Chapter 2

Primitive Data Types and Operations

2.1 Introduction

- You will be introduced to Java **primitive** data types and related subjects, such as variables, constants, data types, operators, and expressions.
- You will learn how to write programs using primitive data types, input, and simple calculations.

2.2 Writing Simple Programs

- Writing a program involves designing algorithms and data structures, as well as translating algorithms into programming code.
- An **Algorithm** describes how a problem is solved in terms of the actions to be executed, and it specifies the order in which the actions should be executed.
- Computing an area of a circle. The algorithm for this program can be described as follows:
  1. Read in the Radius
  2. Compute the area using the following formula
     \[ \text{Area} = \text{radius} \times \text{radius} \times \pi \]
  3. Display the area.
- Java provides data types for representing integers, floating-point numbers, characters, and Boolean types. These types are known as **primitive data types**.
- When you **code**, you translate an algorithm into a **programming language** understood by the computer.
- The outline of the program is:

```java
// ComputeArea.Java: compute the area of a circle Comment
public class ComputeArea // Class Name
{
    public static void main(String[] args)// Main Method signature
    {
        double radius; // Data type & variable
double area;

        // Assign a radius
        radius = 20;

        // Compute area
        area = radius * radius * 3.14159; // Expression

        // Display results
        System.out.println("The area for the circle of radius " +
radius + " is " + area);
    }
}
```
• The program needs to declare a symbol called a variable that will represent the radius. Variables are used to store data and computational results in the program.
• Use descriptive names rather than x and y. Use radius for radius, and area for area. Specify their data types to let the compiler know what radius and area are, indicating whether they are integer, float, or something else.
• The program declares radius and area as double-precision variables. The reserved word double indicates that radius and area are double-precision floating-point values stored in the computer.
• For the time being, we will assign a fixed number to radius in the program. Then, we will compute the area by assigning the expression radius * radius * 3.14159 to area.
• The program’s output is:
  The area for the circle of radius 20.0 is 1256.636
• A string constant should not cross lines in the source code. Use the concatenation operator (+) to overcome such problem.

2.3 Identifiers

• Programming languages use special symbols called identifiers to name such programming entities as variables, constants, methods, classes, and packages.
• The following are the rules for naming identifiers:
  o An identifier is a sequence of characters that consist of letters, digits, underscores (_), and dollar signs ($).
  o An identifier must start with a letter, an underscore (_), or a dollar sign ($). It cannot start with a digit.
  o An identifier cannot be a reserved word. (See Appendix A, “Java Keywords,” for a list of reserved words).
  o An identifier cannot be true, false, or null.
  o An identifier can be of any length.
• For example:
  o Legal identifiers are for example: $2, ComputeArea, area, radius, and showMessageDialog.
  o Illegal identifiers are for example: 2A, d+4.
  o Since Java is case-sensitive, X and x are different identifiers.

2.4 Variables

• Variables are used to store data in a program.
• You can write the code shown below to compute the area for different radii:

```java
// Compute the first area
radius = 1.0;
area = radius*radius*3.14159;
System.out.println("The area is " + area + " for radius "+radius);

// Compute the second area
radius = 2.0;
```
area = radius*radius*3.14159;
System.out.println("The area is "+area+" for radius "+radius);

2.4.1 Declaring Variables

- Variables are used for representing data of a certain type.
- To use a variable, you declare it by telling the compiler the name of the variable as well as what type of data it represents. This is called variable declaration.
- Declaring a variable tells the compiler to allocate appropriate memory space for the variable based on its data type. The following are examples of variable declarations:

  ```java
  int x;         // Declare x to be an integer variable;
  double radius; // Declare radius to be a double variable;
  char a;        // Declare a to be a character variable;
  ```

- If variables are of the same type, they can be declared together using short-hand form:

  ```java
  Datatype var1, var2, ..., varn;  // variables are separated by commas
  ```

2.5 Assignment Statements and Assignments Expressions

- After a variable is declared, you can assign a value to it by using an assignment statement. The syntax for assignment statement is:

  ```java
  variable = expression;
  ```

  ```java
  x = 1;              // Assign 1 to x; ➔ Thus 1 = x is wrong
  radius = 1.0;       // Assign 1.0 to radius;
  a = 'A';            // Assign 'A' to a;
  x = 5 * (3 / 2) + 3 * 2; // Assign the value of the expression to x;
  x = y + 1;          // Assign the addition of y and 1 to x;
  ```

