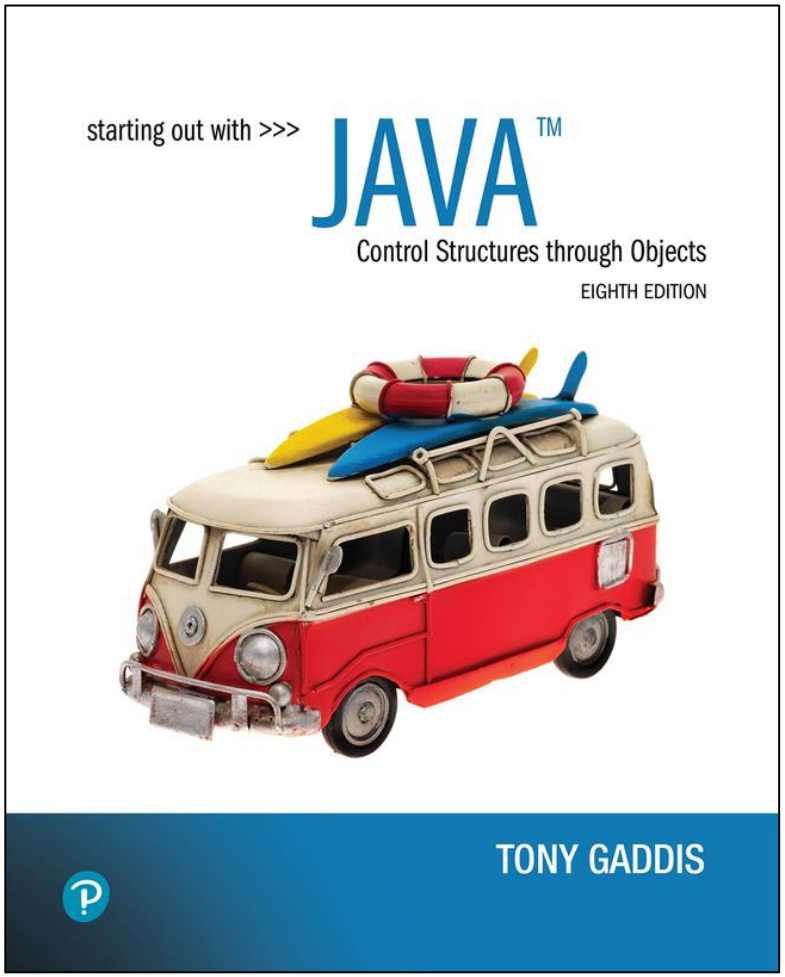
Starting Out with Java Control Structures Through Objects

Eighth Edition



Chapter 8

A Second Look At Classes and Objects

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Chapter Topics (1 of 2)

- Chapter 8 discusses the following main topics:
  - Static Class Members
  - Passing Objects as Arguments to Methods
  - Returning Objects from Methods
  - The `toString` method
  - Writing an `equals` Method
  - Methods that Copy Objects

Chapter Topics (2 of 2)

