CMSC201
Computer Science I for Majors

Lecture 17 – Classes and Modules (Continued)

Prof. Katherine Gibson

Last Class We Covered

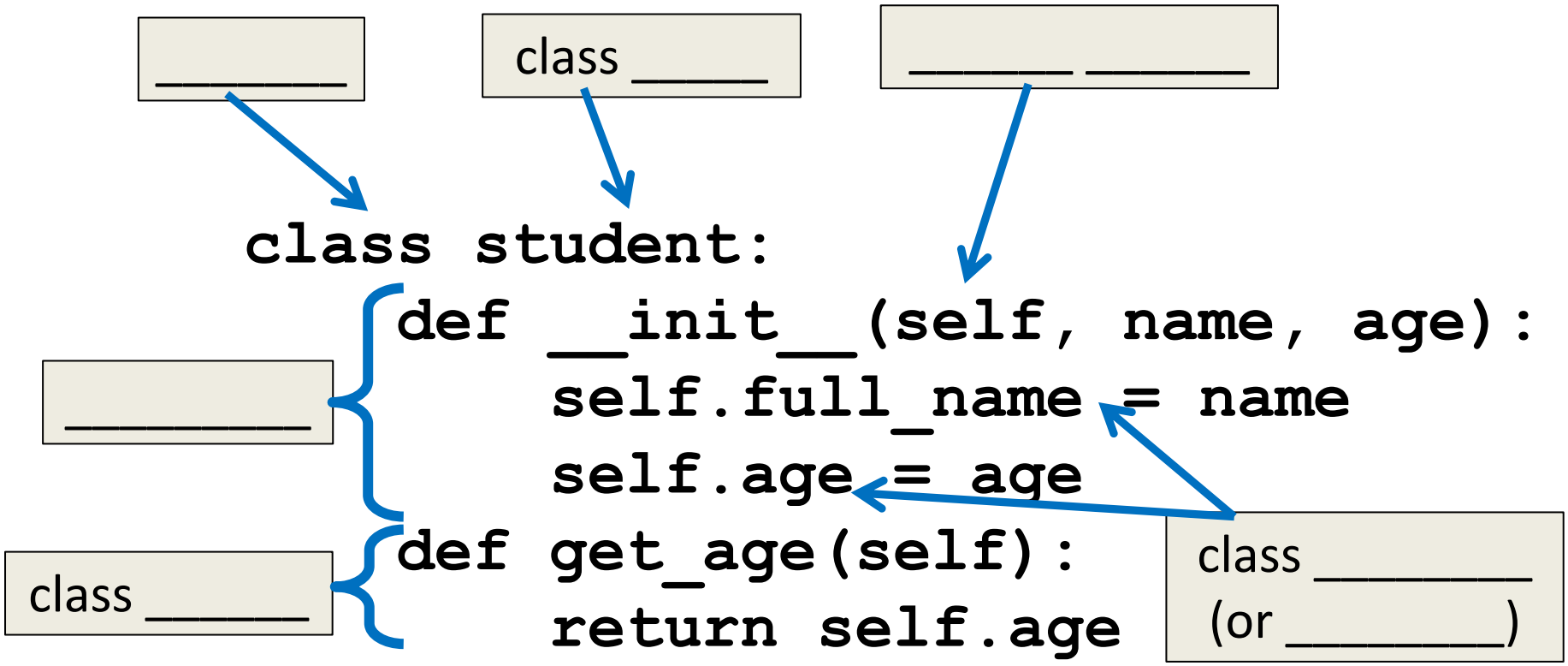
- More about "good quality" code
- Modules
- The **`import`** keyword
  - Three different ways to import modules
- Classes
  - Creating an instance of a class
  - Vocabulary related to classes

Any Questions from Last Time?

