Classes & objects

JC08-2.1

(A. Nguyen)

Class vs. object

- A class represents a category of objects that share common **characteristics** and **behaviors**; it is a blue print for all objects in that class
- For example,
  - a class many be `BankAccount`
  - an object of that class may be `momsAccount` or `bobsAccount`

The Java Library

- The Java Library is a collection of classes that are available for Java programmers to use
- Some examples:
  - Class `PrintStream` provides the printing capabilities (`println`, `print`), etc.
  - Class `JOptionPane` provides functionality with dialog windows, etc.
  - Class `String` provides functionality with handling pieces of text
- To see ***what*** is available and ***how*** to use, search "Java API" on the Internet
- API stands for Application Programming Interface

The API

- Programmers consult the Java API when using the Java Library
- Programmers' own classes can be "automatically" documented in the same manner, including documentation within symbols /** … */, called Javadoc documentation – you can easily switch between the source code and the documentation in BlueJ
- Thanks to the Javadoc documentation, past & present & concurrent programmers can "show" one another how to use their own classes

The PrintStream class

- The `PrintStream` class provides the "printing" functionality to the console window, where the parameter/input may be of type `String` or `int`, etc.
- `System.out` is an object of the `PrintStream` class
- `PrintStream` has a method called `println` (& `print`, etc.), which can be called by any object of the `PrintStream` class
- To invoke/call the method, we write the object name, a period, the method name, and possibly the parameter(s) in parentheses; e.g.,

```
System.out.println("Hello");
```

The String class

- The `String` class represents a sequence of text, with various methods/functionalities relating to manipulating the text
- Some functionalities are: finding certain (smaller) sequence of text, extracting (smaller) sequence of text, etc.
- When a programmer writes a piece of text in double quotes in a Java program, a `String` object is automatically created to represent that text

The Scanner class

- The class `PrintStream` provides the functionality to display the output to the console window; the `Scanner` class provides the functionality to accept input from the user (from the keyboard, etc.)
- In preparing the keyboard for input, a programmer creates a keyboard object:

```
Scanner kboard = new Scanner(System.in);
```

- When done, the programmer writes:

```
kboard.close();
```

- In between these two statements, the programmer can accept inputs from the user, of various data types (text, integer, etc.)

The Scanner class (cont.)

- After the keyboard object, called `kboard`, is created, the programmers use the following statements to accept inputs from the user:

```
String name = kboard.nextLine(); // Get text & save in name
int age = kboard.nextInt(); // Get integer & save in age
double dist = kboard.nextDouble(); // Get floating-point # & save in dist
```

- Note that, before accepting the user's input, you must remember to ask/request; e.g., `System.out.print("Your name? ");`
- Certain library classes (e.g., `String`) are automatically included in a Java program. The `Scanner` class is not. Therefore we must import it, before the class header: `import java.util.Scanner;`

Variables

JC08-2.2

(A. Nguyen)

Data types

- There are 2 kinds of data types: primitive data types and classes
- There are 8 primitive data types in Java :

  `int, double, boolean, char,`
  `byte, short, long, float`

- Some classes from the Java Library are `String, Scanner, Color, Rectangle`

Data types (cont.)

- In the following statements:

```
String name = kboard.nextLine(); // Get text & save in name
int age = kboard.nextInt(); // Get integer & save in age
double dist = kboard.nextDouble(); // Get floating-point # & save in dist
```

… `name` is an object (aka instance of a class) of the `String` class

… `age` is a variable of primitive data type called `int`

… `dist` is a variable of primitive data type called `double`

Data types (cont.)

- Classes come from the Java Library (e.g., `String`, `Scanner`, etc.), and also from creation by programmers/you (e.g., `HelloPrinter`, etc.)
- Different data types need different amounts of RAM space
- Note that `String` is a class; `char` is a primitive data type:

```
String firstName = "Abraham";  // in double quotes
char lastInitial = 'L';        // in single quotes
```

Variable names

- A variable is a piece of RAM space where we store some data.
- A variable is named, based on the java syntax & convention:
  - May contain letters and numbers and underscore (_); no space or special characters – Names are case-sensitive: variable `area` is NOT variable `Area`
  - Must start with a letter, in camel case
  - Should be meaningful, and cannot be a reserved word (like `int`, `class` etc.)
- Good variable names: `firstName, score1, score2`
- Bad variable names:
  - `6pack` – syntax error: name cannot start with a number
  - `stuff` – bad style/convention: name is not meaningful
  - `car color` – error: space not allowed; use `carColor`

