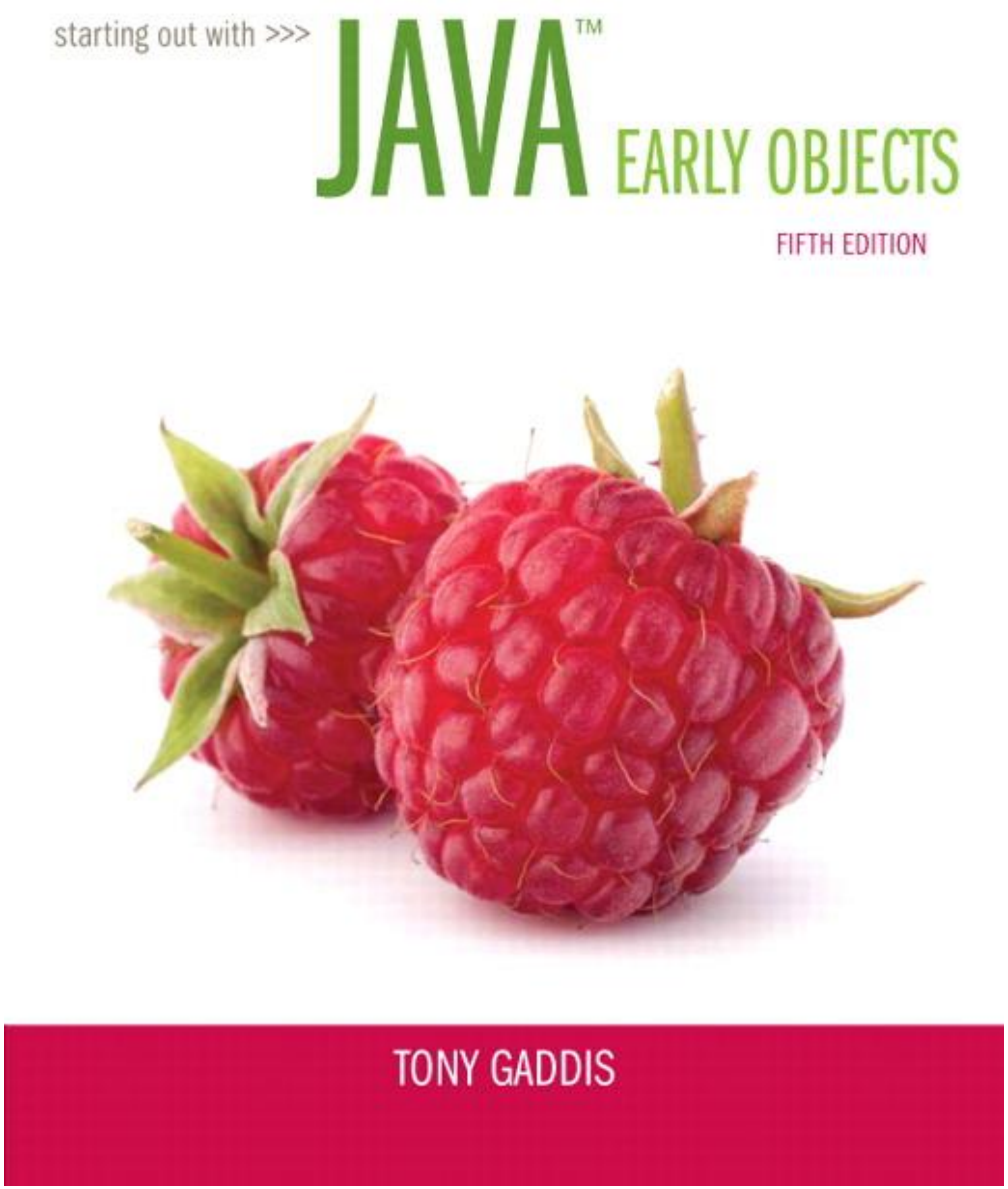
CHAPTER 6

A Second Look at Classes and Objects



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Topics

- Static Class Members
- Overloaded Methods
- Overloaded Constructors
- Passing Objects as Arguments to Methods
- Returning Objects from Methods
- The `toString` method
- Writing an `equals` method

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Topics (cont’d)

- Methods that copy objects
- Aggregation
- The `this` Reference Variable
- Inner Classes
- Enumerated types
- Garbage Collection
- Object collaboration

Review of Instance Fields and Methods

- **Each instance of a class has its own copy of instance variables.**
  - Example:
    - The `Rectangle` class defines a `length` and a `width` field.
    - Each instance of the `Rectangle` class can have different values stored in its `length` and `width` fields.
- **Instance methods require that an instance of a class be created in order to be used.**
- **Instance methods typically interact with instance fields or calculate values based on those fields.**

Static Class Members

- ***Static fields*** **and** ***static methods*** **do not belong to a single instance of a class.**
- **To invoke a static method or use a static field, the class name, rather than the instance name, is used.**
- **Example:**

```
double val = Math.sqrt(25.0);
```

Class name

Static method

Static Fields

- **Class fields are declared using the `static` keyword between the access specifier and the field type.**

```
private static int instanceCount = 0;
```

- **The field is initialized to 0 only once, regardless of the number of times the class is instantiated.**
  - Primitive static fields are initialized to 0 if no initialization is performed.

