Chapter 2 - Fundamental Data Types

APROG – Algoritmia e Programação

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Bibliography:
Big Java Late Objects
Book by Cay S. Horstmann

Chapter Goals

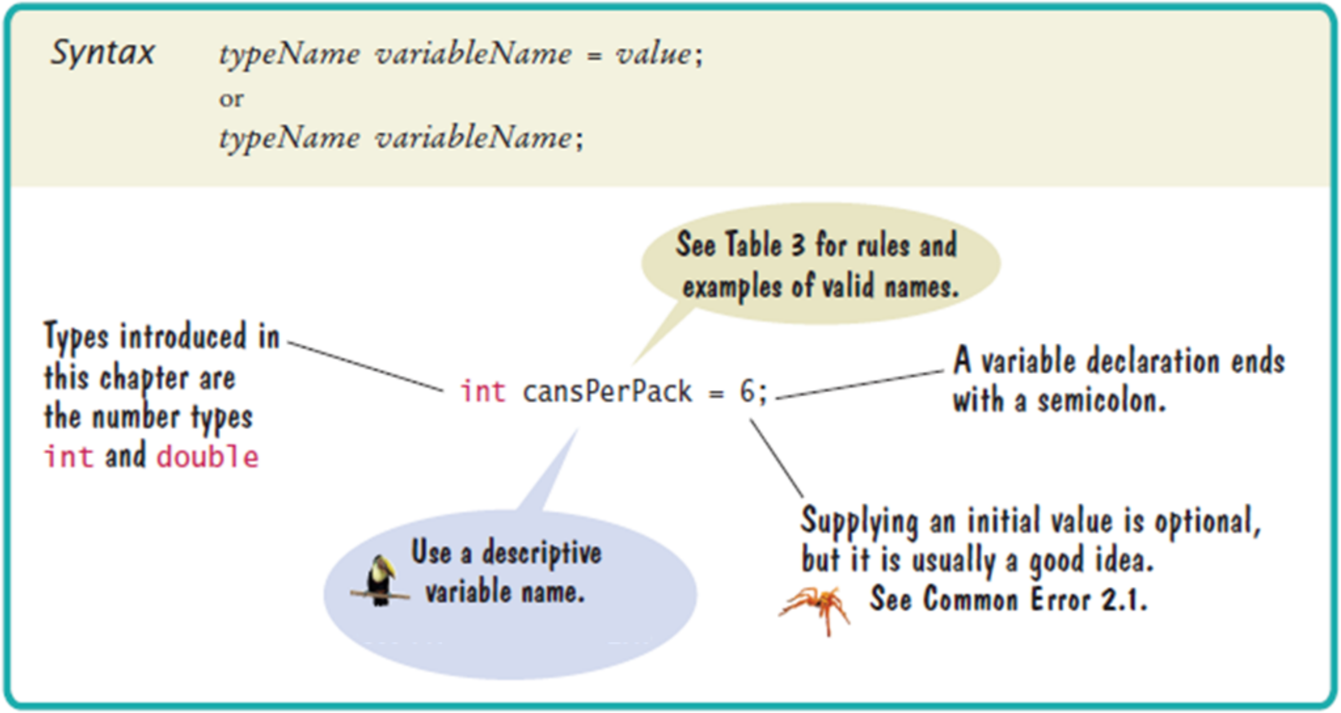
- To declare and initialize variables and constants
- To understand the properties and limitations of integers and floating-point numbers
- To appreciate the importance of comments and good code layout
- To write arithmetic expressions and assignment statements
- To create programs that read and process inputs, and display the results
- To learn how to use the Java String type

Variables

- Most computer programs hold temporary values in named storage locations
    - Programmers name them for easy access
- There are many different types (sizes) of storage to hold different things
- You ‘declare’ a variable by telling the compiler:
    - What type (size) of variable you need
    - What name you will use to refer to it

Variable Declaration

- When declaring a variable, you often specify an initial value
- This is also where you tell the compiler the size (type) it will hold



Syntax *typeName variableName* = *value*;

or

typeName variableName;

```
int cansPerPack = 6;
```

See Table 3 for rules and examples of valid names.

Types introduced in this chapter are the number types `int` and `double`

A variable declaration ends with a semicolon.

Use a descriptive variable name.

Supplying an initial value is optional, but it is usually a good idea. See Common Error 2.1.

An Example: Soda Deal

- Soft drinks are sold in cans and bottles. A store offers a six-pack of 12-ounce cans for the same price as a two-liter bottle. Which should you buy? (12 fluid ounces equal approximately 0.355 liters.)

List of variables:	**Type of number:**
Number of cans per pack	Whole number
Ounces per can	Whole number
Ounces per bottle	Number with fraction

Variables and Contents

- Each variable has an identifier (name) and contents
- You can (optionally) set the contents of a variable when you declare it

```
        int cansPerPack = 6;
```

- Imagine a parking space in a parking garage
    - Identifier: J053
    - Contents: Bob's Chevy

Example Declarations

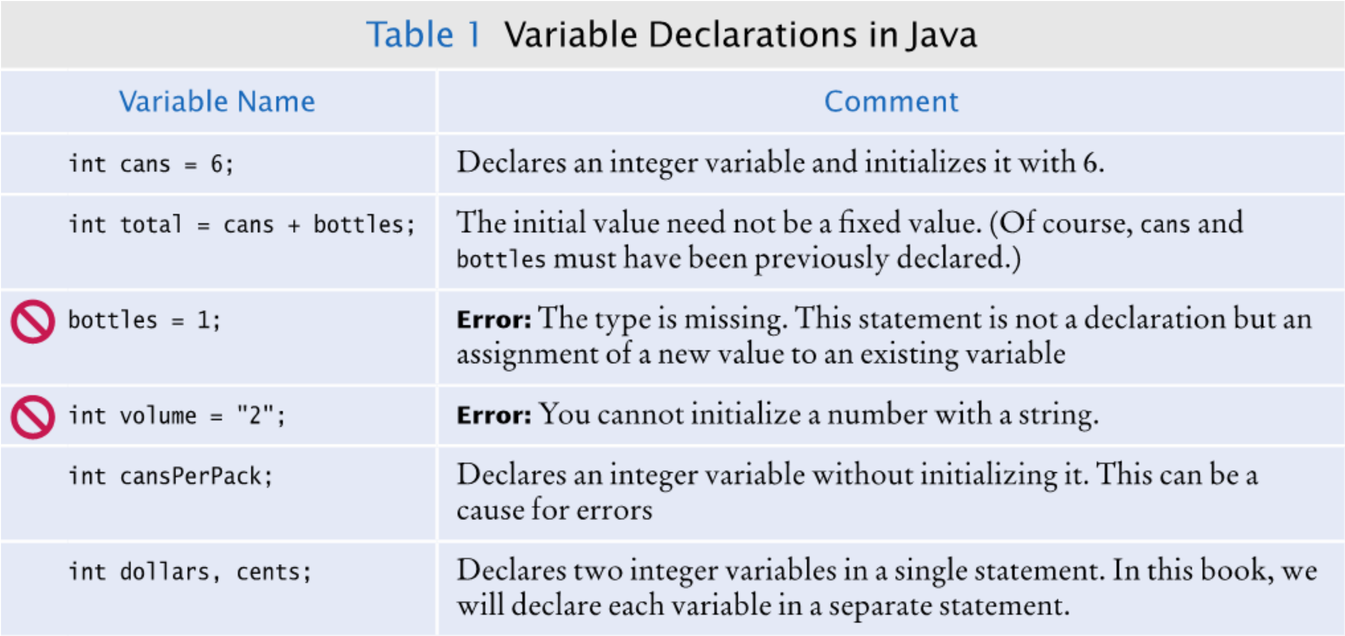


Table 1 Variable Declarations in Java

Variable Name	Comment
`int cans = 6;`	Declares an integer variable and initializes it with 6.
`int total = cans + bottles;`	The initial value need not be a fixed value. (Of course, `cans` and `bottles` must have been previously declared.)
🚫 `bottles = 1;`	**Error:** The type is missing. This statement is not a declaration but an assignment of a new value to an existing variable
🚫 `int volume = "2";`	**Error:** You cannot initialize a number with a string.
`int cansPerPack;`	Declares an integer variable without initializing it. This can be a cause for errors
`int dollars, cents;`	Declares two integer variables in a single statement. In this book, we will declare each variable in a separate statement.

Why Different Types?

- There are three different types of variables that we will use in this chapter:

1) A whole number (no fractional part)	`int`
2) A number with a fraction part	`double`
3) A word (a group of characters)	`String`

- Specify the type before the name in the declaration

```
int cansPerPack = 6;
double canVolume = 12.0;
```

Why Different Variables?

- Back to the garage analogy, parking spaces may be different sizes for different types of vehicles
    - Bicycle
    - Motorcycle
    - Full Size
    - Electric Vehicle

Number Literals in Java

- Sometimes when you just type a number, the compiler has to ‘guess’ what type it is

```
amt = 6 * 12.0;
PI = 3.14;
canVol = 0.335;
```

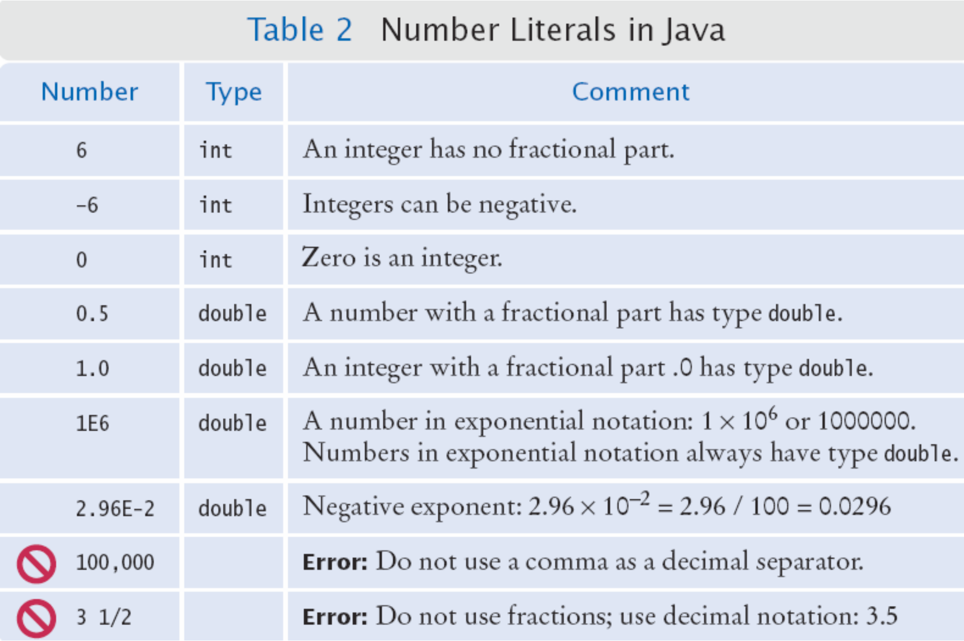


Table 2 Number Literals in Java

Number	Type	Comment
`6`	`int`	An integer has no fractional part.
`-6`	`int`	Integers can be negative.
`0`	`int`	Zero is an integer.
`0.5`	`double`	A number with a fractional part has type `double`.
`1.0`	`double`	An integer with a fractional part .0 has type `double`.
`1E6`	`double`	A number in exponential notation: 1×10^6 or 1000000. Numbers in exponential notation always have type `double`.
`2.96E-2`	`double`	Negative exponent: $2.96 \times 10^{-2} = 2.96 / 100 = 0.0296$
🚫 `100,000`		**Error:** Do not use a comma as a decimal separator.
🚫 `3 1/2`		**Error:** Do not use fractions; use decimal notation: 3.5