Declaration: asking for RAM space

- A declaration is a **request for some RAM space**
- Declaration is composed of **at least** the following:

  <dataType> <variableName>; // for a local variable

  <accessSpecifier> <dataType> <variableName>; // for a field

- Example:

  ```
  int numOfYrs; // request RAM space for primitive data type int
  String firstName; // request RAM space for an address (or reference) of String class
  ```

- A variable must be declared ***before*** being used
- A local variable (i.e., of the same name) cannot be declared more than once – or else syntax error

Assignment

- After a variable is declared, we can assign a value to it (using the equal sign):

```
numOfYrs = 10;
```

- Note that this equal sign does NOT mean "equal" as in math; it means "is assigned to" or "gets/has the value of"
- Later in the code, the variable may be assigned to another value (*do NOT declare it again*):

```
numOfYrs = numOfYrs * 2; // double the # of years
```

- A declaration and an assignment may be combined into 1 statement:

```
int numOfYrs = 10;
```

Assignment (cont.)

- In an assignment statement, the left side of the symbol ***must*** be a variable name; the right side may be one of the following:

```
numOfYrs = 10;              // constant
sumOfInts = 1 + 2 + 3;      // arithmetic expression
numOfYrs = initValue;       // another variable, previously declared & assigned
age = kboard.nextInt();     // result from a method call
```

- Bad assignment statements:

```
numOfYrs = "Hello";         // data type of value is not same as data type of variable
1 + 2 + 3 = sumOfInts;      // the variable must be on the left
```

Method call

JC08-2.3

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Method signatures

- A class has 2 main parts:
  - Instance variables, aka fields, representing characteristics
  - Methods, representing behaviors
- The API for a class mostly methods but fields (which are usually private)
- Each method is documented with the method name, parameters/inputs (inside parentheses), and return value/output

Some String methods

- From the Java API:

`String`	`toUpperCase()` Converts all of the characters in this `String` to upper case using the rules of the default locale.
`String`	`toLowerCase()` Converts all of the characters in this `String` to lower case using the rules of the default locale.
`String`	`substring(int beginIndex)` Returns a new string that is a substring of this string.
`String`	`substring(int beginIndex, int endIndex)` Returns a new string that is a substring of this string.
`int`	`length()` Returns the length of this string.
`String`	`replace(char oldChar, char newChar)` Returns a new string resulting from replacing all occurrences of `oldChar` in this string with `newChar`.

Examples of method signatures

- Example: a method (**`replace`**) may accept parameters/arguments/inputs. (**`oldChar`** & **`newChar`** of type **`char`**), and returns a value of type String, as shown in the API:

`String`	`replace(char oldChar, char newChar)` Returns a new string resulting from replacing all occurrences of `oldChar` in this string with `newChar`.

- Example: `Scanner` has one method called `nextInt`; it takes no parameters (empty parentheses) and returns a value of type `int`, as shown in the API:

`int`	`nextInt()` Scans the next token of the input as an `int`.

Calling methods

- To call a method (of a class) is to ask the object of that class to carry out the instructions in that method
- For example, after creating a Scanner object:

```
Scanner kboard = new Scanner(System.in);
```

… we can ask `kboard` to get the input by making an appropriate method call:

```
String name = kboard.nextLine(); // get text
int age = kboard.nextInt(); // get integer
```

etc.

- **Note the syntax**: object name, dot, method name, parameters in parentheses (if any)

Calling methods (cont.)

- The call to that method must provide appropriates parameters:

```
int nameLen = name.length();  // no param to String name
System.out.print("Hello");     // 1 param
```

- A method may return a value (i.e., one output) or not. In the method signature, if it returns a value, the data type is shown; if not, `void` is shown

```
int nameLen = name.length();  // with return value
System.out.print("Hello");     // without return value
```