- **Examples: Countable.java, StaticDemo.java**

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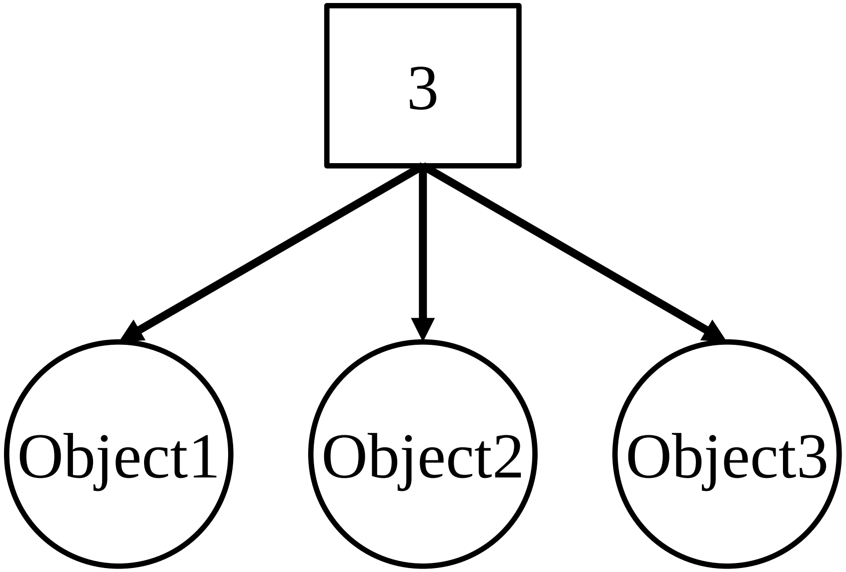
Static Fields

`instanceCount` field
(static)



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Object1

Object2

Object3

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Static Methods

- Methods can also be declared static by placing the `static` keyword between the access modifier and the return type of the method.

```
public static double milesToKilometers(double miles)
{…}
```

- When a class contains a static method, it is not necessary to create an instance of the class in order to use the method.

```
double kilosPerMile = Metric.milesToKilometers(1.0);
```

- Examples: Metric.java, MetricDemo.java

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Static Methods

- Static methods are convenient because they may be called at the class level.
- They are typically used to create utility classes, such as the `Math` class in the Java Standard Library.
- Static methods may not communicate with instance fields, only static fields.

Overloaded Methods

- Two or more methods in a class may have the same name; however, their parameter lists must be different.

```
public class MyMath{
   public static int square(int number){
      return number * number;
   }
   public static double square(double number){
      return number * number;
   }
}
```

- Example: OverloadingDemo.java

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Overloaded Methods

- Java uses the method signature (name, type of parameters and order of parameters) to determine which method to call.
- This process is known as *binding*.
- The return type of the method is not part of the method signature.
- Example: Pay.java, WeeklyPay.java

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Overloaded Constructors

- Class constructors are also methods.
- This means that they can also be overloaded.
- Overloading constructors gives programmers more than one way to construct an object of that class.
- All of the previous restrictions on overloading apply to constructors as well.
- Example: Rectangle.java, TwoRectangles.java

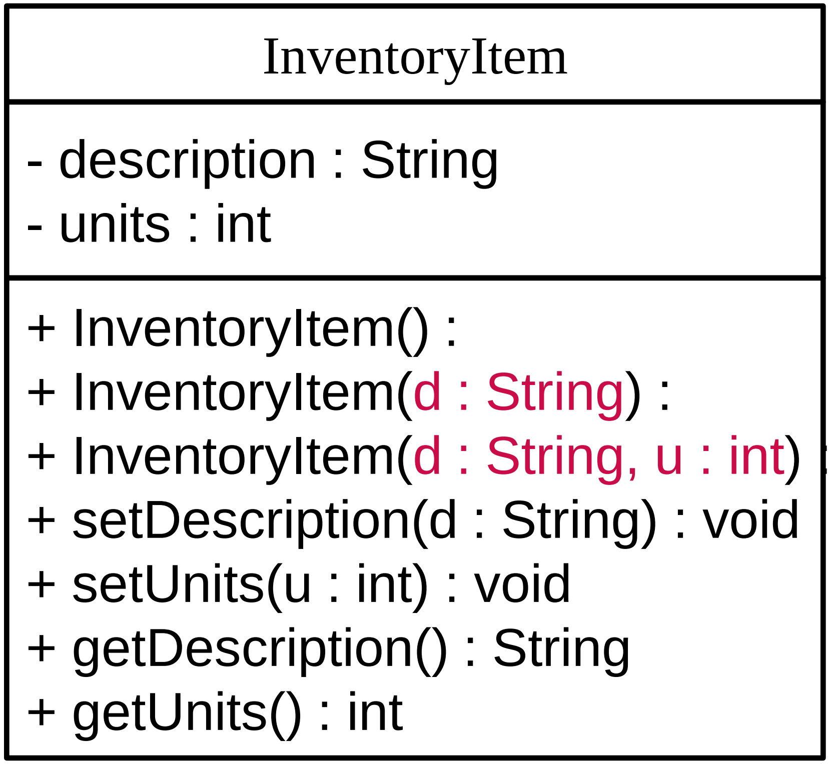
Revisiting The Default Constructor

- **Java automatically provides a default constructor for a class if a constructor is not explicitly written.**
- **The default constructor provided by Java:**
  - sets all numeric instance fields to 0
  - sets all char instance fields to ' ' (empty char)
  - sets all reference instance fields to null
  - sets all boolean instance fields to false

Revisiting The Default Constructor

- **We, as programmers, can provide a *no-arg* constructor. This is a constructor that accepts no arguments.**
- **If a constructor that accepts arguments is written, we should also write a no-arg constructor.**
- **If we write a no-arg constructor, we should provide the initialization of all instance fields.**

Revisiting The Default Constructor



InventoryItem

- description : String
- units : int

+ InventoryItem() :
+ InventoryItem(d : String) :
+ InventoryItem(d : String, u : int) :
+ setDescription(d : String) : void
+ setUnits(u : int) : void
+ getDescription() : String
+ getUnits() : int

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Passing Objects as Arguments

- **Objects can be passed to methods as arguments.**
- **Java passes all arguments *by value*.**
- **When an object is passed as an argument, the value of the reference variable is passed.**
- **The value of the reference variable is an address or reference to the object in memory.**
- **A *copy* of the object is *not passed*, just a pointer to the object.**
- **When a method receives a reference variable as an argument, it is possible for the method to modify the contents of the object referenced by the variable.**
- **Example: Dealer.java, Player.java, ChoHan.java**

