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Topic 7 Inheritance and Introduction to Event-driven Programming

ICT167 Principles of Computer Science

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Objectives

- Define **inheritance** and **polymorphism**
- Be able to give examples of uses of inheritance
- Be able to use the correct terminology for inheritance (**base** class and **derived** class)
- Understand inheritance between Java classes
- Explain the concept of **overriding** of methods
- Distinguish between **overriding and overloading**

Objectives

- Explain the use of the term **super** in a constructor
- Understand a **class hierarchy**
- Know that a derived class object can have a super class reference
- Be able to define and use **derived classes** in Java
- Understand the concept of multiple inheritance
- Understand Java **interfaces**

Objectives

- Understand the basics of event-driven programming
- Explain the term GUI
- Give a brief description of the Java Swing event-driven programming
- Be able to determine and explain the behaviour of simple Java GUI programs

Reading Savitch: Chapters 8.1, 8.2, 8.3 and Chapter 13 (see textbook website)

Inheritance

- Inheritance enables us to define a new class based on a (general) class that already exists
- The new class will be similar to the existing class, it will be able to use all the facilities of the existing class, but will have some new characteristics
- This makes programming easier, because you can build upon your previous work instead of starting out from scratch

Inheritance

- In Java it is easy to code the more specialized class without having to re-write any of the code which it inherits from the more general class
- Inheritance is a powerful and very useful feature of OOP
  - Graphical user interfaces (GUIs) define each visual component by using inheritance with a "toolkit" of basic components

Inheritance

- For example in the libraries:
  - Buttons inherit from Components
  - Labels inherit from Components
  - FileNotFoundException inherits from IOException
  - HttpURLConnection inherits from URLConnection
  - Time inherits from Date
  - Set inherits from Collection

Inheritance

- Example in possible applications,
  - ReferenceBook inherits from LibraryBook
  - UnderGraduateStudent inherits from Student
  - Secretary inherits from Employee
  - CreditCardCustomer inherits from Customer

Terminology

- The class that is used as a basis for defining a new class is called the `base class` (or `super class` or `parent class`)
- The new class based on the `base class` is called a `derived class` (or `sub-class` or `child class`)
- We say, the `derived class` inherits from the `base class`

Terminology

- In Java, (unlike with humans) child classes inherit characteristics from just one parent
  - This is called `single inheritance`
- Some languages allow child classes to inherit from more than one parent
  - This is called `multiple inheritance`

Terminology

- With `multiple inheritance`, it is sometimes hard to tell which parent class will contribute what characteristics to the child class
- Java avoids these problems by using `single inheritance`

Example: Base Class

```
//  A Base Class: Person.java (from Savitch chapter 8)
public class Person {
  private String name;    // instance variable
  public Person() {       // constructor
     name = "No name yet.";
  }
  // another constructor
  public Person(String initialName) {
     name = initialName;
  }
  public String getName() {  // get method
     return name;
  }
```

Example: Base Class

```
  // set method
  public void setName(String newName) {
     name = newName;
  }
  public void writeOutput(){ // output method
     System.out.println("Name: " + name);
  }
  // equal method
  public boolean sameName(Person otherPerson) {
     return (this.name.equalsIgnoreCase(
                              otherPerson.name));
  }
} // end class Person
```

Example: Derived Class

```
// A Derived Class: Student.java from Savitch chapter 8
public class Student extends Person {
  private int studentNumber; // instance variable
  public Student() {            // default constructor
     //call to default constructor of super class Person
     super();
     studentNumber = 0; // Indicating no number yet
  }
```

Example: Derived Class

```
// Another constructor
public Student(String initialName,
                     int initialStudentNumber) {
   // call to other constructor of super class Person
   super(initialName);
   studentNumber = initialStudentNumber;
}
public void reset(String newName,
                         int newStudentNumber) {
   // call to the super class method
   setName(newName);
   studentNumber = newStudentNumber;
}
```

Example: Derived Class

```
public int getStudentNumber() {
   return studentNumber;
}
public void setStudentNumber(int
                              newStudentNumber) {
   studentNumber = newStudentNumber;
}
public void writeOutput() {
   System.out.println("Name: " + getName());
   System.out.println("Student Number : " +
                                    studentNumber);
}
```

Example: Derived Class

```
  public boolean equals(Student otherStudent) {
     return (this.sameName(otherStudent)
                 && (this.studentNumber ==
                    otherStudent.studentNumber));
  }
} // end class Student
```

Example: Client Class

```
// InheritanceDemo.java - a client program
public class InheritanceDemo {
  public static void main(String[] args) {
     Student s = new Student();
     s.writeOutput();
     // setName is inherited from the Person class
     s.setName("Jason Bourne");
     s.setStudentNumber(12345678);
     s.writeOutput();
```

Example: Client Class

```
     Student s1 = new Student("James Bond", 007);
     s1.writeOutput();
     if (s.equals(s1))
        System.out.println("Same");
     else
        System.out.println("Not Same");
    }
} // end class InheritanceDemo
```

Example: Output

```
/* OUTPUT
Name: No name yet.
Student Number : 0
Name: Jason Bourne
Student Number : 12345678
Name: James Bond
Student Number: 7
Not Same
*/
```

Overriding Methods and `super` Constructors

- In the above example (consisting of two useful classes and a client) notice the following:
  - `Person` is the `base` class (or `super` class)
  - Student is `derived` from the `base` class
  - We also say, `Student` **`inherits`** from `Person`, or, `Student` **`extends`** `Person`
  - The most important thing to note is that each `Student` object (like any other `Person` object) has a name and has methods such as `setName(…)` and `getName()` available to it
  - This is inheritance

Overriding Methods and `super` Constructors

- Each `Student` object also has an extra instance variable `studentNumber`
- An object of type `Student` has the following members in it:

Overriding Methods and super Constructors

Member	**Explanation**
name	inherited from Person
studentNumber	defined in Student
setName(…)	inherited from Person
getName()	inherited from Person
sameName(…)	inherited from Person
reset(…)	defined in Student
getStudentNumber()	defined in Student
setStudentNumber (…)	defined in Student
writeOutput()	redefined in Student
equals(…)	defined in Student

Overriding Methods and `super` Constructors

- Also note that where the `derived` class has a method with exactly the same name and the same number, order and types of parameters as a method in the `base` class then the derived class method will be used for a `derived` class object
  - Eg: the method `writeOutput()` in `Student` class above
- This is called **overriding**

Overriding Methods and `super` Constructors

- Also note that since a `Student` is a type of `Person` then a new `Student` object must be set up properly as a `Person` first
- In general, a constructor for the `super` class must be called as part of the activity of a constructor for the `derived` class. If you do not specify which `super` constructor to call by writing **`super(arg1, ..., argn)`** in the `derived` class constructor then the default constructor is called automatically

Overriding Methods and `super` Constructors

- The class definition for `Person` has two constructors, one of which will initialise the member data of `Person` objects
- The class `Student` also has two constructors that initialise the data of `Student` objects
- The second constructor for class `Student` looks like following:

Overriding Methods and `super` Constructors

```
// another constructor
public Student(String initialName,
                     int initialStudentNumber) {
   // call to the constructor of superclass
   super(initialName);
   //  initialise the member that only Student has
   studentNumber = initialStudentNumber;
}
```

Overriding Methods and `super` Constructors

- The statement **`super(initialName)`** invokes the `super` class's constructor to initialize some of the data
- The next statement initializes the member that only the `Student` has
- Note that when `super` is used as above, it must be the first statement in the `derived` class's constructor

