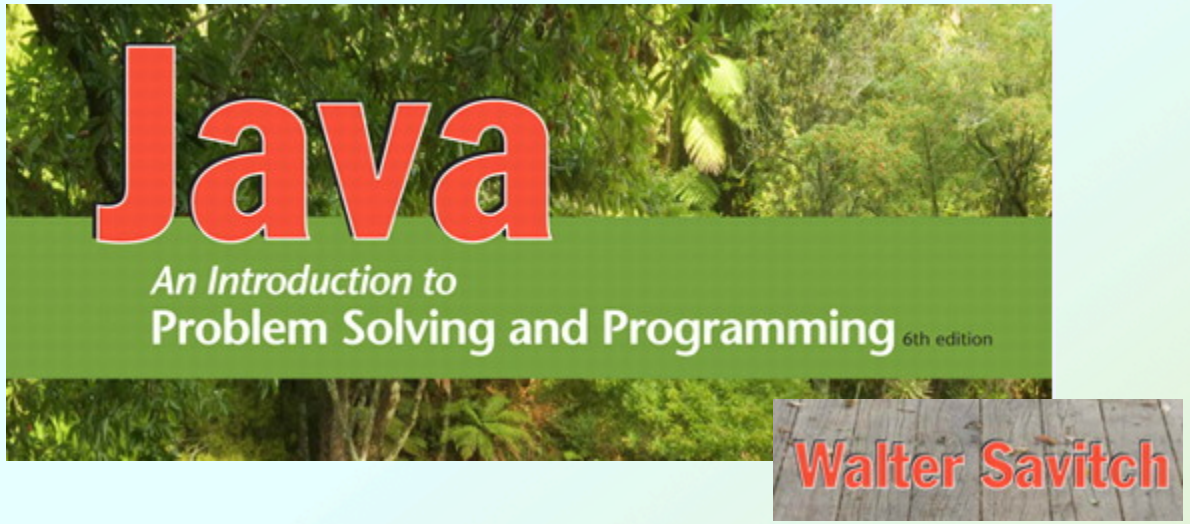


Defining Classes and Methods

Chapter 5

*JAVA: An Introduction to Problem Solving & Programming, 6*th Ed. By Walter Savitch
ISBN 0132162709

Objectives

- Describe concepts of class, class object
- Create class objects
- Define a Java class, its methods
- Describe use of parameters in a method
- Use modifiers **`public`**, **`private`**
- Define accessor, mutator class methods
- Describe information hiding, encapsulation
- Write method pre- and postconditions

Objectives

- Describe purpose of **`javadoc`**
- Draw simple UML diagrams
- Describe references, variables, parameters of a class type
- Define boolean-valued methods such as **`equals`**
- In applets use class **`Graphics`**, labels, **`init`** method

Class and Method Definitions: Outline

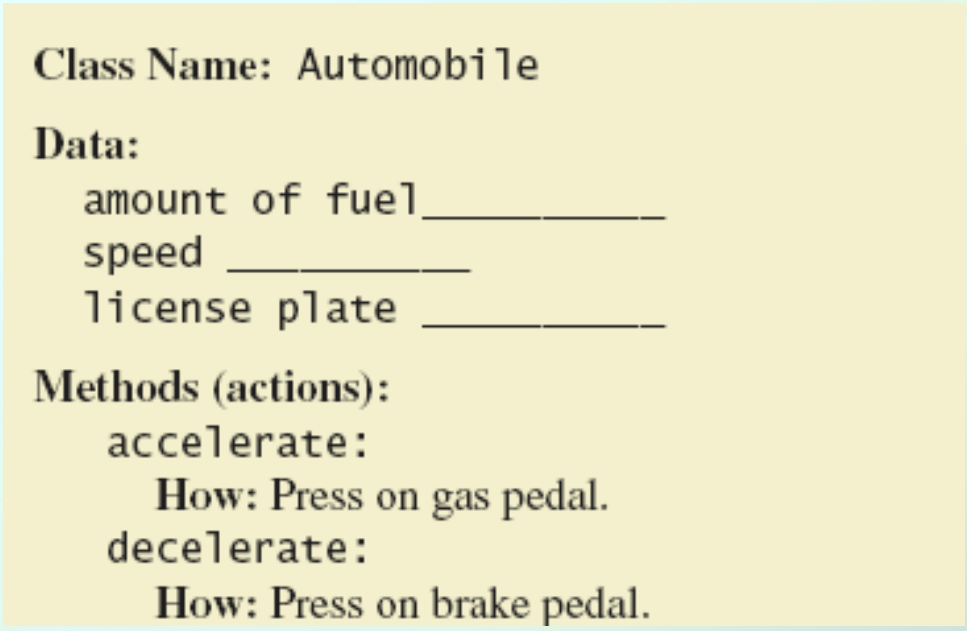
- Class Files and Separate Compilation
- Instance Variables
- Methods
- The Keyword this
- Local Variables
- Blocks
- Parameters of a Primitive Type

Class and Method Definitions

- Java program consists of objects
  - Objects of class types
  - Objects that interact with one another
- Program objects can represent
  - Objects in real world
  - Abstractions