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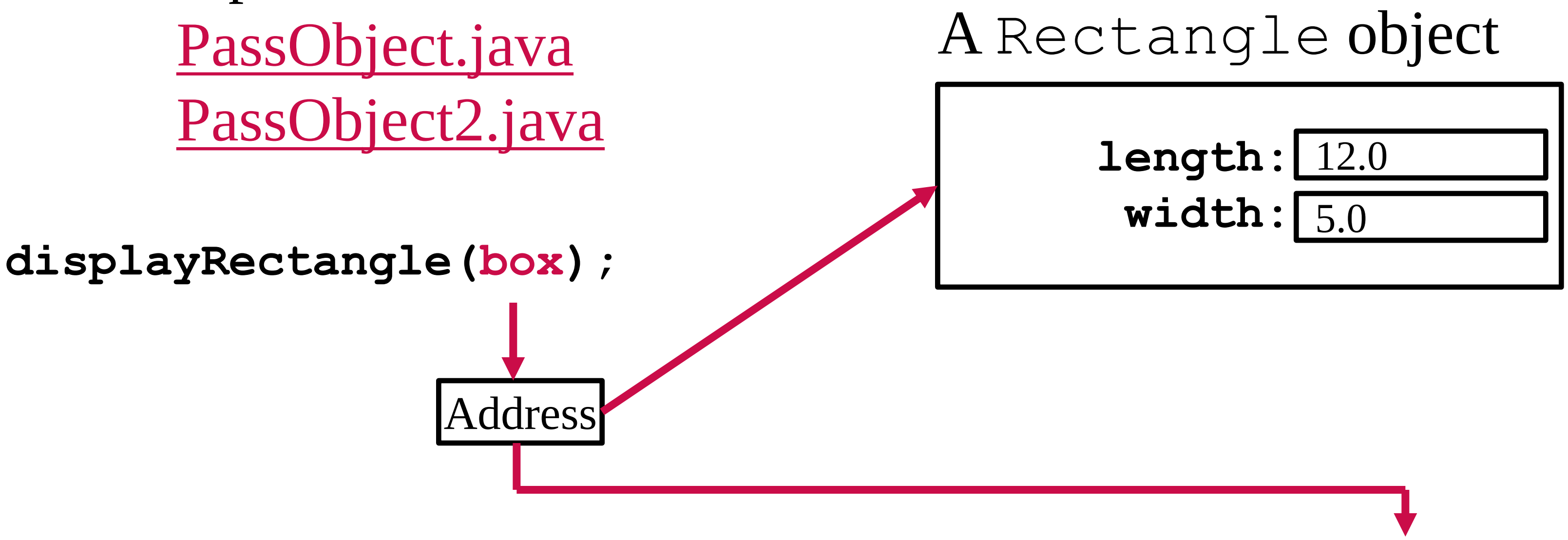
Passing Objects as Arguments

Examples:

PassObject.java

PassObject2.java



A Rectangle object

length: 12.0

width: 5.0

displayRectangle(box);

Address

```
public static void displayRectangle(Rectangle r)
{
   // Display the length and width.
   System.out.println("Length: " + r.getLength() +
                      " Width: " + r.getWidth());
}
```

