Chapter 2: Objects and Primitive Data

Presentation slides for

Java Software Solutions

Foundations of Program Design

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Objects and Primitive Data

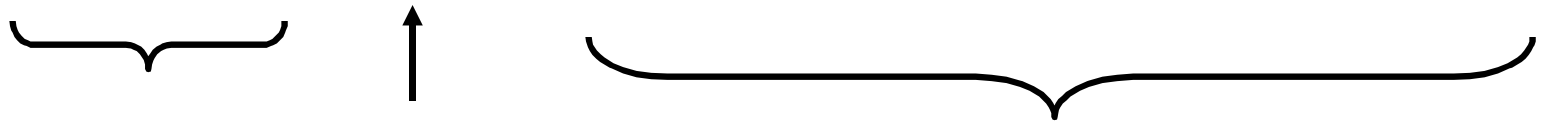
- **We can now explore some more fundamental programming concepts**

- **Chapter 2 focuses on:**
  - **predefined objects**
  - **primitive data**
  - **the declaration and use of variables**
  - **expressions and operator precedence**
  - **class libraries**
  - **Java applets**
  - **drawing shapes**

Introduction to Objects

- **Initially, we can think of an *object* as a collection of services that we can tell it to perform for us**
- **The services are defined by methods in a class that defines the object**
- **In the Lincoln program, we invoked the `println` method of the `System.out` object:**

```
System.out.println ("Whatever you are, be a good one.");
```



object **method** **Information provided to the method (parameters)**

The println and print Methods

- The `System.out` object provides another service as well
- The `print` method is similar to the `println` method, except that it does not advance to the next line
- Therefore anything printed after a `print` statement will appear on the same line
- See Countdown.java (page 53)

Abstraction

- **An *abstraction* hides (or ignores) the right details at the right time**
- **An object is abstract in that we don't really have to think about its internal details in order to use it**
- **We don't have to know how the `println` method works in order to invoke it**
- **A human being can only manage seven (plus or minus 2) pieces of information at one time**
- **But if we group information into chunks (such as objects) we can manage many complicated pieces at once**
- **Therefore, we can write complex software by organizing it carefully into classes and objects**

The String Class

- **Every character string is an object in Java, defined by the `String` class**
- **Every string literal, delimited by double quotation marks, represents a `String` object**
- **The *string concatenation operator* (+) is used to append one string to the end of another**
- **It can also be used to append a number to a string**
- **A string literal cannot be broken across two lines in a program**
- **See Facts.java (page 56)**

String Concatenation

- The plus operator (+) is also used for arithmetic addition
- The function that the + operator performs depends on the type of the information on which it operates
- If both operands are strings, or if one is a string and one is a number, it performs string concatenation
- If both operands are numeric, it adds them
- The + operator is evaluated left to right
- Parentheses can be used to force the operation order
- See Addition.java (page 58)

Escape Sequences

- What if we wanted to print a double quote character?
- The following line would confuse the compiler because it would interpret the second quote as the end of the string

```
System.out.println ("I said "Hello" to you.");
```

- An *escape sequence* is a series of characters that represents a special character
- An escape sequence begins with a backslash character (\), which indicates that the character(s) that follow should be treated in a special way

```
System.out.println ("I said \"Hello\" to you.");
```

Escape Sequences

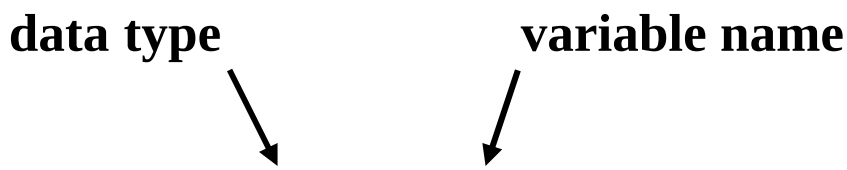
- **Some Java escape sequences:**

Escape Sequence	Meaning
`\b`	backspace
`\t`	tab
`\n`	newline
`\r`	carriage return
`\"`	double quote
`\'`	single quote
`\\`	backslash

- **See Roses.java (page 59)**

Variables

- **A *variable* is a name for a location in memory**
- **A variable must be *declared*, specifying the variable's name and the type of information that will be held in it**




```
int total;

int count, temp, result;
```

Multiple variables can be created in one declaration

Variables

- A variable can be given an initial value in the declaration

```
int sum = 0;
int base = 32, max = 149;
```

- When a variable is referenced in a program, its current value is used

- See PianoKeys.java (page 60)