Floating-Point Numbers

- Java stores numbers with fractional parts as ‘floating point’ numbers.
- They are stored in four parts
    - Sign
    - Mantissa
    - Radix
    - Exponent
- A ‘double’ is a double-precision floating point number: It takes twice the storage (52 bit mantissa) as the smaller ‘float’ (23 bit mantissa)

Parts of a floating point number -5:

Sign	Mantissa	$\text{Radix}^{\text{exponent}}$
-1	5	10^{0}

Naming Variables

- Name should describe the purpose
  - ‘`canVolume`’ is better than ‘`cv`’

- Use These Simple Rules

  1) Variable names must start with a letter or the underscore (_) character
     - Continue with letters (upper or lower case), digits or the underscore

  2) You cannot use other symbols (? or %...) and spaces are not permitted

  3) Separate words with ‘camelHump’ notation
     - Use upper case letters to signify word boundaries

  4) Don’t use reserved ‘Java’ words (see Appendix C)

Variable Names in Java

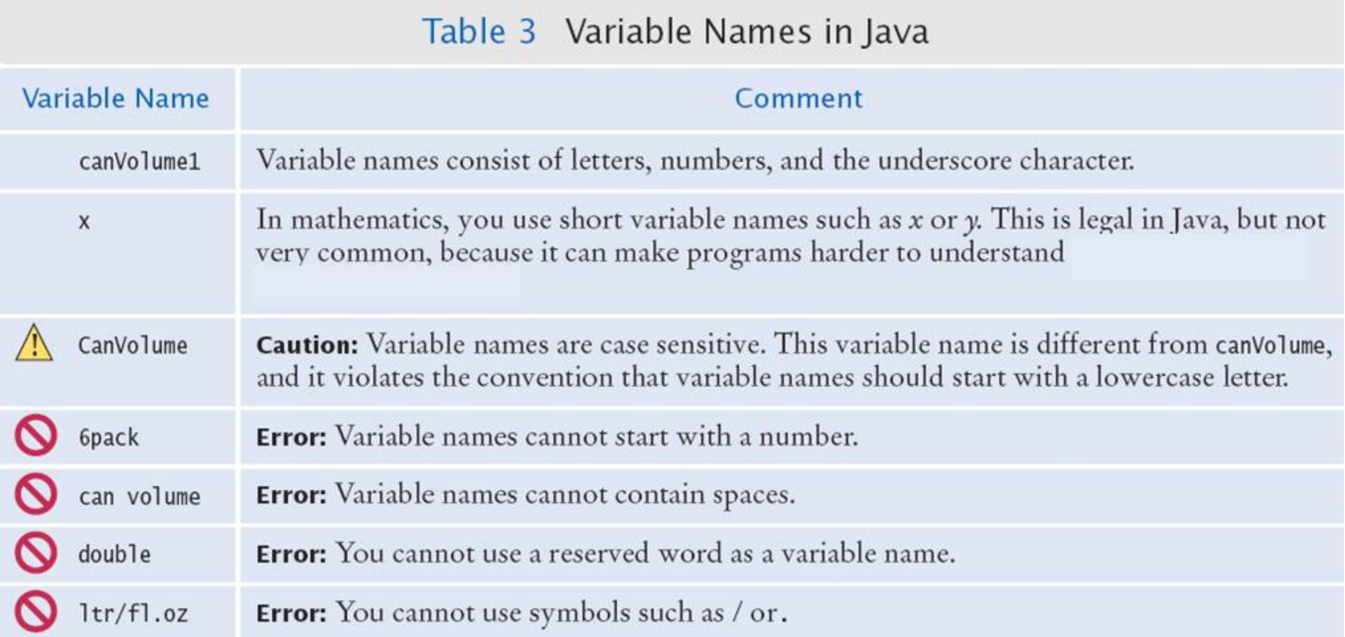


Table 3 Variable Names in Java

Variable Name	Comment
canVolume1	Variable names consist of letters, numbers, and the underscore character.
x	In mathematics, you use short variable names such as *x* or *y*. This is legal in Java, but not very common, because it can make programs harder to understand
⚠ CanVolume	**Caution:** Variable names are case sensitive. This variable name is different from canVolume, and it violates the convention that variable names should start with a lowercase letter.
🚫 6pack	**Error:** Variable names cannot start with a number.
🚫 can volume	**Error:** Variable names cannot contain spaces.
🚫 double	**Error:** You cannot use a reserved word as a variable name.
🚫 ltr/fl.oz	**Error:** You cannot use symbols such as / or .

The Assignment Statement

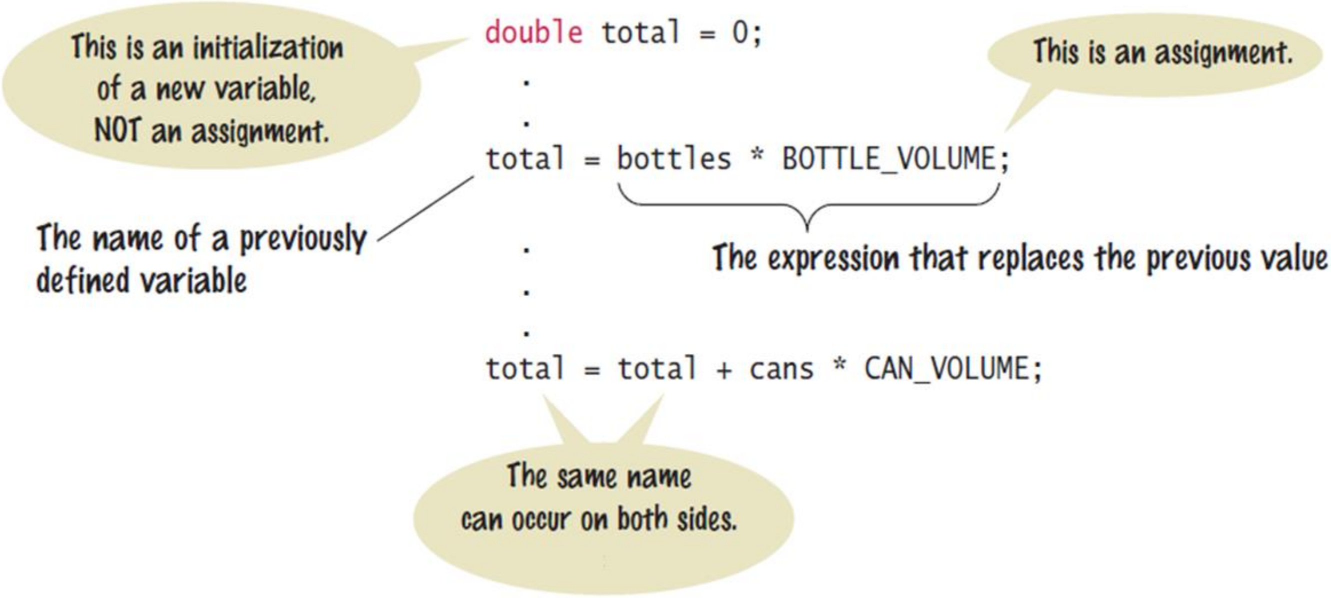
- Use the ‘assignment statement’ (with an '=') to place a new value into a variable

```
int cansPerPack = 6;   // declare & initialize
cansPerPack = 8;       // assignment
```

- Beware: The **=** sign is **NOT** used for comparison:
    - It copies the value on the right side into the variable on the left side
    - You will learn about the comparison operator in the next chapter

Assignment Syntax

- The value on the right of the '=' sign is copied to the variable on the left



```
double total = 0;
   .
   .
total = bottles * BOTTLE_VOLUME;
   .
   .
   .
total = total + cans * CAN_VOLUME;
```

This is an initialization of a new variable, NOT an assignment.

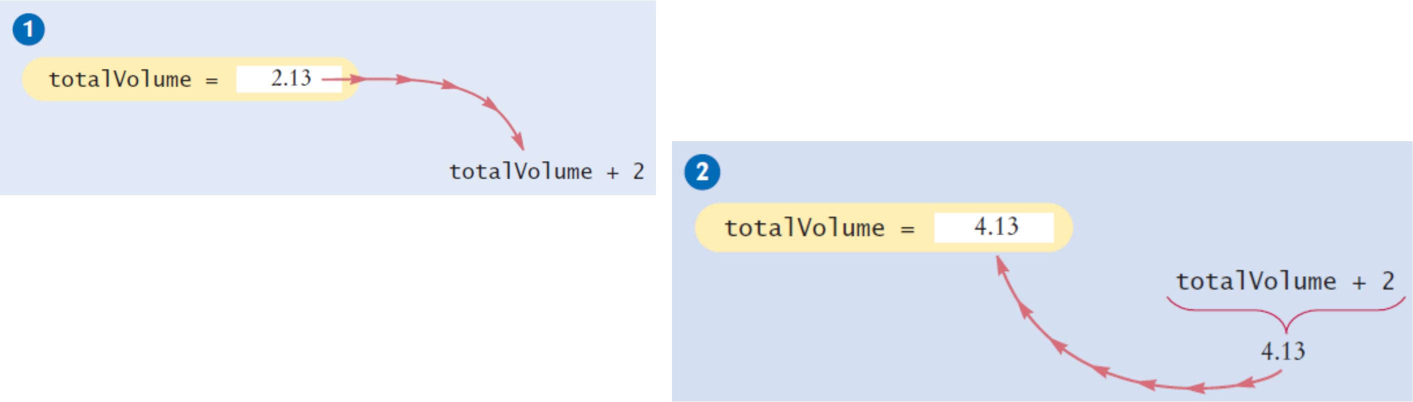
This is an assignment.

The name of a previously defined variable

The expression that replaces the previous value

The same name can occur on both sides.