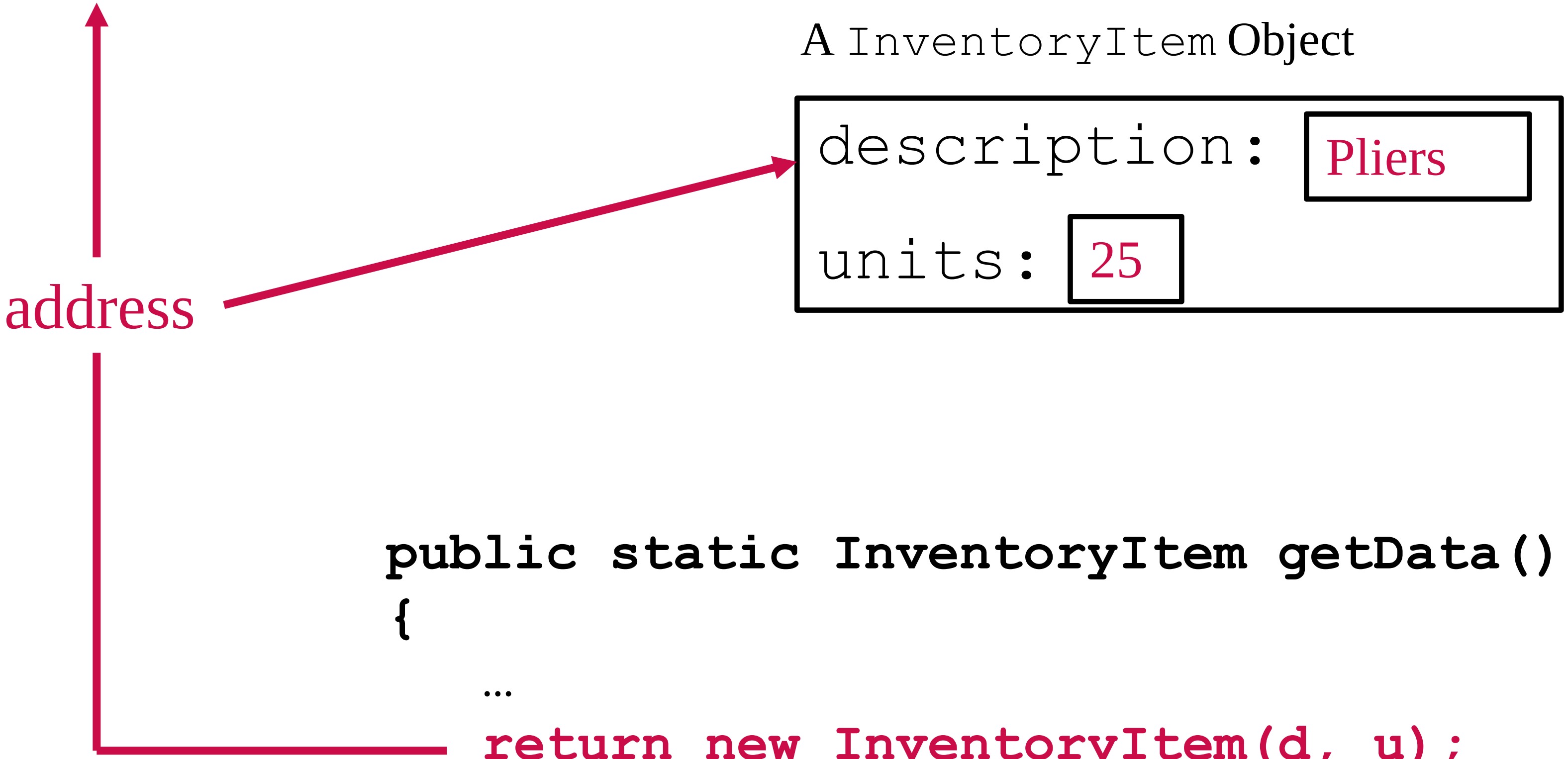
Returning References From Methods

- Methods are not limited to returning the primitive data types.
- Methods can return references to objects as well.
- Just as with passing parameters, a copy of the object is not returned, only its address.
- Example: ReturnObject.java
- Method return type:

```
public static InventoryItem getData()
{
    …
    return new InventoryItem(d, u);
}
```

Returning Objects from Methods

```
item = getData();
```



A InventoryItem Object

description: Pliers

units: 25

address

```
public static InventoryItem getData()
{
    …
    return new InventoryItem(d, u);
}
```

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The `toString` Method

- **The `toString` method of a class can be called *explicitly*:**

```
Stock xyzCompany = new Stock ("XYZ", 9.62);
System.out.println(xyzCompany.toString());
```

- **However, the `toString` method does not have to be called explicitly but is called implicitly whenever you pass an object of the class to `println` or `print`.**

```
Stock xyzCompany = new Stock ("XYZ", 9.62);
System.out.println(xyzCompany);
```

The toString method

- The toString method is also called implicitly whenever you concatenate an object of the class with a string.

```
Stock xyzCompany = new Stock ("XYZ", 9.62);
System.out.println("The stock data is:\n" +
                   xyzCompany);
```

The `toString` Method

- All objects have a `toString` method that returns the class name and a hash of the memory address of the object.
- We can override the default method with our own to print out more useful information.
- Examples: Stock.java, StockDemo1.java

The `equals` Method

- When the == operator is used with reference variables, the memory address of the objects are compared.
- The contents of the objects are not compared.
- All objects have an `equals` method.
- The default operation of the `equals` method is to compare memory addresses of the objects (just like the == operator).

The `equals` Method

- The `Stock` class has an `equals` method.
- If we try the following:

```
Stock stock1 = new Stock("GMX", 55.3);
Stock stock2 = new Stock("GMX", 55.3);
if (stock1 == stock2) // This is a mistake!
  System.out.println("The objects are the same.");
else
  System.out.println("The objects are not the same.");
```

only the addresses of the objects are compared

The equals Method

- Compare objects by their contents rather than by their memory addresses.
- Instead of simply using the == operator to compare two Stock objects, we should use the equals method.

```
public boolean equals(Stock object2)
{
  boolean status;
  if(symbol.equals(Object2.symbol) &&
     sharePrice == Object2.sharePrice)
       status = true;
  else
       status = false;
  return status;
}
```

- See example: StockCompare.java

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Methods That Copy Objects

- **There are two ways to copy an object.**
  - You cannot use the assignment operator to copy reference types
  - Reference only copy
    - This is simply copying the address of an object into another reference variable.
  - Deep copy (correct)
    - This involves creating a new instance of the class and copying the values from one object into the new object.
  - Example: ObjectCopy.java

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Copy Constructors

- A copy constructor accepts an existing object of the same class and clones it.

```
public Stock(Stock object 2)
{
    symbol = object2.symbol;
    sharePrice = object2.sharePrice;
}

// Create a Stock object
Stock company1 = new Stock("XYZ", 9.62);
//Create company2, a copy of company1
Stock company2 = new Stock(company1);
```

Aggregation

- **Creating an instance of one class as a reference in another class is called *object aggregation*.**
- **Aggregation creates a "has a" relationship between objects.**
- **Examples:**
  - Instructor.java, Textbook.java, Course.java, CourseDemo.java

