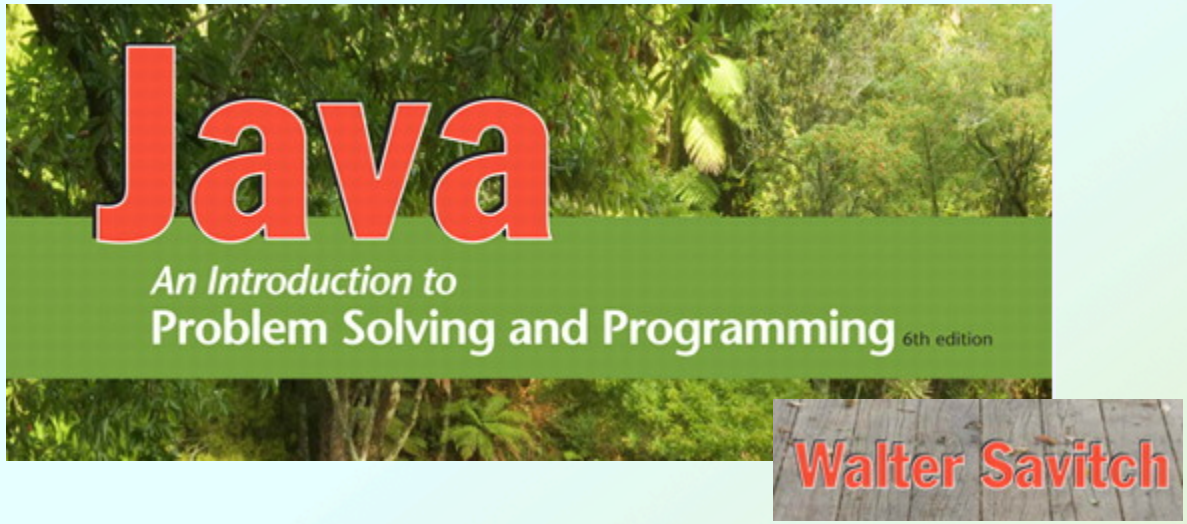

Inheritance, Polymorphism, and Interfaces

Chapter 8

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

- Describe polymorphism and inheritance in general
- Define interfaces to specify methods
- Describe dynamic binding
- Define and use derived classes in Java
- Understand how inheritance is used in the **`JFrame`** class

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Inheritance Basics: Outline

- Derived Classes
- Overriding Method Definitions
- Overriding Versus Overloading
- The `final` Modifier
- Private Instance Variables and Private Methods of a Base Class
- UML Inheritance Diagrams

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Inheritance Basics

- Inheritance allows programmer to define a general class
- Later you define a more specific class
  - Adds new details to general definition
- New class inherits all properties of initial, general class
- View example class, listing 8.1

```
class Person
```


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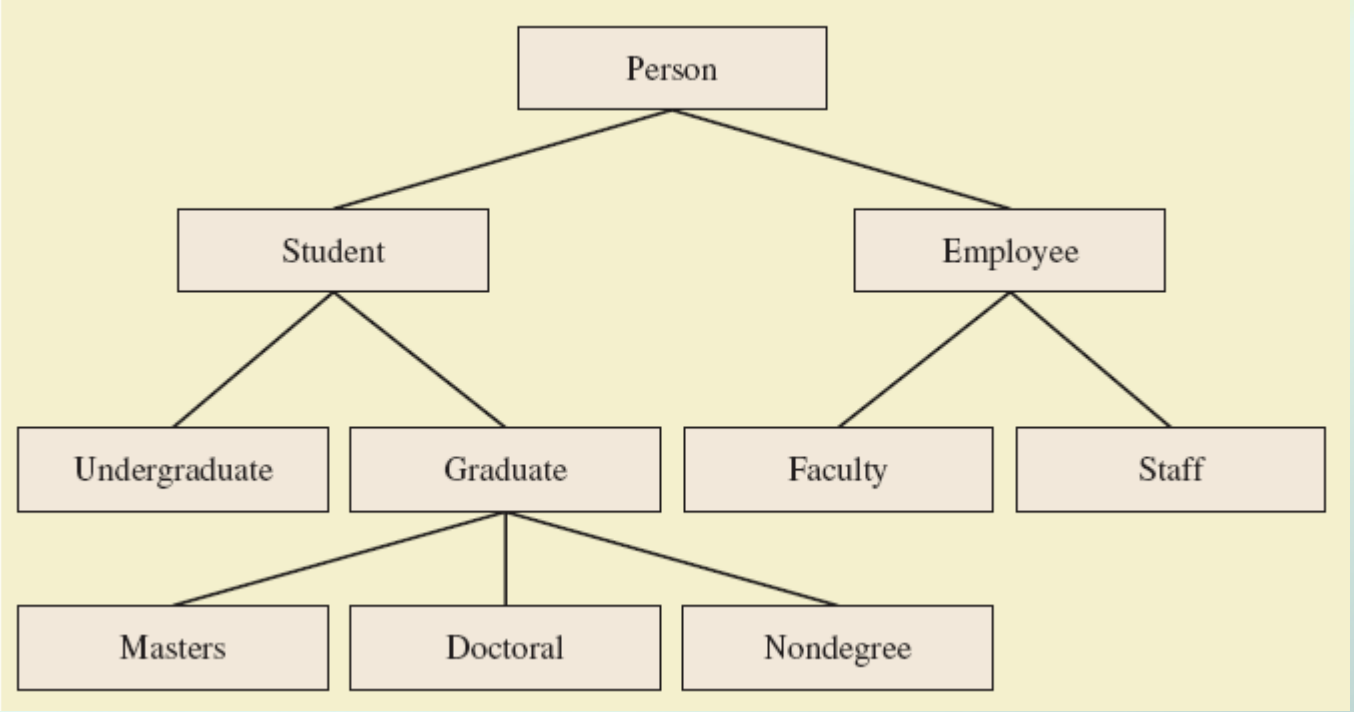
Derived Classes