- The variable can also be used in the expression.

  ```java
  x = x + 1;          // the result of x + 1 is assigned to x;
  ```

- To assign a value to a variable, the variable name must be on the left of the assignment operator.

  ```java
  1 = x would be wrong.
  ```

- In Java, an assignment statement can also be treated as an expression that evaluates to the value being assigned to the variable on the left-hand side of the assignment operator. For this reason, an assignment statement is also known as an assignment expression, and the symbol = is referred to as the assignment operator.

  ```java
  System.out.println(x = 1);
  ```

  which is equivalent to
x = 1;
System.out.println(x);

The following statement is also correct:

i = j = k = 1;

which is equivalent to

k = 1; j = k; i = j;

2.5.1 Declaring and Initializing Variables in One Step

- You can declare a variable and initialize it in one step.

  int x = 1;

  This is equivalent to the next two statements:

  int x;
  x = 1;

  // shorthand form to declare and initialize vars of same type
  int i = 1, j = 2;

- **Tip**: A variable must be declared **before** it can be assigned a value.

2.6 Constants

- The value of a variable may change during the execution of the program, but a constant represents permanent data that **never** change.
- The syntax for declaring a constant:

  ```java
  final datatype CONSTANTNAME = VALUE;
  final double PI = 3.14159;  // Declare a constant
  final int SIZE = 3;
  ```

- A constant **must** be declared and initialized before it can be used. You **cannot** change a constant’s value once it is declared. By convention, constants are named in **uppercase**.

```java
// ComputeArea.Java: compute the area of a circle Comment
public class ComputeArea  // Class Name
{
    public static void main(String[] args) // Main Method signature
    {
        final double PI = 3.14159;  // declare a constant
double radius = 20;  // assign a radius

        // Compute area
double area = radius * radius * PI;  // Expression

        // Display results
    }
}
```
System.out.println("The area for the circle of radius " +
  radius + " is " + area);
}
}

• Note: There are three benefits of using constants:
  o You don’t have to repeatedly type the same value.
  o The value can be changed in a single location.
  o The program is easy to read.

2.7 Numerical Data Types and Operations

• Every data type has a range of values. The compiler allocates memory space to store each variable or constant according to its data type.
• Java has six numeric types: four for integers and two for floating-point numbers.

<table>
<thead>
<tr>
<th>Name</th>
<th>Storage Size</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>8 bits</td>
<td>-2^7 (-128) to 2^7 - 1 (127)</td>
</tr>
<tr>
<td>short</td>
<td>16 bits</td>
<td>-2^15 (-32768) to 2^15 - 1 (32767)</td>
</tr>
<tr>
<td>int</td>
<td>32 bits</td>
<td>-2^31 (-2147483648) to 2^31 - 1 (2147483647)</td>
</tr>
<tr>
<td>long</td>
<td>64 bits</td>
<td>-2^63 to 2^63 - 1</td>
</tr>
<tr>
<td>float</td>
<td>32 bits</td>
<td>6 - 7 significant digits of accuracy</td>
</tr>
<tr>
<td>double</td>
<td>64 bits</td>
<td>14 - 15 significant digits of accuracy</td>
</tr>
</tbody>
</table>

2.7.1 Numerical Operators

+,-,*,/, and %

5/2 yields an integer 2. 5.0/2 yields a double value 2.5.

5 % 2 yields 1 (the remainder of the division.)

• Remainder is very useful in programming. For example, an even number % 2 is always 0 and an odd number % 2 is always 1. So you can use this property to determine whether a number is even or odd. Suppose you know January 1, 2005 is Saturday, you can find that the day for February 1, 2005 is Tuesday using the following expression:

Saturday is the 6th day in a week

\[(6 + 31) \% 7 \text{ is } 2\]

A week has 7 days

The 2nd day in a week is Tuesday

January has 31 days

• A unary operator has only one operand. A binary operator has two operands.

NOTE
Calculations involving floating-point numbers are approximated because these numbers are not stored with complete accuracy. For example,
System.out.println(1 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1);
displays 0.5000000000000001, not 0.5, and
System.out.println(1.0 - 0.9);
displays 0.09999999999999998, not 0.1.

Integers are stored precisely. Therefore, calculations with integers yield a precise integer result.

