Slides with a blue heading are for "self-study".

Shapes

Topics:

– Inheritance

– Accessors/Modifiers (*aka* Getters/Setters)

– Abstract Classes

– Interfaces

including

These slides are provided to students for review only. – *They will <u>not</u> be covered in class.*

Example (1/6): Rectangle Class

```
class Rectangle { // instance variables (attributes)
  int width;
  int height;

  /* draw the rectangle on the terminal */
  void draw() {
    for (int i = 0; i < height; i++) {
      for (int j = 0; j < width; j++) {
        System.out.print("*");
      } // end for
      System.out.println("");
    } // end for
  } // end draw() method

  /* returns the area of the rectangle */
  int area() {
    return width * height;
  } // end area() method
} // end class Rectangle
```

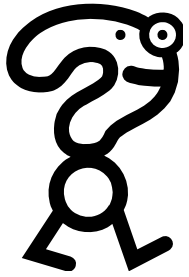
Example (2/6): Rectangle Class Description

- Declares a class **`Rectangle`** with two attributes, **`width`** and **`height`**, both of which are integers.
- These instance variables are not *qualified*, so are assumed to be *public*.

  (This is not the whole truth – they actually fall into that default access we talked about!)
- There are two operations that can be performed on an instance of the **`Rectangle`** class:
  - **`draw()`**, which tells the **`Rectangle`** to draw itself;
  - **`area()`**, which causes the **`Rectangle`** to compute and return its own area.

Example (3/6): Using the Rectangle Class

```
class RectangleTest {
  public static void main (String[] argv) {
    Rectangle r1;
    r1 = new Rectangle();
    r1.draw();
    System.out.println("area is " + r1.area());
  } // end main() method
} // end class RectangleTest
```



1. What will this program do?
2. How can it be improved?

Example (4/6): Improving the Test Program

```
class RectangleTest {
  public static void main (String[] argv) {
    // 1: declare (create) a rectangle variable
    Rectangle r1;
    // 2: create *instance of* a rectangle
    r1 = new Rectangle();
    // 3: set the width of r1
    r1.width = 10;
    // 4: set the height of r1
    r1.height = 20;
    // 5: tell r1 to draw itself
    r1. draw();
    // 6: print the area of r1
    System.out.println("area is " + r1.area());
  } // end main() method
} // end class RectangleTest
```

Example (5/6): Analysis of Test Program

- Line (1): Declares a variable **`r1`** to be a **`Rectangle`**.
  - At this point, no **`Rectangle`** object has been created.
  - The default value for an object variable is a special value called **`null`**, which means "no object".

- Line (2): *Creates* a rectangle object.
  - The **`new`** keyword says "create me a…".
  - Call to **`Rectangle()`** is to the object's default *constructor*.
  - Upon creation, all instance variables in an object are initialised to their default values.

What values are **`width`** and **`height`** initialised to?

Example (6/6): Analysis of Test Program (cont.)

- Line (3): *Accesses* the instance variable **`width`**, and sets it to *10*.
  - This direct access is only possible because **`width`** is publicly accessible.

- Line (4): As Line (3), but *sets* the **`height`** instance variable.

- Line (5): Tells the **`r1`** object to invoke the **`draw()`** method.
  - The idea is very similar to the function call in C.

- Line (6): This line *invokes* the **`area()`** method on the **`r1`** object, which returns the area of **`r1`** (200).
  - The area is returned from the method via the **`return`** operation.

Access Control (*Review Only*) – 1/4

- Remember, we don't *want* to make all our instance variables and methods public – this defeats the purpose of *information hiding*.

```
class Rectangle {
  // instance variables (attributes)
  /* the width of the rectangle in cm */
  private int width;
  /* the height of the rectangle in cm */
  private int height;
{...}
```

- However, now in our **`main()`** program, the following will cause an error:

```
Rectangle r1 = new Rectangle();
r1.height = 10; // ERROR HERE!
```

Access Control (*Review Only*) – 2/4

- The **`area()`** and **`draw()`** methods will still work; because they are *part* of the object, they can see its private parts …
- To explicitly make an instance variable or method public, we qualify the declaration with the **`public`** keyword:

```
/* returns the area of rectangle */
public int area() {
  return width * height;
} // end area() method
```

- By default, you should make all instance variables **`private`**.

Access Control (*Review Only*) – 3/4

- *Accessor methods: "get" for* ***width***

```
/* get method for width */
public int getWidth() {
  return this.width;
} // end width() method
```

  - Simply returns the value of the variable.
  - Convention: give the *get* method same name as the variable.