Overriding Methods and `super` Constructors

- Sometimes you want a `derived` class to have its own method, but that method includes everything the `base` class does
  - You can use the `super` reference in this case
- For example, here is class `Person's` method:

```
WriteOutput()
public void writeOutput(){
 System.out.println("Name:  " + name);
}
```

Overriding Methods and `super` Constructors

- And here is `Student's` method:

```
public void writeOutput(){
  System.out.println("Name: "+getName());
  System.out.println("Student Number:"
                                       + studentNumber);
}
```

Overriding Methods and `super` Constructors

- `Student's` method can better be written using `super`:

```
public void writeOutput(){
  super.writeOutput();
  System.out.println("StudentNumber:"
                         + studentNumber);
}
```

Overriding Methods and `super` Constructors

- **Note:** Unlike the case when `super` is used in a constructor, inside a method `super` does not have to be used in the first statement
- Note that you can form a new class from a `derived` class and can build inheritance to multiple levels
- Eg: class `Undergraduate` is `derived` from `Student` (see textbook Listing 8.4)

The `final` Modifier

- It is possible to specify that a method **cannot** be overridden in a sub-class by adding the **final** modifier to the method heading
- Eg:

```
public final void specialMethod()
{
    // method body
}
```

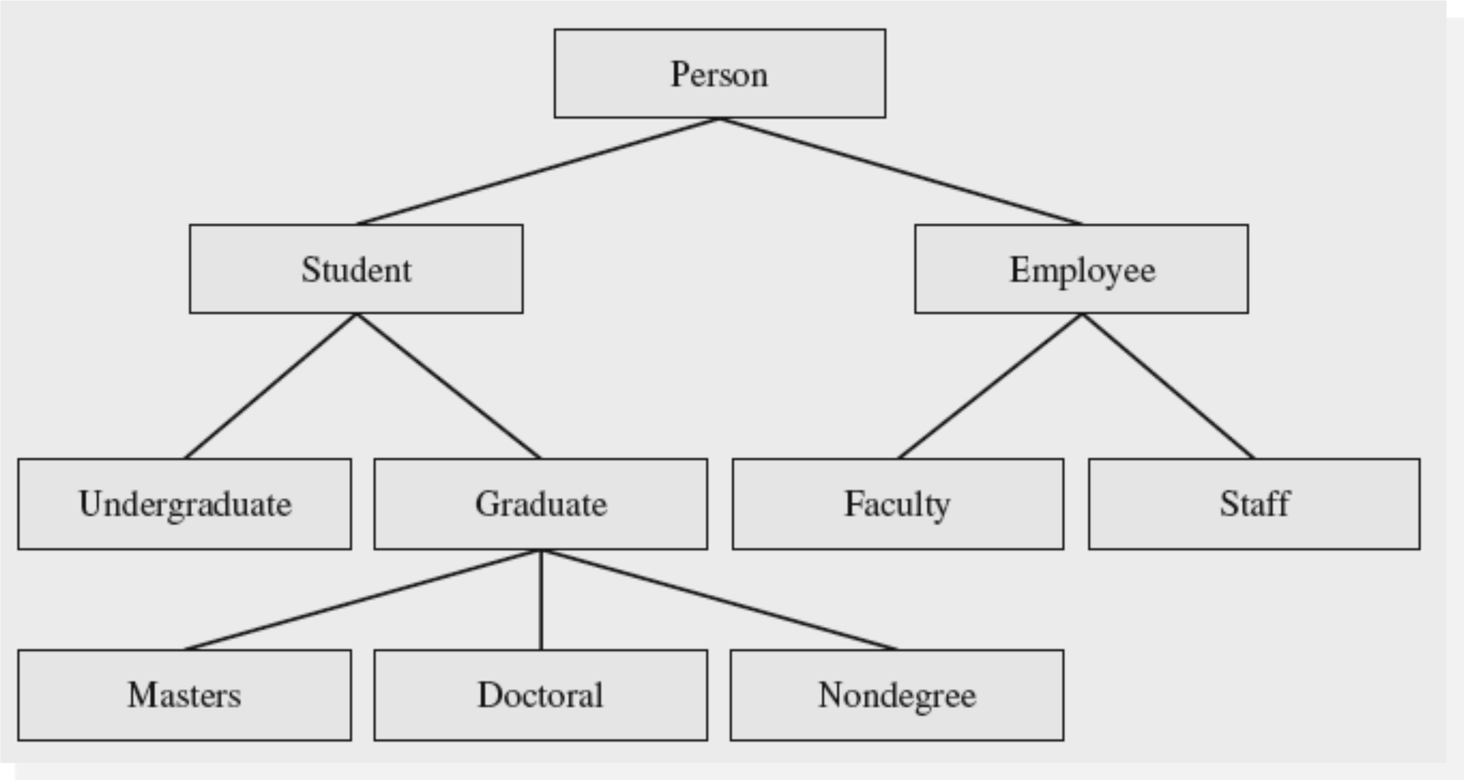
The `final` Modifier

- An entire class may be declared as `final`, which means it cannot be used as a `base` class to `derive` another class
- Eg: the Java API class String is declared as `final`

```
public final class String extends Object
{
     . . . . .
}
```