Updating a Variable



- Step by Step:

```
totalVolume = totalVolume + 2;
```

1. Calculate the right hand side of the assignment; Find the value of `totalVolume`, and add 2 to it
2. Store the result in the variable named on the left side of the assignment operator (`totalVolume` in this case)

Declarations vs. Assignments

- Variable declarations and an assignment statements are different

```
int cansPerPack = 6;  Declaration
...
cansPerPack = 8; Assignment statement
```

- Declarations define a new variable and can give it an initial value

- Assignments modify the value of an existing variable

Constants

- When a variable is defined with the reserved word final, its value can never be changed

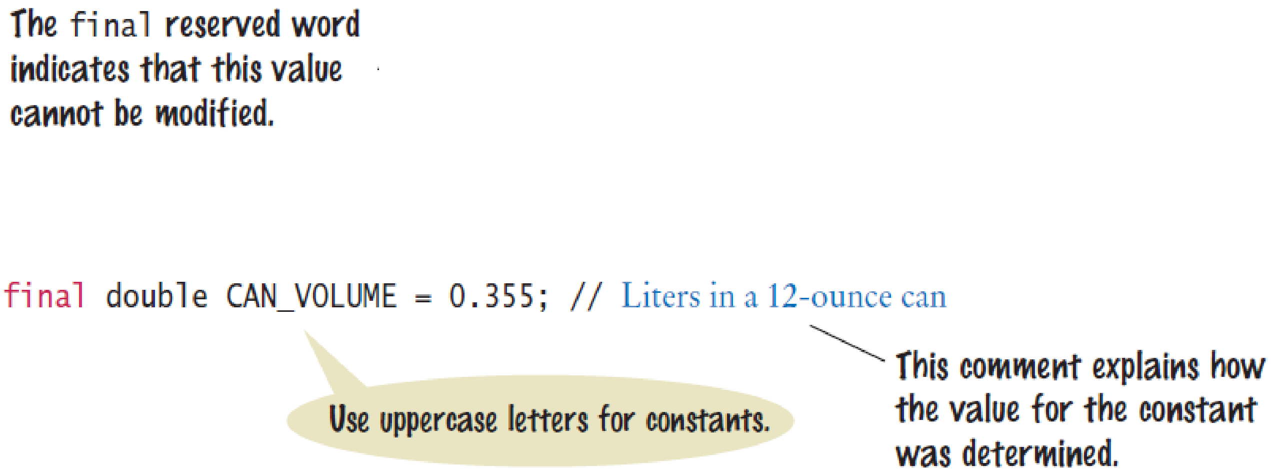
```
final double BOTTLE_VOLUME = 2;
```

- It is good style to use named constants to explain numerical values to be used in calculations
  - Which is clearer?

```
double totalVolume = bottles * 2;
double totalVolume = bottles * BOTTLE_VOLUME;
```

- A programmer reading the first statement may not understand the significance of the 2
-
- Also, if the constant is used in multiple places and needs to be changed, only the initialization changes

Constant Declaration



The final reserved word indicates that this value cannot be modified.

```
final double CAN_VOLUME = 0.355; // Liters in a 12-ounce can
```

Use uppercase letters for constants.

This comment explains how the value for the constant was determined.

- It is customary (not required) to use all UPPER_CASE letters for constants

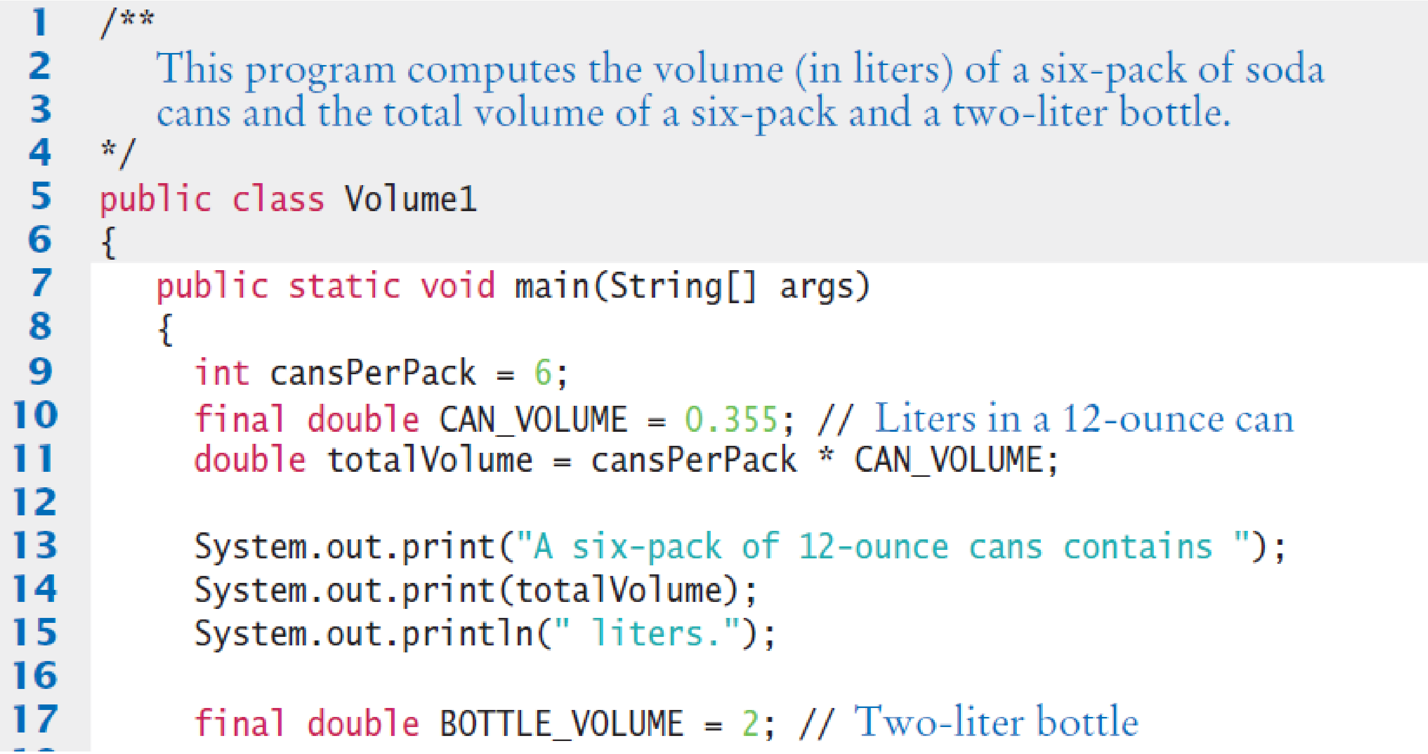
Java Comments

- There are three forms of comments:

```
1: // single line (or rest of line to right)
2: /*
      multi-line – all comment until matching
    */
3: /**
      multi-line Javadoc comments
   */
```

- Use comments at the beginning of each program, and to clarify details of the code
- Use comments to add explanations for humans who read your code
- The compiler ignores comments

Java Comment Example



```
1   /**
2       This program computes the volume (in liters) of a six-pack of soda
3       cans and the total volume of a six-pack and a two-liter bottle.
4   */
5   public class Volume1
6   {
7       public static void main(String[] args)
8       {
9          int cansPerPack = 6;
10         final double CAN_VOLUME = 0.355; // Liters in a 12-ounce can
11         double totalVolume = cansPerPack * CAN_VOLUME;
12
13         System.out.print("A six-pack of 12-ounce cans contains ");
14         System.out.print(totalVolume);
15         System.out.println(" liters.");
16
17         final double BOTTLE_VOLUME = 2; // Two-liter bottle
```

- Lines 1 - 4 are Javadoc comments for the class Volume1
- Lines 10 and 17 use single-line comment to clarify the unit of measurement

Self Check

What is wrong with the following variable declaration?

```
int ounces per liter = 28.35
```

Answer: There are three errors:

- You cannot have spaces in variable names.
- The variable type should be double because it holds a fractional value.
- There is a semicolon missing at the end of the statement.

Declare and initialize two variables, `unitPrice` and `quantity`, to contain the unit price of a single bottle and the number of bottles purchased. Use reasonable initial values.

Answer:

```
double unitPrice = 1.95;
int quantity = 2;
```

What is wrong with this comment?

```
double canVolume = 0.355; /* Liters in a 12-ounce can //
```

Answer: You need to use a `*/` delimiter to close a comment that begins with a `/*`:

```
double canVolume = 0.355;
/* Liters in a 12-ounce can */
```

Common Error 2.1

- Undeclared Variables
  - You must declare a variable before you use it: (i.e. above in the code)

```
double canVolume = 12 * literPerOunce; // ??
double literPerOunce = 0.0296;
```

- Uninitialized Variables
  - You must initialize (i.e. set) a variable's contents before you use it

```
int bottles;
int bottleVolume = bottles * 2;   // ??
```

Common Error 2.2

- Overflow means that storage for a variable cannot hold the result

  ```
  int fiftyMillion = 50000000;
  System.out.println(100 * fiftyMillion);
       // Expected: 5000000000
  ```

  - Will print out 705032704

- Why?
  - The result (5 billion) overflowed `int` capacity
  - Maximum value for an `int` is **+2,147,483,647**

- Use a `long` instead of an `int` (or a `double`)

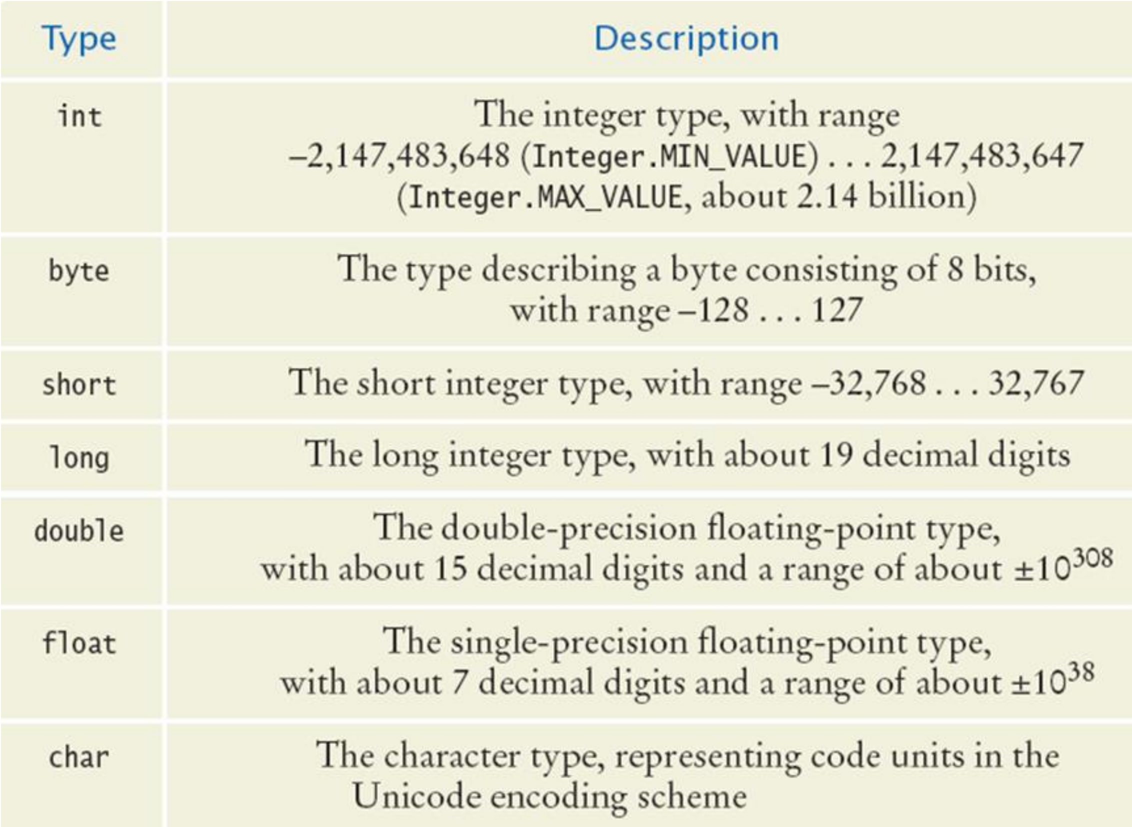
Common Error 2.3

- Roundoff Errors
  - Floating point values are not exact
    - This is a limitations of binary values (no fractions):

```
double price = 4.35;
double quantity = 100;
double total = price * quantity;
// Should be 100 * 4.35 = 435.00
System.out.println(total); // Prints 434.99999999999999
```

- You can deal with roundoff errors by rounding to the nearest integer or by displaying a fixed number of digits after the decimal separator.