- *Mutator methods: "set" for* ***width***

```
/* set method for width */
public void setWidth(int i) {
  if (i >= 0) { this.width = i; }
  else { System.out.println("bad width"); } // end if-else
} // end setWidth() method
```

Access Control (*Review Only*) – 4/4

- Improved RectangleTest program:

```
class RectangleTest {
  public static void main(String[ ] argv) {
    Rectangle r1 = new Rectangle();
    r1.setWidth(10);
    r1.setHeight(20);
    r1.draw();
    System.out.println("area is " + r1.area());
  } // end main() method
} // end class RectangleTest
```

Writing your own Constructors

- Previously to create a new rectangle and initialise it, the following code was required:

```
Rectangle r1 = new Rectangle();
r1.setWidth(10);
r1.setHeight(20);
```

- Can simplify this by writing our own constructor method:

```
public Rectangle(int w, int h) {
  setWidth(w);
  setHeight(h);
}
```

- Thus the original 3 lines of code above can be reduced to:

```
Rectangle r1 = new Rectangle(10,20);
```

Using `this` (*Review Only*)

- Sometimes, an object needs to be able to refer to itself.
  - It does this using the keyword **`this`**.
  - **Example**:

```
public boolean isSquare() {
  if (this.width == this.height) {
    return true;
  }
  else {
    return false;
  }
}
```

Example (1/2): Inheritance

- We will create a **`Square`** class as a subclass of **`Rectangle`**, which *reuses* much of its code.

```
class Square extends Rectangle {
  public Square(int w, int h) {
    if (w != h) {
      System.out.println("bad square!");
    }
    else {
      setWidth(w);
      setHeight(h);
    } // end else
  }
  public Square(int w) {
    setWidth(w);
    setHeight(w);
  }
} // end class Square
```

Example (2/2): Overriding Constructors

- This class **`Square`** *inherits* all the instance variables and methods of the **`Rectangle`** class.
- **Example**:

```
Square s1 = new Square(10,10);
System.out.println("area s1 = " + s1.area());
```

- When methods or constructors in the *subclass* are provided that take the same name and parameters as those in the *superclass*, then the ones in the *subclass* are used.
- The constructor

```
public Square(int w, int h) {
  // some code
}
```

overrides the similar constructor in **`Rectangle`**.

Interfaces (1/5)

- Suppose we have classes **`Square`**, **`Circle`**, **`Triangle`**, **`Hexagon`**, and so on for implementing shapes.
  - We want to build a list of shapes and process the list to *get the total area of all shapes*.
  - This is what we *want* to write:

```
ArrayList list = new ArrayList();
// add shapes to the list ...

double totalArea = 0.0;
for (int i=1; i<list.size(); i++) {
  totalArea += (list.get(i)).area();
}
```

This will cause a problem, since the compiler doesn't know that each object in the list implements the **`area()`** method.

Interfaces (2/5)

- One possibility: define a class **`Shape`**, with a default method **`area()`**, and get each sub-class (**`Triangle`**, **`Square`**, …) to overwrite this method. But what if the method is *not* overwritten?
  - Implement an *interface* for shapes!
- **Interface**:
  - The interface is a number of methods, without providing an implementation for them.
  - Any class that *implements* the interface *must* provide an implementation for these methods.
  - E.g. the interface for **`Shape`** could be written as:

```
public interface Shape {
  public double area();
} // end interface Shape
```

Interfaces (3/5)

- How we state that **Rectangle** and **Circle** implement the **Shape** interface:

```
public class Rectangle implements Shape {
  // ...
  public double area() {
    return (double)(this.width*this.height);
  }
  // ...
} // end class Rectangle

public class Circle implements Shape {
  // ...
  public double area() {
    return Math.PI*(this.radius*this.radius);
  }
  // ...
} // end class Circle
```

Java interface ⇔
100% pure abstract class

Interfaces (4/5)

- The code to process the list of **Shape** is then:

```
ArrayList<Shape> list = new ArrayList<Shape>();
// add shapes to the list ...
double totalArea = 0.0;
for (int i=1; i<list.size(); i++) {
  totalArea += (list.get(i)).area();
}
```

How can this **for** loop be rewritten in Java 5.0 syntax?

Interfaces (5/5)

- At *design time*, we can write code that needn't worry about the *implementation* of any class that implements **`Shape`**.
  - We can treat the implementation as a black box, and rest safe in the knowledge that it must provide **`area()`**.
- Interfaces are then like *certificates*, which say "I provide these services".
  - You *can't* make an instance of an interface so e.g.,

```
Shape a = new Shape(); // ERROR!
```