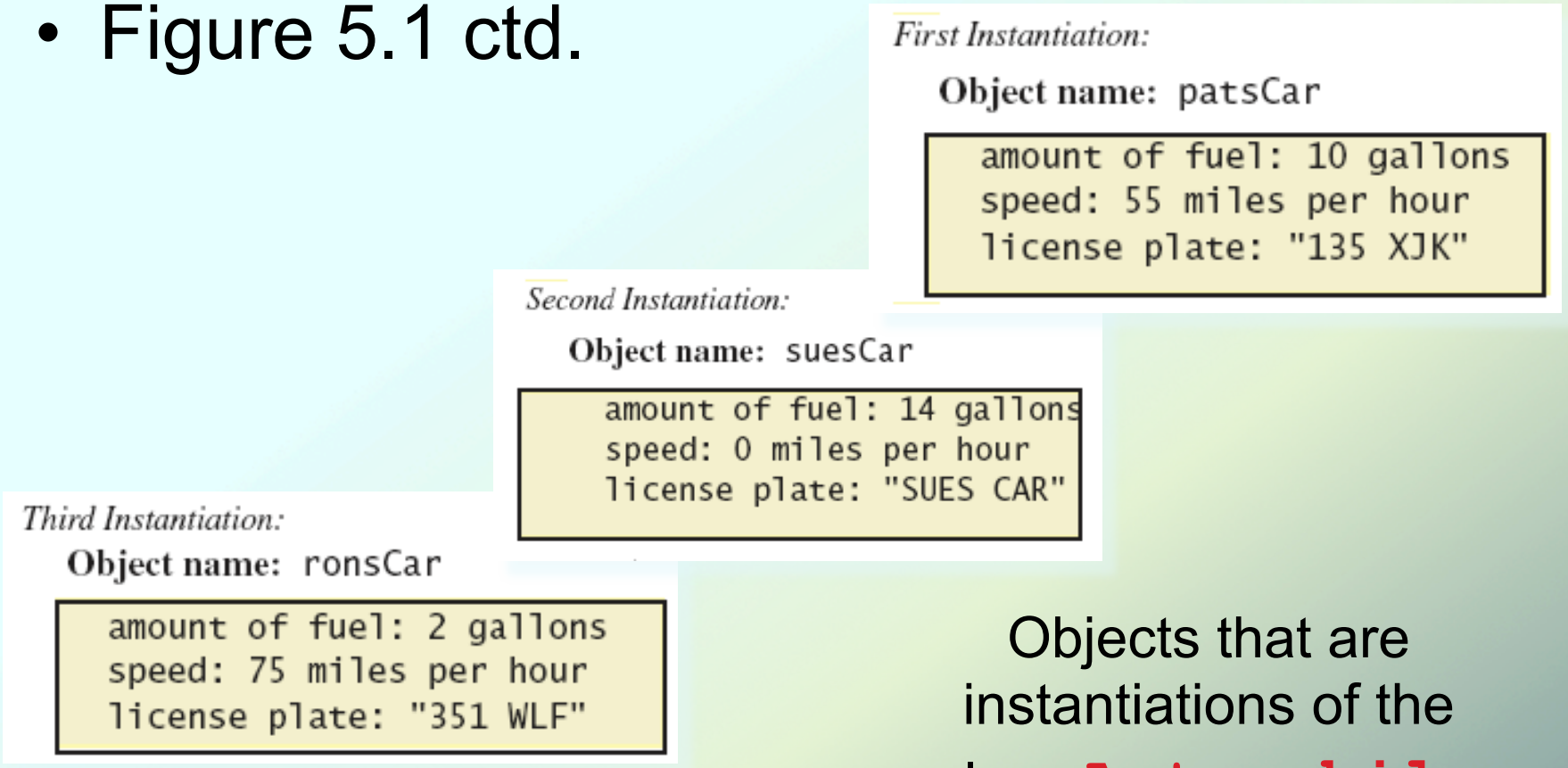
Class and Method Definitions

- Figure 5.1 A class as a blueprint



Class and Method Definitions

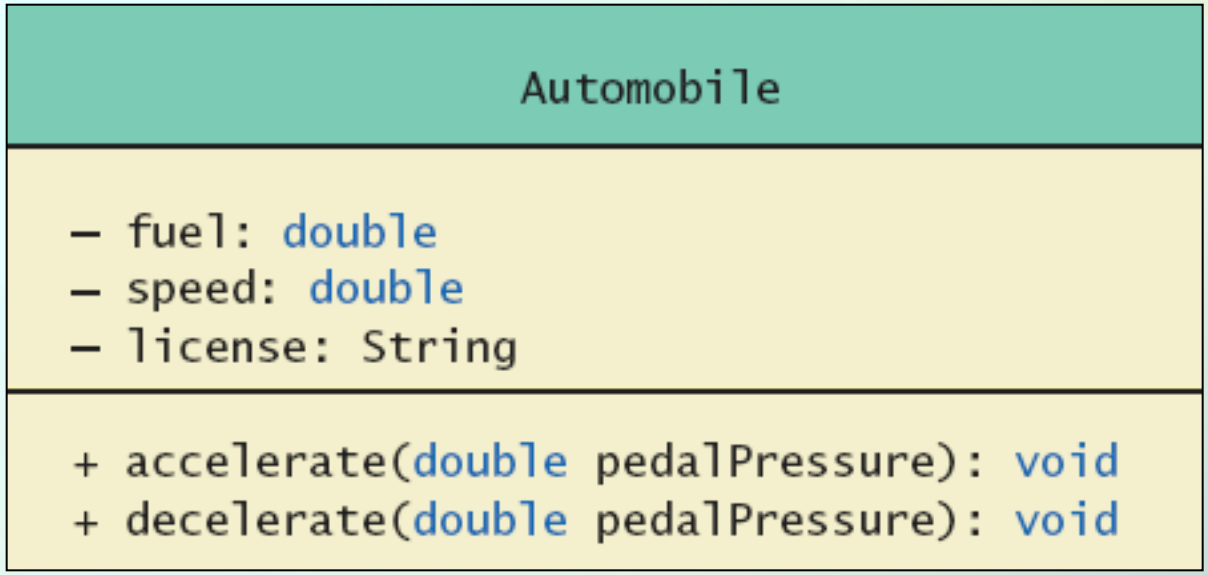
- Figure 5.1 ctd.



Objects that are instantiations of the class **`Automobile`**

Class and Method Definitions

- Figure 5.2 A class outline as a UML class diagram



Class Files and Separate Compilation

- Each **`Java`** class definition usually in a file by itself
  - File begins with name of the class
  - Ends with .**`java`**
- Class can be compiled separately
- Helpful to keep all class files used by a program in the same directory

`Dog` class and Instance Variables

- View sample program, listing 5.1
  `class Dog`
- Note class has
  - Three pieces of data (instance variables)
  - Two behaviors
- Each instance of this type has its own copies of the data items
- Use of `public`
  - No restrictions on how variables used
  - Later will replace with `private`

Using a Class and Its Methods

- View sample program, listing 5.2

  `class DogDemo`

```
Name: Balto
Breed: Siberian Husky
Age in calendar years: 8
Age in human years: 52

Scooby is a Great Dane.
He is 42 years old, or 222 in human years.
```

Sample screen output

Methods

- When you use a method you "invoke" or "call" it
- Two kinds of Java methods
  - Return a single item
  - Perform some other action – a **`void`** method
- The method **`main`** is a **`void`** method
  - Invoked by the system
  - Not by the application program

Methods

- Calling a method that returns a quantity
  - Use anywhere a value can be used
- Calling a void method
  - Write the invocation followed by a semicolon
  - Resulting statement performs the action defined by the method

Defining `void` Methods

- Consider method `writeOutput` from Listing 5.1

```
public void writeOutput()
{
    System.out.println("Name: " + name);
    System.out.println("Breed: " + breed);
    System.out.println("Age in calendar years: " +
                       age);
    System.out.println("Age in human years: " +
                       getAgeInHumanYears());
    System.out.println();
}
```

- Method definitions appear inside class definition
  - Can be used only with objects of that class

Defining `void` Methods

- Most method definitions we will see as **`public`**
- Method does not return a value
  - Specified as a **`void`** method
- Heading includes parameters
- Body enclosed in braces **`{ }`**
- Think of method as defining an action to be taken

Methods That Return a Value

- Consider method **`getAgeInHumanYears( )`**

```
public int getAgeInHumanYears()
{
    int humanAge = 0;
    if (age <= 2)
    {
        humanAge = age * 11;
    }
    else
    {
        humanAge = 22 + ((age-2) * 5);
    }
        return humanAge;
}
```

- Heading declares type of value to be returned
- Last statement executed is **`return`**

Second Example – Species Class

- Class designed to hold records of endangered species
- View the class listing 5.3
  `class SpeciesFirstTry`
  - Three instance variables, three methods
  - Will expand this class in the rest of the chapter
- View demo class listing 5.4
  `class SpeciesFirstTryDemo`

The Keyword `this`

- Referring to instance variables outside the class – must use
  - Name of an object of the class
  - Followed by a dot
  - Name of instance variable
- Inside the class,
  - Use name of variable alone
  - The object (unnamed) is understood to be there

The Keyword `this`

- Inside the class the unnamed object can be referred to with the name **`this`**
- Example

```
this.name = keyboard.nextLine();
```

- The keyword **`this`** stands for the receiving object
- We will seem some situations later that require the **`this`**

Local Variables

- Variables declared inside a method are called *local* variables
  - May be used only inside the method
  - All variables declared in method **`main`** are local to **`main`**
- Local variables having the same name and declared in different methods are different variables

Local Variables

- View sample file, listing 5.5A
  `class BankAccount`
- View sample file, listing 5.5B
  `class LocalVariablesDemoProgram`
- Note two different variables **`newAmount`**
  - Note different values output

```
With interest added, the new amount is $105.0
I wish my new amount were $800.0
```

Sample screen output

Blocks

- Recall compound statements
  - Enclosed in braces { }
- When you declare a variable within a compound statement
  - The compound statement is called a *block*
  - The scope of the variable is from its declaration to the end of the block
- Variable declared outside the block usable both outside and inside the block