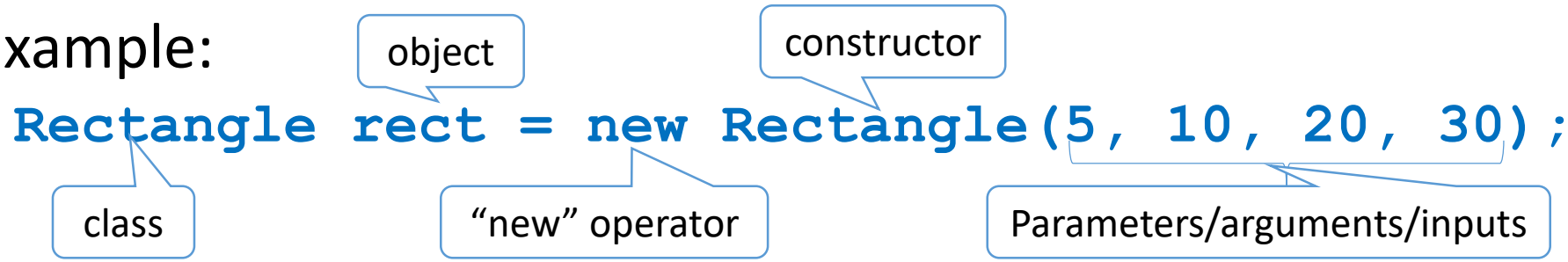
Constructing objects

JC08-2.4

(A. Nguyen)

Constructor

- A Java program is a “world” of objects that interact with one another
- Before an object can exist (to interact), it **must be created,** which is done with the **`new`** operator and a call to the class’s constructor
- Example:



- A constructor is a special “method” whose purpose is to initialize the instance variables (aka fields) of a newly created object
- Just about all objects must be created this way – except the String class: `String school = "Cal";` // automatically did “new”

Constructor (cont.)

- A constructor's name is the same as the name of the class and the .java file; class `Rectangle` is in file `Rectangle.java` and has constructor `Rectangle`
- Like a method, a constructor may accept parameter(s) or not
- The result of `new` and a constructor call is a newly created object:

```
new Rectangle(5, 10, 20, 30);
```

- … and you can store it in a variable, like **`rect`**:

```
Rectangle rect = new Rectangle(5, 10, 20, 30);
```