- Figure 8.1 A class hierarchy



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Derived Classes

- Class **`Person`** used as a *base* class
  - Also called *superclass*
- Now we declare *derived* class **`Student`**
  - Also called *subclass*
  - Inherits methods from the superclass
- View derived class, listing 8.2

```
class Student extends Person
```

- View demo program, listing 8.3

```
class InheritanceDemo
```

Sample screen output

```
Name: Warren Peace
Student Number: 1234
```


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Overriding Method Definitions

- Note method **`writeOutput`** in class **`Student`**
  - Class Person also has method with that name
- Method in subclass with same signature overrides method from base class
  - Overriding method is the one used for objects of the derived class
- Overriding method must return same type of value

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Overriding Versus Overloading

- Do not confuse overriding with overloading
  - Overriding takes place in subclass – new method with same signature
- Overloading
  - New method in same class with different signature

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The `final` Modifier

- Possible to specify that a method cannot be overridden in subclass
- Add modifier final to the heading
  ```
  public final void specialMethod()
  ```
- An entire class may be declared **`final`**
  - Thus cannot be used as a base class to derive any other class

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Private Instance Variables, Methods

- Consider private instance variable in a base class
  - It is not inherited in subclass
  - It can be manipulated only by public accessor, modifier methods
- Similarly, private methods in a superclass not inherited by subclass

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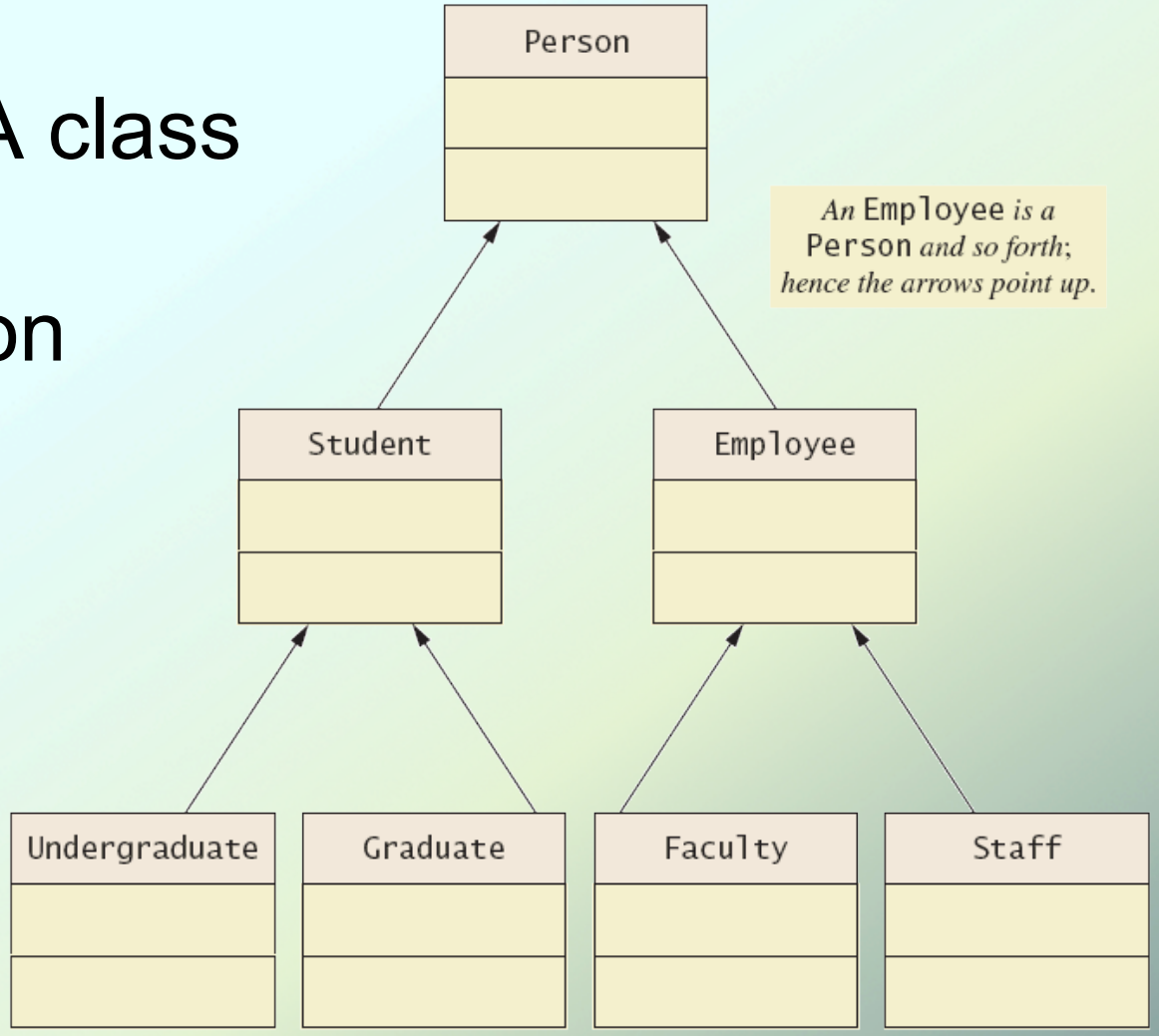
UML Inheritance Diagrams