Parameters of Primitive Type

```
public int getPopulationIn10()
{
    int result = 0;
    double populationAmount = population;
    int count = 10;
```

- Recall method declaration in listing 5.3
  - Note it only works for 10 years
  - We can make it more versatile by giving the method a parameter to specify how many years
- Note sample program, listing 5.6

`class SpeciesSecondTry`

Parameters of Primitive Type

- Note the declaration

```
public int predictPopulation(int years)
```

  - The *formal* parameter is `years`

- Calling the method

```
int futurePopulation =
 speciesOfTheMonth.predictPopulation(10);
```

  - The *actual* parameter is the integer 10

- View sample program, listing 5.7

```
class SpeciesSecondClassDemo
```

Parameters of Primitive Type

- Parameter names are local to the method
- When method invoked
  - Each parameter initialized to value in corresponding actual parameter
  - Primitive actual parameter cannot be altered by invocation of the method
- Automatic type conversion performed

```
byte -> short -> int ->
        long -> float -> double
```

Information Hiding, Encapsulation: Outline

- Information Hiding
- Pre- and Postcondition Comments
- The public and private Modifiers
- Methods Calling Methods
- Encapsulation
- Automatic Documentation with `javadoc`
- UML Class Diagrams

Information Hiding

- Programmer using a class method need not know details of implementation
  - Only needs to know *what* the method does
- Information hiding:
  - Designing a method so it can be used without knowing details
- Also referred to as *abstraction*
- Method design should separate *what* from *how*

Pre- and Postcondition Comments

- Precondition comment
  - States conditions that must be true before method is invoked
- Example

```
/**
 Precondition: The instance variables of the calling
 object have values.
 Postcondition: The data stored in (the instance variables
 of) the receiving object have been written to the screen.
*/
public void writeOutput()
```

Pre- and Postcondition Comments

- Postcondition comment
  - Tells what will be true after method executed
- Example

```
/**
 Precondition: years is a nonnegative number.
 Postcondition: Returns the projected population of the
 receiving object after the specified number of years.
*/
public int predictPopulation(int years)
```

The `public` and `private` Modifiers

- Type specified as `public`
  - Any other class can directly access that object by name
- Classes generally specified as `public`
- Instance variables usually not `public`
  - Instead specify as `private`
- View sample code, listing 5.8
  `class SpeciesThirdTry`

Programming Example

- Demonstration of need for private variables
- View sample code, listing 5.9
- Statement such as

  ```
  box.width = 6;
  ```

  is illegal since width is `private`
  - Keeps remaining elements of the class consistent in this example

Programming Example

- Another implementation of a Rectangle class
- View sample code, listing 5.10
  `class Rectangle2`
- Note **`setDimensions`** method
  - This is the only way the **`width`** and **`height`** may be altered outside the class

Accessor and Mutator Methods

- When instance variables are private must provide methods to access values stored there
  - Typically named **`getSomeValue`**
  - Referred to as an accessor method
- Must also provide methods to change the values of the private instance variable
  - Typically named **`setSomeValue`**
  - Referred to as a mutator method

Accessor and Mutator Methods

- Consider an example class with accessor and mutator methods
- View sample code, listing 5.11
  `class SpeciesFourthTry`
- Note the mutator method
  - **`setSpecies`**
- Note accessor methods
  - **`getName`**, **`getPopulation`**, **`getGrowthRate`**

Accessor and Mutator Methods

- Using a mutator method
- View sample program, listing 5.12
  classSpeciesFourthTryDemo

```
Name = Ferengie fur ball
Population = 1000
Growth rate = -20.5%
In 10 years the population will be 100
The new Species of the Month:
Name = Klingon ox
Population = 10
Growth rate = 15.0%
In 10 years the population will be 40
```

Sample screen output

Programming Example

- A Purchase class
- View sample code, listing 5.13
  `class Purchase`
  - Note use of private instance variables
  - Note also how mutator methods check for invalid values
- View demo program, listing 5.14
  `class purchaseDemo`

Programming Example

```
Enter name of item you are purchasing:
pink grapefruit
Enter price of item as two numbers.
For example, 3 for $2.99 is entered as
3 2.99
Enter price of item as two numbers, now:
4 5.00
Enter number of items purchased:
0
Number must be positive. Try again.
Enter number of items purchased:
3
3 pink grapefruit
at 4 for $5.0
Cost each $1.25
Total cost $3.75
```

Sample screen output

Methods Calling Methods

- A method body may call any other method
- If the invoked method is within the same class
  - Need not use prefix of receiving object
- View sample code, listing 5.15 class Oracle
- View demo program, listing 5.16 class OracleDemo

Methods Calling Methods

```
yes

I am the oracle. I will answer any one-line question.
What is your question?
What time is it?
Hmm, I need some help on that.
Please give me one line of advice.
Seek and ye shall find the answer.
Thank you. That helped a lot.
You asked the question:
  What time is it?
Now, here is my answer:
  The answer is in your heart.
Do you wish to ask another question?
```

Sample screen output

Encapsulation

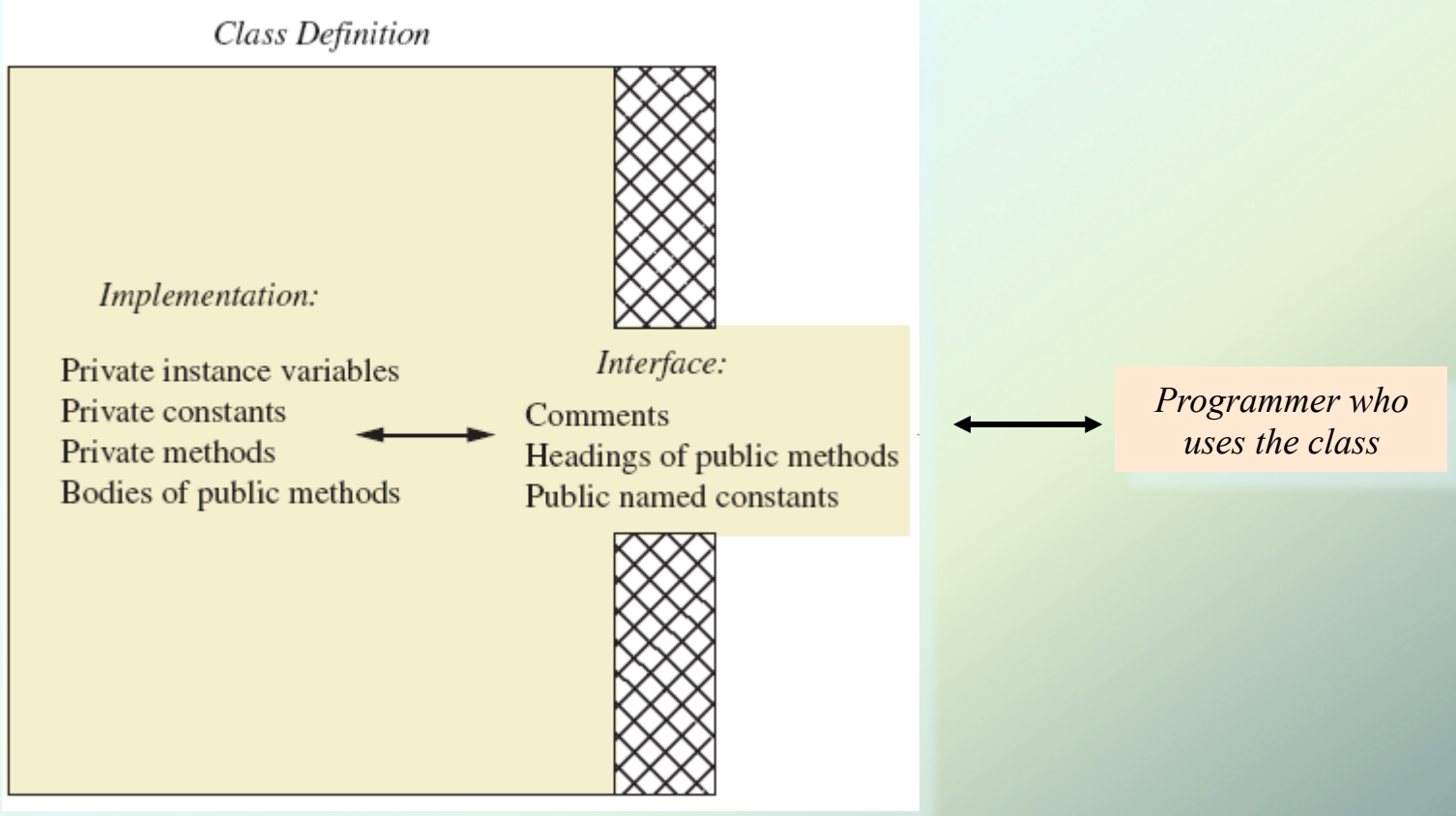
- Consider example of driving a car
  - We see and use break pedal, accelerator pedal, steering wheel – know what they do
  - We do not see mechanical details of how they do their jobs
- Encapsulation divides class definition into
  - Class interface
  - Class implementation