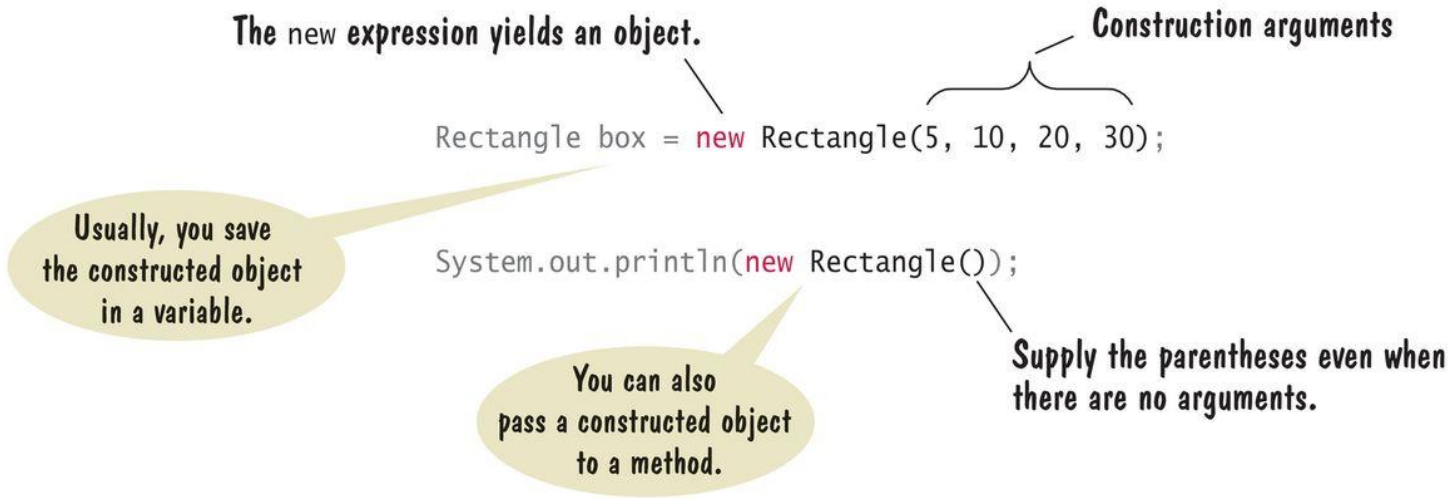
Constructors of class Rectangle

Constructors

Constructor and Description
`Rectangle()` Constructs a new `Rectangle` whose upper-left corner is at (0, 0) in the coordinate space, and whose width and height are both zero.
`Rectangle(Dimension d)` Constructs a new `Rectangle` whose top left corner is (0, 0) and whose width and height are specified by the `Dimension` argument.
`Rectangle(int width, int height)` Constructs a new `Rectangle` whose upper-left corner is at (0, 0) in the coordinate space, and whose width and height are specified by the arguments of the same name.
`Rectangle(int x, int y, int width, int height)` Constructs a new `Rectangle` whose upper-left corner is specified as `(x,y)` and whose width and height are specified by the arguments of the same name.
`Rectangle(Point p)` Constructs a new `Rectangle` whose upper-left corner is the specified `Point`, and whose width and height are both zero.
`Rectangle(Point p, Dimension d)` Constructs a new `Rectangle` whose upper-left corner is specified by the `Point` argument, and whose width and height are specified by the `Dimension` argument.
`Rectangle(Rectangle r)` Constructs a new `Rectangle`, initialized to match the values of the specified `Rectangle`.

Syntax 2.3 Object Construction

Syntax new *ClassName*(*arguments*)



Accessors & Mutators

JC08-2.5

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The Rectangle API

Methods

Modifier and Type	Method and Description
`void`	`add(int newx, int newy)` Adds a point, specified by the integer arguments `newx,newy` to the bounds of this `Rectangle`.
`void`	`add(Point pt)` Adds the specified `Point` to the bounds of this `Rectangle`.
`void`	`add(Rectangle r)` Adds a `Rectangle` to this `Rectangle`.
`boolean`	`contains(int x, int y)` Checks whether or not this `Rectangle` contains the point at the specified location `(x,y)`.
`boolean`	`contains(int X, int Y, int W, int H)` Checks whether this `Rectangle` entirely contains the `Rectangle` at the specified location `(X,Y)` with the specified dimensions `(W,H)`.
`boolean`	`contains(Point p)` Checks whether or not this `Rectangle` contains the specified `Point`.
`boolean`	`contains(Rectangle r)` Checks whether or not this `Rectangle` entirely contains the specified `Rectangle`.
`Rectangle2D`	`createIntersection(Rectangle2D r)` Returns a new `Rectangle2D` object representing the intersection of this `Rectangle2D` with the specified `Rectangle2D`.
`Rectangle2D`	`createUnion(Rectangle2D r)` Returns a new `Rectangle2D` object representing the union of this `Rectangle2D` with the specified `Rectangle2D`.

The Rectangle API (cont.)

`boolean`	`equals(Object obj)` Checks whether two rectangles are equal.
`Rectangle`	`getBounds()` Gets the bounding `Rectangle` of this `Rectangle`.
`Rectangle2D`	`getBounds2D()` Returns a high precision and more accurate bounding box of the `Shape` than the `getBounds` method.
`double`	`getHeight()` Returns the height of the bounding `Rectangle` in `double` precision.
`Point`	`getLocation()` Returns the location of this `Rectangle`.
`Dimension`	`getSize()` Gets the size of this `Rectangle`, represented by the returned `Dimension`.
`double`	`getWidth()` Returns the width of the bounding `Rectangle` in `double` precision.
`double`	`getX()` Returns the X coordinate of the bounding `Rectangle` in `double` precision.
`double`	`getY()` Returns the Y coordinate of the bounding `Rectangle` in `double` precision.
`void`	`grow(int h, int v)` Resizes the `Rectangle` both horizontally and vertically.
`boolean`	`inside(int X, int Y)`

The Rectangle API (cont.)

void	`setBounds(int x, int y, int width, int height)` Sets the bounding `Rectangle` of this `Rectangle` to the specified `x`, `y`, `width`, and `height`.
void	`setBounds(Rectangle r)` Sets the bounding `Rectangle` of this `Rectangle` to match the specified `Rectangle`.
void	`setLocation(int x, int y)` Moves this `Rectangle` to the specified location.
void	`setLocation(Point p)` Moves this `Rectangle` to the specified location.
void	`setRect(double x, double y, double width, double height)` Sets the bounds of this `Rectangle` to the integer bounds which encompass the specified `x`, `y`, `width`, and `height`.
void	`setSize(Dimension d)` Sets the size of this `Rectangle` to match the specified `Dimension`.
void	`setSize(int width, int height)` Sets the size of this `Rectangle` to the specified width and height.
void	`translate(int dx, int dy)` Translates this `Rectangle` the indicated distance, to the right along the X coordinate axis, and downward along the Y coordinate axis.
`Rectangle`	`union(Rectangle r)` Computes the union of this `Rectangle` with the specified `Rectangle`.