- Chapter 8 discusses the following main topics:
  - Aggregation
  - The `this` Reference Variable
  - Mutable and Immutable Classes
  - Enumerated Types
  - Garbage Collection
  - Focus on Object-Oriented Design: Class 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);
```

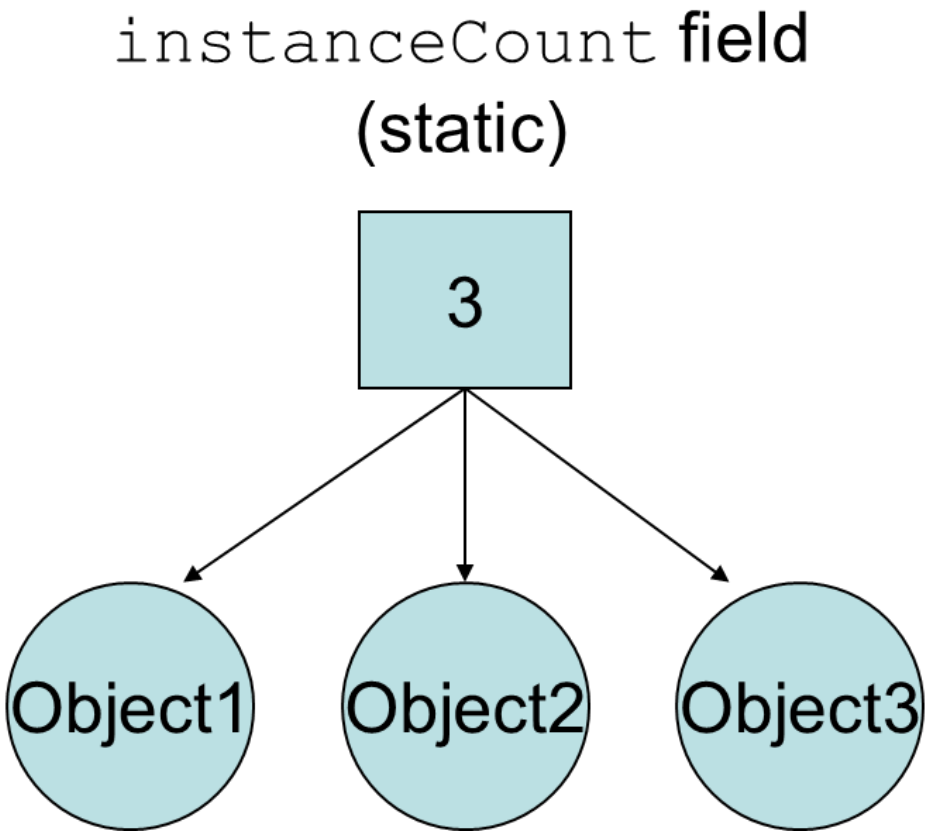
Static Fields (1 of 2)

- 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

Static Fields (2 of 2)



Static Methods (1 of 2)

- 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

Static Methods (2 of 2)