Encapsulation

- A *class interface*
  - Tells what the class does
  - Gives headings for public methods and comments about them
- A *class implementation*
  - Contains private variables
  - Includes definitions of public and private methods

Encapsulation

- Figure 5.3 A well encapsulated class definition



Encapsulation

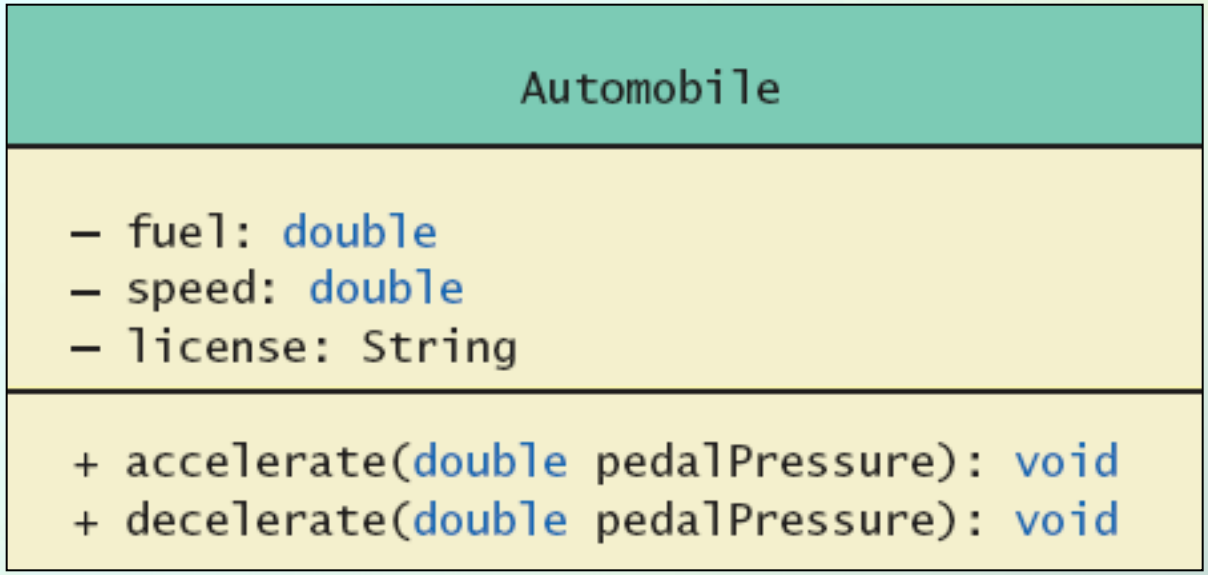
- Preface class definition with comment on how to use class
- Declare all instance variables in the class as private.
- Provide public accessor methods to retrieve data Provide public methods manipulating data
  - Such methods could include public mutator methods.
- Place a comment before each public method heading that fully specifies how to use method.
- Make any helping methods private.
- Write comments within class definition to describe implementation details.

Automatic Documentation `javadoc`

- Generates documentation for class interface
- Comments in source code must be enclosed in `/**  */`
- Utility `javadoc` will include
  - These comments
  - Headings of public methods
- Output of `javadoc` is HTML format

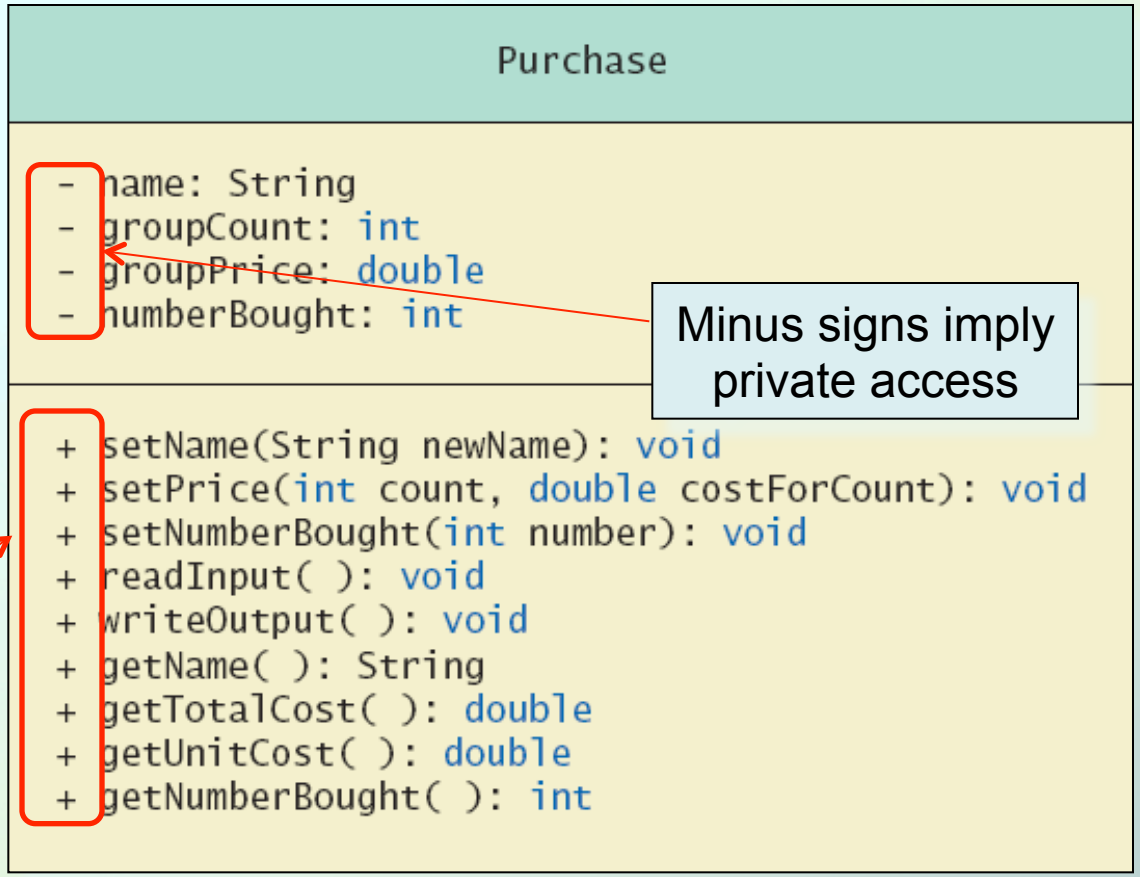
UML Class Diagrams

- Recall Figure 5.2 A class outline as a UML class diagram



UML Class Diagrams

- Note Figure 5.4 for the **`Purchase`** class



UML Class Diagrams

- Contains more than interface, less than full implementation
- Usually written *before* class is defined
- Used by the programmer defining the class
  - Contrast with the interface used by programmer who uses the class