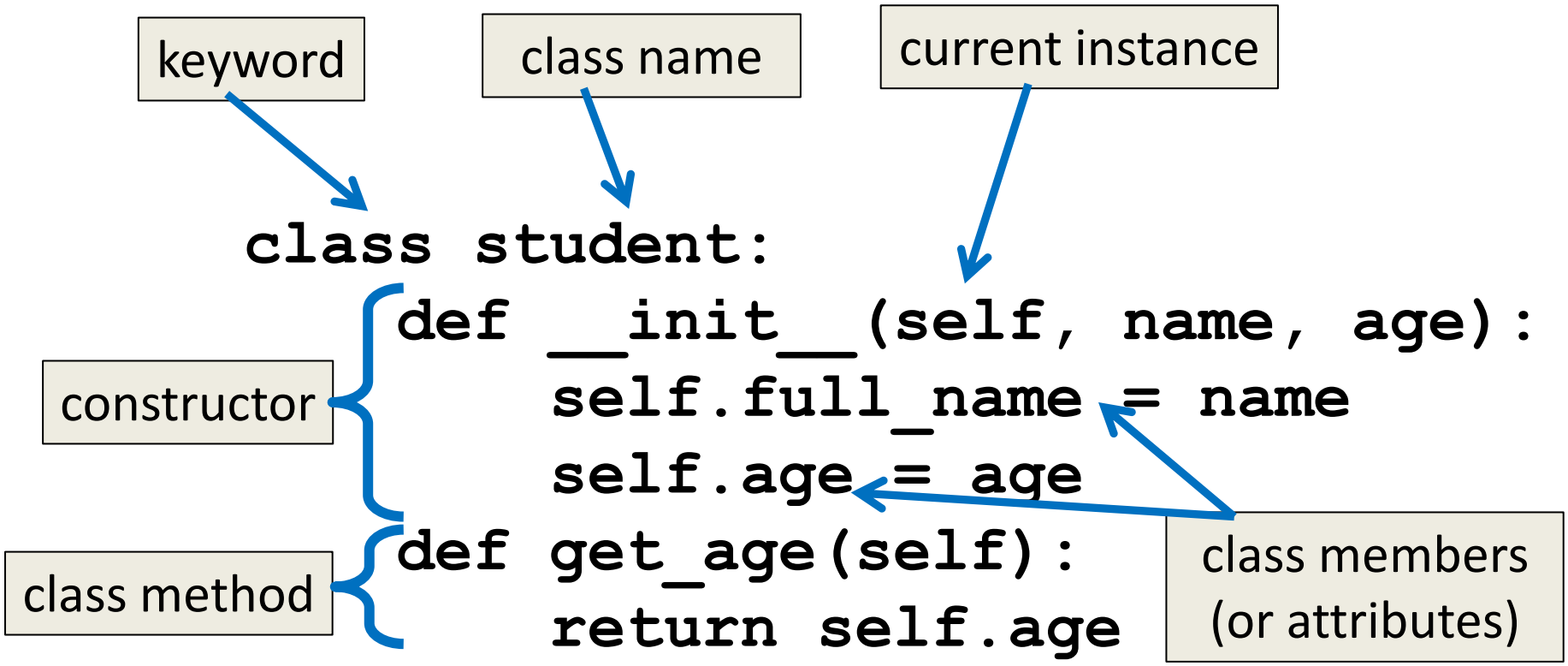
Today's Objectives

- To review the vocabulary for classes
- To better understand how constructors work
- To learn the difference between
  - Data attributes
  - Class attributes
- To explore special built-in methods and attributes

Class Vocabulary



Class Vocabulary



Creating Instances of a Class

Constructor

- In order to use a class we have created, we have to be able to create ***instances*** of it to use
- We can accomplish this using a special type of method (*i.e.*, a class function) called a ***constructor***
  - Using it will allow us to "construct" instances of our class

`__init__`

- The constructor has a special name: the word "**`init`**" with two underscores in front of it, and two underscores in back
  - This special name tells Python how to use it
- The **`__init__()`** method needs to be contained inside our class
  - It normally does initialization of the class data members and other important things

Constructor Example

- Here is an example constructor for **`student`**

```
class student:
    def __init__(self, name, age, gpa):
        self.name = name
        self.age = age
        self.gpa = gpa
```

- It takes in three arguments (plus **`self`**) and initializes our data members with them

Using a Constructor

- To use our constructor:
  - Use the class name with `()` notation
  - Pass in the arguments it needs
  - Assign the results to a variable

```
test1 = student("Jane", 22, 3.2)
```

- Creates a new **`student`** object called **`test1`**

Constructor Code Trace

- What happens when we call a constructor?

```
def main():
    test1 = student("Jane", 22, 3.2)
```

```
def __init__(self, name, age, gpa):
    self.name = name
    self.age = age
    self.gpa = gpa
```

Constructor Code Trace

- What happens when we call a constructor?

```
def main():
    test1 = student("Jane", 22, 3.2)
```

```
name = "Jane"
age = 22
gpa = 3.2
```