2.7.2 Numeric Literals

- A literal is a constant value that appears directly in a program. For example, 34, 1,000,000, and 5.0 are literals in the following statements:
  ```java
  int i = 34;
  long l = 1000000;
  double d = 5.0;
  ```

2.7.2.1 Integer Literals

- An integer literal can be assigned to an integer variable as long as it can fit into the variable. A compilation error would occur if the literal were too large for the variable to hold.
- For example, the statement byte b = 1000 would cause a compilation error, because 1000 cannot be stored in a variable of the byte type.
- An integer literal is assumed to be of the int type, whose value is between \(-2^{31}\) (-2147483648) to \(2^{31}-1\) (2147483647).
- To denote an integer literal of the long type, append it with the letter L or l (lowercase L).
- For example, the following code display the decimal value 65535 for hexadecimal number FFFF.
  ```java
  System.out.println(0x FFFF);
  ```

2.7.2.2 Floating-Point Literals

- Floating-point literals are written with a decimal point. By default, a floating-point literal is treated as a double type value.
- For example, 5.0 is considered a double value, not a float value.
- You can make a number a float by appending the letter f or F, and make a number a double by appending the letter d or D.
- For example, you can use 100.2f or 100.2F for a float number, and 100.2d or 100.2D for a double number.
- The double type values are more accurate than float type values.
2.7.2.3 Scientific Notations

- Floating-point literals can also be specified in scientific notation; for example, 1.23456e+2, same as 1.23456e2, is equivalent to 123.456, and 1.23456e-2 is equivalent to 0.0123456. E (or e) represents an exponent and it can be either in lowercase or uppercase.

2.7.3 Arithmetic Expressions

- For example, the arithmetic expression
  \[
  \frac{3 + 4x}{5} - \frac{10(y - 5)(a + b + c)}{x} + 9\left(\frac{4 + 9 + x}{y}\right)
  \]
  can be translated into a Java expression as:
  \[
  (3 + 4 * x)/5 - 10 * (y - 5)*(a + b + c)/x + 9 * (4 / x + (9 + x)/y)
  \]

- Operators contained within pairs of parentheses are evaluated first.
- Parentheses can be nested, in which case the expression in the inner parentheses is evaluated first.
- Multiplication, division, and remainder operators are applied next. Order of operation is applied from left to right. Addition and subtraction are applied last.

2.7.4 Shortcut Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Example</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>+=</td>
<td>i+=8</td>
<td>i = i+8</td>
</tr>
<tr>
<td>-=</td>
<td>f-=8.0</td>
<td>f = f-8.0</td>
</tr>
<tr>
<td>*=</td>
<td>i*=8</td>
<td>i = i*8</td>
</tr>
<tr>
<td>/=</td>
<td>i/=8</td>
<td>i = i/8</td>
</tr>
<tr>
<td>%=</td>
<td>i%=8</td>
<td>i = i%8</td>
</tr>
</tbody>
</table>

- There are two more shortcut operators for incrementing and decrementing a variable by 1. These two operators are ++, and --. They can be used in prefix or suffix notations.

  suffix  x++; // Same as x = x + 1;
  prefix  ++x; // Same as x = x + 1;
  suffix  x--; // Same as x = x - 1;
  prefix  --x; // Same as x = x - 1;
Operator  Name   Description
++var  preincrement  The expression (++var) increments var by 1 and evaluates to the new value in var after the increment.
var++  postincrement  The expression (var++) evaluates to the original value in var and increments var by 1.
--var  predecrement  The expression (--var) decrements var by 1 and evaluates to the new value in var after the decrement.
var--  postdecrement  The expression (var--) evaluates to the original value in var and decrements var by 1.

Ex:

double x = 1.0;
double y = 5.0;
double z = x-- + (++y);

After execution, y = 6.0, z = 7.0, and x = 0.0;

• Using increment and decrement operators make expressions short; it also makes them complex and difficult to read. Avoid using these operators in expressions that modify multiple variables or the same variable for multiple times such as this: int k = ++i + i.
• Prior to Java 2, all the expressions can be used as statements. Since Java 2, only the following types of expressions can be statements:

```
variable op= expression; // Where op is +, -, *, /, or %
++variable;
variable++;
--variable;
variable--;
3 + 4; // Correct prior to Java 2, but wrong in Java 2
```

2.8 Numeric Type Conversions

• Consider the following statements:

```
byte i = 100;
long k = i*3+4;
double d = i*3.1+k/2;
```
Are these statements correct?

- When performing a binary operation involving two operands of different types, Java **automatically** converts the operand based on the following rules:
  1. If one of the operands is double, the other is converted into double.
  2. Otherwise, if one of the operands is float, the other is converted into float.
  3. Otherwise, if one of the operands is long, the other is converted into long.
  4. Otherwise, both operands are converted into int.