- Figure 8.2 A class hierarchy in UML notation



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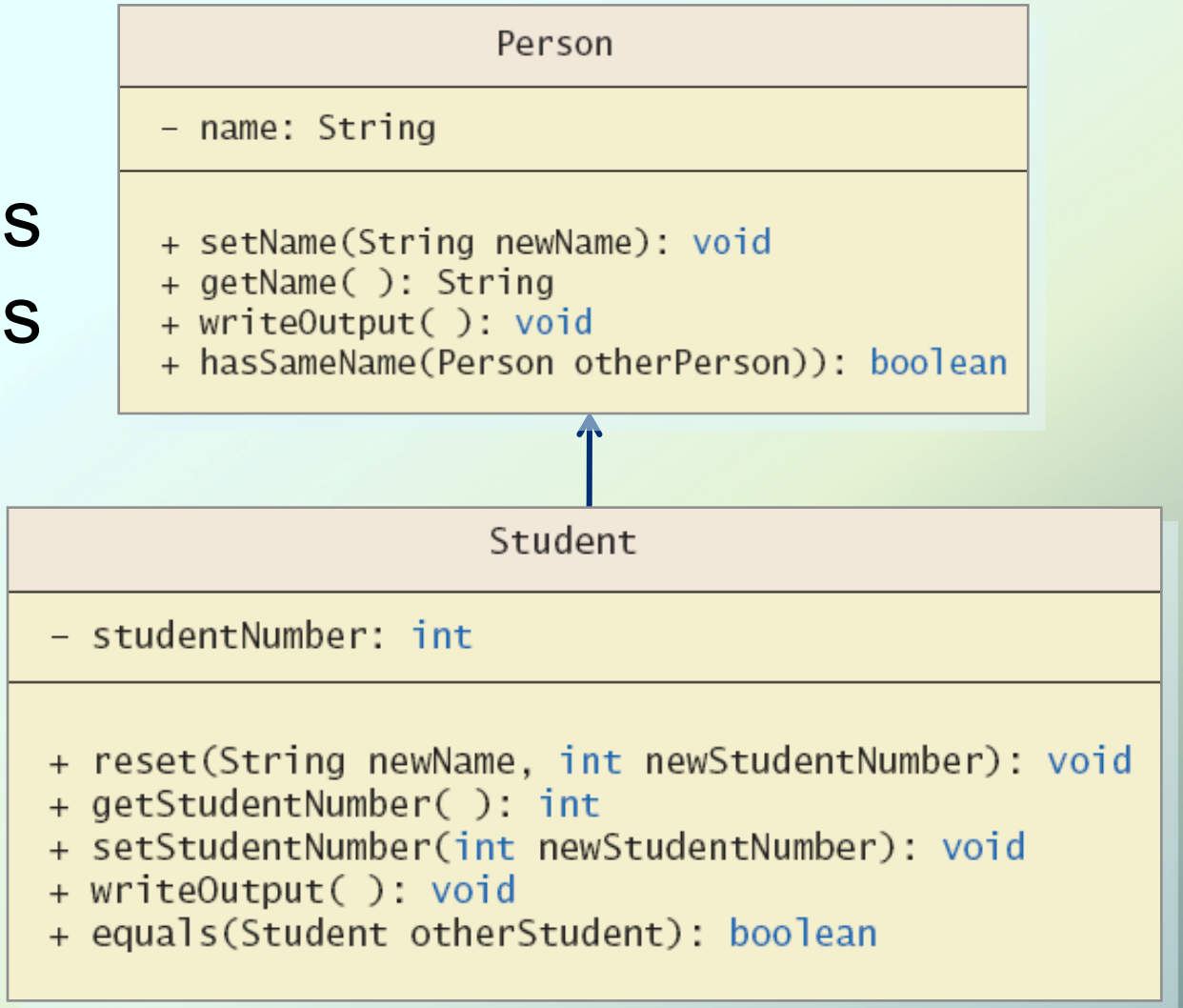
UML Inheritance Diagrams