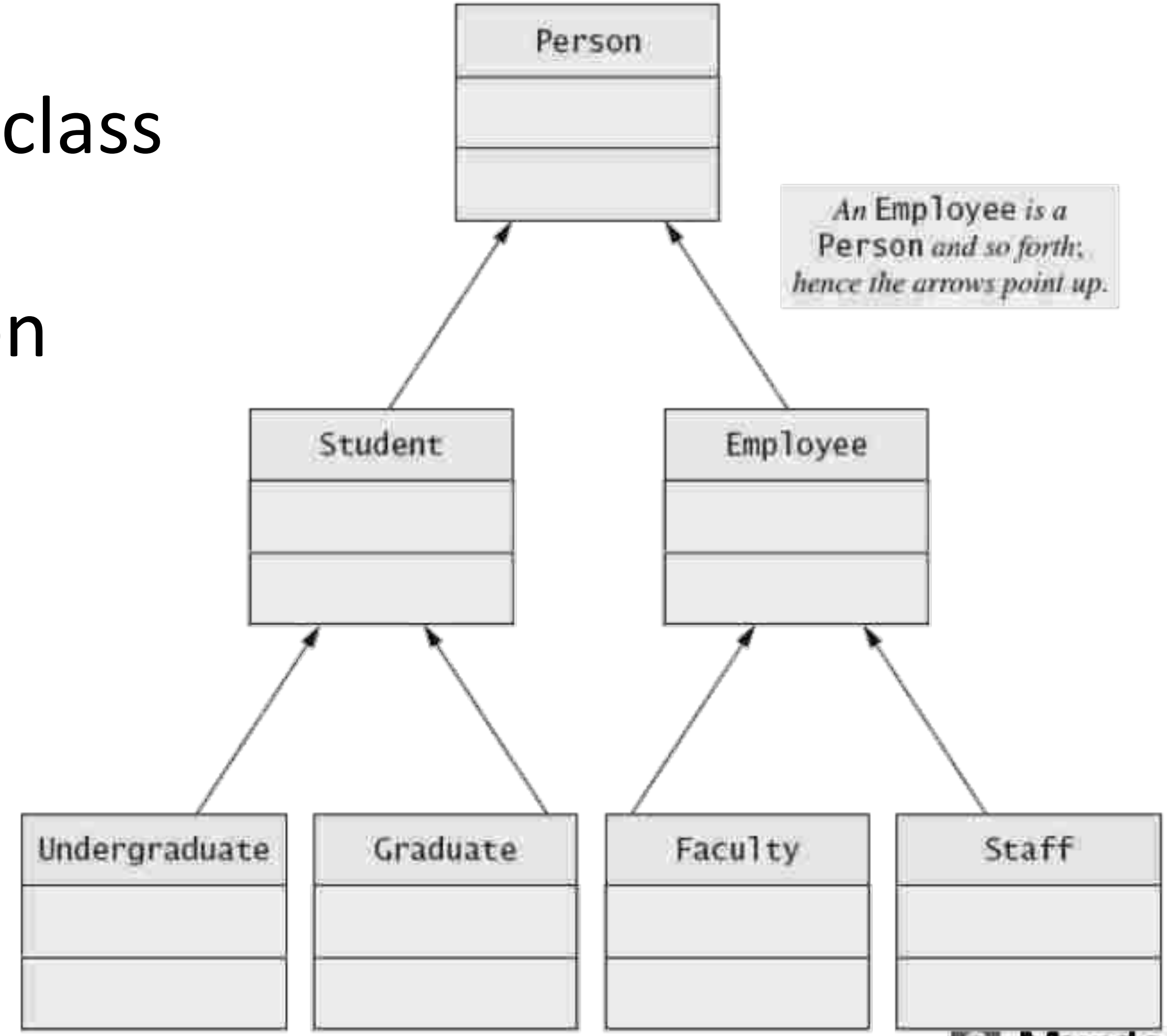
Class Hierarchies

Figure 8.1 A class hierarchy



UML Inheritance Diagrams

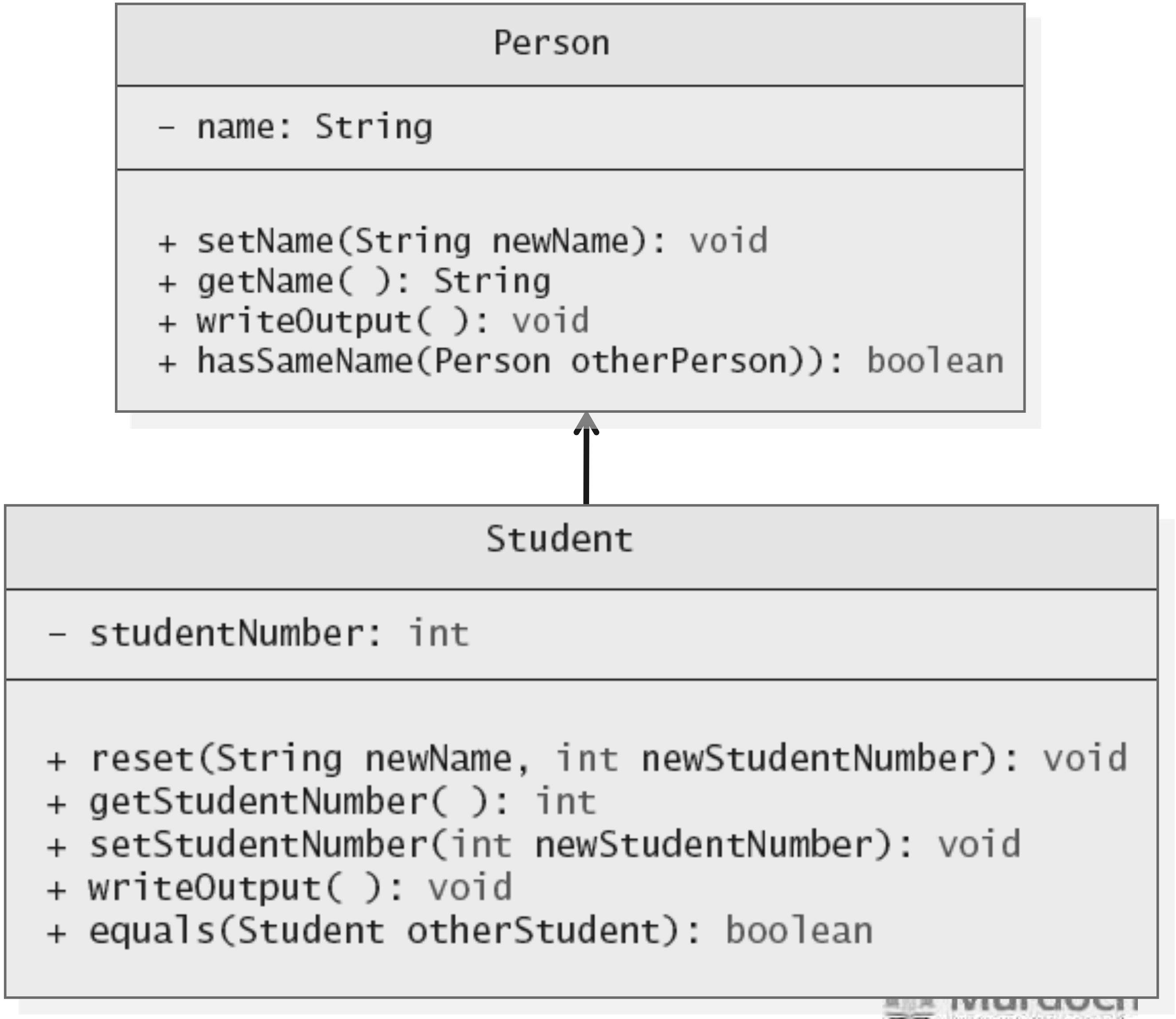
- Figure 8.2 A class hierarchy in UML notation