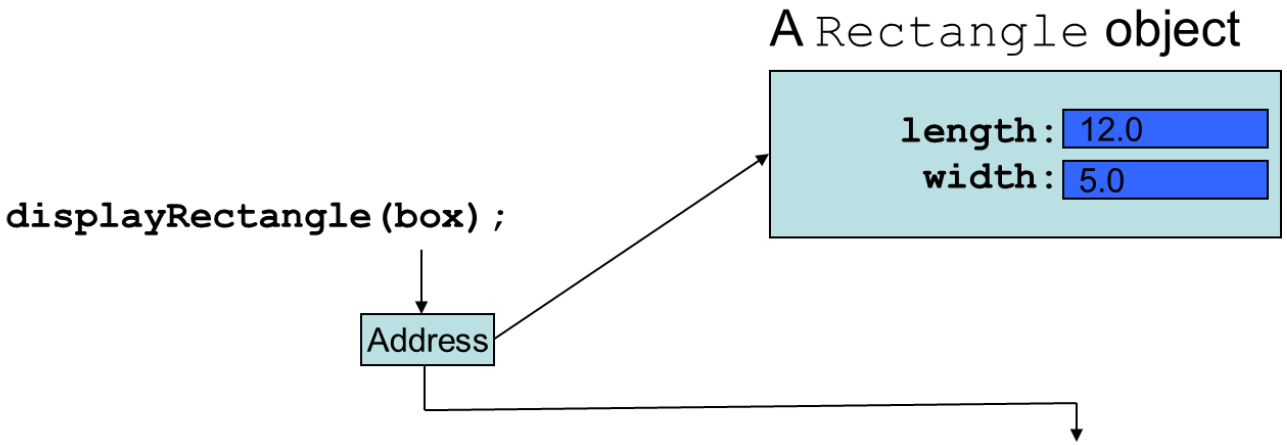
- Static methods are convenient because they may be called at the class level.
- They are typically used to create utility classes, such as the `Math` class in the Java Standard Library.
- Static methods may not communicate with instance fields, only static fields.

Passing Objects as Arguments (1 of 2)

- 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.

Passing Objects as Arguments (2 of 2)

Examples:
PassObject.java
PassObject2.java



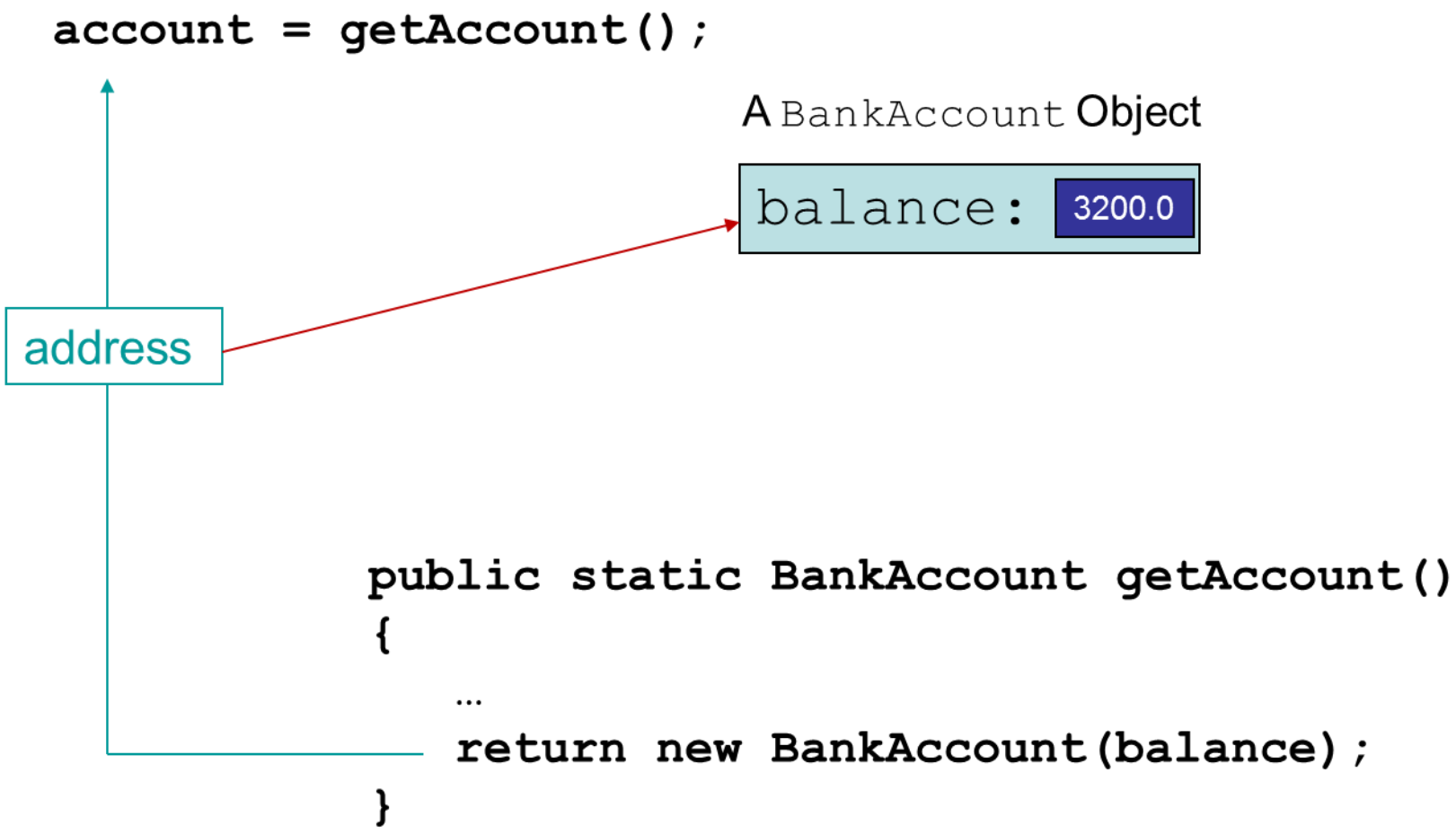