Assignment

- **An *assignment statement* changes the value of a variable**
- **The assignment operator is the = sign**

```
total = 55;
```

- **The expression on the right is evaluated and the result is stored in the variable on the left**
- **The value that was in `total` is overwritten**
- **You can only assign a value to a variable that is consistent with the variable's declared type**
- **See Geometry.java (page 62)**

Constants

- **A constant is an identifier that is similar to a variable except that it holds one value for its entire existence**
- **The compiler will issue an error if you try to change a constant**
- **In Java, we use the `final` modifier to declare a constant**

```
final int MIN_HEIGHT = 69;
```

- **Constants:**
  - **give names to otherwise unclear literal values**
  - **facilitate changes to the code**
  - **prevent inadvertent errors**

Primitive Data

- There are exactly eight primitive data types in Java
- Four of them represent integers:
  - `byte`, `short`, `int`, `long`
- Two of them represent floating point numbers:
  - `float`, `double`
- One of them represents characters:
  - `char`
- And one of them represents boolean values:
  - `boolean`

Numeric Primitive Data

- **The difference between the various numeric primitive types is their size, and therefore the values they can store:**

Type	Storage	Min Value	Max Value
byte	8 bits	-128	127
short	16 bits	-32,768	32,767
int	32 bits	-2,147,483,648	2,147,483,647
long	64 bits	$< -9 \times 10^{18}$	$> 9 \times 10^{18}$
float	32 bits	$+/- 3.4 \times 10^{38}$ with 7 significant digits	
double	64 bits	$+/- 1.7 \times 10^{308}$ with 15 significant digits	

Characters

- A `char` variable stores a single character from the *Unicode character set*
- A *character set* is an ordered list of characters, and each character corresponds to a unique number
- The Unicode character set uses sixteen bits per character, allowing for 65,536 unique characters
- It is an international character set, containing symbols and characters from many world languages
- Character literals are delimited by single quotes:

```
'a'    'X'    '7'    '$'    ','    '\n'
```

Characters

- **The *ASCII character set* is older and smaller than Unicode, but is still quite popular**
- **The ASCII characters are a subset of the Unicode character set, including:**

uppercase letters	A, B, C, …
lowercase letters	a, b, c, …
punctuation	period, semi-colon, …
digits	0, 1, 2, …
special symbols	&, |, \, …
control characters	carriage return, tab, ...

Boolean

- A `boolean` value represents a true or false condition
- A boolean can also be used to represent any two states, such as a light bulb being on or off
- The reserved words `true` and `false` are the only valid values for a boolean type

```
boolean done = false;
```

Arithmetic Expressions

- **An *expression* is a combination of operators and operands**
- ***Arithmetic expressions* compute numeric results and make use of the arithmetic operators:**

Addition	+
Subtraction	-
Multiplication	*
Division	/
Remainder	%

- **If either or both operands to an arithmetic operator are floating point, the result is a floating point**

Division and Remainder

- If both operands to the division operator (/) are integers, the result is an integer (the fractional part is discarded)

`14 / 3`	equals?	`4`
`8 / 12`	equals?	`0`

- The remainder operator (%) returns the remainder after dividing the second operand into the first

`14 % 3`	equals?	`2`
`8 % 12`	equals?	`8`

Operator Precedence

- Operators can be combined into complex expressions

```
result  =  total + count / max - offset;
```

- Operators have a well-defined precedence which determines the order in which they are evaluated
- Multiplication, division, and remainder are evaluated prior to addition, subtraction, and string concatenation
- Arithmetic operators with the same precedence are evaluated from left to right
- Parentheses can always be used to force the evaluation order

Operator Precedence

- **What is the order of evaluation in the following expressions?**

```
a + b + c + d + e
  1   2   3   4
```

```
a + b * c - d / e
  3   1   4   2
```

```
a / (b + c) - d % e
  2     1     4   3
```

```
a / (b * (c + (d - e)))
  4     3     2     1
```

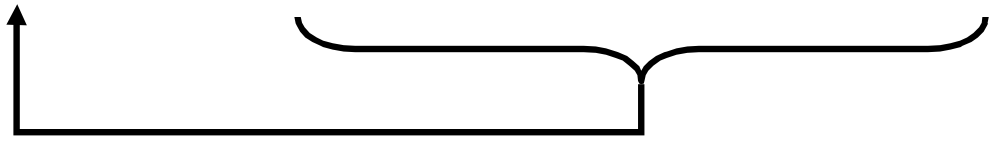
Assignment Revisited

- **The assignment operator has a lower precedence than the arithmetic operators**