An Employee *is a* Person *and so forth; hence the arrows point up.*

UML Inheritance Diagrams

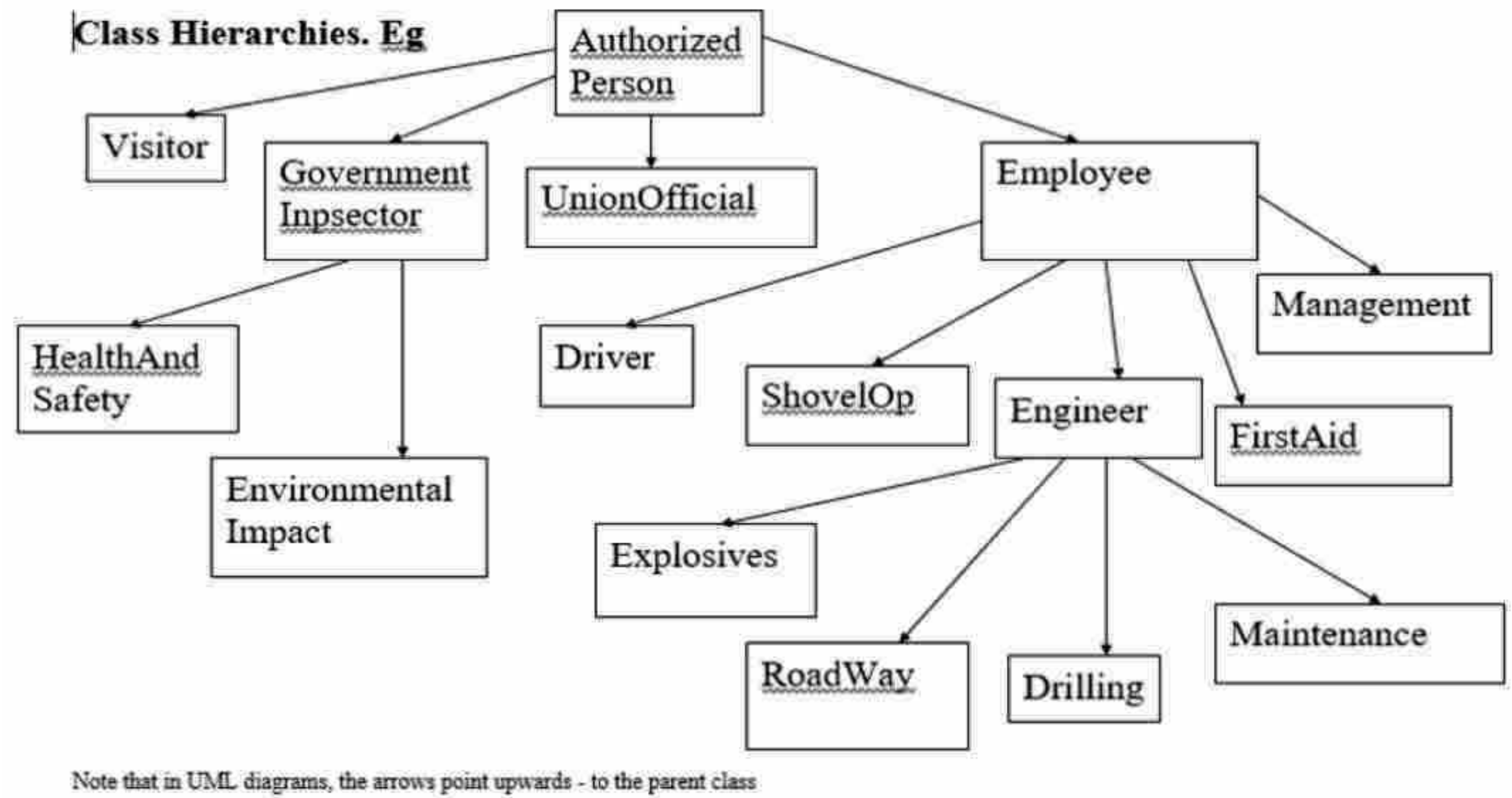
- Figure 8.3 Some details of UML class hierarchy from figure 8.2



```
Person
- name: String
+ setName(String newName): void
+ getName( ): String
+ writeOutput( ): void
+ hasSameName(Person otherPerson)): boolean
```

```
Student
- studentNumber: int
+ reset(String newName, int newStudentNumber): void
+ getStudentNumber( ): int
+ setStudentNumber(int newStudentNumber): void
+ writeOutput( ): void
+ equals(Student otherStudent): boolean
```

Class Hierarchies



Class Hierarchies. Eg

Note that in UML diagrams, the arrows point upwards - to the parent class

Using Inheritance

- The diagram on the previous slide shows a *hierarchy* of classes
- In this class hierarchy, many methods and instance variables may be inherited downwards from `super` class to `derived` class
    - Java supports this easily
- In a hierarchy, each class has at most one `base` class (`super` or `parent`), but can have several `derived` (`sub` or `child`) classes

Using Inheritance

- Now in the above hierarchy, every driller or a first-aid person is also an employee
- Thus every object of the class `Driller` is also an object of the class `Employee`
- One of the most useful aspects of inheritance is that a `derived` class object can be used wherever a `super` class object can be

Using Inheritance

- Eg:

```
Date today = new Date();
Employee emp = new Employee();
emp = userChooseEmployee();
System.out.println(“You have chosen to retire
                                    the following employee”);
emp.writeName();
System.out.println(“Are you sure(yes/no)?”);
Scanner kb = new Scanner (System.in);
String reply = kb.next();
```

Using Inheritance

```
if (reply.equals(“yes”)){
    emp.FinalizeRecords(today);
} else {
    System.out.println(“Request ignored.”);
}
System.out.println(“End of this request.”);
```

- This will work no matter whether `emp` refers to a `Driller` or a `FirstAid` object etc.

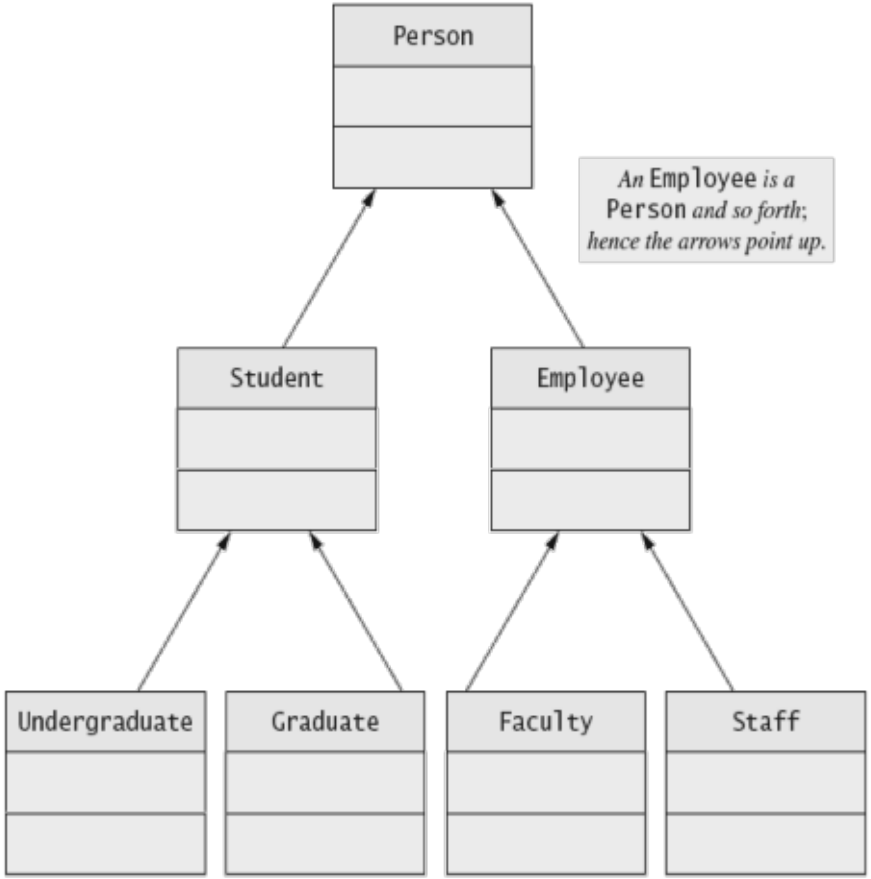
Polymorphism

- 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
- You will need to read more in the textbook under Chapter 8.3

Polymorphism

- Consider a program uses Person, Student, and Undergraduate classes

- E.g. if we want to set up a list of committee members (can be a person who are student or employee), it is better make an array of type `Person`
- Array of type `Person` can accommodate any class derived from it