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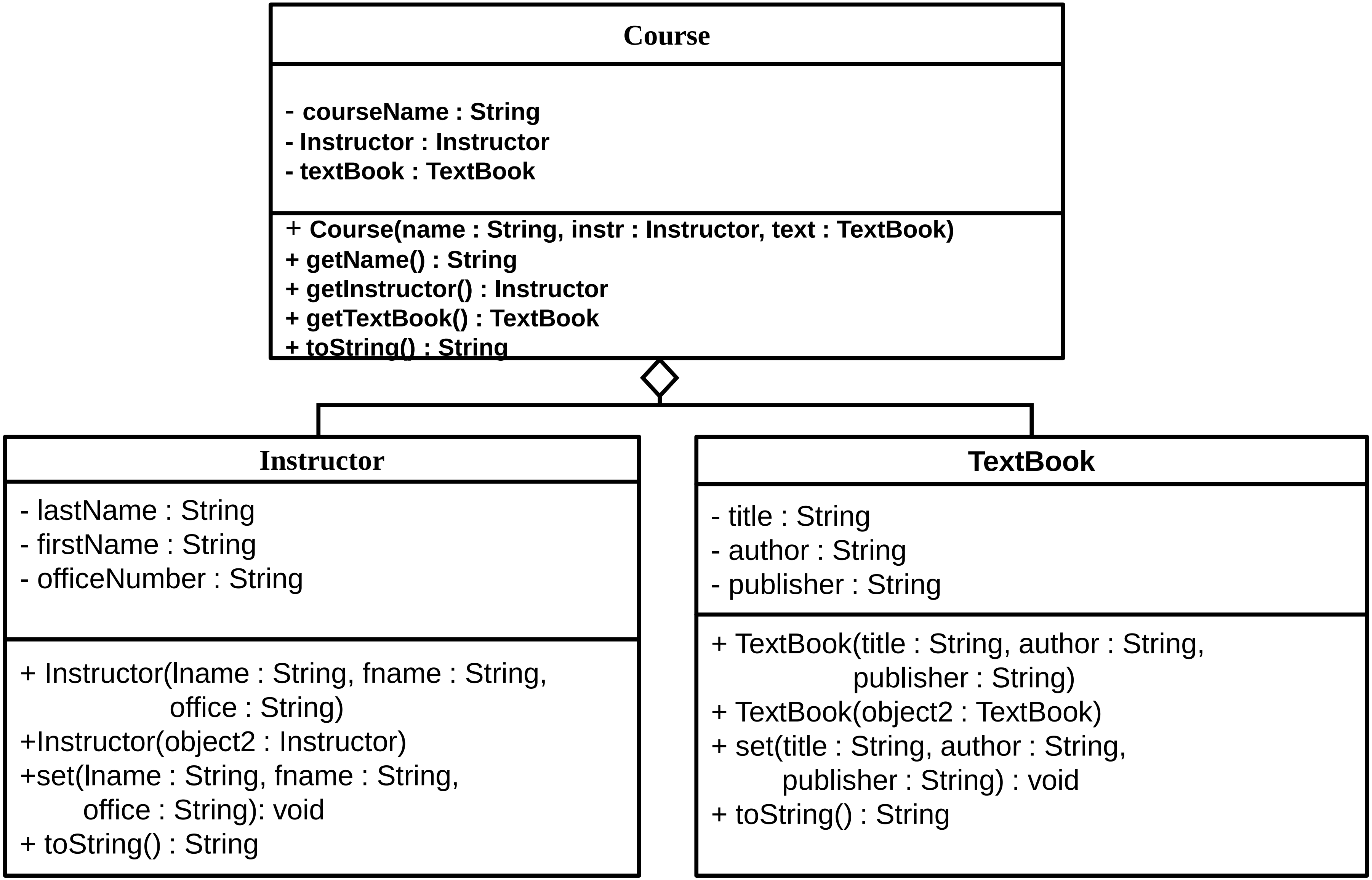
Aggregation in UML Diagrams



Course

- courseName : String
- Instructor : Instructor
- textBook : TextBook

+ Course(name : String, instr : Instructor, text : TextBook)
+ getName() : String
+ getInstructor() : Instructor
+ getTextBook() : TextBook
+ toString() : String

Instructor

- lastName : String
- firstName : String
- officeNumber : String

+ Instructor(lname : String, fname : String,
office : String)
+Instructor(object2 : Instructor)
+set(lname : String, fname : String,
office : String): void
+ toString() : String

TextBook

- title : String
- author : String
- publisher : String

+ TextBook(title : String, author : String,
publisher : String)
+ TextBook(object2 : TextBook)
+ set(title : String, author : String,
publisher : String) : void
+ toString() : String

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Returning References to Private Fields

- Avoid returning references to private data elements.
- Returning references to private variables will allow any object that receives the reference to modify the variable.

Null References

- A *null reference* is a reference variable that points to nothing.
- If a reference is null, then no operations can be performed on it.
- References can be tested to see if they point to null prior to being used.

```
if(name != null)
   System.out.println("Name is: " +
                             name.toUpperCase());
```

- Examples: FullName.java, NameTester.java

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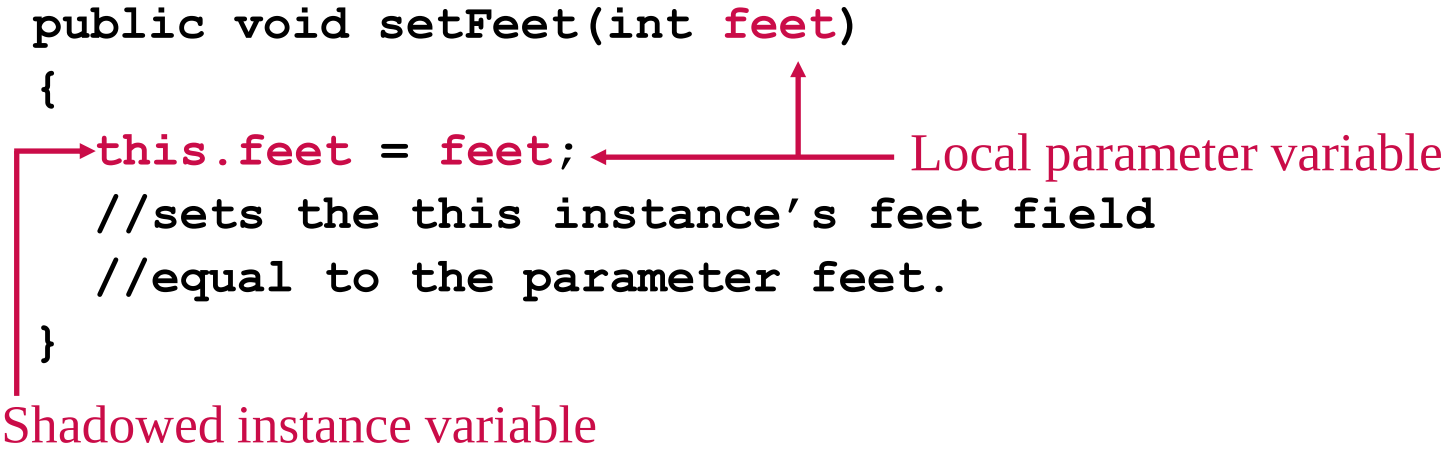
The `this` Reference

- The `this` reference is simply a name that an object can use to refer to itself.
- The `this` reference can be used to overcome shadowing and allow a parameter to have the same name as an instance field.



```
public void setFeet(int feet)
{
   this.feet = feet;
   //sets the this instance's feet field
   //equal to the parameter feet.
}
```

Local parameter variable

Shadowed instance variable

The `this` Reference

- **The `this` reference can be used to call a constructor from another constructor.**

```
public Stock(String sym)
{
   this(sym, 0.0);
}
```

  - This constructor would allow an instance of the `Stock` class to be created using only the symbol name as a parameter.
  - It calls the constructor that takes the symbol and the price, using *`sym`* as the symbol argument and 0 as the price argument.
- **Elaborate constructor chaining can be created using this technique.**
- **If `this` is used in a constructor, it must be the first statement in the constructor.**

Inner Classes

- **Classes my have other classes nested within them.**
- **These *inner classes* have unique properties.**
  - An outer class can access the public members of an inner class.
  - An inner class is not visible or accessible to code outside the outer class.
  - An inner class can access the private members of the outer class.