Objects and References: Outline

- Variables of a Class Type
- Defining an equals Method for a Class
- Boolean-Valued Methods
- Parameters of a Class Type

Variables of a Class Type

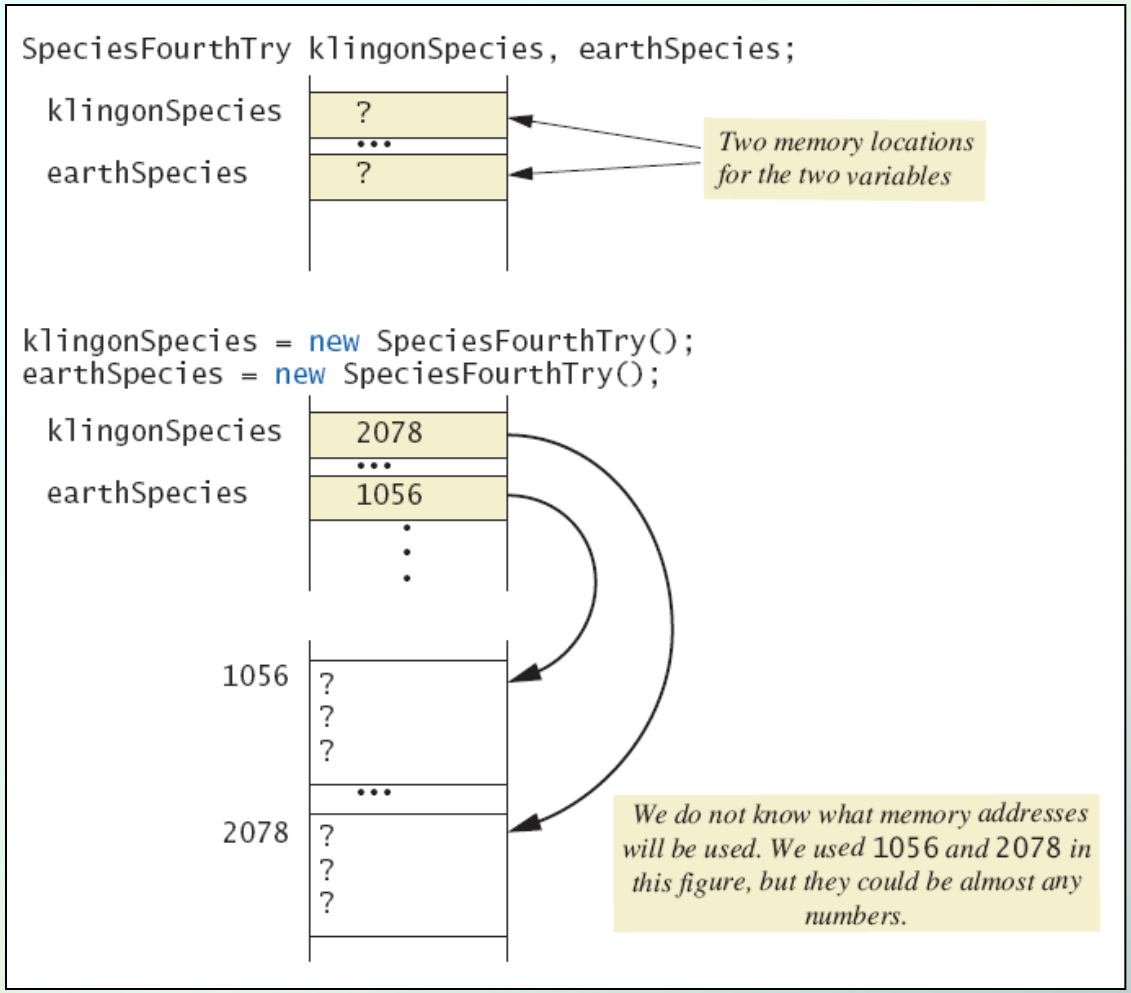
- All variables are implemented as a memory location
- Data of *primitive type* stored in the memory location assigned to the variable
- Variable of *class type* contains memory address of object named by the variable

Variables of a Class Type

- Object itself not stored in the variable
  - Stored elsewhere in memory
  - Variable contains address of where it is stored
- Address called the *reference* to the variable
- A *reference type* variable holds references (memory addresses)
  - This makes memory management of class types more efficient