First the expression on the right hand side of the = operator is evaluated

```
answer  =  sum / 4 + MAX * lowest;
```

4 1 3 2



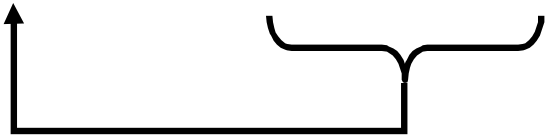
Then the result is stored in the variable on the left hand side

Assignment Revisited

- **The right and left hand sides of an assignment statement can contain the same variable**

First, one is added to the original value of `count`

```
count  =  count + 1;
```



Then the result is stored back into `count` (overwriting the original value)

Data Conversions

- **Sometimes it is convenient to convert data from one type to another**
- **For example, we may want to treat an integer as a floating point value during a computation**
- **Conversions must be handled carefully to avoid losing information**
- ***Widening conversions* are safest because they tend to go from a small data type to a larger one (such as a `short` to an `int`)**
- ***Narrowing conversions* can lose information because they tend to go from a large data type to a smaller one (such as an `int` to a `short`)**

Data Conversions

- **In Java, data conversions can occur in three ways:**
  - **assignment conversion**
  - **arithmetic promotion**
  - **casting**

- ***Assignment conversion* occurs when a value of one type is assigned to a variable of another**
- **Only widening conversions can happen via assignment**

- ***Arithmetic promotion* happens automatically when operators in expressions convert their operands**

Data Conversions

- *Casting* is the most powerful, and dangerous, technique for conversion
- Both widening and narrowing conversions can be accomplished by explicitly casting a value
- To cast, the type is put in parentheses in front of the value being converted
- For example, if `total` and `count` are integers, but we want a floating point result when dividing them, we can cast `total`:

```
result = (float) total / count;
```

Creating Objects

- **A variable either holds a primitive type, or it holds a *reference* to an object**
- **A class name can be used as a type to declare an *object reference variable***

```
String title;
```

- **No object has been created with this declaration**
- **An object reference variable holds the address of an object**
- **The object itself must be created separately**

Creating Objects

- We use the `new` operator to create an object

```
title = new String ("Java Software Solutions");
```

This calls the `String` *constructor*, which is a special method that sets up the object

- Creating an object is called *instantiation*
- An object is an *instance* of a particular class

Creating Objects

- Because strings are so common, we don't have to use the `new` operator to create a `String` object

```
title = "Java Software Solutions";
```

- This is special syntax that only works for strings

- Once an object has been instantiated, we can use the *dot operator* to invoke its methods

```
title.length()
```

String Methods

- **The `String` class has several methods that are useful for manipulating strings**
- **Many of the methods *return a value*, such as an integer or a new `String` object**
- **See the list of `String` methods on page 75 and in Appendix M**
- **See StringMutation.java (page 77)**

Class Libraries

- A *class library* is a collection of classes that we can use when developing programs
- There is a *Java standard class library* that is part of any Java development environment
- These classes are not part of the Java language per se, but we rely on them heavily
- The `System` class and the `String` class are part of the Java standard class library
- Other class libraries can be obtained through third party vendors, or you can create them yourself

Packages

- The classes of the Java standard class library are organized into packages
- Some of the packages in the standard class library are:

Package	Purpose
`java.lang`	General support
`java.applet`	Creating applets for the web
`java.awt`	Graphics and graphical user interfaces
`javax.swing`	Additional graphics capabilities and components
`java.net`	Network communication
`java.util`	Utilities

The import Declaration

- When you want to use a class from a package, you could use its *fully qualified name*

```
java.util.Random
```

- Or you can *import* the class, then just use the class name

```
import java.util.Random;
```

- To import all classes in a particular package, you can use the * wildcard character

```
import java.util.*;
```

The import Declaration

- All classes of the `java.lang` package are automatically imported into all programs
- That's why we didn't have to explicitly import the `System` or `String` classes in earlier programs

- The `Random` class is part of the `java.util` package
- It provides methods that generate pseudo-random numbers
- We often have to *scale* and *shift* a number into an appropriate range for a particular purpose
- See RandomNumbers.java (page 82)

Class Methods

- **Some methods can be invoked through the class name, instead of through an object of the class**
- **These methods are called *class methods* or *static methods***
- **The `Math` class contains many static methods, providing various mathematical functions, such as absolute value, trigonometry functions, square root, etc.**

```
temp = Math.cos(90) + Math.sqrt(delta);
```