All of the Java Numeric Types



Type	Description
`int`	The integer type, with range –2,147,483,648 (`Integer.MIN_VALUE`) . . . 2,147,483,647 (`Integer.MAX_VALUE`, about 2.14 billion)
`byte`	The type describing a byte consisting of 8 bits, with range –128 . . . 127
`short`	The short integer type, with range –32,768 . . . 32,767
`long`	The long integer type, with about 19 decimal digits
`double`	The double-precision floating-point type, with about 15 decimal digits and a range of about $\pm 10^{308}$
`float`	The single-precision floating-point type, with about 7 decimal digits and a range of about $\pm 10^{38}$
`char`	The character type, representing code units in the Unicode encoding scheme

Whole Numbers (no fractions)

Floating point Numbers

Characters (no math)

- Each type has a range of values that it can hold

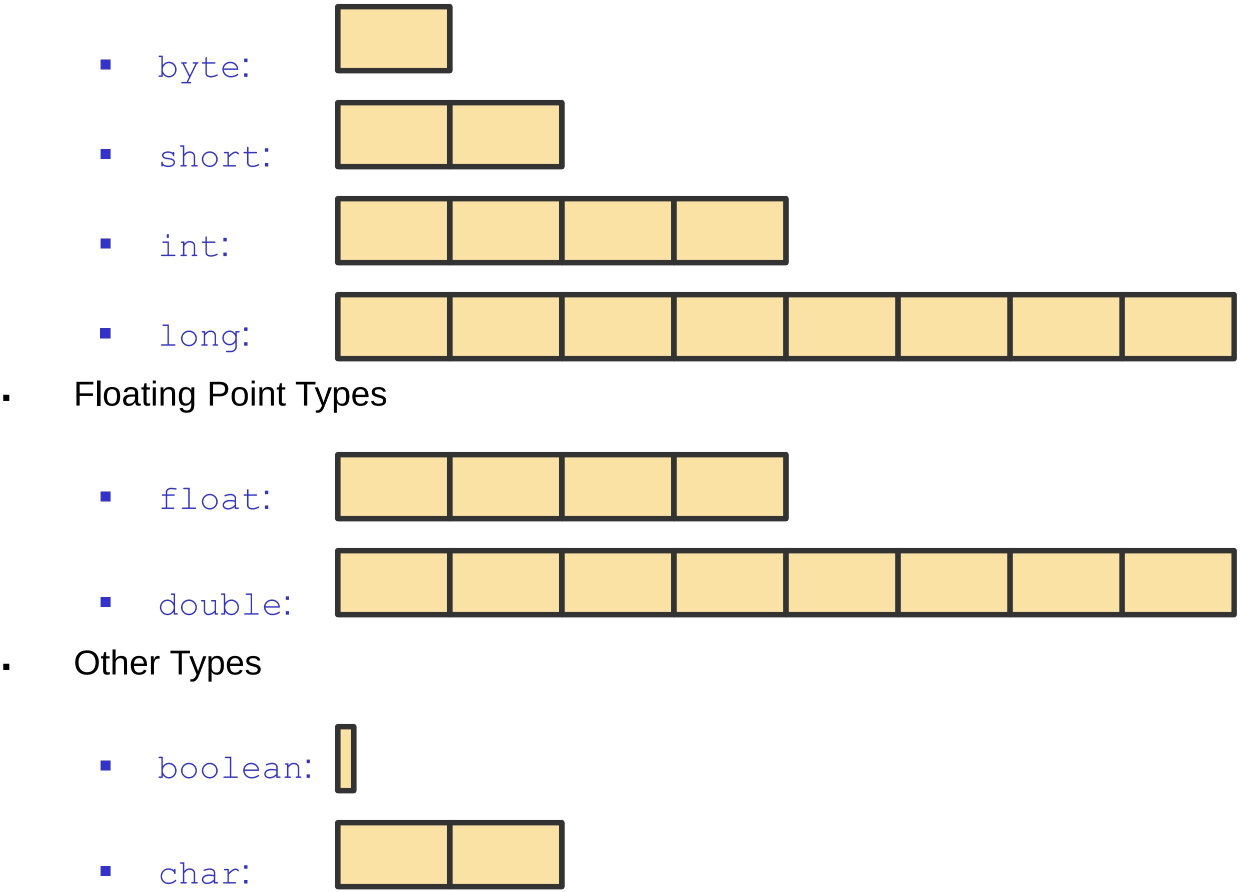
Value Ranges per Type

- Integer Types
  - `byte`: A very small number (-128 to +127)
  - `short`: A small number (-32768 to +32767)
  - `int`: A large number (-2,147,483,648 to +2,147,483,647)
  - `long`: A huge number

- Floating Point Types
  - `float`: A huge number with decimal places
  - `double`: Much more precise, for heavy math

- Other Types
  - `boolean`: `true` or `false`
  - `char`: One symbol in single quotes ‘a’

Storage per Type (in bytes)



- Integer Types
  - `byte:`
  - `short:`
  - `int:`
  - `long:`
- Floating Point Types
  - `float:`
  - `double:`
- Other Types
  - `boolean:`
  - `char:`

Arithmetic

- Java supports all of the same basic math as a calculator:

Addition	+
Subtraction	-
Multiplication	*
Division	/

- You write your expressions a bit differently though

$$\frac{a+b}{2}$$

```
(a + b) / 2
```

- Precedence is similar to Algebra:
  - PEMDAS
    - Parenthesis, Exponent, Multiply/Divide, Add/Subtract

Mixing Numeric Types

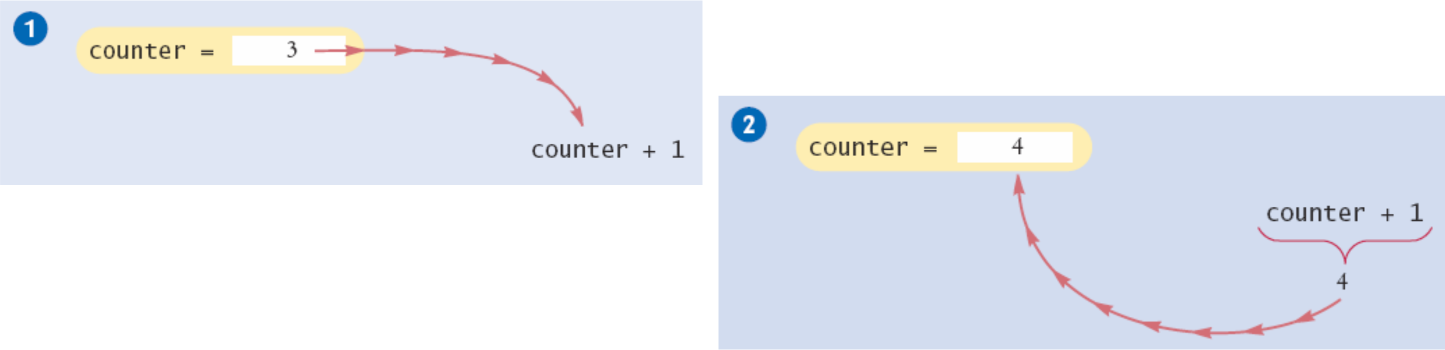
- It is safe to convert a value from an integer type to a floating-point type
    - No ‘precision’ is lost

- But going the other way can be dangerous
    - All fractional information is lost
    - The fractional part is discarded (not rounded)

- If you mix types integer and floating-point types in an expression, no precision is lost:

```
double area, pi = 3.14;
int radius = 3;
area = radius * radius * pi;
```

Incrementing a Variable



- Step by Step:

```
    counter = counter + 1;
```

1. Do the right hand side of the assignment first:

   Find the value stored in counter, and add 1 to it

2. Store the result in the variable named on the left side of the assignment operator (counter in this case)

Shorthand for Incrementing

- Incrementing (+1) and decrementing (-1) integer types is so common that there are shorthand version for each

Long Way	Shortcut
`counter = counter + 1;`	`counter++ ;`
`counter = counter - 1;`	`counter-- ;`

Integer Division and Remainder

- When both parts of division are integers, the result is an integer.
    - All fractional information is lost (no rounding)

    ```
    int result = 7 / 4;
    ```

    - The value of result will be 1

- If you are interested in the remainder of dividing two integers, use the `%` operator (called modulus):

    ```
    int remainder = 7 % 4;
    ```

    - The value of remainder will be 3
    - Sometimes called modulo divide

Powers and Roots

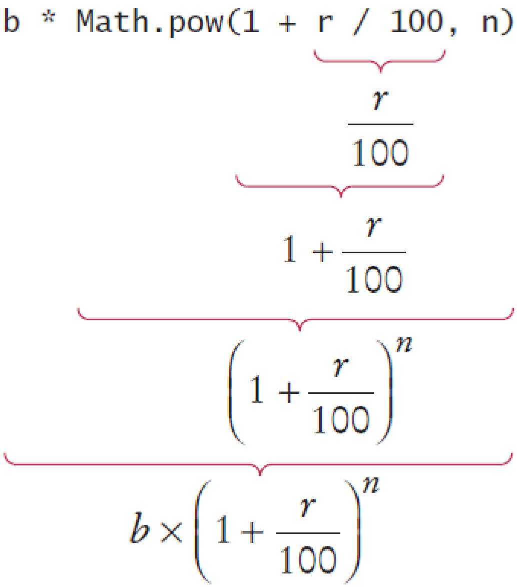
- In Java, there are no symbols for power and roots

$$b \times \left(1 + \frac{r}{100}\right)^{n}$$

Becomes:

```
b * Math.pow(1 + r / 100, n)
```

- Analyzing the expression:



```
b * Math.pow(1 + r / 100, n)
```

$$\frac{r}{100}$$

$$1 + \frac{r}{100}$$

$$\left(1 + \frac{r}{100}\right)^{n}$$

$$b \times \left(1 + \frac{r}{100}\right)^{n}$$

- The Java library declares many mathematical functions, such as `Math.sqrt` (square root) and `Math.pow` (raising to a power)