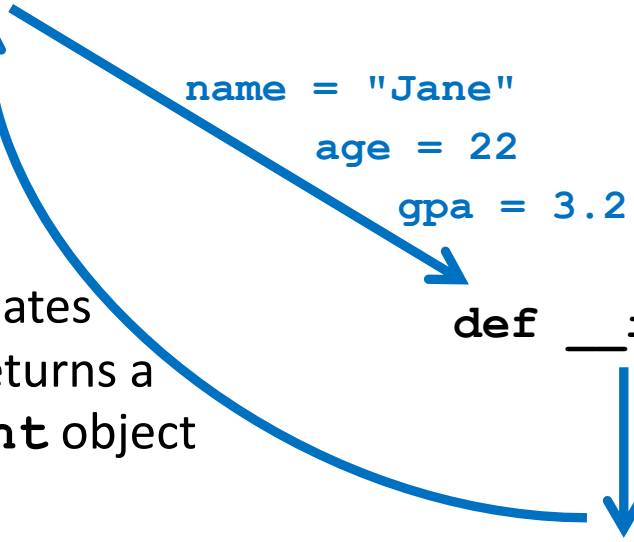
```
def __init__(self, name, age, gpa):
    self.name = name
    self.age = age
    self.gpa = gpa
```

name:	"Jane"
age:	22
gpa:	3.2

Constructor Code Trace

- What happens when we call a constructor?

```
def main():
    test1 = student("Jane", 22, 3.2)
```



Notice that all of the local variables in **`__init__`** disappeared!

The `self` Variable

- The **`self`** variable is the first parameter of every single class method – we must use it!
  - But we **don't** explicitly pass it in
  - Python implicitly passes it in (for us!)

- Calling the constructor:

```
test1 = student("Jane", 22, 3.2)
```

- The constructor definition:

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

The `self` Variable

- The **`self`** variable is how we refer to the current instance of the class
- In **`__init__`**, **`self`** refers to the object that is currently being created

- In other methods, **`self`** refers to the instance the method was called on

Deleting an Instance

- Some languages expect you to delete instances of a class after you are done with them
  - Python is not one of those languages
- Python has automatic "garbage collection"
  - It automatically detects when all of the references to a piece of memory have gone out of scope
  - Generally works pretty well

Attributes

Attributes

- There are two types of attributes:

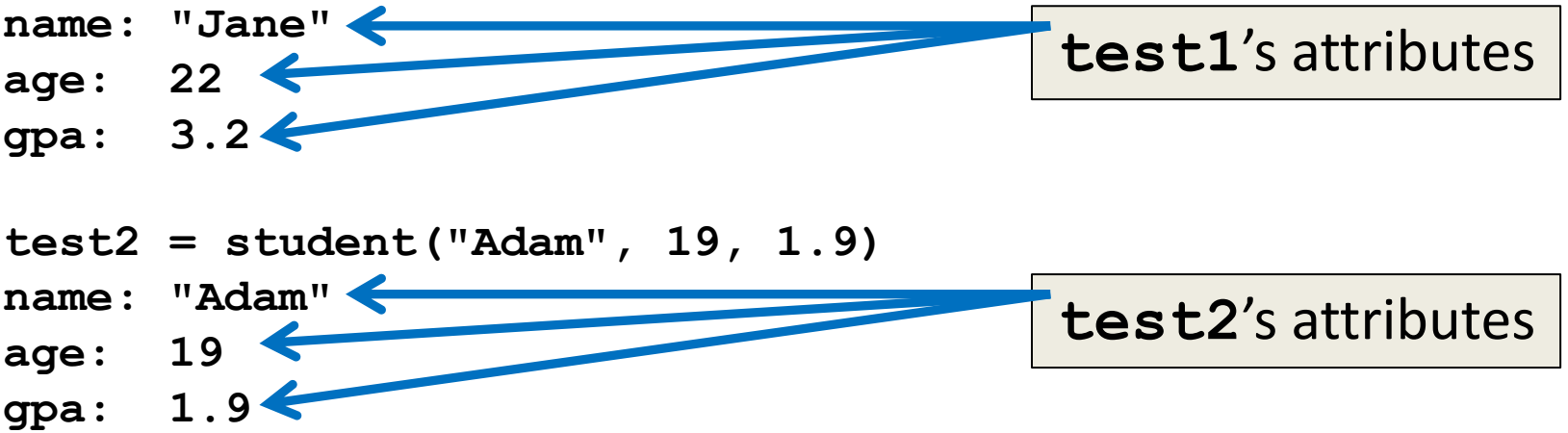
1. Data attributes
   – Also called instance variables
2. Class attributes
   – Also called class variables