An Employee *is a* Person *and so forth; hence the arrows point up.*

Polymorphism

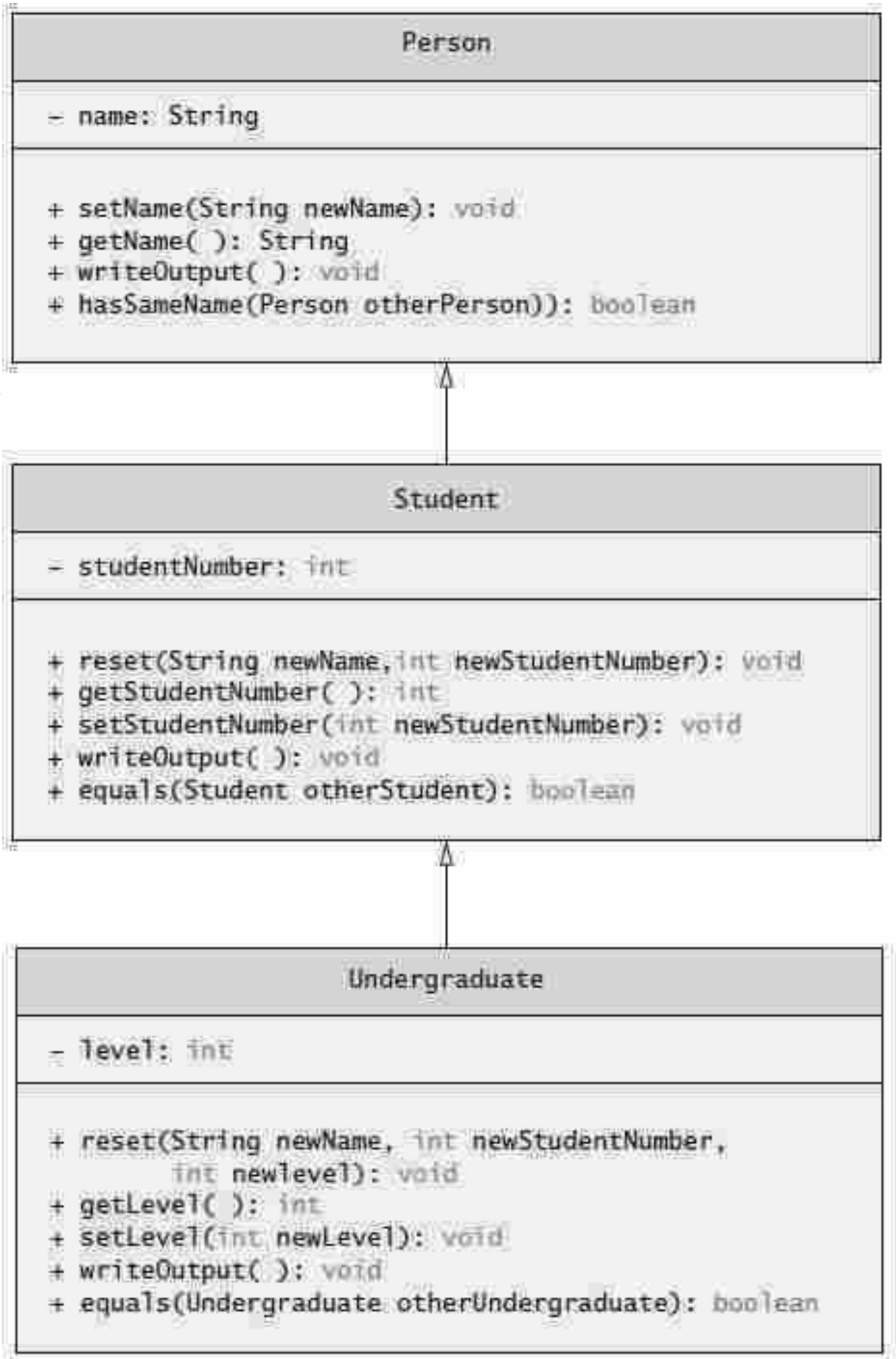
- Consider an array of **Person**

```
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);
```


Person
- name: String
+ setName(String newName): void
+ getName( ): String
+ writeOutput( ): void
+ hasSameName(Person otherPerson)): boolean
Student
- studentNumber: int
+ reset(String newName, int newStudentNumber): void
+ getStudentNumber( ): int
+ setStudentNumber(int newStudentNumber): void
+ writeOutput( ): void
+ equals(Student otherStudent): boolean
Undergraduate
- level: int
+ reset(String newName, int newStudentNumber,
int newLevel): void
+ getLevel( ): int
+ setLevel(int newLevel): void
+ writeOutput( ): void
+ equals(Undergraduate otherUndergraduate): boolean

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*

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

Polymorphism Example - listing 8.6

```
public class PolymorphismDemo
{
    public static void main(String[] args)
    {
        Person[] people = new Person[4];
        people[0] = new Undergraduate("Cotty, Manny", 4910, 1);
        people[1] = new Undergraduate("Kick, Anita", 9931, 2);
        people[2] = new Student("DeBanque, Robin", 8812);
        people[3] = new Undergraduate("Bugg, June", 9901, 4);

        for (Person p : people)
        {
            p.writeOutput();
            System.out.println();
        }
    }
}
```

Even though **p** is type Person, the **writeOutput** method associated with **Undergraduate** or **Student** is invoked depending upon which class was used to create the object

Dynamic binding

Polymorphism

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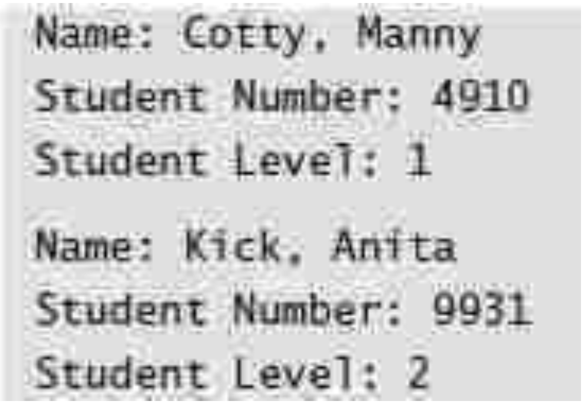
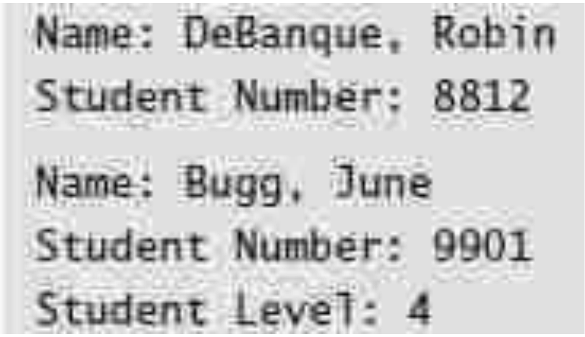
Polymorphism Example