Inner Classes

- **Inner classes are defined inside the outer class.**
- **Compiled byte code for inner classes is stored in a separate file.**
  - The file's name consists of:
    - the name of the outer class
    - followed by a `$` character
    - followed by the name of the inner class
    - followed by `.class`

```
RetailItem$CostData.class
```

- **Example: RetailItem.java, InnerClassDemo.java**

Enumerated Types

- **Known as an `enum`**
- **Requires declaration and definition like a class**
- **Syntax:**

  `enum` ***`typeName`*** **`{`** *one or more* `enum` *constants* **`}`**

  - Definition:

    ```
    enum Day { SUNDAY, MONDAY, TUESDAY, WEDNESDAY,
               THURSDAY, FRIDAY, SATURDAY }
    ```

  - Declaration:

    ```
    Day WorkDay; // creates a Day enum
    ```

  - Assignment:

    ```
    Day WorkDay = Day.WEDNESDAY;
    ```

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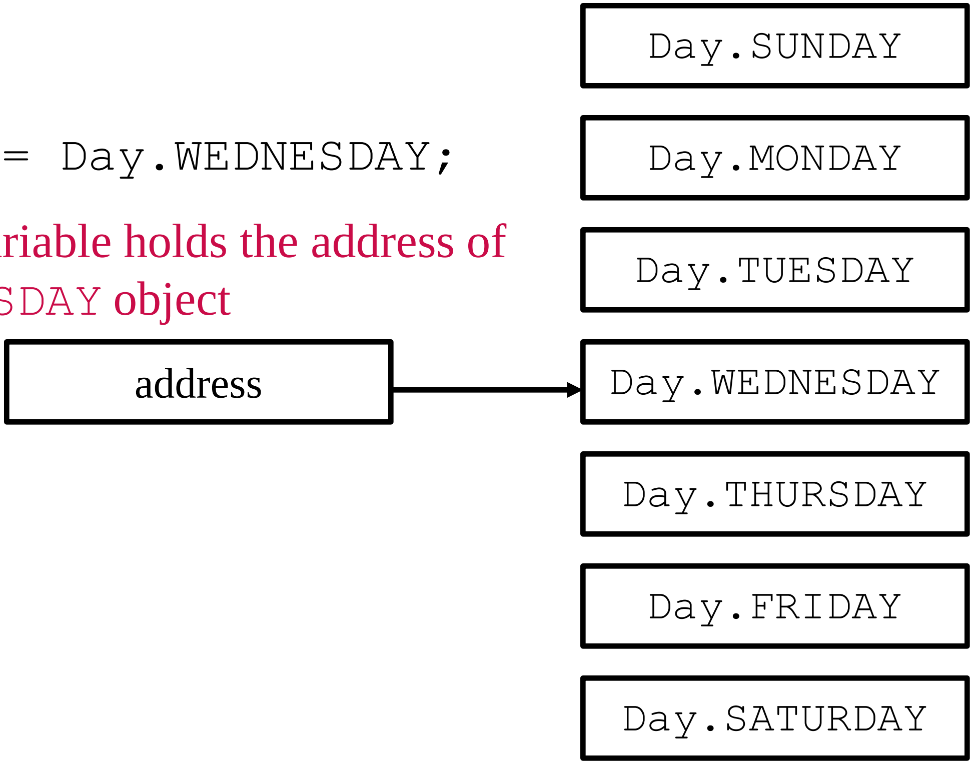
Enumerated Types

- An **`enum`** is a specialized class

Each are objects of type `Day`, a specialized class

```
Day workDay = Day.WEDNESDAY;
```

The `workDay` variable holds the address of the `Day.WEDNESDAY` object



address

Day.SUNDAY

Day.MONDAY

Day.TUESDAY

Day.WEDNESDAY

Day.THURSDAY

Day.FRIDAY

Day.SATURDAY

Enumerated Types - Methods

- **`toString` – returns name of calling constant**
- **`ordinal` – returns the zero-based position of the constant in the enum. For example the ordinal for `Day.THURSDAY` is 4**
- **`equals` – accepts an object as an argument and returns true if the argument is equal to the calling enum constant**
- **`compareTo` - accepts an object as an argument and returns a negative integer if the calling constant's ordinal < than the argument's ordinal, a positive integer if the calling constant's ordinal > than the argument's ordinal and zero if the calling constant's ordinal == the argument's ordinal.**
- **Examples:**
  - EnumDemo.java, CarType.java, SportsCar.java, SportsCarDemo.java

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Enumerated Types - Switching

- Java allows you to test an enum constant with a `switch` statement.

Example: SportsCarDemo2.java

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Garbage Collection

- When objects are no longer needed they should be destroyed.
- This frees up the memory that they consumed.
- Java handles all of the memory operations for you.
- Simply set the reference to *null* and Java will reclaim the memory.

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Garbage Collection

- The Java Virtual Machine has a process that runs in the background that reclaims memory from released objects.
- The *garbage collector* will reclaim memory from any object that no longer has a valid reference pointing to it.

```
InventoryItem item1 = new InventoryItem ("Wrench", 20);
InventoryItem item2 = item1;
```

- This sets item1 and item2 to point to the same object.