The Keyboard Class

- The `Keyboard` class is NOT part of the Java standard class library
- It is provided by the authors of the textbook to make reading input from the keyboard easy
- Details of the `Keyboard` class are explored in Chapter 8
- For now we will simply make use of it
- The `Keyboard` class is part of a package called `cs1`, and contains several static methods for reading particular types of data
- See Echo.java (page 86)
- See Quadratic.java (page 87)

Formatting Output

- The `NumberFormat` class has static methods that return a formatter object

```
getCurrencyInstance()
getPercentInstance()
```

- Each formatter object has a method called `format` that returns a string with the specified information in the appropriate format

- See Price.java (page 89)

Formatting Output

- The `DecimalFormat` class can be used to format a floating point value in generic ways
- For example, you can specify that the number be printed to three decimal places
- The constructor of the `DecimalFormat` class takes a string that represents a pattern for the formatted number
- See CircleStats.java (page 91)

Applets

- A Java application is a stand-alone program with a `main` method (like the ones we've seen so far)
- An *applet* is a Java program that is intended to transported over the web and executed using a web browser
- An applet can also be executed using the appletviewer tool of the Java Software Development Kit
- An applet doesn't have a `main` method
- Instead, there are several special methods that serve specific purposes
- The `paint` method, for instance, is automatically executed and is used to draw the applets contents

Applets

- **The paint method accepts a parameter that is an object of the `Graphics` class**
- **A `Graphics` object defines a *graphics context* on which we can draw shapes and text**
- **The `Graphics` class has several methods for drawing shapes**

- **The class that defines the applet *extends* the Applet class**
- **This makes use of *inheritance*, an object-oriented concept explored in more detail in Chapter 7**