- Thus the result of `1 / 2` is 0, and the result of `1.0 / 2` is 0.5.
- **Type Casting** is an operation that converts a value of one data type into a value of another data type.
  - Casting a variable of a type with a small range to variable with a larger range is known as **widening** a type. Widening a type can be performed **automatically** without explicit casting.
  - Casting a variable of a type with a large range to variable with a smaller range is known as **narrowing** a type. Narrowing a type must be performed **explicitly**.
- **Caution:** Casting is necessary if you are assigning a value to a variable of a smaller type range. A compilation **error** will occur if casting is not used in situations of this kind. Be careful when using casting. **Lost** information might lead to inaccurate results.

```java
float f = (float) 10.1;
int i = (int) f;

double d = 4.5;
int i = (int) d;  // d is not changed
System.out.println("d " + d + " i " + i); // answer is d 4.5 i 4
```

**Implicit casting**

```java
double d = 3;  // type widening
```

**Explicit casting**

```java
int i = (int) 3.0;  // type narrowing
```

What is wrong?

```java
int x = 5 / 2.0;  // loss of precision
int i = 1;
byte b = i;  // Error because explicit casting is required
```

### 2.9 Character Data Type and Operations

- The character data type, char, is used to represent a single character.
- A character literal is enclosed in **single** quotation marks.
char letter = 'A';  // Assigns A to char variable letter (ASCII)
char numChar = '4';  // Assigns numeric character 4 to numChar (ASCII)

• **Caution:** A string literal must be enclosed in quotation marks. A character literal is a single character enclosed in single quotation marks. So “A” is a string, and ‘A’ is a character.

### 2.9.1 Unicode and ASCII code

- Java uses Unicode, a **16-bit** encoding scheme established by the Unicode Consortium to support the interchange, processing, and display of written texts in the world’s diverse languages (See the Unicode Web site at [www.unicode.org](http://www.unicode.org) for more information.)
- Unicode takes **two** bytes, precoded by \u, expressed in four hexadecimal digits that run from ‘\u0000’ to ‘\uFFFF’. For example, the “coffee” is translated into Chinese using two characters. The Unicode of these two characters are “\u5496\u5561”.

```
char letter = '\u0041'; (Unicode  16-bit encoding scheme)
char numChar = '\u0034'; (Unicode)
```

- Unicode can represent 65,536 characters, since FFFF in hexadecimal is 65535.
- Most computer ASCII (American Standard Code for Information Interchange), a **7-bit** encoding scheme for representing all uppercase and lowercase letter, digits, punctuation marks, and control characters.
- Unicode includes ASCII code with ‘\u0000’ to ‘\u007F’ corresponding to **128** ASCII characters. (See Appendix B).
- **Note:** The increment and decrement operators can also be used on char variables to get the next or preceding Unicode character.
- For example, the following statements display character b:

```
char ch = 'a';
System.out.println(++ch);
```

```
\begin{table}[h]
\centering
\footnotesize
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|}
\hline
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\
\hline
\hline
0 & nul & sob & stx & etx & exa & exq & msk & bsp & bs & hcr
1 & scr & ctrl & x1f & x1e & x1c & x1a & x18 & x16 & x14 & x12
2 & x06 & x07 & x08 & x09 & x0a & x0b & x0c & x0d & x0e & x0f
3 & x10 & x11 & x12 & x13 & x14 & x15 & x16 & x17 & x18 & x19
4 & x1a & x1b & x1c & x1d & x1e & x1f & x20 & x21 & x22 & x23
5 & x24 & x25 & x26 & x27 & x28 & x29 & x2a & x2b & x2c & x2d
6 & x2e & x2f & x30 & x31 & x32 & x33 & x34 & x35 & x36 & x37
7 & x38 & x39 & x3a & x3b & x3c & x3d & x3e & x3f & x40 & x41
8 & x42 & x43 & x44 & x45 & x46 & x47 & x48 & x49 & x4a & x4b
9 & x4c & x4d & x4e & x4f & x50 & x51 & x52 & x53 & x54 & x55
10 & x56 & x57 & x58 & x59 & x5a & x5b & x5c & x5d & x5e & x5f
11 & x60 & x61 & x62 & x63 & x64 & x65 & x66 & x67 & x68 & x69
12 & x6a & x6b & x6c & x6d & x6e & x6f & x70 & x71 & x72 & x73
\hline
\end{tabular}
\caption{ASCII Character Set in the Decimal Index}
\end{table}
```
2.9.2 Escape Sequences for Special Characters