Accessors

- A method is an accessor if it **does not change** the value of the field(s)
- In the `Rectangle` class, some accessors are: `getHeight`, `getWidth`, `getX`, `getY`
- An accessor's name usually starts with `get`
- All `String` methods are accessors. I.e., when a method is called, the original text is unchanged; the method returns new text
- The String class is called immutable, i.e., the fields are never changed

Mutators

- A method is an mutator if it **changes** the value of the field(s)
- In the `Rectangle` class, some mutators are: `setHeight`, `setWidth`, `setX`, `setY`, `setBounds`, `setLocations`, `add`, `grow`, `translate`, `union`
- Some mutator names start with `set`

Testing

JC08-2.7

(A. Nguyen)

Tester

- A Tester is a (main) program that is used to test *all the methods* of a class
- When a method returns a value, print it to the console window, along with the “expected” value that you/programmer have calculated to verify
- When printing something, remember to start with a label to identify the meaning of the value

Test Script

- Programs are usually more complicated then displaying one result; so we use a test script
- A test script is a list of inputs and expected outputs, of different situations:
  - General cases
  - Boundary cases
- When testing, the programmer gives the program input(s), then compares the output(s) from the program with the output(s) from the test script to verify

Object Reference

JC08-2.8

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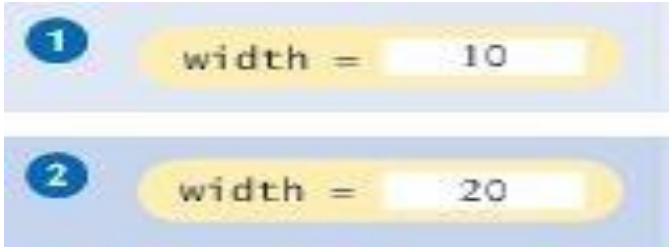
Primitive data type

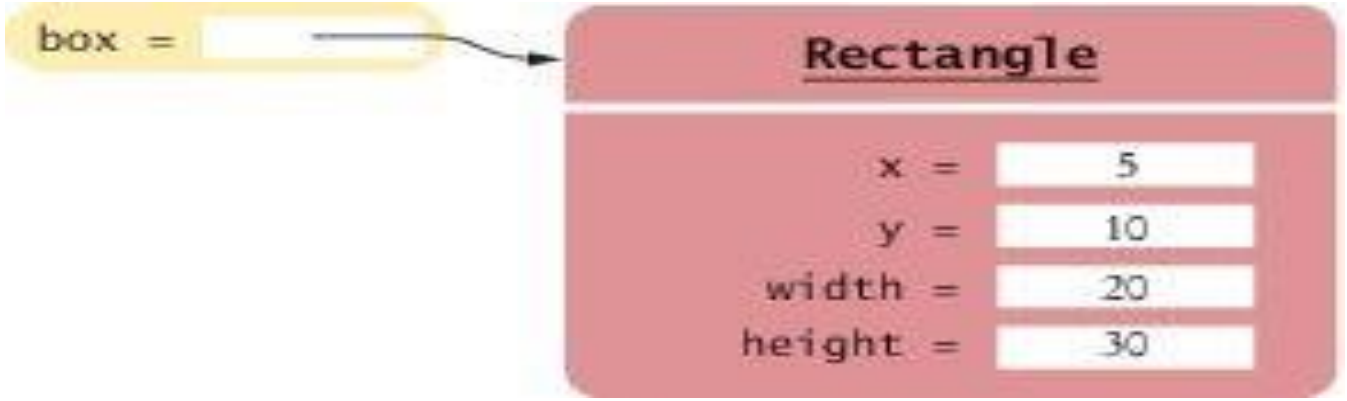
- When a variable is of primitive data type, its value is stored directly in the memory slot
- Example: `int width;`

```
width = 10;
width = 20;
```



Object

- When a variable is an object, its value is stored via the address/reference to the memory slot
- Example: `box` is an object of the `Rectangle` class, with top left corner at (5, 10), width 20, length 30:



- See Fig. 19 on p. 57 – Be careful

BlueJ Debugger

Demo

Some library classes

The Random class

- Must `import java.util.Random;`
- To create an object:

```
Random randGen = new Random(); // create object
```