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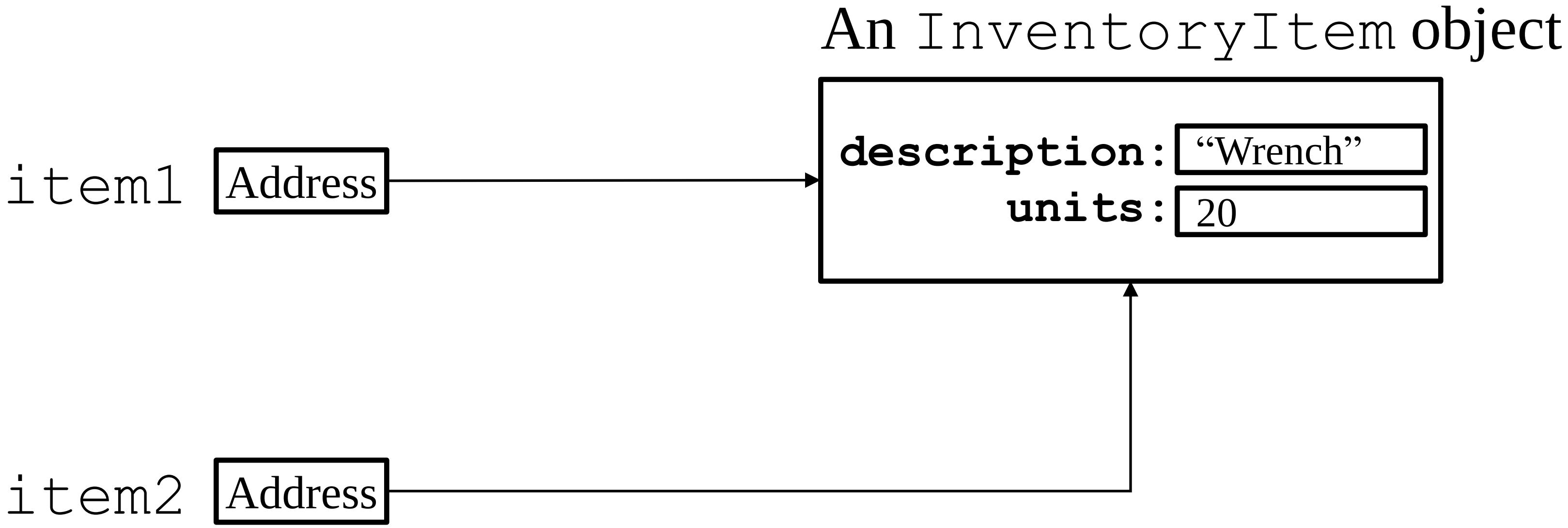
Garbage Collection



Here, both item1 and item2 point to the same instance of the InventoryItem class.

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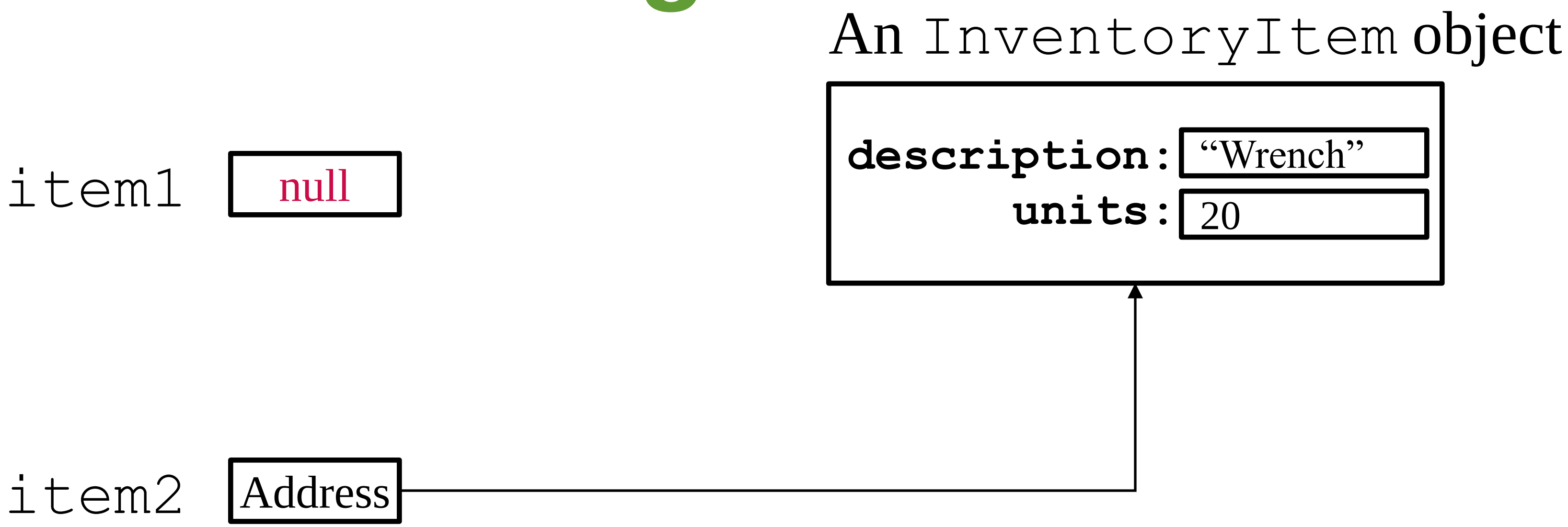
Garbage Collection



However, by running the command:

```
item1 = null;
```

only `item2` will be pointing to the object.