```
public static void displayRectangle(Rectangle r)
{
  // Display the length and width.
  System.out.println("Length: " + r.getLength() +
                     " Width: " + r.getWidth());
}
```

Returning Objects From Methods (1 of 2)

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

```
public static BankAccount getAccount()
{
    …
     return new BankAccount(balance);
}
```

Returning Objects From Methods (2 of 2)



The `toString` Method (1 of 3)

- 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 (2 of 3)

- 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 (3 of 3)

- 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 (1 of 3)

- 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 (2 of 3)

- 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 (3 of 3)

- Instead of 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;
}
```

- Now, objects can be compared by their contents rather than by their memory addresses.
- See example: StockCompare.java

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

Copy Constructors

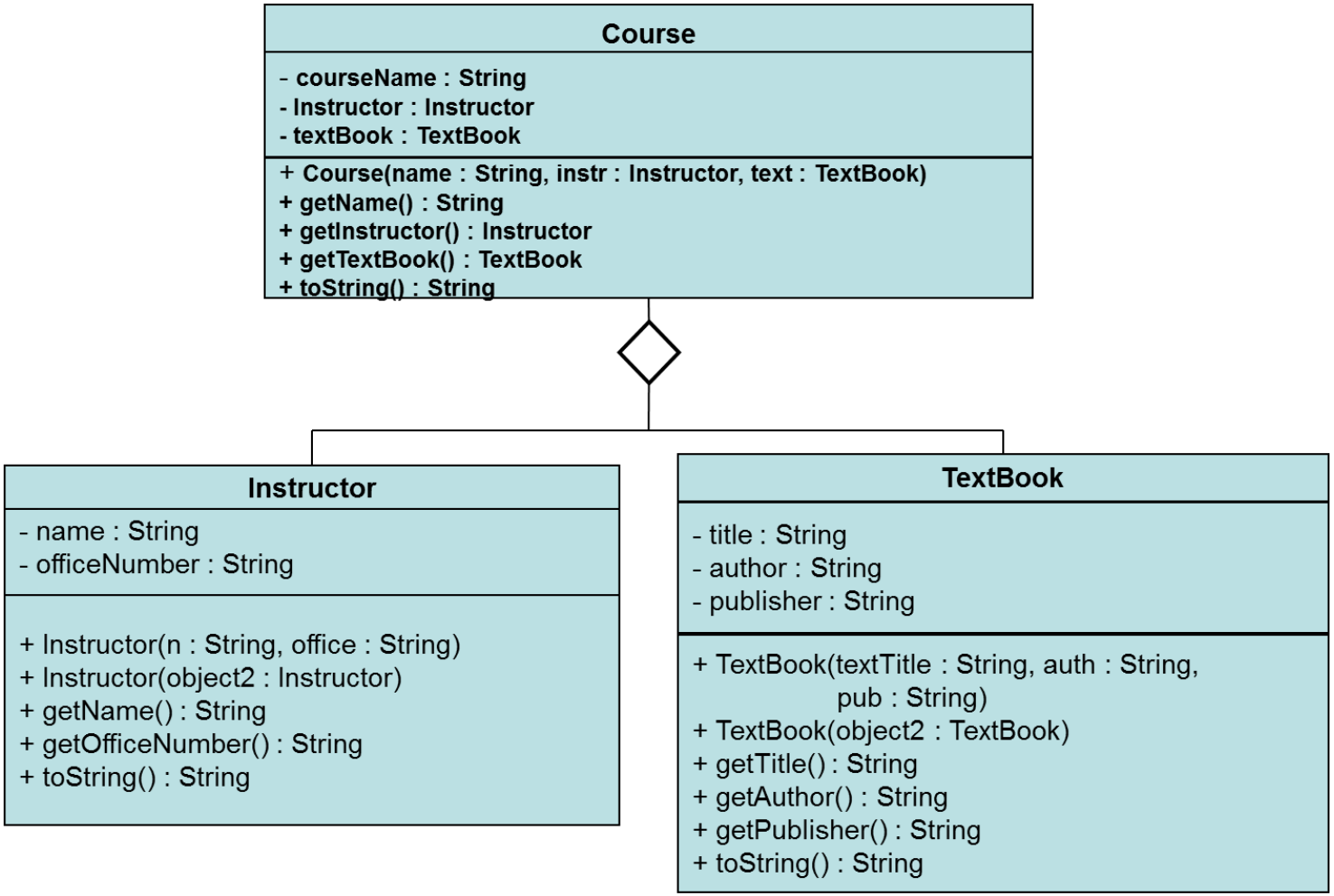
- A copy constructor accepts an existing object of the same class and clones it

```
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

Aggregation in UML Diagrams



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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

Method Chaining (1 of 4)

- When working with aggregate objects, you sometimes need to work through several layers of objects to call a method.
- Example: suppose you have a `Course` object named `course`, and you want to get the name of the course's instructor, converted to uppercase.

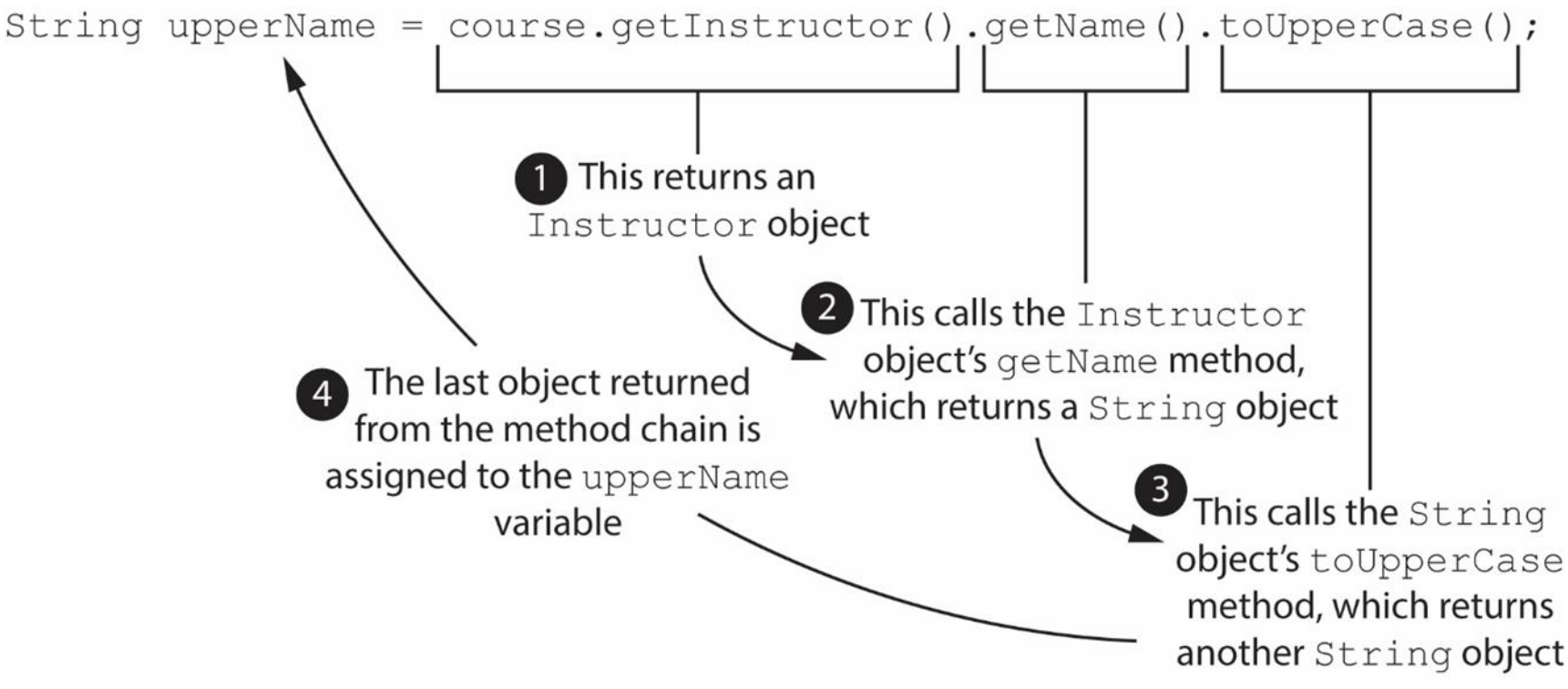
```
// Get the Instructor object.
Instructor instr = course.getInstructor();

// Get the instructor's name.
String name = instr.getName();

// Convert the name to uppercase.
String upperName = name.toUpperCase();
```

Method Chaining (2 of 4)

- The previous code requires three statements, and declares three variables.
- The code can be simplified with method chaining:

```
String upperName = course.getInstructor().getName().toUpperCase();
```

Method Chaining (3 of 4)



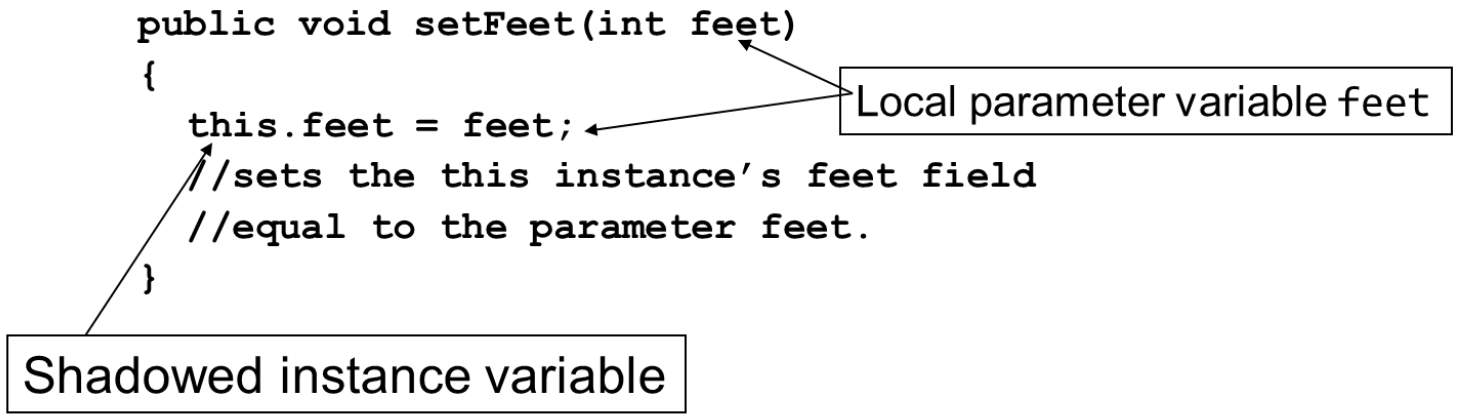
Method Chaining (4 of 4)

- To improve readability, method chain statements are commonly written across multiple lines:

```
String upperName = course.getInstructor()
                         .getName()
                         .toUpperCase();
```

The `this` Reference (1 of 2)

- 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.



The `this` Reference (2 of 2)

- 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.

Mutable and Immutable Classes (1 of 3)

- You have seen examples of classes that have mutators or other methods that change the contents of the class's fields.
- A class that allows its fields to be changed is known as a mutable class.
- A mutable object is an instance of a mutable class.

Mutable and Immutable Classes (2 of 3)

- An immutable class is a class that does not allow its fields to be changed once they are initialized with values.
- An immutable object is an instance of an immutable class.
- The internal state of an immutable object cannot be changed once the object is created.

Mutable and Immutable Classes (3 of 3)

- These are some of the benefits to using immutable classes and objects:
  - Immutable classes are simple to design and easy to understand.
  - Because the internal state of an immutable object never changes, it is easier to debug the code that uses the object.
  - You do not have to make defensive copies of immutable objects.
  - Immutable objects are safe to use in a multithreaded program.

Guidelines for Creating Immutable Classes

- The class should be declared `final` in the class header.
- All the class's field variables should be declared `private` and `final`.
- The class should have a constructor that initializes all the class's fields.
- The class cannot have mutators, or any methods that change the class's internal state.
- If the class has a field that is a mutable object, the class should not have an accessor or other method that returns a reference to that field. Instead, the method should make a deep copy of the mutable field and return a reference to the copy. Any changes that are made to the copy will not affect the original object.
- If the constructor accepts a reference to a mutable object, that reference should not be stored in a field. Instead, the constructor should make a deep copy of the mutable object and store a reference to the copy.
- Examples: Contact.java and GetContactInfo.java

Immutable Classes with Mutable Objects as Fields (1 of 3)

- A `final` reference variable cannot point to any object other than the one it is initialized with.
- An error will occur if you try to reassign a `final` reference variable to a different object.
- Although a `final` reference variable cannot be changed, the contents of the object that the variable refers to can be changed, if that object is mutable.
- Example:

```
final CellPhone mycell = new CellPhone("Motorola", "M1", 799.99);
mycell.setModel("M75");
mycell.setRetailPrice(899.99);
```

  - In this code, even though `mycell` is declared as `final`, it can still be used to change the contents of the object it refers to.

Immutable Classes with Mutable Objects as Fields (2 of 3)

- If your immutable class contains a field that refers to a mutable object, be sure not to write methods in the immutable class that return a reference to the mutable object.
- Doing so makes it possible for code outside the class to change the state of the mutable object.
- If you need to provide an accessor for the mutable object, make sure it returns a reference to a copy of the mutable object instead of the original.

Immutable Classes with Mutable Objects as Fields (3 of 3)

- If your immutable class's constructor accepts a reference to a mutable object as an argument, do not assign that reference to a field.
  - If another reference to the same object happens to exist outside the class, it's possible for code outside the class to change the state of the mutable object.
  - Instead, make a copy of the mutable object and assign the field a reference to the copy.
- Examples: City.java, Country.java, CountryData.java

Enumerated Types (1 of 2)

- 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:

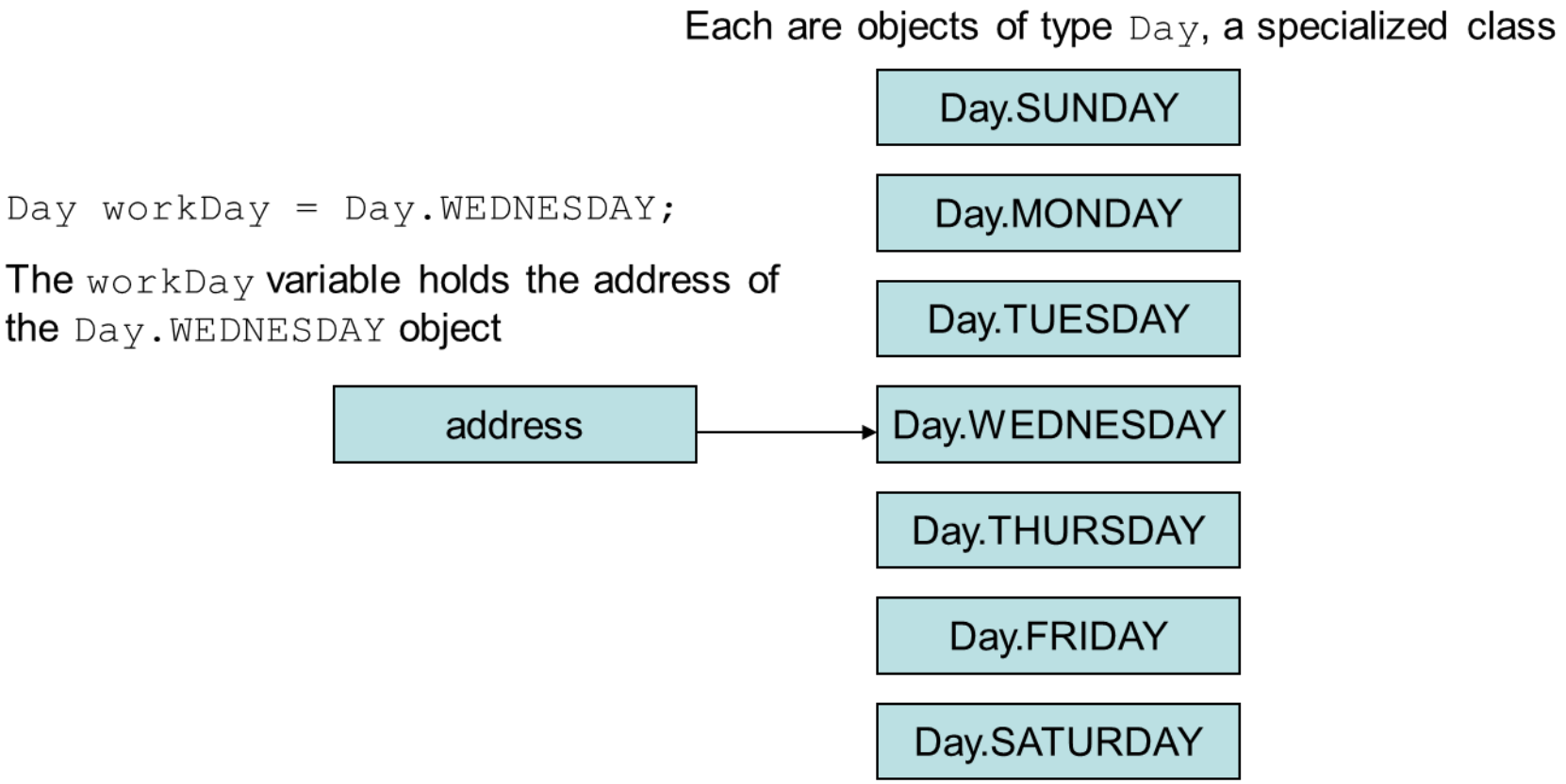
```
Day WorkDay; // creates a Day enum
```

  - Assignment:

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

Enumerated Types (2 of 2)

- An `enum` is a specialized class



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

Enumerated Types - Switching

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

Example: SportsCarDemo2.java

Garbage Collection (1 of 6)

- 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.

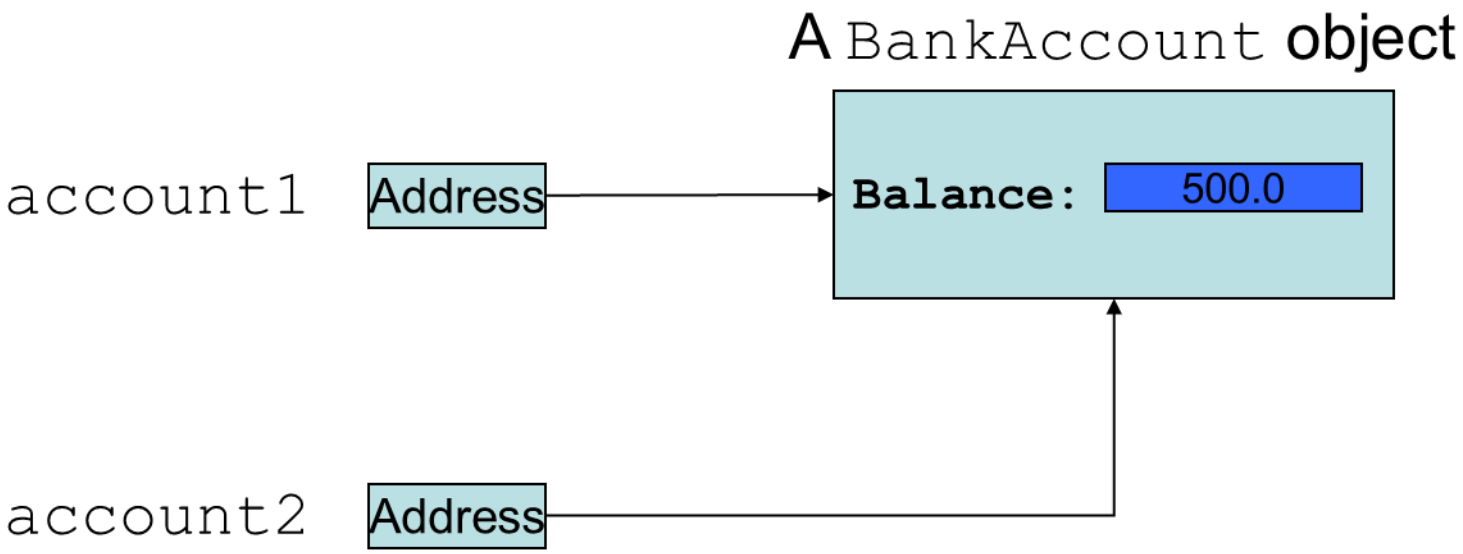
Garbage Collection (2 of 6)

- 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.