- **See Einstein.java (page 93)**

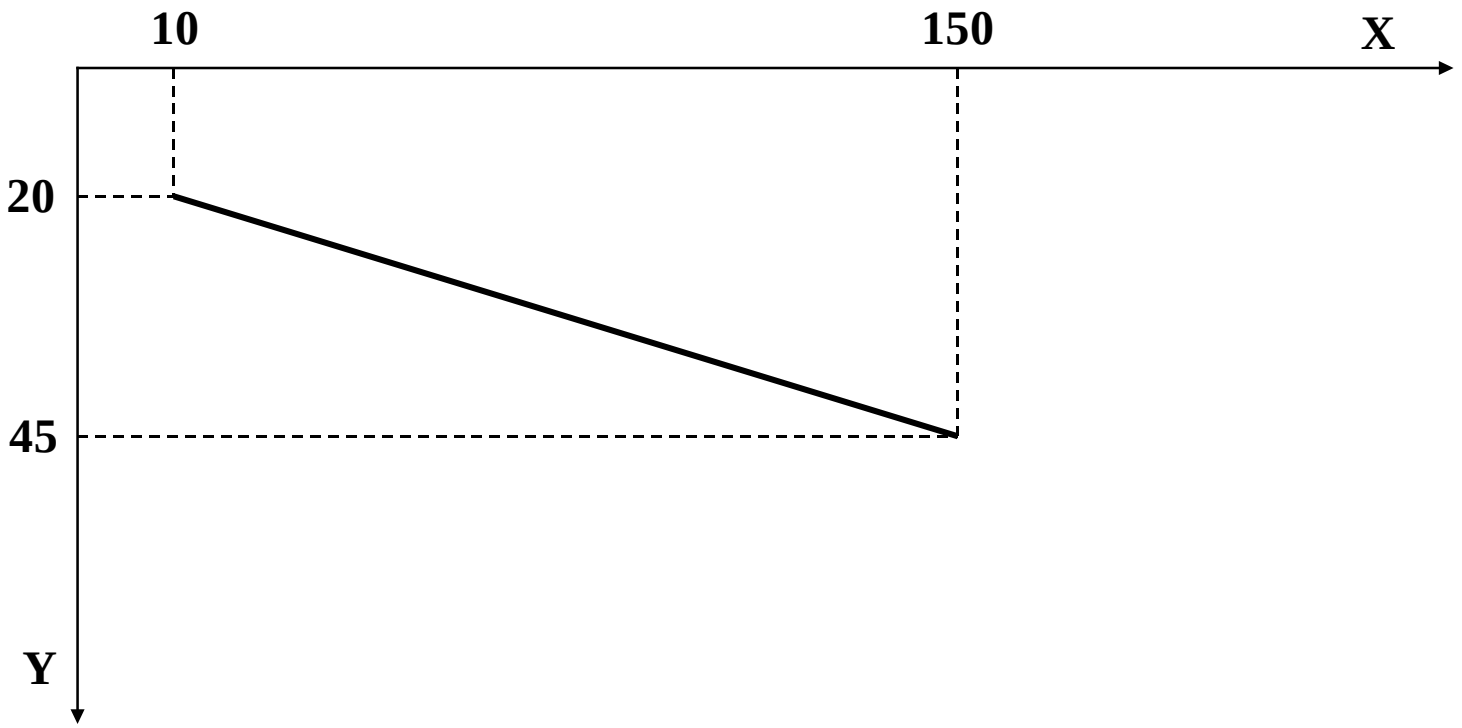
Applets

- **An applet is embedded into an HTML file using a tag that references the bytecode file of the applet class**
- **It is actually the bytecode version of the program that is transported across the web**
- **The applet is executed by a Java interpreter that is part of the browser**

Drawing Shapes

- Let's explore some of the methods of the `Graphics` class that draw shapes in more detail
- A shape can be filled or unfilled, depending on which method is invoked
- The method parameters specify coordinates and sizes
- Recall from Chapter 1 that the Java coordinate system has the origin in the upper left corner
- Many shapes with curves, like an oval, are drawn by specifying its *bounding rectangle*
- An arc can be thought of as a section of an oval

Drawing a Line

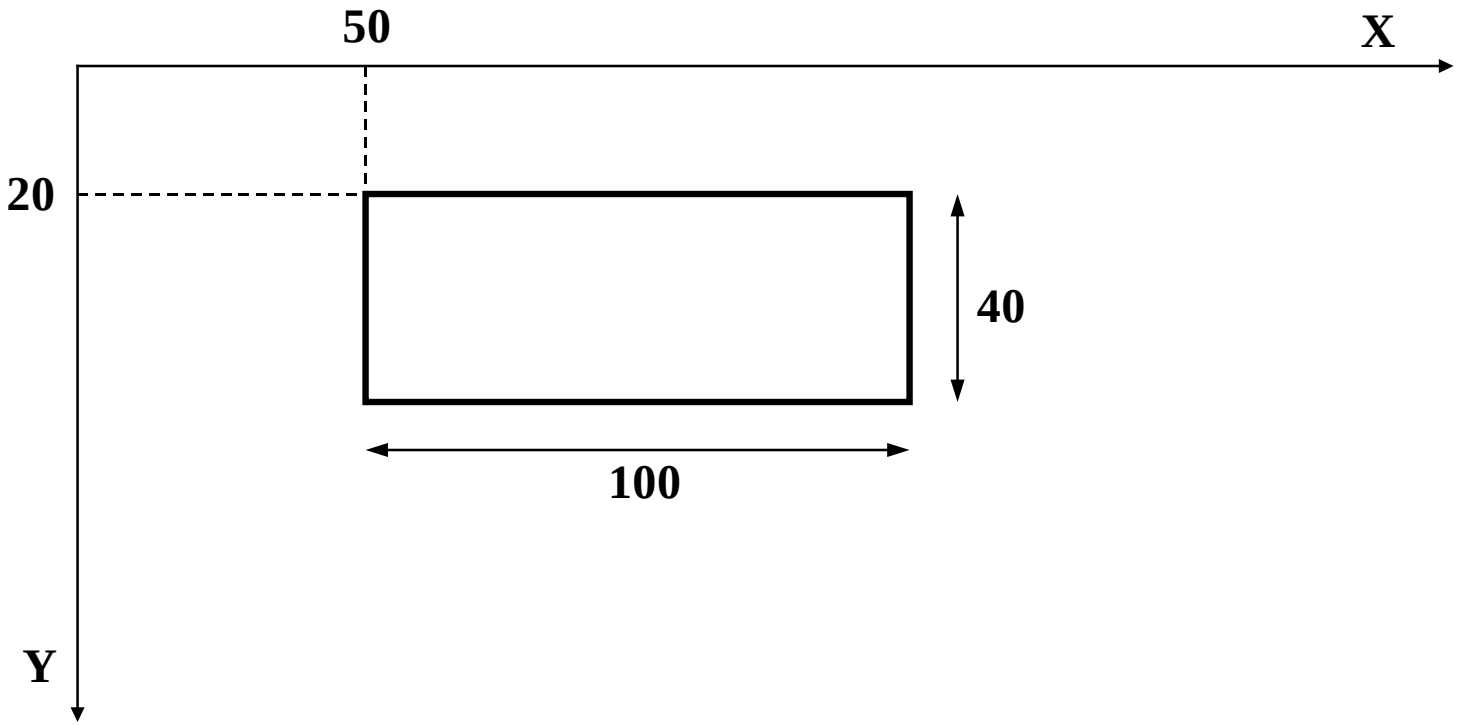



```
page.drawLine (10, 20, 150, 45);
```