- Figure 8.3 Some details of UML class hierarchy from figure 8.2



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Constructors in Derived Classes

- A derived class does not inherit constructors from base class
  - Constructor in a subclass must invoke constructor from base class
- Use the reserve word **`super`**

```
public Student(String initialName, int initialStudentNumber)
{
    super(initialName);
    studentNumber = initialStudentNumber;
}
```

  - Must be first action in the constructor

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The `this` Method – Again

- Also possible to use the **`this`** keyword
  - Use to call any constructor in the class

```
public Person()
{
    this("No name yet");
}
```

- When used in a constructor, this calls constructor in same class
  - Contrast use of **`super`** which invokes constructor of base class

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Calling an Overridden Method

- Reserved word **`super`** can also be used to call method in overridden method

```
public void writeOutput()
{
    super.writeOutput(); //Display the name
    System.out.println("Student Number: " + studentNumber);
}
```

- Calls method by same name in base class

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Programming Example

- A derived class of a derived class
- View sample class, listing 8.4
  `class Undergraduate`
- Has all public members of both
  - **`Person`**
  - **`Student`**
- This reuses the code in superclasses

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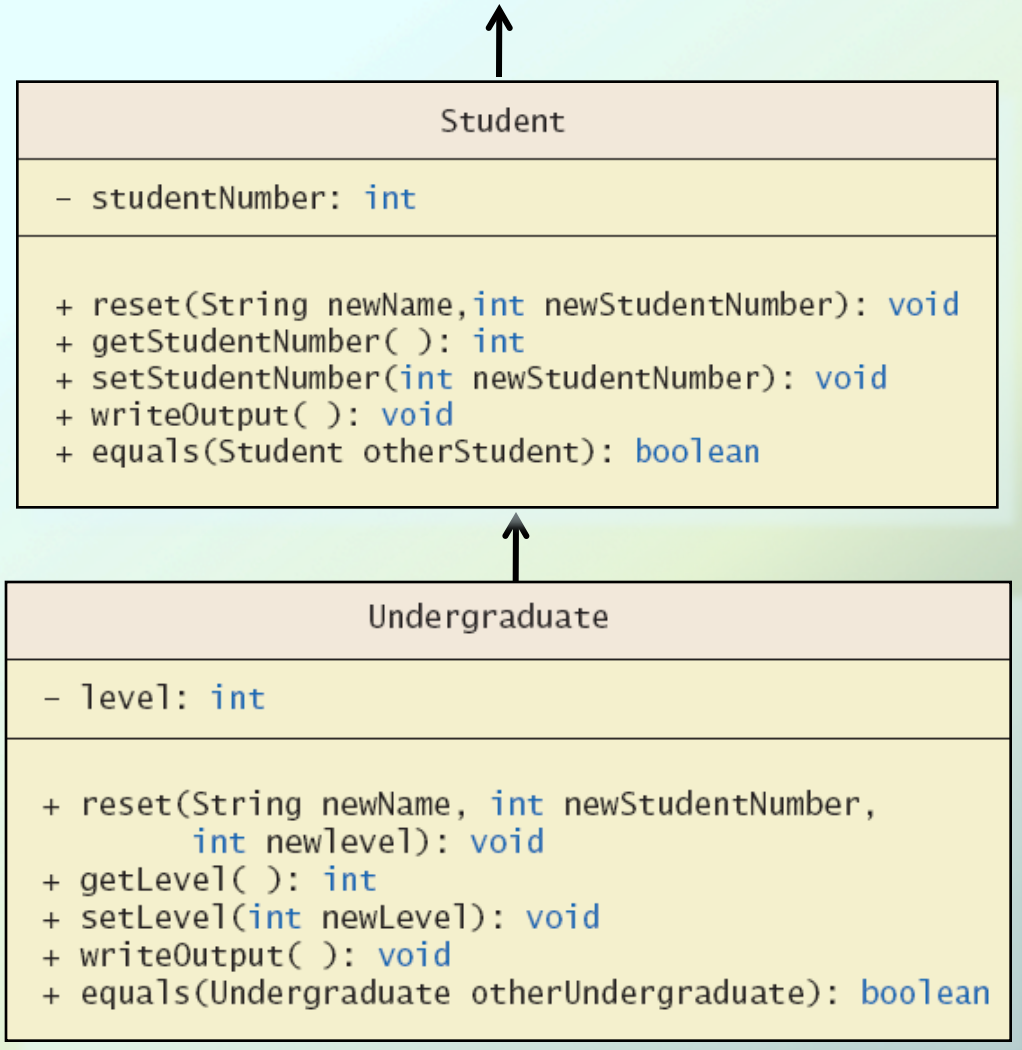
Programming Example