- Output



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

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



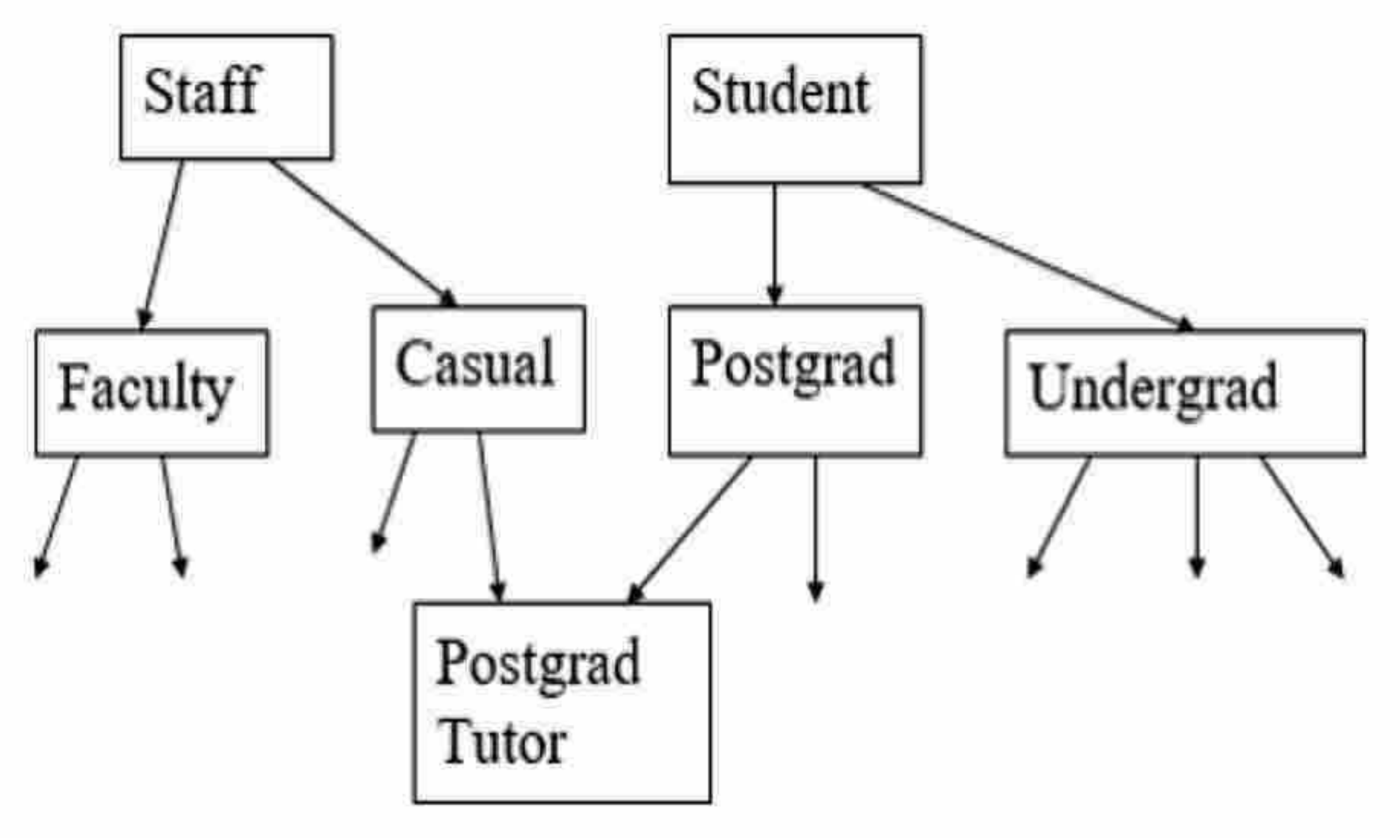
```
Name: DeBanque, Robin
Student Number: 8812

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

Multiple Inheritance

- Occasionally, the natural description of a problem suggests a different form of inheritance, not like an upside down tree
  - For example, a postgraduate tutor may be both a staff member and a student
  - We may need methods to deal with paying them for taking lab classes, and methods for dealing with their student number, HECS fees and unit results
  - We want to inherit these methods from different `super` classes
- This is called **multiple inheritance**

Multiple Inheritance



Java Interfaces

- O-O languages get confused with multiple inheritance
  - Eg: if a postgrad tutor changes their office phone number, do we use the `changeOfficePhone` method supplied in the `Staff` class or in the `Postgrad` class?
- Some O-O languages provide ways to deal with this

Java Interfaces

- Java does **not** allow multiple inheritance except in a very special case:
  - One of the `super` classes must be an ***interface***, which is like a class with methods with no bodies. (Do not confuse two uses of the word in this topic)
- A Java ***interface*** is a collection of constants and method declarations
  - The method declarations do not include an implementation (i.e. there is no method body)

Java Interfaces

- A `derived` class that `extends` a `base` class can also `implement` an `interface` to gain some additional behaviour
- An interface definition has the following general form:

```
 // File: InterfaceName.java
public interface InterfaceName {
      constant definitions
      method declarations (without
                                    implementations)
}
```

Java Interfaces

- A class definition then `implements` an `interface` as follows:

```
public class SomeClass extends
                SomeParent implements
InterfaceName
 {
     // body of the class SomeClass
 }
```

- You will know that an **interface** is involved if you see the word **implements** which is used instead of extends for interfaces

Java Interfaces

- Eg:

```
public class ButtonDemo extends JFrame
                          implements ActionListener
```

- Here we do not `inherit` any code from `ActionListener` except the ability to treat `ButtonDemo` objects as `ActionListener` Objects

The Swing Package and GUI Programming

- A *Graphical User Interface* (GUI) is a system of visible components (such as windows, menus, buttons, text fields) which allow a program to interact with a user
  - Modern programs use these windowing interfaces to allow the user to make choices with a mouse
- **Swing** is a package that comes with Java 2, and contains classes for creating these sorts of components (graphics) and other classes which help them to be used (GUI programming)

The Swing Package and GUI Programming

- GUI programming, i.e. writing programs that set up and use GUIs, is complicated (but made much easier by the swing library)
  - The swing library makes extensive use of inheritance
- Swing can be viewed as an improved version of an older package called the **Abstract Windows Toolkit (AWT)**

The Swing Package and GUI Programming

- Also, designing and implementing a GUI using the swing (and AWT) requires skill at *event-driven programming*
  - That is, a certain way of programming which makes use of objects representing events such as mouse click, keyboard press, windows becoming visible, etc.
- GUI programming is advanced and we just give a brief overview here

The Swing Package and GUI Programming

- GUIs in Java are often managed by special programs called Applets which run in Internet browsers
  - Setting up an applet is easy (and you will see this in many other units)
  - Programming the working of an applet is much the same as programming a GUI application (i.e. a non-applet GUI program) and needs the same understanding of inheritance, the swing library and event-handling

Brief Overview of Java Event Handling

- What the user sees is determined by what visible **swing** components the programmer "adds" to a frame (JFrame object).
- In Java, a **frame** is a window that has a border, a place for a title, various buttons along the top border (eg: close button), and other built-in things
  - What we usually call a "window" Java calls a "frame"

Brief Overview of Java Event Handling

- The layout of the frame (window) is controlled by the programmer and a layout manager object
- The user interacts with the application by:
  - Clicking on a window's *close* button
  - Clicking on a button to choose one of the program's options
  - Making a choice from a menu
  - Entering text in a text field

Brief Overview of Java Event Handling

- When you perform an action (like mouse-clicking, keyboard presses) on a graphical component you generate an ***event***
- In ***event-driven programming*** the program responds to events
- The program responds to events that occur:
  - Whenever the user chooses, and
  - In whatever order the user chooses

Brief Overview of Java Event Handling

- *Events* are said to be **fired** by the component which they happen to
- The events will not cause anything else to happen unless a ***listener object*** has been added to the firing component
  - Zero, one or more listening objects can be added
- Eg: in swing every object that can fire events, such as a button that might be clicked, can have one or more listener objects

Brief Overview of Java Event Handling

- If an event is fired then all the listening objects attached to the firing object are notified
- The listening object can have a method which says what to do if that particular event is fired
- This method is called an ***event handler***
- The programmer defines these event-handler methods

Brief Overview of Java Event Handling

- Most **swing** objects have methods for getting or setting their properties like what text is written on them or whether they are clickable etc.
  - Check on-line documentation for details
- Event handlers can change the component’s properties, or remove or add components, or listeners, or do some calculation, or change the whole look of the GUI or close the whole program down

Brief Overview of Java Event Handling

- Thus a GUI program consists of three types of software:
  - Components that make up the Graphical User Interface
  - Listeners that receive the events and respond to them
  - Application code that does useful work for the user

Brief Overview of Java Event Handling

- A GUI program consists of a collection of graphical components that are all placed inside one or more windows - called *container* objects
- A frame (JFrame) object is a container object, so GUI components can be placed in it

Brief Overview of Java Event Handling

- Like all software objects, a frame-object is actually a section of main memory that holds information and methods
- The Java system, with the help of the operating system and the graphics board, paints a picture on the computer monitor that represents the frame

GUI Components

- The GUI components are – windows, labels, text fields or text areas, buttons, etc.
- The components (labels, text areas/text fields and buttons) are added to the content pane (the area below the title bar and inside border) of a window and not to the window itself
- All GUI components are objects in Java and therefore are instances of a particular class type

GUI Components

- Below are some of the GUI components which can be created from swing classes (contained in package `javax.swing`):
  - `JLabel` – an area where un-editable text or icons can be displayed
  - `JTextField` – an area in which the user inputs data from the keyboard
    - It can also display information
    - It can have only one line of text

GUI Components

- `JTextArea` – an area as in `JTextField` above
  - It can have many lines of text
- `JButton` – an area that triggers an event when clicked with the mouse
- `JPanel` – a container in which components can be placed and organized

Windows

- The GUI component **window** can be created using an instance of `JFrame` class
- The swing library class `JFrame` provides various methods to control attributes of a window
- The attributes associated with windows are:
  - Title
  - Width and height (in pixels)

Windows

- Some methods provided by the `JFrame` class:
  - JFrame(String title)
    - Constructor for creating a JFrame with a title
  - Container getContentPane()
    - Returns the content pane of the JFrame, which has the add method for adding components
  - void setSize(int width, int height)
    - Method to set the size of the window
    - Eg: `myWindow.setSize(500, 300);`
  - void setTitle(String title)
    - Method to set the title of the window

Windows

- Some methods provided by the `JFrame` class:
  - void setVisible(boolean b)
    - Method to display window in the program
    - Displays window on the screen if `b` is true
  - public void addWindowListener(WindowEvent e)
    - Method to register a window listener object to a Jframe
  - public void setDefaultCloseOperation (int operation)
    - Method to determine action to be taken when the user clicks on window closing button, x, to close the window
    - Eg:

```
setDefaultCloseOperation(EXIT_ON_CLOSE)
;
```

Windows

- Some methods provided by the `JFrame` class:
  - void setBackgroundColor(Color c)
  - void setForegroundColor(Color c)

Windows

- There are two ways to create a window in an application:
- The first way:
  - Declare object of type `JFrame`
  - Instantiate the object using **new**
  - Use various methods to manipulate window

Windows

- Alternatively:
  - Create the class containing the application program by extending definition of class `JFrame` using inheritance
  - The new class can use features such as methods it inherits from the existing class (`JFrame`), and can add some functionality of it own

Control Pane

- Content Pane is the inner area of GUI a window (below the title bar and inside the border)
- GUI components are added to the content pane through a container class
- To access the content pane:
  - Declare reference variable of type `Container`
  - Use method `getContentPane` of class `JFrame`

Control Pane

- Eg:

```
Container c1;
c1 = getContentPane();
```

- or,

```
Container c1 = getContentPane();
```

- In order to design the layout to decide where to place the GUI components in the content pane, the class `Container` provides the method `setLayout`

Control Pane

- The components can be added/attached to the content pane by using method `add` of the `Container` class
- The class `Container` is contained in the package `java.awt`
- To use this class in your program, you need to include either the statement:

```
import java.awt.*;
```

- or

```
import java.awt.Container;
```

Labels

- A label is a special kind of text that can be added to a `JFrame` (or to any of a number of other kinds of objects)
- It provides instruction or information on a GUI
- It displays a single line of read-only text, an image or a mixture of both
- Labels are created by instantiating objects of class `Jlabel` (which is contained in the package `java.swing`)

Labels

- Eg: Give a string as an argument to the constructor for the `JLabel` class:

```
JLabel label1;
label1 = new JLabel(“Please don’t
click that button!”);
c1.add(label1,BorderLayout.CENTER);
```

- Eg: set string describing `label2` as right-justified

```
JLabel label2;
label2 = new JLabel(“Enter your
name:”,
SwingConstants.RIGHT);
```

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Text Fields and Text Areas

- Text fields (objects of class `JTextField`) are single-line areas in which the user can enter text (via keyboard) or the program can display text
- When the user enters data into a text field and presses the Enter key, an action event (ActionEvent) occurs
- If the program has registered an event listener, the listener will process the event enabling the program to use the data entered in the text field

Text Fields and Text Areas

```
JTextField mytext;
mytext = new JTextField(50);
```

- This statement instantiates the object `mytext` and sets the width of this text field to 50 characters
- The object `mytext` will be added to the content pane using the `add` method of `Container` class

Text Fields and Text Areas

- Some methods provided by `JTextfield` class:
  - public JTextField(int size)
    - Constructor to set the size of the text field
  - public JTextField(String str)
    - Constructor to initialise object with text specified by str
  - public void setText(String str)
    - Method to set text of text field to string specified by str
  - public String getText()
    - Method to return the text contained in the text field
  - public void addActionListener(ActionListener e)
    - Method to register a listener object to a JTextField

Text Fields and Text Areas

- **Text areas** (objects of class `JTextArea`) are areas in which the many lines of text can be entered and/or displayed
- Eg:

```
 JTextArea text2 = new JTextArea(10, 50);
```

- `text2` is big enough to hold 10 lines, where each line can hold up to 50 characters

Text Fields and Text Areas

- Similar methods, as those in `JTextField` class, are also available in `JTextArea` class
- Eg: `getText(), setText(String str), addActionListener(ActionListener e)`
- The text fields/areas are then added to the content pane of a window using the `add` method and a layout manager

Buttons

- A button (created with class `JButton`) is a component the user clicks to trigger an action (`ActionEvent`). The text on the face of a button is called button label
- An `ActionEvent` can be processed by any `ActionListener` object
- To create a button, we use the same techniques as creating labels and text fields

Buttons

- Some methods provided by the class `JButton`:
  - public JButton(String str)
    - Constructor to initialise the object to text specified by str
  - public void setText(String str)
    - method to set text of the button to string specified by str
  - public String getText()
    - method to return the text contained in button
  - public void addActionListener(ActionListener e)
    - method to register a listener object to the button object

Layout Managers

- Layout Managers are objects that decides how components will be arranged in a container
- Some types of layout managers:
  - BorderLayout
  - FlowLayout
  - GridLayout
- Each type of layout manager has rules about how to rearrange components when the size or shape of the container changes

The Border Layout Manager

- It has five regions that can each have one component added to them:

<table>
<tr><td colspan="3">BorderLayout.NORTH</td></tr>
<tr><td>BorderLayout.WEST</td><td>BorderLayout.CENTER</td><td>BorderLayout.EAST</td></tr>
<tr><td colspan="3">BorderLayout.SOUTH</td></tr>
</table>

```
c1.setLayout(new BorderLayout());
. . .
c1.add(label1, BorderLayout.NORTH);
```

The Flow Layout Manager

- Flow is the simplest layout manager; it display's components from left to right in the order they are added to the container
- The `add` method has one parameter which is the component to add

```
Container c2 = getContentPane();
C2.setLayout(new FlowLayout());
JLabel label1=new JLabel("1st label here");
C2.add(label1);
JLabel label2=new JLabel("2nd label there");
C2.add(label2);
```

The Grid Layout Manager

- The programmer specifies the number of rows and columns in the grid
- **All regions in the grid are of equal size**
- When the container changes size, each region grows or shrinks by the same amount

The Grid Layout Manager

- The following example creates a grid layout with two rows and three columns:

```
Container c3 = getContentPane();
c3.setLayout(new GridLayout(2, 3));
. . .
c3.add(label1);
c3.add(label2);
```

- Note that the rows are filled before columns in the grid

Handling an Event

- When button (`JButton`) is clicked, an event is created – called **action event**
- Action event sends a signal to another object, known as **action listener**
- When the listener receives the message, it performs some action
- Sending a message or an event to a listener simply means that some method (eg, `actionedPerformed`) in the listener object is invoked with the event as the argument

Handling an Event

- This invocation happens automatically – there is no code corresponding to the method call
- However, you must specify two things:
  - For each `JButton`, you must specify a corresponding listener object – called **registering** the listener
  - You must define the methods that will be called when the event is fired (i.e., sent to the listener)
- Java does not allow us to instantiate an object of type `ActionListener`

Class ActionListener

- The class `ActionListener` (part of the package `java.awt.event`) handles action events
- It is a special type of class called an **interface** and contains the method `actionPerformed`
- An interface is a class that only contains the method headings (terminated with a semicolon) and not their definitions/implementations
- Java does not allow us to instantiate an object of type `ActionListener`

Class ActionListener

- One way to register an event is to create a class on top of `ActionListener` so that the required object can be instantiated
- Eg:

```
private class MyButtonHandler implements
                               ActionListener {
  public void actionedPerformed
                                (ActionEvent e){
     //Code for tasks to be performed go here
  }// end actionedPerformed
}// end class MyButtonHandler
```

Example: SimpleApp

```
//SimplApp.java - a simple example of a GUI program
//You should be able to give a brief description of what
//such a program will do and the steps involved
import javax.swing.*;  //for JFrame, JButton, JLabel
import java.awt.*;     //for Container, BorderLayout
import java.awt.event.*; //for WindowAdapter,
                             ActionListner, ActionEvent
public class SimplApp extends JFrame {
  // define window's width and height in pixels
  private static final int WIDTH = 400;
  private static final int HEIGHT = 200;
```

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Example: SimpleApp

```
// used for displaying text in the window
private JLabel infoLabel;
private class ButtonAction implements
                                   ActionListener {
   public void actionPerformed(ActionEvent e){
      infoLabel.setText("You fool !!");
   } //end of actionPerformed
 } //end of class ButtonAction
```

Example: SimpleApp

```
// used to destroy/close the window
private class WindowDestroyer extends
                                   WindowAdapter  {
   public void windowClosing(WindowEvent e){
      dispose();
      System.exit(0);
   } //end of windowClosing()
} //end of class WindowDestroyer
```

Example: SimpleApp

```
// Below is the constructor for the class SimplApp
public SimplApp(String windowTitle) {
   super(windowTitle);
   setSize(WIDTH, HEIGHT);
   // create content pane to add components to
 window
   Container c1 = getContentPane();
   c1.setLayout( new BorderLayout());
   // create a label component with the String
 centred
   infoLabel = new JLabel( "Initial",
                                       JLabel.CENTER);
   c1.add( infoLabel, BorderLayout.CENTER);
```

Example: SimpleApp

```
   // create a button component
   JButton button1=new JButton("Don't Press

   Me!");
   c1.add( button1, BorderLayout.NORTH);
   //goes at top
   // add an action event to button
   ButtonAction myAction = new ButtonAction();
   button1.addActionListener(myAction);
   // add action event to window close button
   WindowDestroyer myListener = new
                                 WindowDestroyer();
   addWindowListener( myListener);
} //end of SimplApp constructor
```

Example: SimpleApp

```
  public static void main(String[] args) {
     // calls constructor
     SimplApp app = new SimplApp("Zzzz");
     // display window on the screen
     app.setVisible(true);
     System.out.println("Finished
                                SimplApp.main()");
  } //end of SimplApp.main()
} //end of SimplApp class
```

Example: BinarySearch

```
// BinarySearch.java revised (by P S Dhillon) from
   Deitel and Deitel
// Binary search of an array
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import java.text.*;
public class BinarySearch extends JFrame
                  implements ActionListener {
  JLabel enterLabel, resultLabel;
  JTextField enterField, resultField;
```

Example: BinarySearch

```
JTextArea initial, output;
int arr[];
String display = "";
public static void main (String[] args) {
   BinarySearch myApplication = new
                  BinarySearch("Binary Search");
   myApplication.setVisible(true);
   myApplication.setDefaultCloseOperation(
                                   EXIT_ON_CLOSE);
} // end main
```

Example: BinarySearch

```
// constructor for BinarySearch
public BinarySearch(String title) {
   super (title);
   setSize(800, 300);
   Container c = getContentPane();
   c.setLayout( new FlowLayout() );
   // set up JLabel and JTextField for user input
   enterLabel = new JLabel( "Enter an integer
                                 key to search" );
   c.add( enterLabel );
```

Example: BinarySearch

```
      enterField = new JTextField( 5 );
      enterField.addActionListener( this );
      c.add( enterField );
// set up JLabel and JTextField for displaying
   results
      resultLabel = new JLabel( "Result" );
      c.add( resultLabel );
      resultField = new JTextField(20);
      resultField.setEditable( false );
      c.add( resultField );
```

Example: BinarySearch

```
// create array and fill with odd integers 1 to 29
     arr = new int[ 15 ];
     for (int i = 0;i < arr.length;i++)
        arr[ i ] = 2 * i + 1;
// set up JTextArea for displaying the array
   contents
     JTextArea initial = new JTextArea(3,60 );
     c.add( initial );
```

Example: BinarySearch

```
// build the initial array for displaying
     String arrayContents=“Contents of array:\n";
     for (int i = 0;i < arr.length;i++)
        arrayContents = arrayContents + (arr[i])
                                           + "   " ;
     initial.setText(arrayContents);
// set up JTextArea for displaying comparison
     output = new JTextArea(10,60);
     c.add( output );
  } //end of constructor
```

Example: BinarySearch

```
// obtain user input and call method binSearch
  public void actionPerformed(actionEvent e) {
     String searchKey = e.getActionCommand();
// initialize display string for the new search
     display = "Portions of array searched:\n";
// perform the binary search
     int index = binarySearch(arr,
     Integer.parseInt(searchKey));
     output.setText( display );
```

Example: BinarySearch

```
   if ( index != -1 )
      resultField.setText("Value found at
                                index " + index);
   else
      resultField.setText("Value not found");
}//end of actionPerformed method
```

Example: BinarySearch

```
  public int binarySearch(int ar[], int key) {
     int first = 0;
     int last = ar.length - 1;
     int mid;
     while (first <= last) {
        mid = (first + last)/2;
// The following line is used to display the part
// of the array currently being manipulated
// during each iteration of the binary search loop.
        buildOutput( first, mid, last );
```

Example: BinarySearch

```
        if (key == ar[mid]) // match found
           return mid;          // exit
        else if(key < ar[mid])
// search low end of array
           last = mid - 1;
        else      //search high end of array
           first = mid + 1;
     }// end while
     return -1;   // match not found
  }// end binarySearch
```

Example: BinarySearch

```
// Build one row of output showing the current
// part of the array being processed.
   void buildOutput(int low,int mid,int high) {
     DecimalFormat twoDigits = new
                                 DecimalFormat( "00" );
     for (int i = 0;i < arr.length;i++) {
```

Example: BinarySearch

```
        if ( i < low || i > high )
           display = display + "    ";
        else if ( i == mid ) //mark middle element
           display = display + twoDigits.format(
                                   arr[ i ] ) + "* ";
        else
           display = display + twoDigits.format(
                                   arr[ i ] ) + "  ";
     } // end for
     display = display + "\n";
  }// end of buildOutput
}//end of class
```

End of Topic 7