or

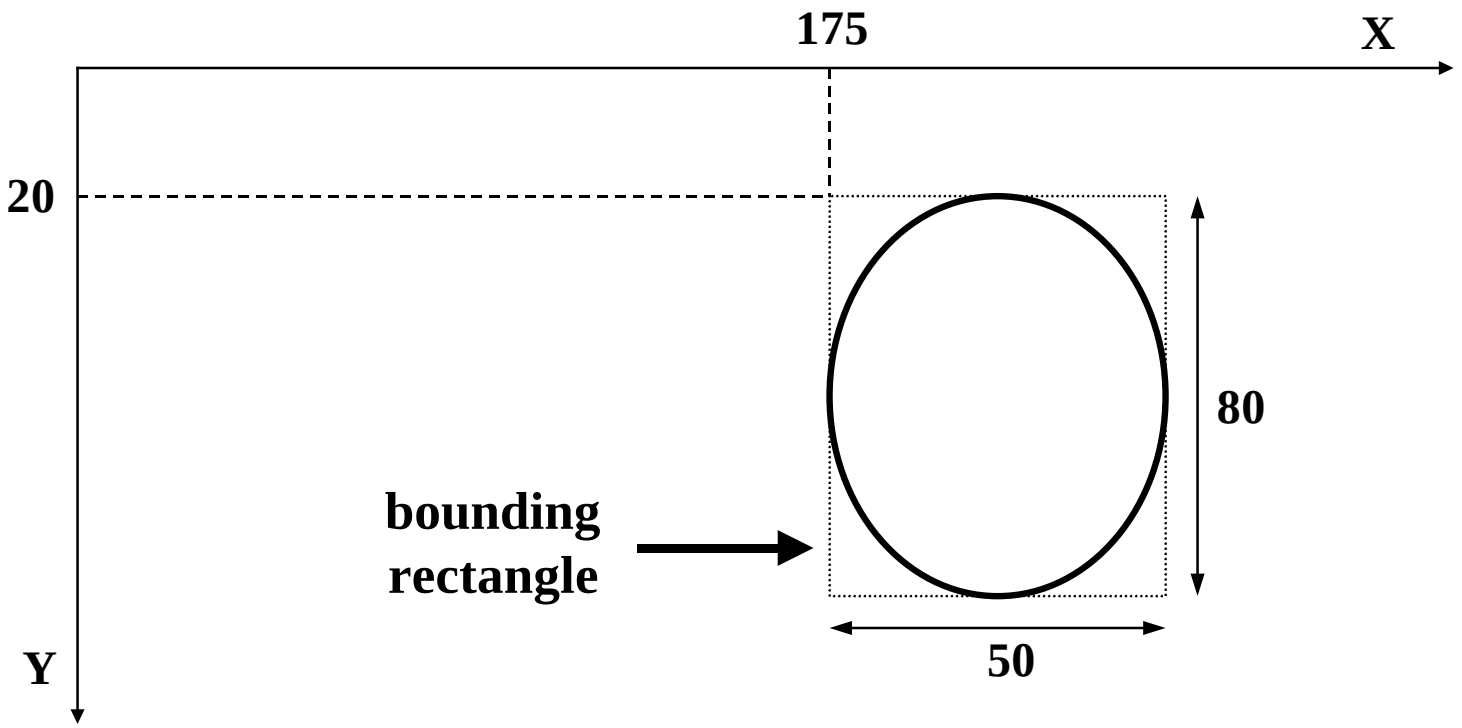
```
page.drawLine (150, 45, 10, 20);
```

Drawing a Rectangle




```
page.drawRect (50, 20, 100, 40);
```

Drawing an Oval




```
page.drawOval (175, 20, 50, 80);
```

The Color Class

- A color is defined in a Java program using an object created from the `Color` class
- The `Color` class also contains several static predefined colors

- Every graphics context has a current foreground color
- Every drawing surface has a background color

- See Snowman.java (page 99-100)