- Figure 8.4 More details of the UML class hierarchy



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Type Compatibility

- In the class hierarchy
  - Each **`Undergraduate`** is also a **`Student`**
  - Each **`Student`** is also a **`Person`**
- An object of a derived class can serve as an object of the base class
  - Note this is not typecasting
- An object of a class can be referenced by a variable of an ancestor type

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Type Compatibility

- Be aware of the "is-a" relationship
  - A **`Student`** *is a* **`Person`**
- Another relationship is the "has-a"
  - A class can contain (as an instance variable) an object of another type
  - If we specify a date of birth variable for **`Person`** – it "has-a" **`Date`** object

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The Class `Object`

- Java has a class that is the ultimate ancestor of every class
  - The class `Object`
- Thus possible to write a method with parameter of type `Object`
  - Actual parameter in the call can be object of any type
- Example: method

```
println(Object theObject)
```


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The Class `Object`

- Class Object has some methods that every Java class inherits
- Examples
  - Method `equals`
  - Method `toString`
- Method `toString` called when `println(theObject)` invoked
  - Best to define your own `toString` to handle this

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A Better `equals` Method

- Programmer of a class should override method equals from `Object`
- View code of sample override, listing 8.8

```
public boolean equals
            (Object theObject)
```


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Polymorphism

- Inheritance allows you to define a base class and derive classes from the base class
- Polymorphism allows you to make changes in the method definition for the derived classes and have those changes apply to methods written in the base class

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Polymorphism

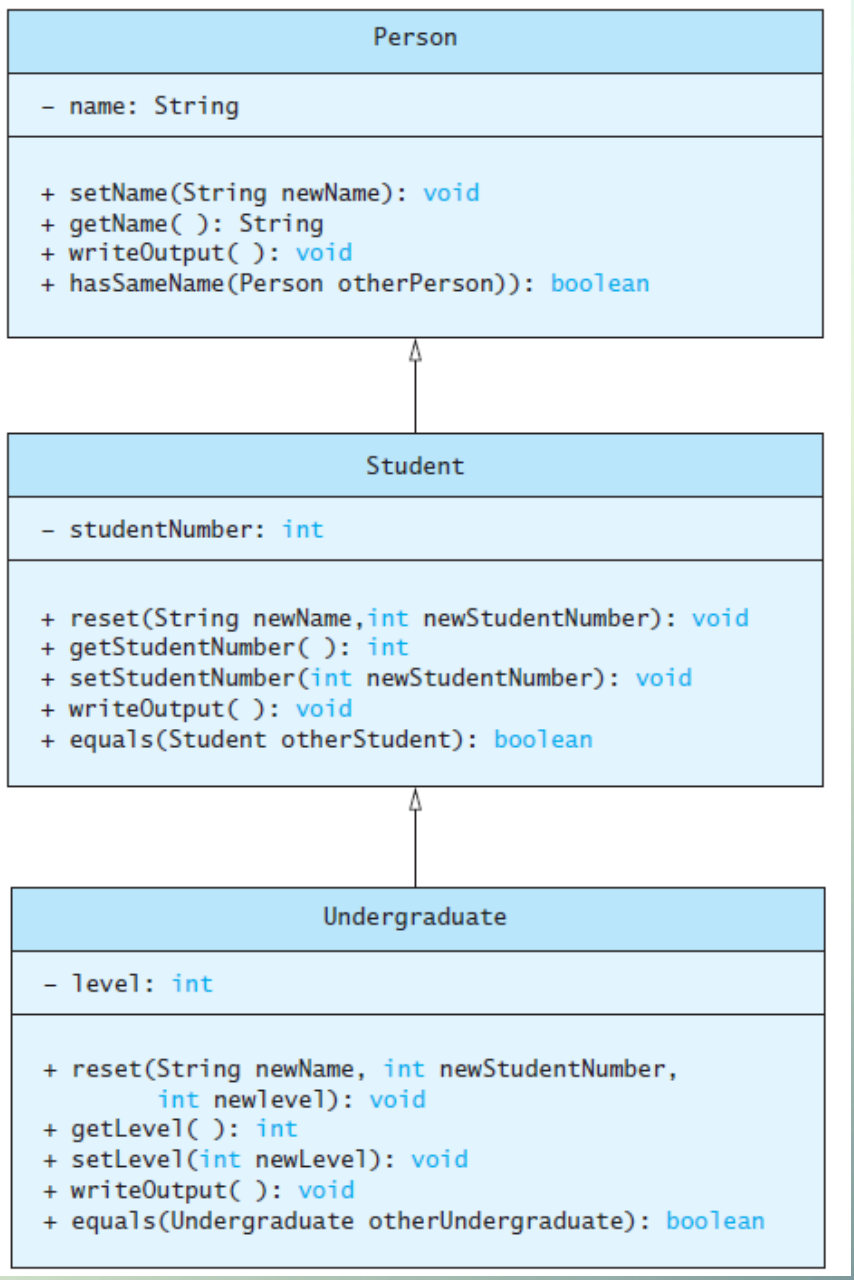
- Consider an array of **Person**

```
Person[] people = new
Person[4];
```