Data Attributes

- ***Data attributes***
  - Variables are owned by a particular instance
  - Each instance has its own value for each attribute

```
test1 = student("Jane", 22, 3.2)
name:  "Jane"
age:   22
gpa:   3.2

test2 = student("Adam", 19, 1.9)
name:  "Adam"
age:   19
gpa:   1.9
```



Data Attributes

- Data attributes are created and initialized by the class's **`__init__`** method

- Inside the class, data attributes must have "**`self.`**" appended to the front of them

```
def setAge(self, age):
        if age > 0:
            self.age = age
        else:
            self.age = 1
```

Class Attributes

- ***Class attributes*** are owned by the whole class
- All instances share the same value for it
  - When any instance of the class changes it, it changes for all instances of the class
- Class attributes are often used for:
  - Class-wide constants
  - Counting how many instances of a class exist

Class Attributes

- Class attributes must be defined within the class definition, but outside any methods

```
class student:
    MAX_ID_LENGTH = 4    # constant
    numStudents = 0      # counter

    def __init__(self, name, age, gpa):
        # __init__ method definition...

    # rest of class definition
```

Class Attributes

- Since there is one of these attributes per class and not one per instance, they're accessed via a different notation:

```
self.__class__.name
```

  - Use the actual keyword "**`class`**"
  - This is the safest way to access these attributes

```
def increment(self):
    self.__class__.numStudents += 1
```

Data vs. Class Attributes Example

```
class counter:
    # class attribute
    overall_total = 0

    def __init__(self):
        # data attribute
        self.my_total = 0

    def increment(self):
        self.my_total += 1
        self.__class__.overall_total += 1
```

Data vs. Class Attributes Example

```
one = counter()
two = counter()
one.increment()
two.increment()
two.increment()
print("one's total", one.my_total)
print("class total", one.__class__.overall_total)
print("two's total", two.my_total)
print("class total", two.__class__.overall_total)
```

```
one's total 1
class total 3
two's total 2
class total 3
```

Special Built-In Methods

Built-In Methods

- Python automatically includes many methods that are available to every class
  - Even if you don't explicitly define them
- These methods define functionality triggered by special operators or usage of that class
- All built-in methods have double underscores around their name: **`__init__`**

Special Methods

- Here are some special methods and their uses:

`__init__`

  - The constructor for the class
  - Often initializes the data members

`__repr__`

  - Defining how to "turn" an instance into a string
  - Used whenever we call **`print()`** with an instance

More Special Methods

- There are additional special methods, including ones that let you define how these work:
  - Comparison
  - Assignment
  - Copying
  - **`len()`**
  - Using `[]` notation like a list
  - Using `()` notation like a function

Special Built-In Attributes

Built-In Attributes

- Python also has special attributes that exist for all classes

`__class__`

  - Gives a reference to the class from any instance
  - We already use this for accessing class attributes

`__module__`

  - Gives a reference to the module it's defined in

The `__doc__` Attribute

- We can also use documentation strings in our class, and access them using `__doc__`
- To add documentation, use 3 double quotes

```
class student:
    """This is a class for a student"""
    MAX_ID_LENGTH = 4
    numStudents = 0

    def __init__(self, name, age, gpa):
        """Constructor for a student""“
        # constructor definition...
```

The `__doc__` Attribute

- To access the documentation, use `__doc__`

```
test1 = student("Jane", 22, 3.2)

print(test1.__doc__)
print(test1.__init__.__doc__)
```

```
This is a class for a student
Constructor for a student
```

The `dir()` Function

- If you want a list of all the available attributes and methods, you can call the **`dir()`** function on any instance of the class:

```
dir(testStudent)
```

```
['MAX_ID_LENGTH', '__class__', '__delattr__', '__dict__',
'__dir__', '__doc__', '__eq__', '__format__', '__ge__',
'__getattribute__', '__gt__', '__hash__', '__init__',
'__le__', '__lt__', '__module__', '__ne__', '__new__',
'__reduce__', '__reduce_ex__', '__repr__', '__setattr__',
'__sizeof__', '__str__', '__subclasshook__', '__weakref__',
'age', 'checkGraduate', 'getNumStudents', 'gpa', 'idNum',
'increment', 'name', 'numStudents', 'printStudent', 'setAge',
'setIDNum']
```

If we have time…

LIVECODING!!!

Any Other Questions?

Announcements

- Midterm Survey (on Blackboard)
  - Due by Friday, November 6th at 8:59:59 PM
- Project 1 is out
  - Due by Tuesday, November 17th at 8:59:59 PM
  - Do NOT procrastinate!
- Next Class: Inheritance