Mathematical Methods

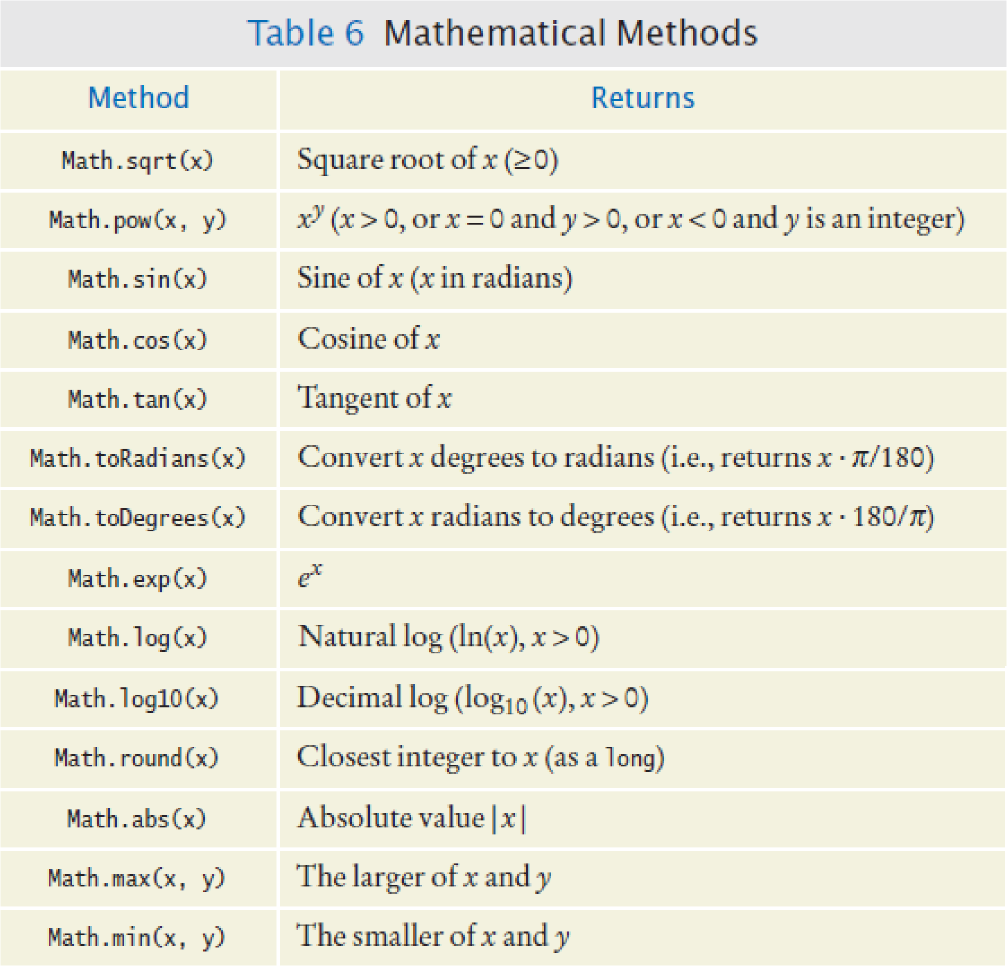


Table 6 Mathematical Methods

Method	Returns
`Math.sqrt(x)`	Square root of x (≥ 0)
`Math.pow(x, y)`	x^y ($x > 0$, or $x = 0$ and $y > 0$, or $x < 0$ and y is an integer)
`Math.sin(x)`	Sine of x (x in radians)
`Math.cos(x)`	Cosine of x
`Math.tan(x)`	Tangent of x
`Math.toRadians(x)`	Convert x degrees to radians (i.e., returns $x \cdot \pi/180$)
`Math.toDegrees(x)`	Convert x radians to degrees (i.e., returns $x \cdot 180/\pi$)
`Math.exp(x)`	e^x
`Math.log(x)`	Natural log ($\ln(x)$, $x > 0$)
`Math.log10(x)`	Decimal log ($\log_{10}(x)$, $x > 0$)
`Math.round(x)`	Closest integer to x (as a `long`)
`Math.abs(x)`	Absolute value $\lvert x \rvert$
`Math.max(x, y)`	The larger of x and y
`Math.min(x, y)`	The smaller of x and y

Floating-Point to Integer Conversion

- The Java compiler does not allow direct assignment of a floating-point value to an integer variable

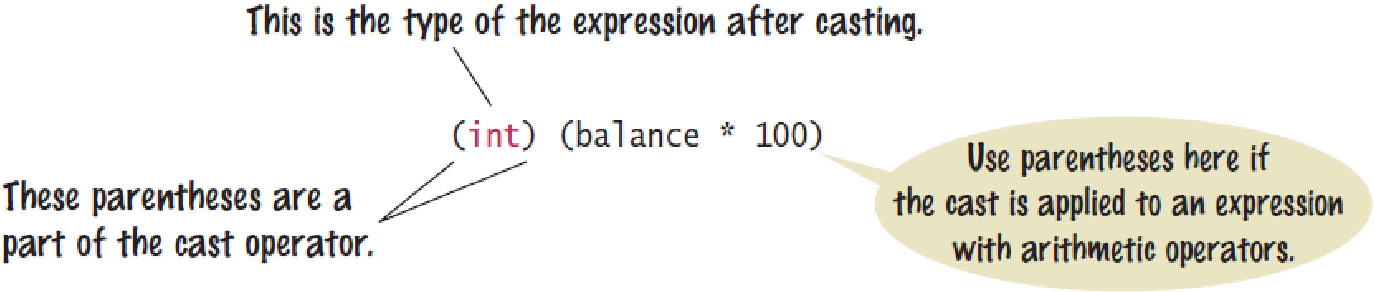
```
double balance = total + tax;
int dollars = balance; // Error
```

- You can use the ‘cast’ operator: `(int)` to force the conversion:

```
double balance = total + tax;
int dollars = (int) balance; // no Error
```

- You lose the fractional part of the floating-point value (no rounding occurs)

Cast Syntax



This is the type of the expression after casting.

`(int) (balance * 100)`

These parentheses are a part of the cast operator.

Use parentheses here if the cast is applied to an expression with arithmetic operators.

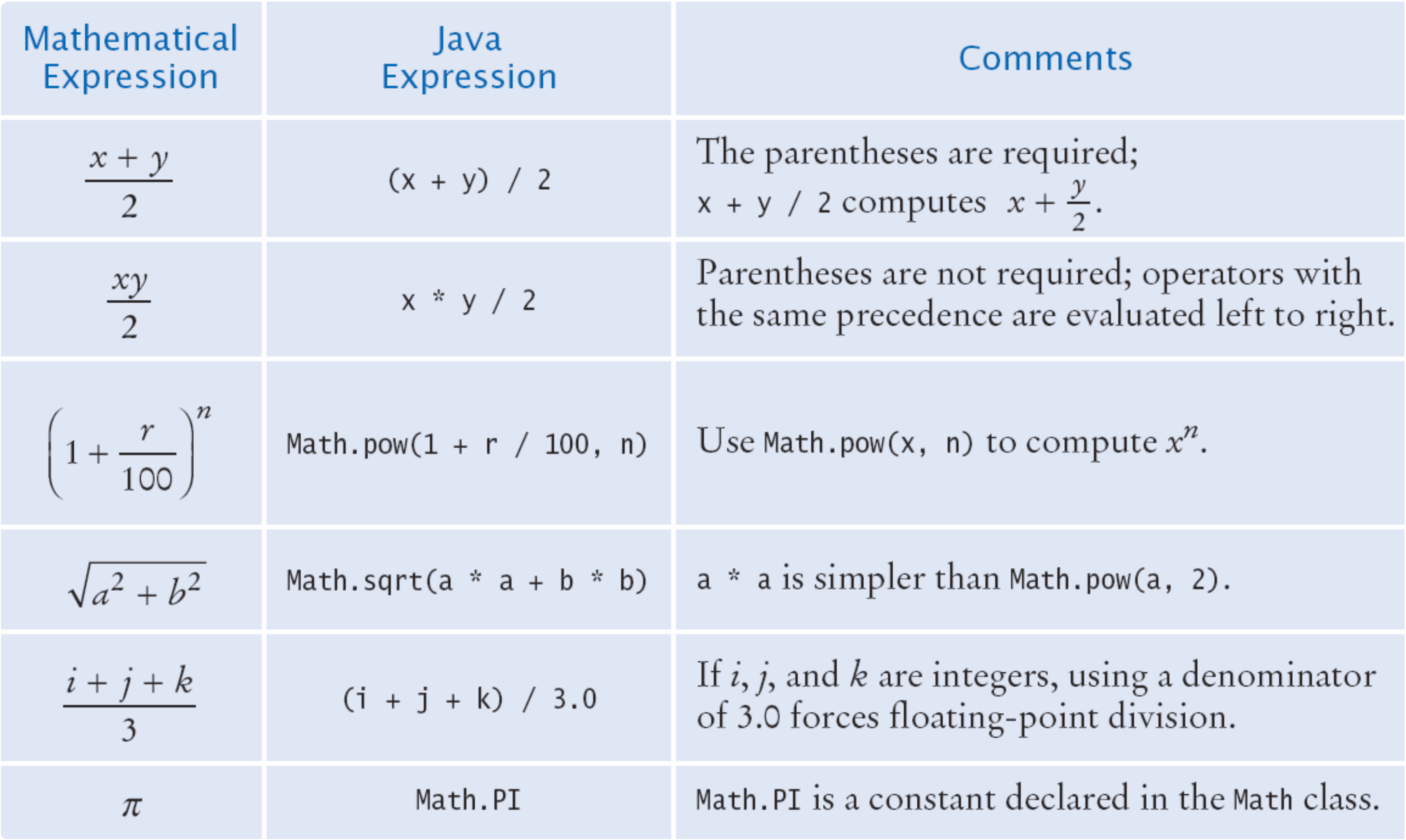
- Casting is a very powerful tool and should be used carefully

- To round a floating-point number to the nearest whole number, use the `Math.round` method

- This method returns a long integer, because large floating-point numbers cannot be stored in an `int`

```
    long rounded = Math.round(balance);
```

Arithmetic Expressions



Mathematical Expression	Java Expression	Comments
$\frac{x+y}{2}$	`(x + y) / 2`	The parentheses are required; `x + y / 2` computes $x + \frac{y}{2}$.
$\frac{xy}{2}$	`x * y / 2`	Parentheses are not required; operators with the same precedence are evaluated left to right.
$\left(1 + \frac{r}{100}\right)^n$	`Math.pow(1 + r / 100, n)`	Use `Math.pow(x, n)` to compute x^n.
$\sqrt{a^2 + b^2}$	`Math.sqrt(a * a + b * b)`	`a * a` is simpler than `Math.pow(a, 2)`.
$\frac{i+j+k}{3}$	`(i + j + k) / 3.0`	If i, j, and k are integers, using a denominator of 3.0 forces floating-point division.
π	`Math.PI`	`Math.PI` is a constant declared in the `Math` class.