- Since **Student** and **Undergraduate** are types of **Person**, we can assign them to **Person** variables

```
people[0] = new
Student("DeBanque, Robin",
8812);

people[1] = new
Undergraduate("Cotty, Manny",
8812, 1);
```



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Polymorphism

- Given:

```
Person[] people = new Person[4];
people[0] = new Student("DeBanque, Robin",
8812);
```

- When invoking:

```
people[0].writeOutput();
```

- Which `writeOutput()` is invoked, the one defined for `Student` or the one defined for `Person`?
- Answer: The one defined for **`Student`**

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An Inheritance as a Type

- The method can substitute one object for another
  - Called *polymorphism*
- This is made possible by mechanism
  - *Dynamic binding*
  - Also known as *late binding*

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Dynamic Binding and Inheritance

- When an overridden method invoked
  - Action matches method defined in class used to create object using **`new`**
  - Not determined by type of variable naming the object
- Variable of any ancestor class can reference object of descendant class
  - Object always remembers which method actions to use for each method name

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Polymorphism Example

- View sample class, listing 8.6
  `class PolymorphismDemo`
- Output

```
Name: Cotty, Manny
Student Number: 4910
Student Level: 1

Name: Kick, Anita
Student Number: 9931
Student Level: 2

Name: DeBanque, Robin
Student Number: 8812

Name: Bugg, June
Student Number: 9901
Student Level: 4
```


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Class Interfaces

- Consider a set of behaviors for pets
  - Be named
  - Eat
  - Respond to a command
- We could specify method headings for these behaviors
- These method headings can form a class interface

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Class Interfaces

- Now consider different classes that implement this interface
  - They will each have the same behaviors
  - Nature of the behaviors will be different
- Each of the classes implements the behaviors/methods differently

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Java Interfaces

- A program component that contains headings for a number of public methods
  - Will include comments that describe the methods
- Interface can also define public named constants
- View example interface, listing 8.7 interface Measurable

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Java Interfaces

- Interface name begins with uppercase letter
- Stored in a file with suffix `.java`
- Interface does not include
  - Declarations of constructors
  - Instance variables
  - Method bodies

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Implementing an Interface

- To implement a method, a class must
  - Include the phrase

    ```
    implements Interface_name
    ```

  - Define each specified method
- View sample class, listing 8.8

  ```
  class Rectangle implements Measurable
  ```

- View another class, listing 8.9 which also implements Measurable
  class Circle

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An Inheritance as a Type

- Possible to write a method that has a parameter as an interface type
  - An interface is a reference type
- Program invokes the method passing it an object of any class which implements that interface

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Extending an Interface

- Possible to define a new interface which builds on an existing interface
  - It is said to extend the existing interface
- A class that implements the new interface must implement all the methods of both interfaces

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Case Study

- Character Graphics
- View interface for simple shapes, listing 8.10 `interface ShapeInterface`
- If we wish to create classes that draw rectangles and triangles
  - We could create interfaces that extend `ShapeInterface`
  - View interfaces, listing 8.11

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Case Study

- Now view base class, listing 8.12 which uses (implements) previous interfaces
  `class ShapeBasics`
- Note
  - Method **`drawAt`** calls **`drawHere`**
  - Derived classes must override **`drawHere`**
  - Modifier **`extends`** comes before **`implements`**

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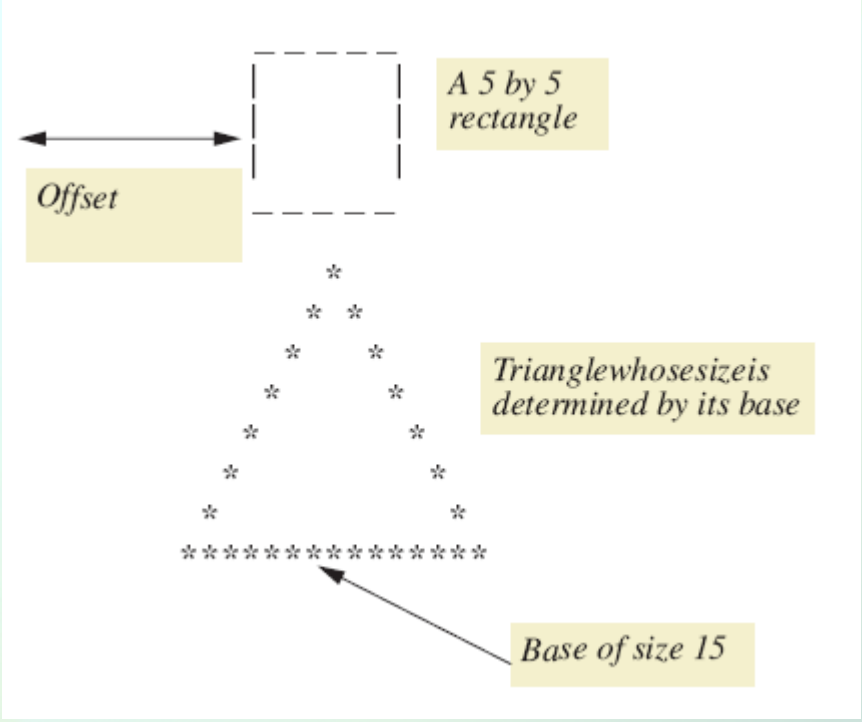
Case Study

