Faculty do
         # not have a major attribute
         rohit.getMajor()
```

major is an attribute of Student, not Person, and it is not defined in Faculty. This will not work.

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-58-19bd647b2008> in <module>
      1 # this doesn't work since instances of Faculty do
      2 # not have a major attribute
----> 3 rohit.getMajor()

AttributeError: 'Faculty' object has no attribute 'getMajor'
```

Staff Class

```
class Staff(Person):
    # fulltime is a Boolean
    __slots__ = ['_fulltime']

    def __init__(self, name, fulltime):
        # call __init__ of super class
        super().__init__(name)
        self._fulltime = fulltime

    def getStatus(self):
        if self._fulltime:
            return "fulltime"
        return "partime"
```

Notice that getter methods can do more than just return an attribute directly

Using the Staff Class

```
In [59]: fred = Staff("Fred", False)

In [60]: print(fred)

         Fred

In [61]: fred.getStatus()

Out[61]: 'partime'
```

This calls __str__ of the Person class

Summary

- Inheritance is a very useful feature of OOP
- Supports code reusability
- One superclass can be used for any number of subclasses in a hierarchy
- Can change the parent class without changing the subclasses
- More next time!