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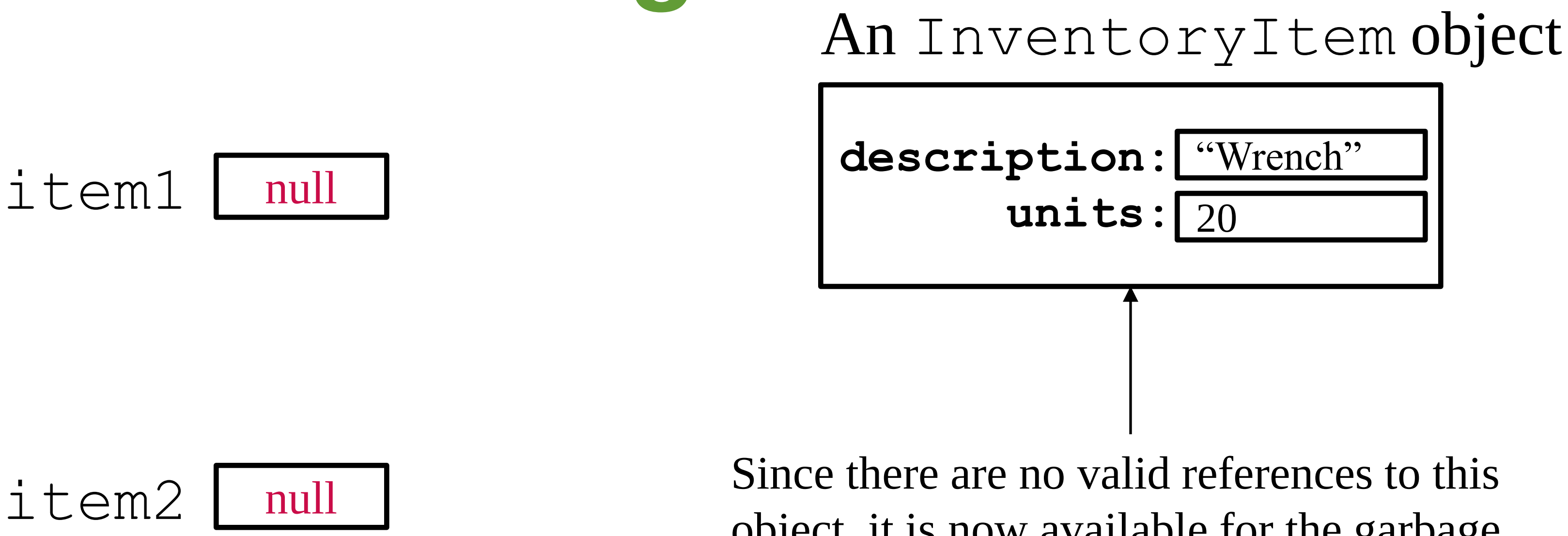
Garbage Collection



An `InventoryItem` object

item1 null

item2 null

description: “Wrench”

units: 20

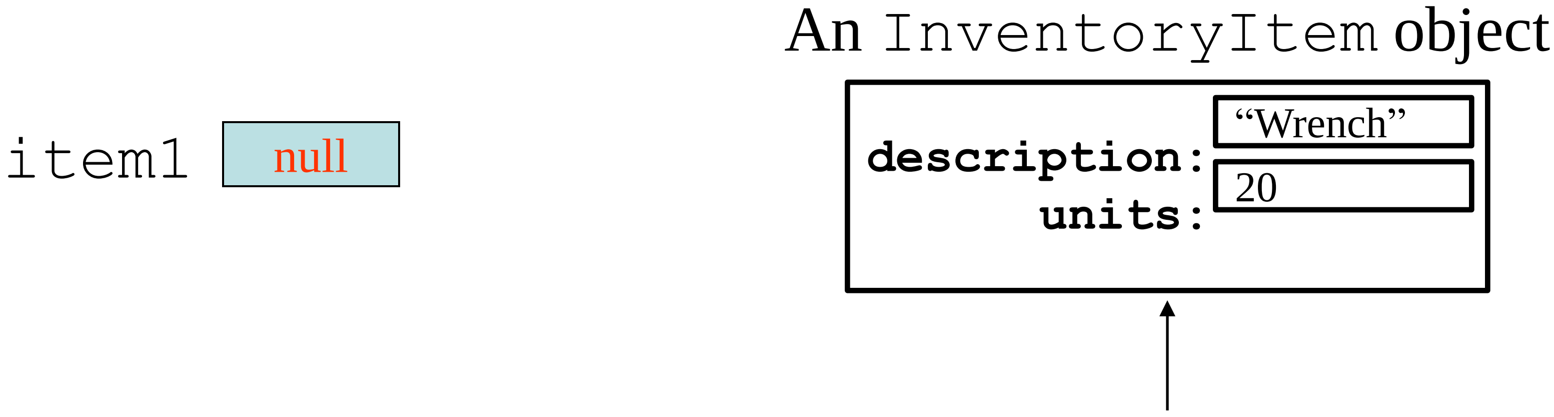
Since there are no valid references to this object, it is now available for the garbage collector to reclaim.

If we now run the command:

```
item2 = null;
```

neither `item1` or `item2` will be pointing to the object.

Garbage Collection



An `InventoryItem` object

`item1` null

`item2` null

`description:` "Wrench"

`units:` 20

The garbage collector reclaims the memory the next time it runs in the background.

The `finalize` Method

- If a method with the signature:

  ```
  public void finalize(){…}
  ```

  is included in a class, it will run just prior to the garbage collector reclaiming its memory.

- The garbage collector is a background thread that runs periodically.
- It cannot be determined when the `finalize` method will actually be run.

Class Collaboration

- Collaboration – two classes interact with each other
- If an object is to collaborate with another object, it must know something about the second object’s methods and how to call them
- If we design a class `StockPurchase` that collaborates with the `Stock` class (previously defined), we define it to create and manipulate a `Stock` object
- See examples: StockPurchase.java, StockTrader.java

CRC Cards

- Class, Responsibilities and Collaborations (CRC) cards are useful for determining and documenting a class's responsibilities
  - The things a class is responsible for knowing
  - The actions a class is responsible for doing

CRC Card Layout (Example for the `Stock` class)

Stock	
Know stock to purchase	Stock class
Know number of shares	None
Calculate cost of purchase	Stock class
Etc.	None or class name