- Figure 8.5 A sample rectangle and triangle



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Case Study

- Note algorithm used by method **`drawHere`** to draw a rectangle
  1. Draw the top line
  2. Draw the side lines
  3. Draw the bottom lines
- Subtasks of **`drawHere`** are realized as private methods
- View class definition, listing 8.13 **`class Rectangle`**

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Case Study

- View next class to be defined (and tested), listing 8.14 class Triangle
- It is a good practice to test the classes as we go
- View demo program, listing 8.15
  `class TreeDemo`

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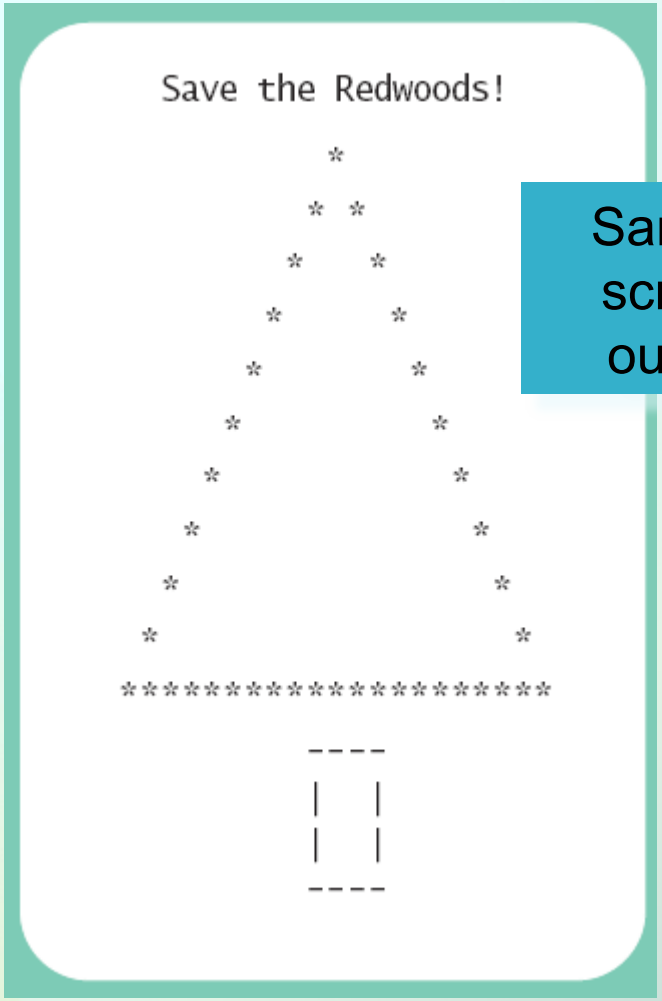
Case Study



Sample screen output

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Case Study
The `Comparable` Interface

- Java has many predefined interfaces
- One of them, the `Comparable` interface, is used to impose an ordering upon the objects that implement it
- Requires that the method `compareTo` be written

```
public int compareTo(Object other);
```


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Sorting an Array of Fruit Objects

- Initial (non-working) attempt to sort an array of **`Fruit`** objects
- View class definition, listing 8.16
  `class Fruit`
- View test class, listing 8.17
  `class FruitDemo`
- Result: Exception in thread "main"
  - Sort tries to invoke **`compareTo`** method but it doesn't exist

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Sorting an Array of Fruit Objects

- Working attempt to sort an array of **`Fruit`** objects – implement **`Comparable`**, write **`compareTo`** method
- View class definition, listing 8.18
  `class Fruit`
- Result: Exception in thread "main"
  - Sort tries to invoke method but it doesn't exist

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`compareTo` Method

- An alternate definition that will sort by length of the fruit name

```
public int compareTo(Object o)
{
    if ((o != null) &&
        (o instanceof Fruit))
    {
         Fruit otherFruit = (Fruit) o;
         if (fruitName.length() >
             otherFruit.fruitName.length())
             return 1;
         else if (fruitName.length() <
                  otherFruit.fruitName.length())
               return -1;
          else
               return 0;
    }
          return -1;  // Default if other object is not a Fruit
}
```


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Abstract Classes

- Class **`ShapeBasics`** is designed to be a base class for other classes
  - Method **`drawHere`** will be redefined for each subclass
  - It should be declared *abstract* – a method that has no body
- This makes the class abstract
- You cannot create an object of an abstract class – thus its role as base class

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Abstract Classes

- Not all methods of an abstract class are abstract methods
- Abstract class makes it easier to define a base class
  - Specifies the obligation of designer to override the abstract methods for each subclass

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Abstract Classes

- Cannot have an instance of an abstract class
  - But OK to have a parameter of that type
- View abstract version, listing 8.19

```
abstract class ShapeBase
```