Common Error 2.4

- Unintended Integer Division

```
System.out.print("Please enter your last three test scores: ");
int s1 = in.nextInt();
int s2 = in.nextInt()
int s3 = in.nextInt();
double average = (s1 + s2 + s3) / 3; // Error
```

- Why?
  - All of the calculation on the right happens first
    - Since all are `int`s, the compiler uses integer division
  - Then the result (an `int`) is assigned to the `double`
    - There is no fractional part of the `int` result, so zero (.0) is assigned to the fractional part of the `double`

Common Error 2.5

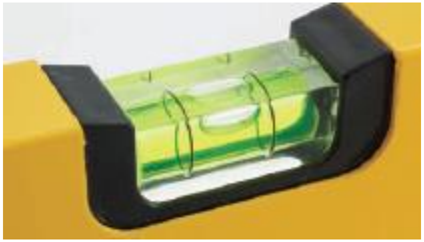
- Unbalanced Parenthesis
  - Which is correct?

```
(-(b * b - 4 * a * c) / (2 * a)    // 3 (, 2 )
-(b * b - (4 * a * c)) / (2 * a)   // 3 (, 3 )
```

- The count of (and) must match

- Unfortunately, it is hard for humans to keep track
  - Here’s a handy trick
  - Count (as +1, and) as -1: Goal: 0

```
-(b * b - (4 * a * c) ) ) / 2 * a)
1   2     1 0 -1  -2
```



Input and Output

- Reading Input

- You might need to ask for input (aka prompt for input) and then save what was entered
  - We will be reading input from the keyboard
  - For now, don’t worry about the details

- This is a three step process in Java
  1. Import the `Scanner` class from its ‘package’

     ```
     java.util  import java.util.Scanner;
     ```

  2. Setup an object of the `Scanner` class

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

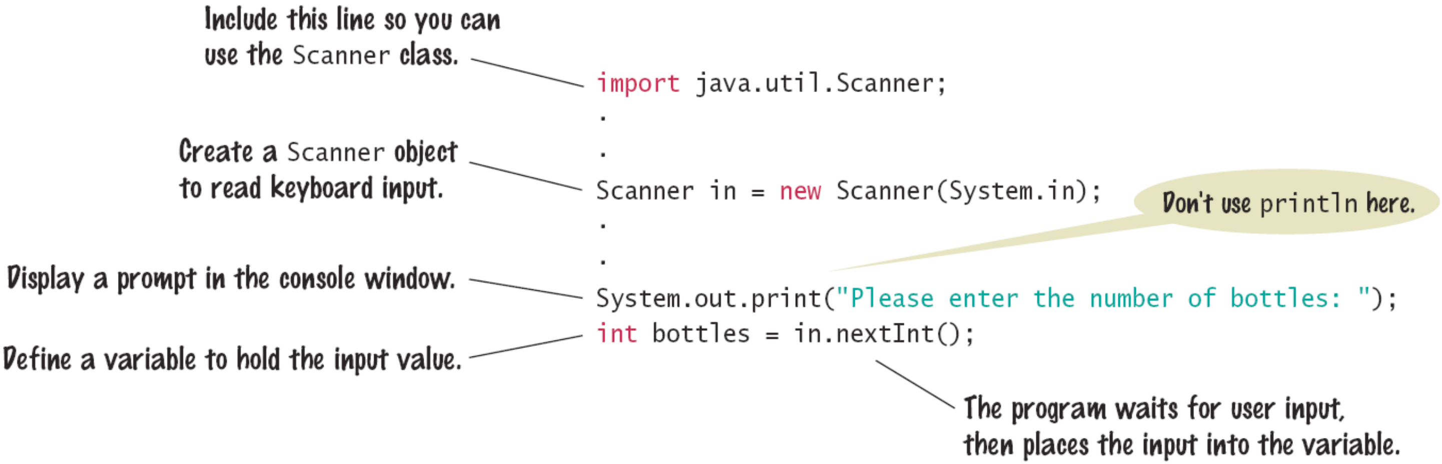
  3. Use methods of the new `Scanner` object to get input

     ```
     int bottles = in.nextInt();
     double price = in.nextDouble();
     ```

Input Statement

- The `Scanner` class allows you to read keyboard input from the user
  - It is part of the Java API `util` package

- Java classes are grouped into packages. Use the `import` statement to use classes from packages



```
import java.util.Scanner;
.
.
Scanner in = new Scanner(System.in);
.
.
System.out.print("Please enter the number of bottles: ");
int bottles = in.nextInt();
```

Include this line so you can use the Scanner class.

Create a Scanner object to read keyboard input.

Display a prompt in the console window.

Define a variable to hold the input value.

Don't use println here.

The program waits for user input, then places the input into the variable.

Formatted Output

- Outputting floating point values can look strange:

```
Price per liter:  1.21997
```

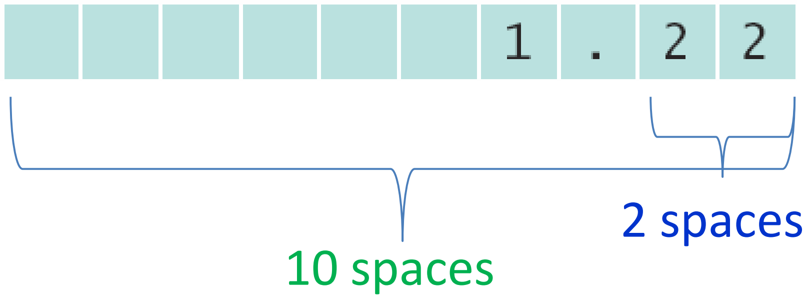
- To control the output appearance of numeric variables, use formatted output tools such as:

```
System.out.printf(“%.2f”, price);
```

```
Price per liter: 1.22
```

```
System.out.printf(“%10.2f”, price);
```

```
Price per liter:      1.22
```



- The `%10.2f` is called a format specifier

Format Types

- Formatting is handy to align columns of output

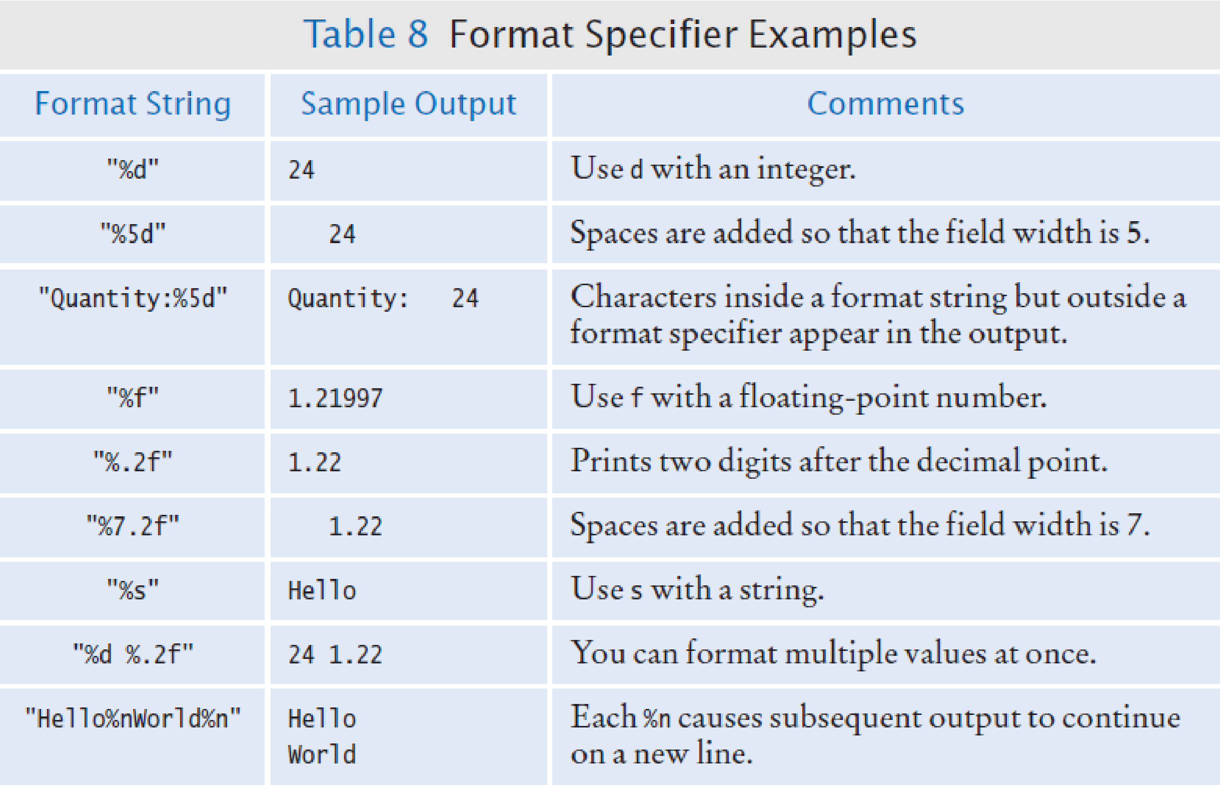


Table 8 Format Specifier Examples

Format String	Sample Output	Comments
`"%d"`	`24`	Use d with an integer.
`"%5d"`	`   24`	Spaces are added so that the field width is 5.
`"Quantity:%5d"`	`Quantity:   24`	Characters inside a format string but outside a format specifier appear in the output.
`"%f"`	`1.21997`	Use f with a floating-point number.
`"%.2f"`	`1.22`	Prints two digits after the decimal point.
`"%7.2f"`	`   1.22`	Spaces are added so that the field width is 7.
`"%s"`	`Hello`	Use s with a string.
`"%d %.2f"`	`24 1.22`	You can format multiple values at once.
`"Hello%nWorld%n"`	`Hello` `World`	Each %n causes subsequent output to continue on a new line.