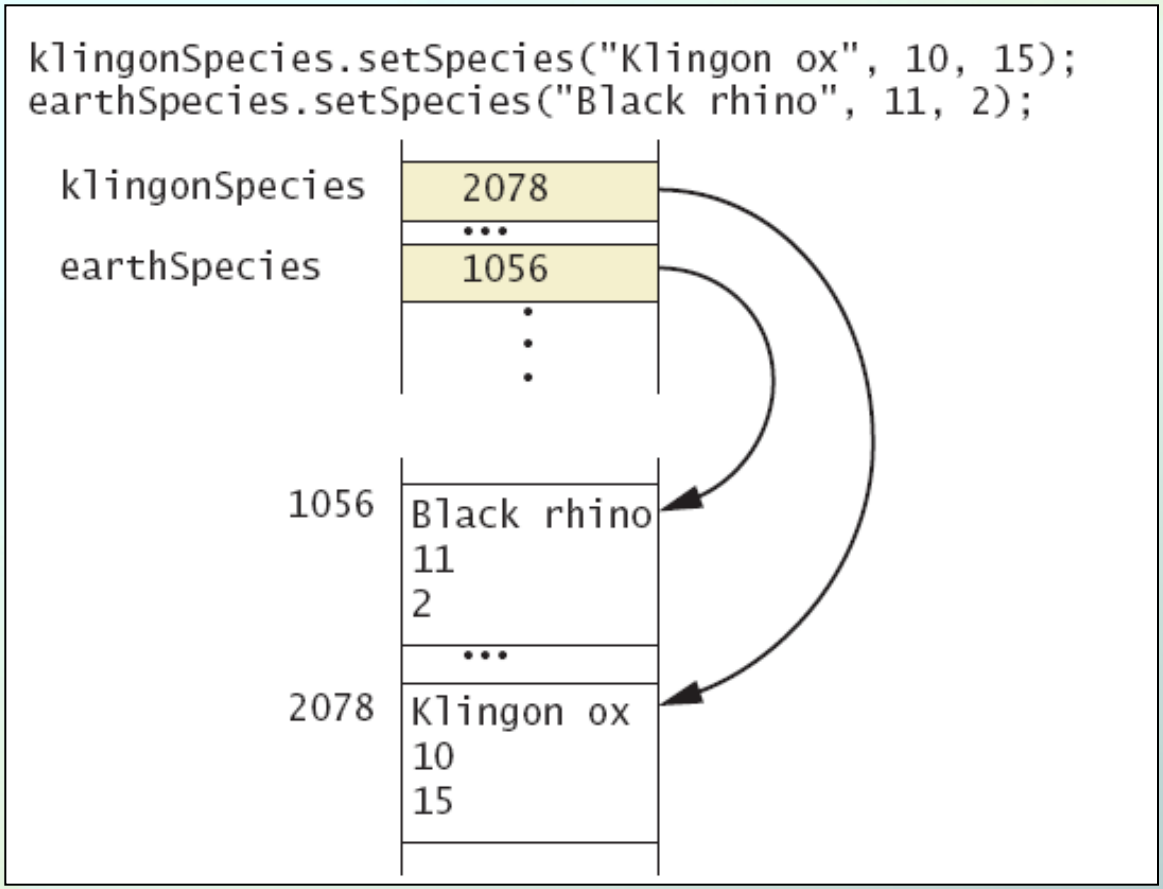
Variables of a Class Type

- Figure 5.5a Behavior of class variables



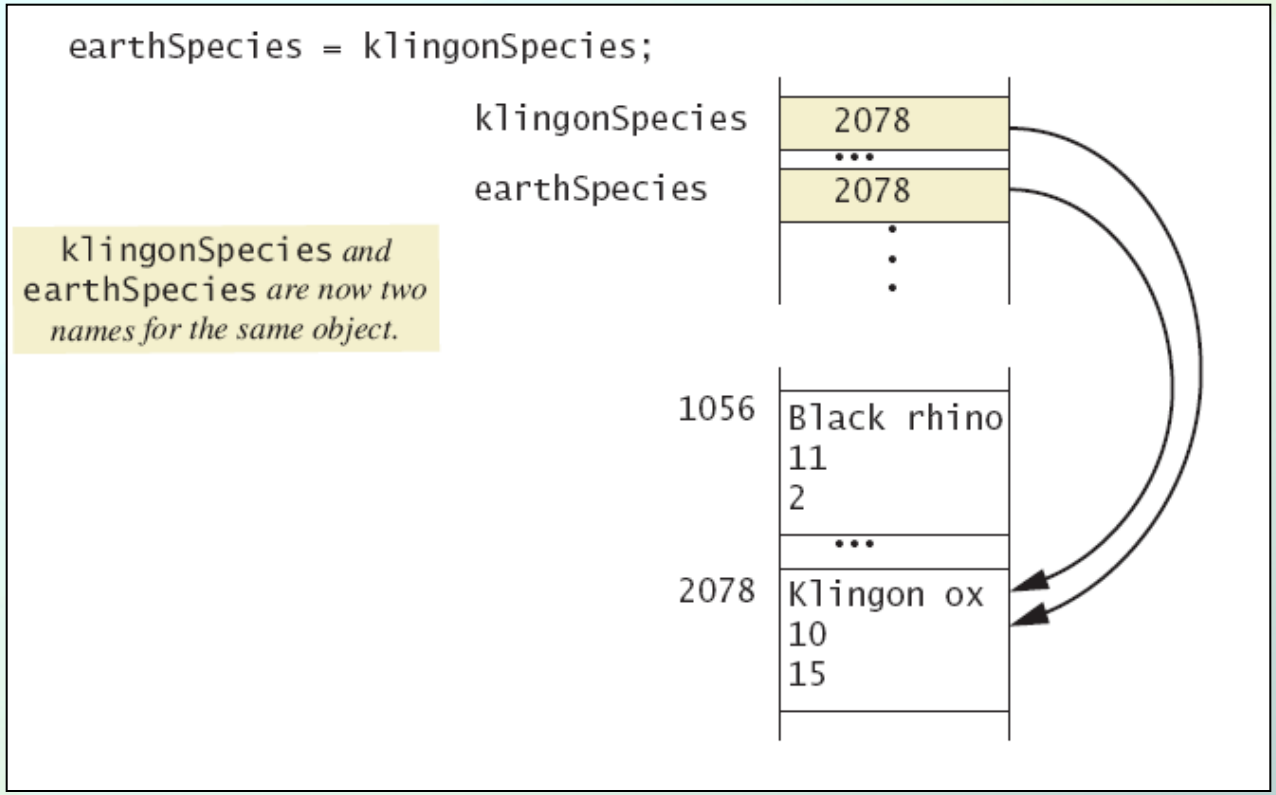
Variables of a Class Type

- Figure 5.5b Behavior of class variables



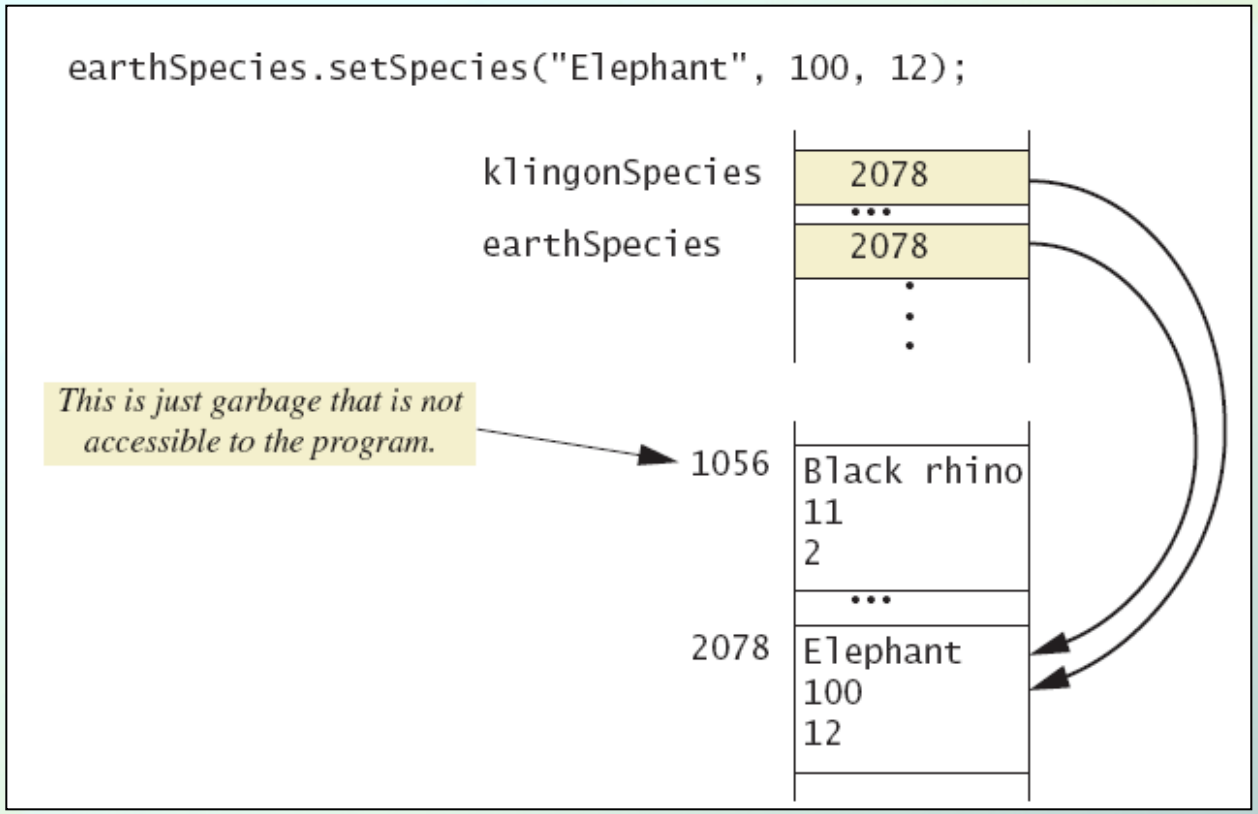
Variables of a Class Type

- Figure 5.5c Behavior of class variables



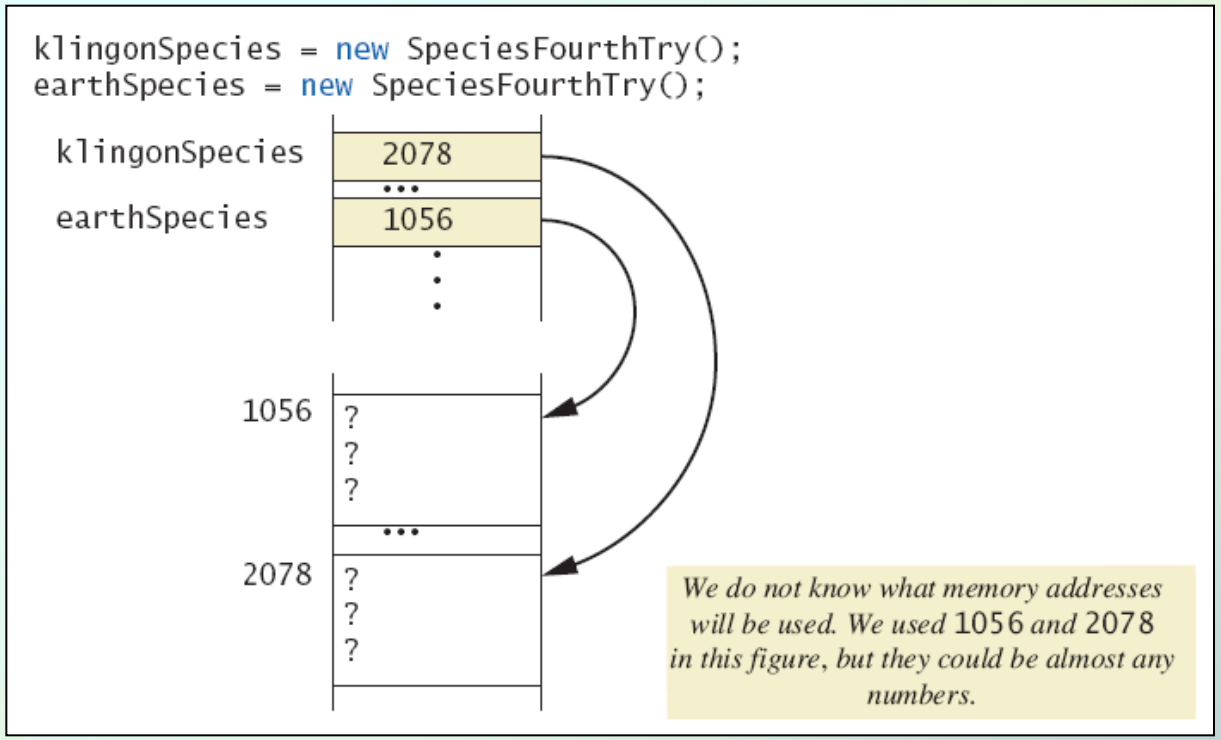
Variables of a Class Type

- Figure 5.5d Behavior of class variables



Variables of a Class Type

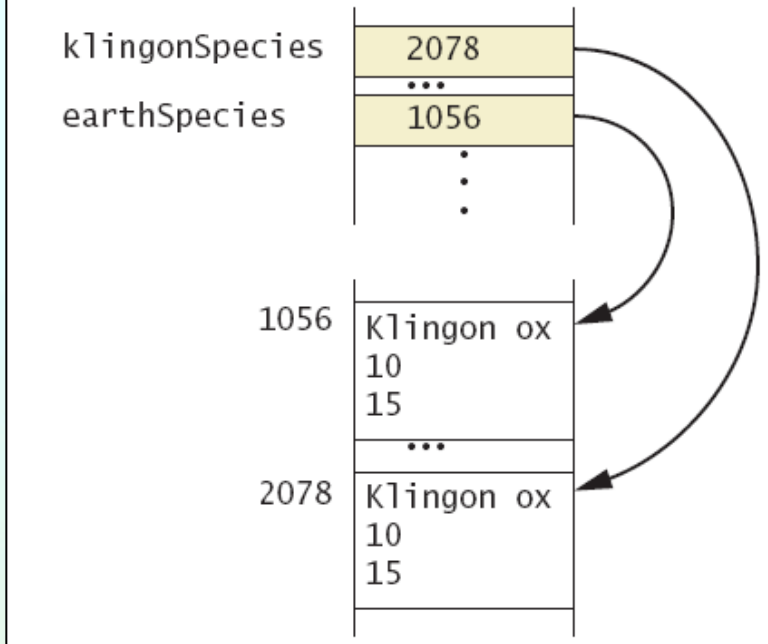
- Figure 5.6a Dangers of using == with objects



Variables of a Class Type

- Figure 5.6b Dangers of using == with objects

```
klingonSpecies.setSpecies("Klingon ox", 10, 15);
earthSpecies.setSpecies("Klingon ox", 10, 15);
```




```