- To get an `int` between `0` and `n`, including `0` but not `n`, (where `int n=6`):

```
int result = randGen.nextInt(n); // get 0 to 5, inclusively
```

- To get an `int` between `1` and `n`, inclusively, (where `int n=6`) to simulate the roll of a 6-sided die:

```
int result = randGen.nextInt(n) + 1; // get 1 to 6, inclusively
```

The Color class

- Must `import java.awt.Color;`
- Search for “java api” on the Internet, and click on the `Color` class to see the documentation for it
- Some default colors are `Color.BLACK, Color.ORANGE`
- There are 13 default colors: `Color.BLACK ... Color.YELLOW`
- Java is case-sensitive, but both `Color.BLACK` and `Color.black` are present in the API, so they both refer to the black color. However, it is better to use the upper-case name, which follows the naming convention for “constants”

The Color class (cont.)

- An object of the Color class is composed of 3 pieces of info: red, green, blue, each of which has value 0-255, referred to as RGB
- To "create" color from scratch, call `Color(int r, int g, int b)` with the `new` operator:

```
Color color1 = new Color(255, 0, 0); // is Color.RED
Color color2 = new Color(200, 150, 180); //purplish
Color color3 = new Color(255, 255, 255); // is Color.WHITE
```

The Color class (cont.)

- To “create” an opaque color from scratch, call constructor `Color(int r, int g, int b, int a)` with the `new` operator, where 4th parameter `a`, with value 0 – 255, determines how opaque it is:

```
Color color4 = new Color(255, 255, 255, 200);
```

The Rectangle class

- Must `import java.awt.Rectangle;`
- Create a rectangle by calling `Rectangle(int x, int y, int width, int height)`, where `x` and `y` are top-left corner:

```
Rectangle box1 = new Rectangle(5, 10, 200, 300);
```

- There are also other `Rectangle` constructors – see Java API
- Some common methods are: `grow, setSize, setLocation, getX, getY, getWidth, getHeight, translate`
- If you have 2 shapes of the same size but at different locations (like 2 windows in a house), create one `Rectangle` object, draw it, translate it, and draw it again

The Ellipse.Double class

- Must `import java.awt.geom.Ellipse2D;`
- Create an ellipse by calling `Ellipse2D.Double(double x, double y, double w, double h)`, where `x` & `y` are top-left corner and `w` & `h` are width & height:

```
Ellipse2D.Double oval1 = new Ellipse2D.Double(150, 250, 100, 50);
```

- There is also another `Ellipse2D.Double` constructor – see Java API
- Some common methods are similar to those of `Rectangle`

The Line.Double class (cont.)

- Must `import java.awt.geom.Line2D.Double;`
- Create a line by calling `Line2D.Double(double x1, double y1, double x2, double y2),` where the parameters are the coordinates of the 2 endpoints:

```
Line2D.Double aLine = new Line2D.Double(50, 100, 95, 75);
```

The Polygon class

- Must `import java.awt.Polygon;`
- Create a line by calling `Polygon(int[] xpoints, int[] ypoints, int npoints)`, where the parameters are x-coordinates, y-coordinates, number of points:

```
int[] xCoords = {120, 140, 130};
int[] yCoords = {150, 190, 220};
Polygon aPoly = new Polygon(xCoords, yCoords, 3);
```

- Some common methods are: `translate, addPoint` – see Java API

The Graphics2D class

- Drawing is done in a subclass of `JComponent`
- Must

```
import java.awt.Graphics;
import java.awt.Graphics2D;
import java. ; // for JComponent
```

- Cast:

```
Graphics2D g2 = (Graphics2D) g;
```

The Graphics2D class (cont.)

- We will use `g2` as the variable name for the object of `Graphic2D` in these examples
- To draw a shape object named `box`, call `g2.draw(box);`
- To fill a shape object named `oval`, call `g2.fill(box);`
- To draw text, call `g2.drawString("9870", 50, 130);`
- What is drawn/filled before will be under those drawn/filled after; e.g., if 2 concentric circles are filled and if the smaller circle is filled before the larger circle, then only the larger circle is visible

The Graphics2D class (cont.)

- To draw or fill in certain color named `aColor`, set the color BEFORE drawing or filling, by calling `g2.setColor(aColor);`
- To draw with thickness 5, set the thickness BEFORE drawing by calling `g2.setStroke(new BasicStroke(5));`
- To use `BasicStroke`, must `import java.awt.BasicStroke;`
- Note that the color & thickness are used until the next setting

THE END