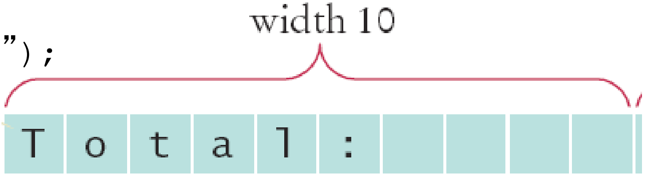
- You can also include text inside the quotes:

```
System.out.printf(“Price per liter: %10.2f”, price);
```

Formatted Output Examples

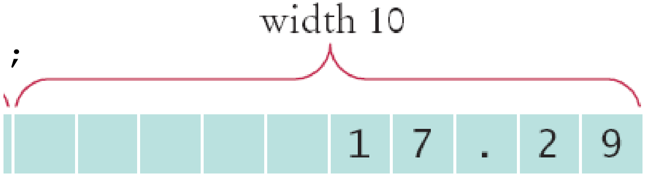
- Left Justify a String:

```
System.out.printf(“%-10s”, “Total:”);
```



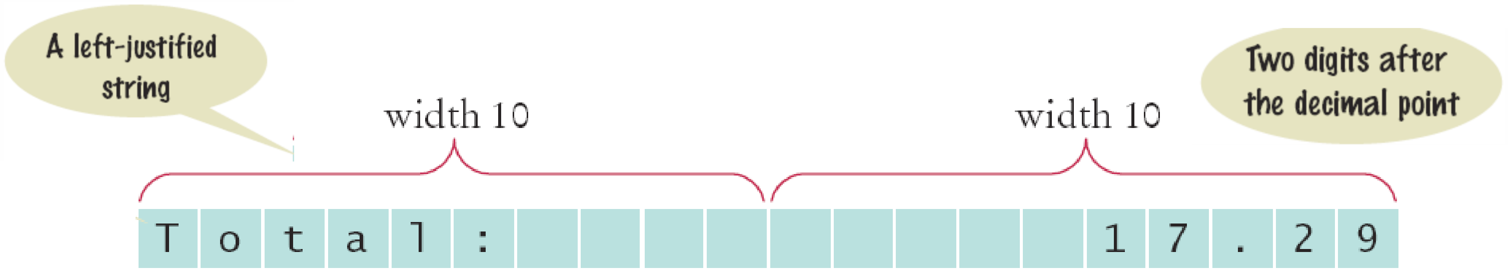
- Right justify a number with two decimal places

```
System.out.printf(“%10.2f”, price);
```

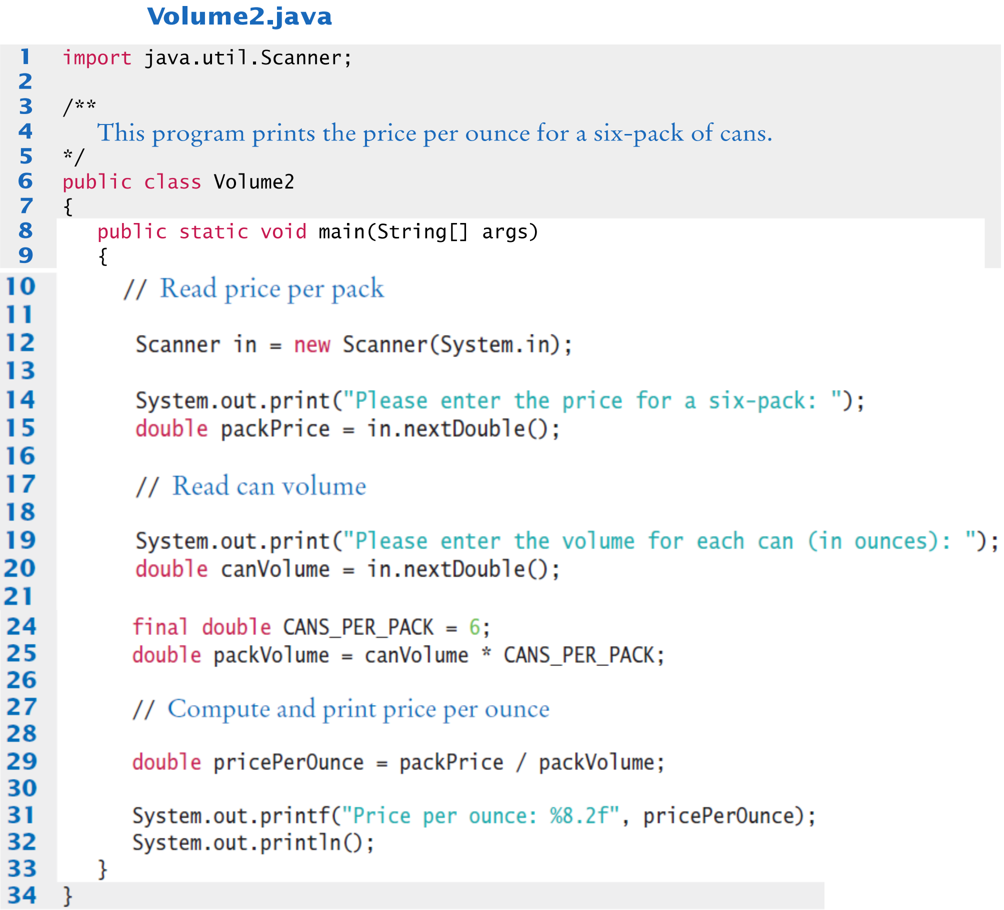


- And you can print multiple values

```
System.out.printf(“%-10s%10.2f”, “Total:”, price);
```



Volume2.java

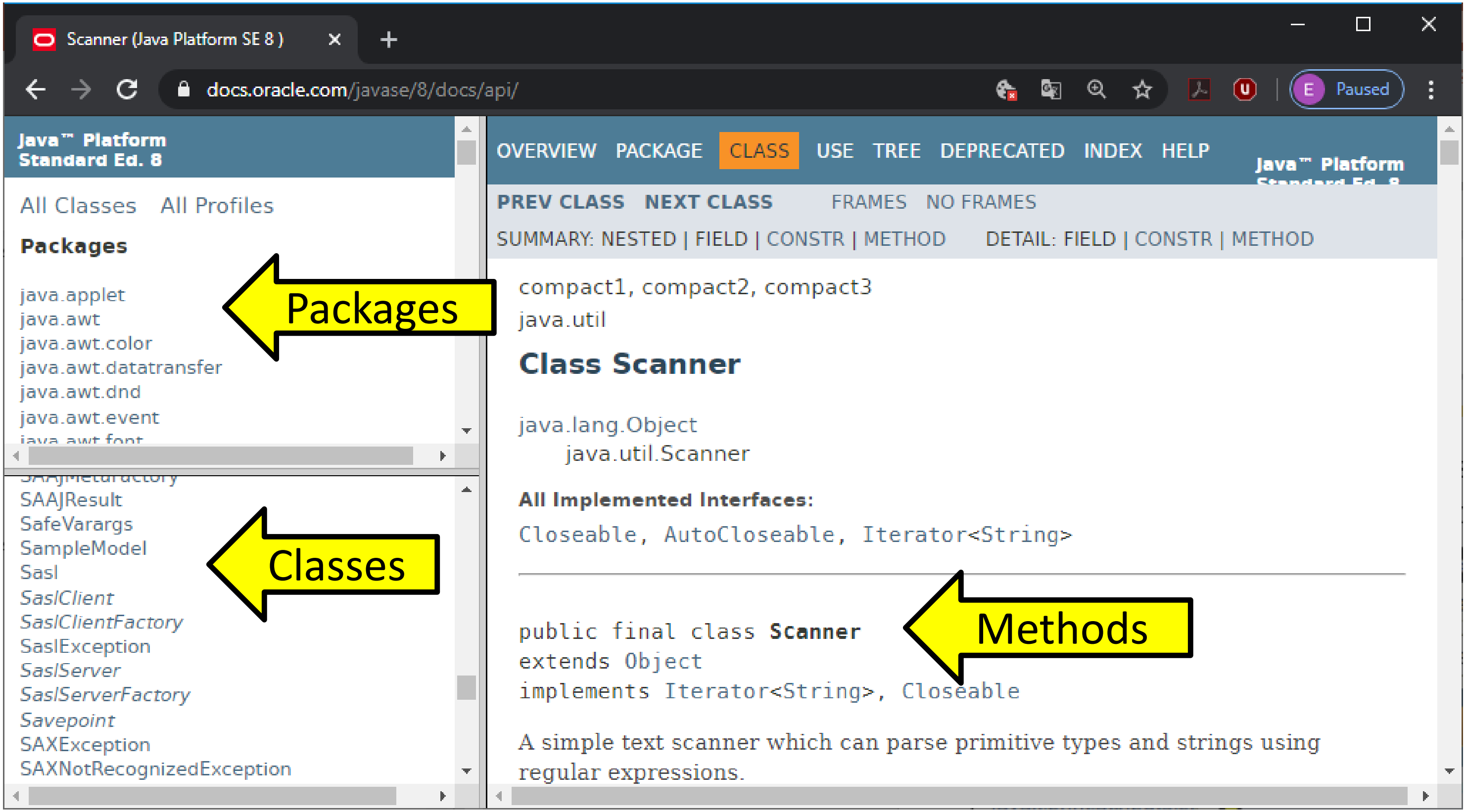


Volume2.java

```java
import java.util.Scanner;

/**
   This program prints the price per ounce for a six-pack of cans.
*/
public class Volume2
{
   public static void main(String[] args)
   {
      // Read price per pack

      Scanner in = new Scanner(System.in);

      System.out.print("Please enter the price for a six-pack: ");
      double packPrice = in.nextDouble();

      // Read can volume

      System.out.print("Please enter the volume for each can (in ounces): ");
      double canVolume = in.nextDouble();

      final double CANS_PER_PACK = 6;
      double packVolume = canVolume * CANS_PER_PACK;

      // Compute and print price per ounce

      double pricePerOunce = packPrice / packVolume;

      System.out.printf("Price per ounce: %8.2f", pricePerOunce);
      System.out.println();
   }
}
```

Java API Documentation

- Lists the classes and methods of the Java API
  - On the web at: http://download.oracle.com/javase/8/docs/api


Scanner (Java Platform SE 8)
docs.oracle.com/javase/8/docs/api/
E
Paused
OVERVIEW
PACKAGE
CLASS
USE
TREE
DEPRECATED
INDEX
HELP
PREV CLASS
NEXT CLASS
FRAMES
NO FRAMES
SUMMARY: NESTED | FIELD | CONSTR | METHOD
DETAIL: FIELD | CONSTR | METHOD

Java™ Platform
Standard Ed. 8

All Classes All Profiles

Packages

java.applet
java.awt
java.awt.color
java.awt.datatransfer
java.awt.dnd
java.awt.event
java.awt.font

Packages

SAAJMetaFactory
SAAJResult
SafeVarargs
SampleModel
Sasl
SaslClient
SaslClientFactory
SaslException
SaslServer
SaslServerFactory
Savepoint
SAXException
SAXNotRecognizedException

Classes

compact1, compact2, compact3
java.util

Class Scanner

java.lang.Object
    java.util.Scanner

All Implemented Interfaces:

`Closeable, AutoCloseable, Iterator<String>`

```
public final class Scanner
extends Object
implements Iterator<String>, Closeable
```

Methods

A simple text scanner which can parse primitive types and strings using regular expressions.