if (klingonSpecies == earthSpecies)
    System.out.println("They are EQUAL.");
else
    System.out.println("They are NOT equal.");
```

The output is `They are Not equal` *, because* `2078` *is not equal to* `1056` *.*

Defining an `equals` Method

- As demonstrated by previous figures
  - We cannot use == to compare two objects
  - We must write a method for a given class which will make the comparison as needed
- View sample code, listing 5.17
  `class Species`
- The `equals` for this class method used same way as `equals` method for `String`

Demonstrating an `equals` Method

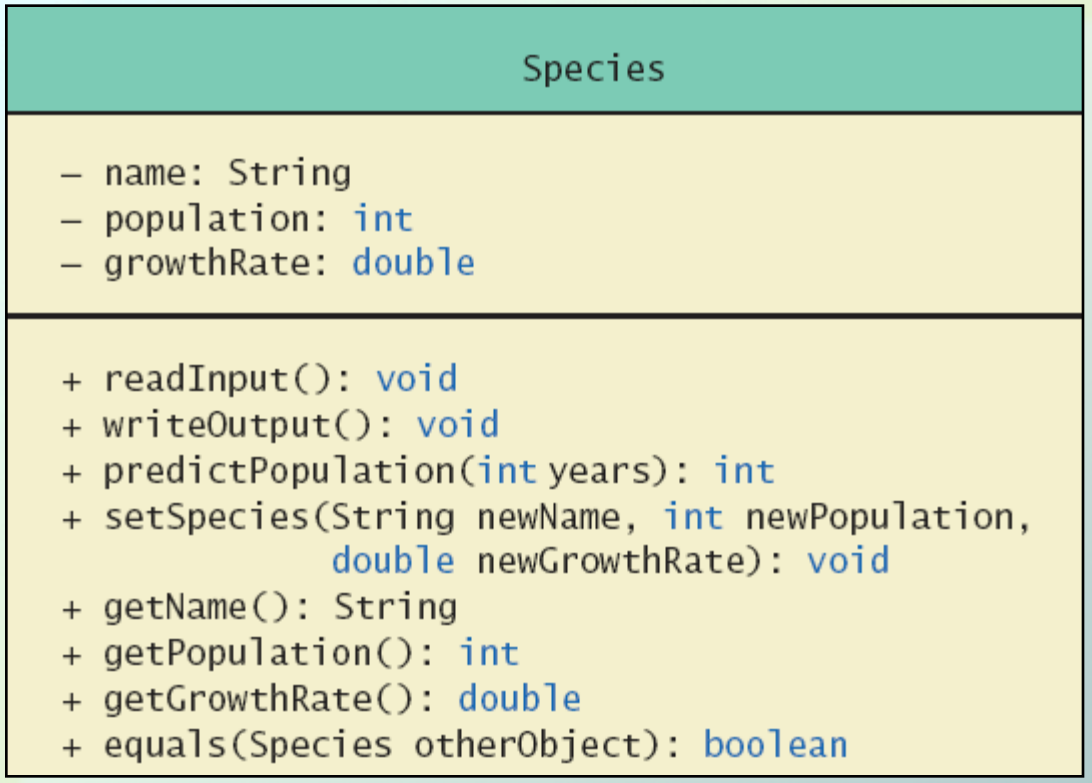
- View sample program, listing 5.18
  `class SpeciesEqualsDemo`
- Note difference in the two comparison methods `==` versus `.equals( )`