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Dynamic Binding and Inheritance

- Note how **`drawAt`** (in **`ShapeBasics`**) makes a call to **`drawHere`**
- Class **`Rectangle`** overrides method **`drawHere`**
  - How does **`drawAt`** know where to find the correct **`drawHere`**?
- Happens with dynamic or late binding
  - Address of correct code to be executed determined at run time

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Graphics Supplement: Outline

- The Class **`JApplet`**
- The Class **`JFrame`**
- Window Events and Window Listeners
- The **`ActionListener`** Interface

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The Class `JApplet`

- Class **`JApplet`** is base class for all applets
  - Has methods **`init`** and **`paint`**
- When you extend **`JApplet`** you override (redefine) these methods
- Parameter shown will use your versions due to polymorphism

```
public void showApplet(JApplet anApplet)
{
    anApplet.init();
    ...
    anApplet.paint();
}
```


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The Class `JFrame`

- For GUIs to run as applications (instead of from a web page)
  - Use class `JFrame` as the base class
- View example program, listing 8.20 class `ButtonDemo`
- Note method `setSize`
  - Width and height given in number of pixels
  - Sets size of window

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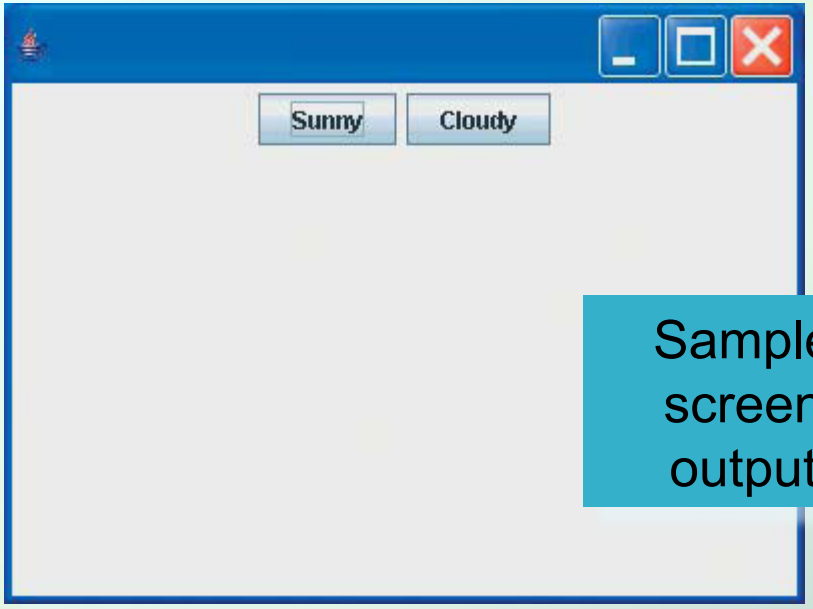
The Class `JFrame`

- View demo program, listing 8.21 class **`ShowButtonDemo`**



Sample screen output

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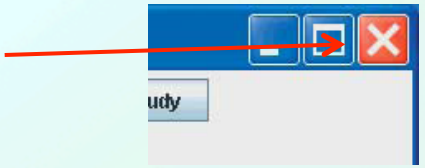
Window Events and Window Listeners

- Close-window button fires an event



  - Generates a *window event* handled by a *window listener*
- View class for window events, listing 8.22, **`class WindowDestroyer`**
- Be careful not to confuse **`JButtons`** and the close-window button

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The `ActionListener` Interface

- Use of interface ActionListener requires only one method

```
public void actionPerformed
     (ActionEvent e)
```

- Listener that responds to button clicks
  - Must be an action listener
  - Thus must `implement ActionListener` interface

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Summary

- An interface contains
  - Headings of public methods
  - Definitions of named constants
  - No constructors, no private instance variables
- Class which implements an interface must
  - Define a body for every interface method specified
- Interface enables designer to specify methods for another programmer

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Summary

- Interface is a reference type
  - Can be used as variable or parameter type
- Interface can be extended to create another interface
- Dynamic (late) binding enables objects of different classes to substitute for one another
  - Must have identical interfaces
  - Called polymorphism

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Summary

- Derived class obtained from base class by adding instance variables and methods
  - Derived class inherits all public elements of base class
- Constructor of derived class must first call a constructor of base class
  - If not explicitly called, Java automatically calls default constructor

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Summary

- Within constructor
  - `this` calls constructor of same class
  - `super` invokes constructor of base class
- Method from base class can be overridden
  - Must have same signature
- If signature is different, method is overloaded

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Summary

- Overridden method can be called with preface of **`super`**
- Private elements of base class cannot be accessed directly by name in derived class
- Object of derived class has type of both base and derived classes
- Legal to assign object of derived class to variable of any ancestor type

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Summary

- Every class is descendant of class **`Object`**
- Class derived from **`JFrame`** produces applet like window in application program
- Method **`setSize`** resizes **`JFrame`** window
- Class derived from **`WindowAdapter`** defined to be able to respond to **`closeWindow`** button

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