```
BankAccount account1 = new BankAccount(500.0);
BankAccount account2 = account1;
```

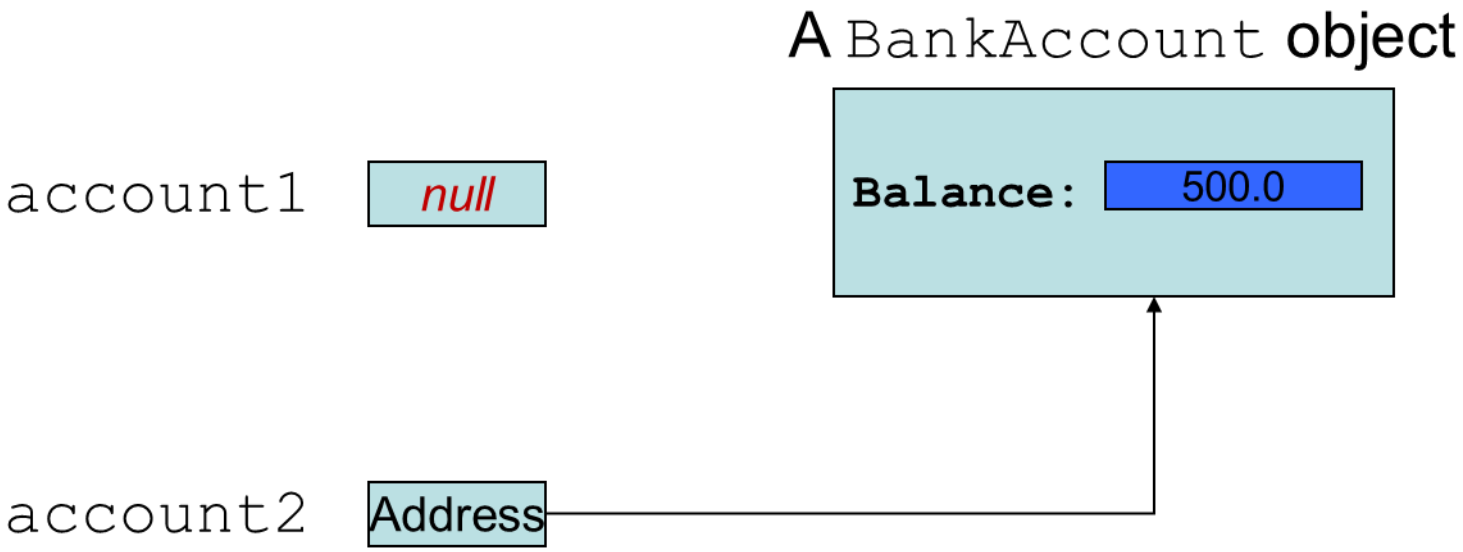
- This sets `account1` and `account2` to point to the same object.

Garbage Collection (3 of 6)



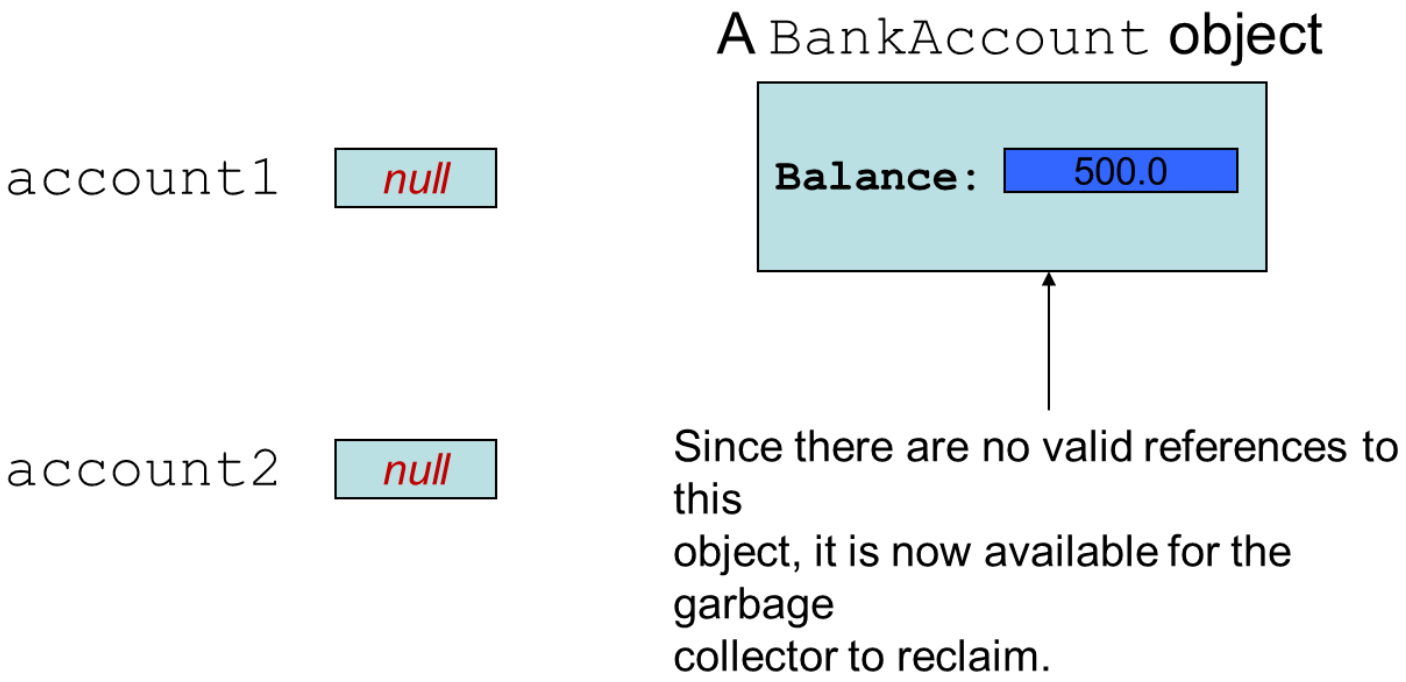
Here, both `account1` and `account2` point to the same instance of the `BankAccount` class.

Garbage Collection (4 of 6)



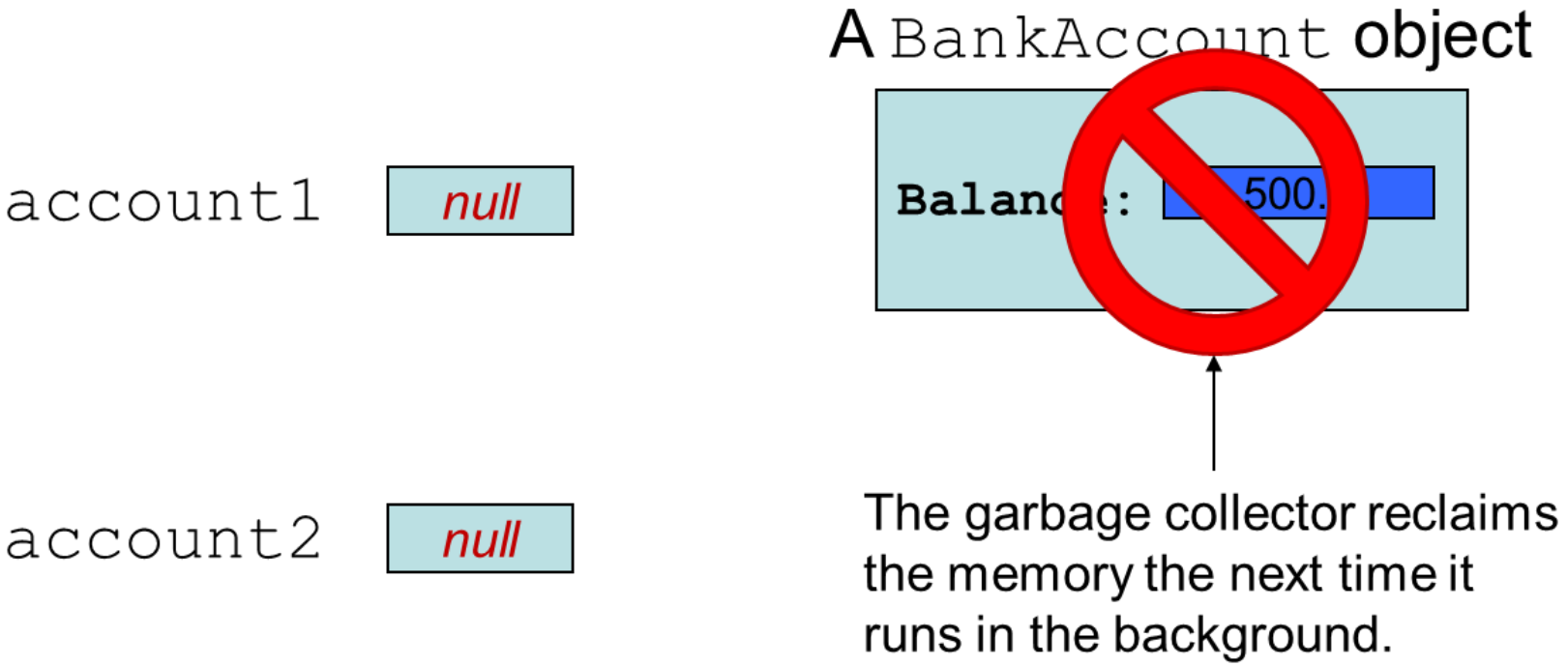
However, by running the statement: **`account1 = null;`**
only `account2` will be pointing to the object.

Garbage Collection (5 of 6)



If we now run the statement: **`account2 = null;`**
neither `account1` or `account2` will be pointing to the object.

Garbage Collection (6 of 6)



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 class Stock)

Stock

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

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