Strings

- The String Type:
    - Type   Variable   Literal
    - String name = “Harry”

- Once you have a String variable, you can use methods such as:

```
int n = name.length();  // n will be assigned 5
```

- A String’s length is the number of characters inside:
    - An empty String (length 0) is shown as “”
    - The maximum length is quite large (an int)

String Concatenation (+)

- You can ‘add’ one `String` onto the end of another

```
String fName = “Harry”
String lName = “Morgan“
String name = fname + lname;  // HarryMorgan
```

- You wanted a space in between?

```
String name = fname + “ “ + lname;  // Harry Morgan
```

- To concatenate a numeric variable to a `String`:

```
String a = “Agent“;
int n = 7;
String bond = a + n;    // Agent7
```

- Concatenate `String`s and numerics inside `println`:

```
System.out.println("The total is " + total);
```

String Input

- You can read a `String` from the console with:

  ```
  System.out.print("Please enter your name: ");
  String name = in.next();
  ```

  - The `next` method reads one word at a time
  - It looks for ‘white space’ delimiters

- You can read an entire line from the console with:

  ```
  System.out.print("Please enter your address: ");
  String address = in.nextLine();
  ```

  - The `nextLine` method reads until the user hits ‘Enter’

- Converting a `String` variable to a number:

  ```
  System.out.print("Please enter your age: ");
  String input = in.nextLine();
  int age = Integer.parseInt(input);  // only digits!
  ```

String Escape Sequences

- How would you print a double quote?
    - Preface the " with a \ inside the double quoted String

```
System.out.print("He said \"Hello\"");
```

- OK, then how do you print a backslash?
    - Preface the \ with another \!

```
System.out.print(""C:\\Temp\\Secret.txt");
```

- Special characters inside Strings
    - Output a newline with a ‘\n’

```
System.out.print("*\n**\n***\n");
```

```
*
**
***
```

Strings and Characters

- Strings are sequences of characters
  - Unicode characters to be exact
  - Characters have their own type: `char`
  - Characters have numeric values
    - See the ASCII code chart in Appendix B
    - For example, the letter ‘H’ has a value of 72 if it were a number
- Use single quotes around a `char`

```
    char initial = ‘B’;
```

- Use double quotes around a `String`

```
    String initials = “BRL”;
```

Copying a char from a String

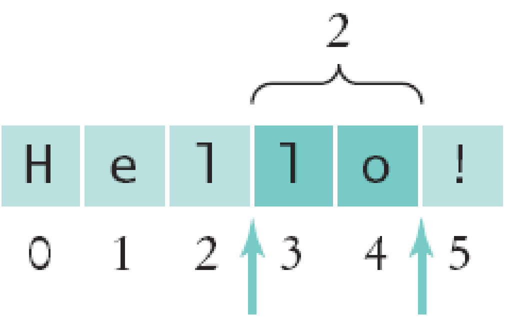
- A substring is a portion of a `String`

- The `substring` method returns a portion of a `String` at a given index for a number of chars, starting at an index:

0	1	2	3	4	5
H	e	l	l	o	!

0	1
H	e

```
String greeting = "Hello!";
String sub = greeting.substring(0, 2);
```



```
String sub2 = greeting.substring(3, 5);
```

Copying a Portion of a `String`

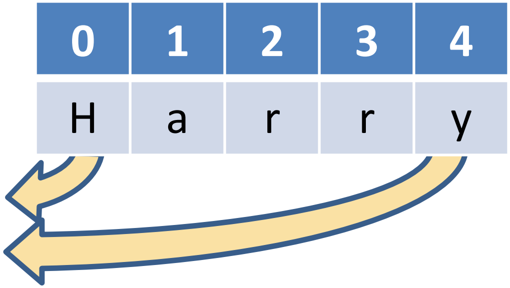
- Each `char` inside a `String` has an index number:

0	1	2	3	4	5	6	7	8	9
c	h	a	r	s		h	e	r	e

- The first `char` is index zero (0)

- The `charAt` method returns a `char` at a given index inside a `String`:

```
String greeting = "Harry";
char start = greeting.charAt(0);
char last = greeting.charAt(4);
```



0	1	2	3	4
H	a	r	r	y

String Operations (1)

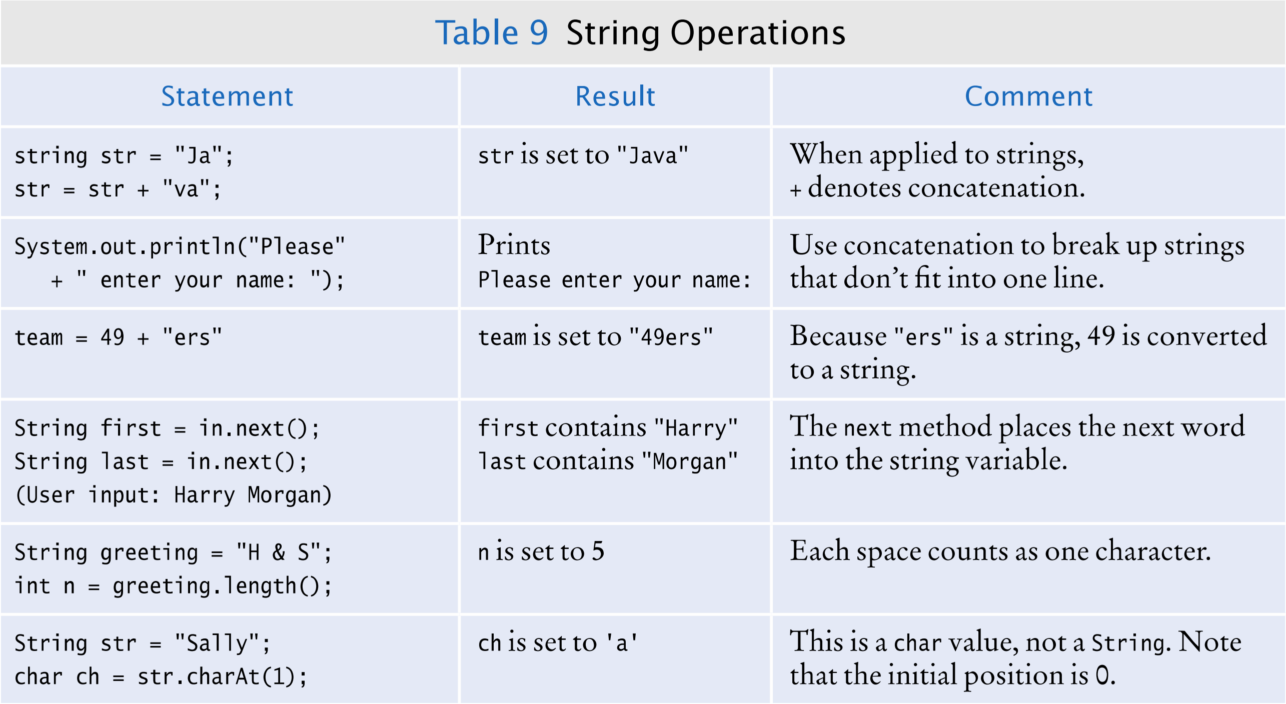


Table 9 String Operations

Statement	Result	Comment

`string str = "Ja";`
`str = str + "va";`
	`str` is set to `"Java"`	When applied to strings,
		+ denotes concatenation.

`System.out.println("Please"`
`   + " enter your name: ");`
	Prints
	`Please enter your name:`
		Use concatenation to break up strings that don't fit into one line.

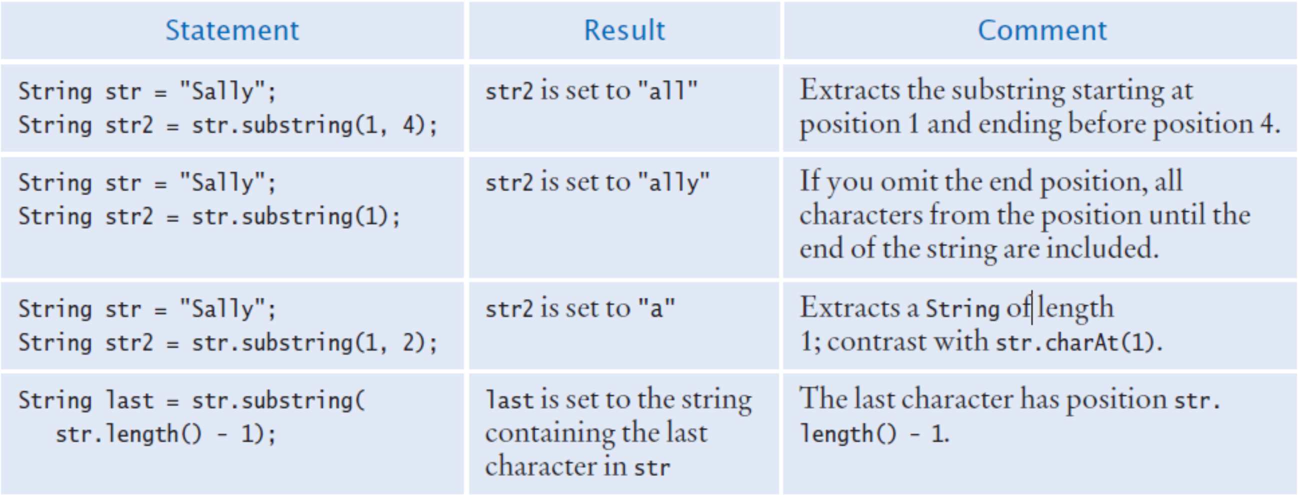
`team = 49 + "ers"`	`team` is set to `"49ers"`	Because `"ers"` is a string, 49 is converted to a string.

`String first = in.next();`
`String last = in.next();`
`(User input: Harry Morgan)`
	`first` contains `"Harry"`
	`last` contains `"Morgan"`
		The `next` method places the next word into the string variable.

`String greeting = "H & S";`
`int n = greeting.length();`
	`n` is set to 5	Each space counts as one character.

`String str = "Sally";`
`char ch = str.charAt(1);`
	`ch` is set to `'a'`	This is a `char` value, not a `String`. Note that the initial position is `0`.

String Operations (2)



Statement	Result	Comment

`String str = "Sally";`
`String str2 = str.substring(1, 4);`
	`str2` is set to `"all"`	Extracts the substring starting at position 1 and ending before position 4.

`String str = "Sally";`
`String str2 = str.substring(1);`
	`str2` is set to `"ally"`	If you omit the end position, all characters from the position until the end of the string are included.

`String str = "Sally";`
`String str2 = str.substring(1, 2);`
	`str2` is set to `"a"`	Extracts a `String` of length 1; contrast with `str.charAt(1)`.

`String last = str.substring(`
`str.length() - 1);`
	`last` is set to the string containing the last character in `str`	The last character has position `str.length() - 1`.

Self Check

Consider this string variable.

```
String str = "Java Program";
```

Give a call to the `substring` method that returns the substring "`gram`".

Answer: `str.substring(8, 12)` or `str.substring(8)`

What does the following statement sequence print?

```
String str = "Harry";
int n = str.length();
String mystery = str.substring(0, 1) + str.substring(n - 1, n);
System.out.println(mystery);
```

Answer: `Hy`

Give an input statement sequence to read a name of the form “John Q. Public”.

Answer:

```
String first = in.next();
String middle = in.next();
String last = in.next();
```