Sample screen output

```
Do Not match with ==.
Match with the method equals.
Now we change one Klingon ox to all lowercase.
Match with the method equals.
```

Complete Programming Example

- View sample code, listing 5.19 class **Species**
- Figure 5.7 Class Diagram for the class **Species** in listing 5.19



Boolean-Valued Methods

- Methods can return a value of type **`boolean`**
- Use a **`boolean`** value in the **`return`** statement
- Note method from listing 5.19

```
/**
 Precondition: This object and the argument otherSpecies
 both have values for their population.
 Returns true if the population of this object is greater
 than the population of otherSpecies; otherwise, returns false.
*/
public boolean isPopulationLargerThan(Species otherSpecies)
{
    return population > otherSpecies.population;
}
```

Unit Testing

- A methodology to test correctness of individual units of code
  - Typically methods, classes
- Collection of unit tests is the **test suite**
- The process of running tests repeatedly after changes are make sure everything still works is **regression testing**

View sample code, listing 5.20
class `SpeciesTest`

Parameters of a Class Type

- When assignment operator used with objects of class type
  - Only memory address is copied
- Similar to use of parameter of class type
  - Memory address of actual parameter passed to formal parameter
  - Formal parameter may access public elements of the class
  - Actual parameter thus can be changed by class methods

Programming Example

- View sample code, listing 5.21

  `class DemoSpecies`

  - Note different parameter types and results
- View sample program, listing 5.22
  - Parameters of a class type versus parameters of a primitive type

    `class ParametersDemo`

Programming Example

```
aPopulation BEFORE calling tryToChange: 42
aPopulation AFTER calling tryToChange: 42
s2 BEFORE calling tryToReplace:
Name = Ferengie Fur Ball
Population = 90
Growth Rate = 56.0%
s2 AFTER calling tryToReplace:
Name = Ferengie Fur Ball
Population = 90
Growth Rate = 56.0%
s2 AFTER calling change:
Name = Klingon ox
Population = 10
Growth Rate = 15.0%
```

Sample screen output

Graphics Supplement: Outline

- The Graphics Class
- The `init` Methods
- Adding Labels to an Applet

The `Graphics` Class

- An object of the `Graphics` class represents an area of the screen
- Instance variables specify area of screen represented
- When you run an Applet
  - Suitable `Graphics` object created automatically
  - This object used as an argument in the `paint` method

The `Graphics` Class

- Figure 5.8a Some methods in class `Graphics`

Graphics_Object`.drawOval(`*X*, *Y*, *Width*, *Height*`)` Draws the outline of an oval having the specified width and height at the point (*X*, *Y*).
Graphics_Object`.fillOval(`*X*, *Y*, *Width*, *Height*`)` Same as `drawOval`, but the oval is filled in.
Graphics_Object`.drawArc(`*X*, *Y*, *Width*, *Height*, *Start_Angle*, *ArcAngle*`)` Draws an arc—that is, draws part of an oval. See the graphics supplement section of Chapter 1 for details.
Graphics_Object`.fillArc(`*X*, *Y*, *Width*, *Height*, *Start_Angle*, *ArcAngle*`)` Same as `drawArc`, but the visible portion of the oval is filled in.

The `Graphics` Class

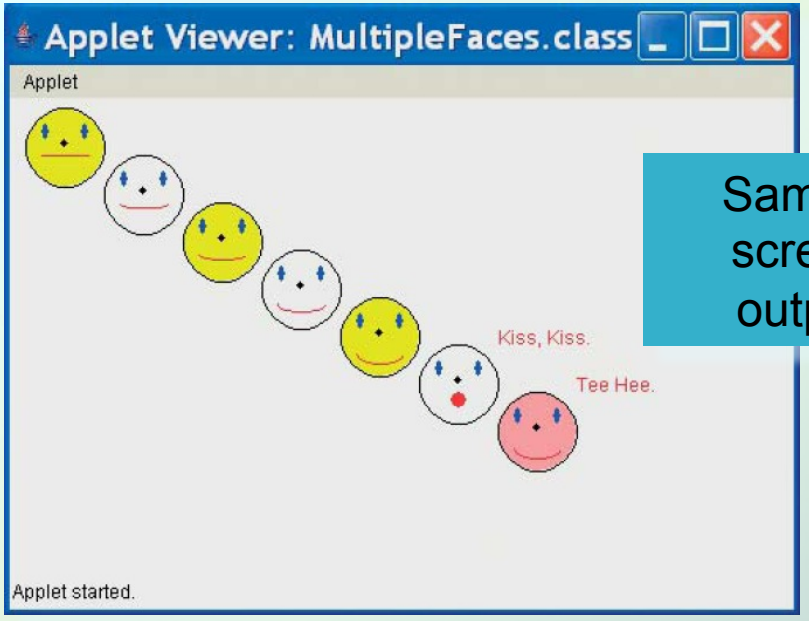
- Figure 5.8b Some methods in class `Graphics`

Graphics_Object.drawRect(*X*, *Y*, *Width*, *Height*) Draws the outline of a rectangle of the specified width and height at the point (*X*, *Y*).
Graphics_Object.fillRect(*X*, *Y*, *Width*, *Height*) Same as `drawRect`, but the rectangle is filled in.
Graphics_Object.drawLine(*X1*, *Y1*, *X2*, *Y2*) Draws a line between points (*X1*, *Y1*) and (*X2*, *Y2*).
Graphics_Object.drawString(*A_String*, *X*, *Y*) Writes the specified string starting at the point (*X*, *Y*).
Graphics_Object.setColor(*Color_Object*) Sets the color for subsequent drawings and text. The color stays in effect until it is changed by another invocation of `setColor`.

Programming Example

- Multiple faces – using a Helping method
- View sample code, listing 5.23

```
class MultipleFaces
```



Sample screen output

The `init` Method

- Method `init` may be defined for any applet
- Like `paint`, method `init` called automatically when applet is run
- Method `init` similar to method `main` in an application program

Adding Labels to Applet

- Provides a way to add text to an applet
- When component (such as a label) added to an applet
  - Use method **`init`**
  - Do not use method **`paint`**

Adding Labels to Applet

- View sample applet, listing 5.24

  `class LabelDemo`

Sample screen output

Summary

- Classes have
  - Instance variables to store data
  - Method definitions to perform actions
- Instance variables should be private
- Class needs accessor, mutator methods
- Methods may be
  - Value returning methods
  - Void methods that do not return a value

Summary

- Keyword this used within method definition represents invoking object
- Local variables defined within method definition
- Formal arguments must match actual parameters with respect to number, order, and data type
- Formal parameters act like local variables

Summary

- Parameter of primitive type initialized with value of actual parameter
  - Value of actual parameter not altered by method
- Parameter of class type initialized with address of actual parameter object
  - Value of actual parameter may be altered by method calls
- A method definition can include call to another method in same or different class

Summary

- Precondition comment states conditions that must be true before method invoked
- Postcondition comment describes resulting effects of method execution
- Utility program **`javadoc`** creates documentation
- Class designers use UML notation to describe classes
- Operators **`=`** and **`==`** behave differently with objects of class types (vs. primitive types)

Summary

- Designer of class should include an **`equals`** method
- Graphics drawn by applet normally done from within **`paint`**
  - Other applet instructions placed in **`init`**
- Parameter of **`paint`** is of type **`Graphics`**
- Method **`setBackground`** sets color of applet pane
- Labels added to content pane within the init method