<table>
<thead>
<tr>
<th>Description</th>
<th>Escape Sequence</th>
<th>Unicode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backspace</td>
<td>\b</td>
<td>\u0008</td>
</tr>
<tr>
<td>Tab</td>
<td>\t</td>
<td>\u0009</td>
</tr>
<tr>
<td>Linefeed</td>
<td>\n</td>
<td>\u000A</td>
</tr>
<tr>
<td>Carriage return</td>
<td>\r</td>
<td>\u000D</td>
</tr>
<tr>
<td>Backslash</td>
<td>\</td>
<td>\u005C</td>
</tr>
<tr>
<td>Single Quote</td>
<td>'</td>
<td>\u0027</td>
</tr>
<tr>
<td>Double Quote</td>
<td>&quot;</td>
<td>\u0022</td>
</tr>
</tbody>
</table>

• Suppose you want to print the quoted message show below:

   He said “Java is fun”

Here is how to write the statement:

   System.out.println(“He said \"Java is fun\"”);

2.9.3 Casting between char and Numeric Types

• A char can be cast into any numeric type, and vice versa.
• Implicit casting can be used if the result of a casting fits into the target variable. Otherwise explicit casting must be used.
• All numeric operation can be applied to the char operands.
• The char operand is cast into a number if the other operand is a number or a character.
• If the other operand is a string, the character is concatenated with the string.

```java
int i = 'a'; // Same as int i = (int)'a'; // (int) a is 97
char c = 99; // Same as char c = (char)99;

int i = '1' + '2'; // (int) 1 is 49 and (int) 2 is 50
System.out.println("i is " + i);

int j = 1 + 'a'; // (int) a is 97
System.out.println("j is " + 98);
System.out.println(j + " is the Unicode for character " + (char) j);
System.out.println("Chapter " + 2);
```

Output is:

| i is 99  
| j is 98  

98 is the Unicode for character b
Chapter 2
2.10 The Boolean Data Type and Operations

- Often in a program you need to compare two values, such as whether \( i \) is greater than \( j \). Java provides six comparison operators (also known as relational operators) that can be used to compare two values. The result of the comparison is a Boolean value: true or false.

```java
System.out.println(1 < 2);   // Displays true
boolean b = (1 > 2);
System.out.println("b is " + b); // Displays b is false
```

### TABLE 2.5 Comparison Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>&lt;=</td>
<td>less than or equal to</td>
</tr>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>&gt;=</td>
<td>greater than or equal to</td>
</tr>
<tr>
<td>==</td>
<td>equal to</td>
</tr>
<tr>
<td>!=</td>
<td>not equal to</td>
</tr>
</tbody>
</table>

### TABLE 2.6 Boolean Operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>not</td>
<td>logical negation</td>
</tr>
<tr>
<td>&amp;&amp;</td>
<td>and</td>
<td>logical conjunction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>^</td>
<td>exclusive or</td>
<td>logical exclusion</td>
</tr>
</tbody>
</table>

```java
&& (and)    (1 < x) && (x < 100)
|| (or)   (lightsOn) || (isDayTime)
!  (not)   !(isStopped)
```

### TABLE 2.7 Truth Table for Operator !

<table>
<thead>
<tr>
<th>( p )</th>
<th>( !p )</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>false</td>
<td>!(1 &gt; 2) is true, because (1 &gt; 2) is false.</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>!(1 &gt; 0) is false, because (1 &gt; 0) is true.</td>
</tr>
</tbody>
</table>

### TABLE 2.8 Truth Table for Operator &&

<table>
<thead>
<tr>
<th>( p1 )</th>
<th>( p2 )</th>
<th>( p1 &amp;&amp; p2 )</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>false</td>
<td>false</td>
<td>(2 &gt; 3) &amp;&amp; (5 &gt; 5) is false, because either (2 &gt; 3) and (5 &gt; 5) is false.</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>false</td>
<td>(3 &gt; 2) &amp;&amp; (5 &gt; 5) is false, because (5 &gt; 5) is false.</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>false</td>
<td>(3 &gt; 2) &amp;&amp; (5 &gt;= 5) is true, b/c (3 &gt; 2) and (5 &gt;= 5) are both true.</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>true</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 2.9 Truth Table for Operator ||

| p1  | p2  | p1 || p2 |
|-----|-----|------|
| false | false | false |
| false | true  | true  |
| true  | false | true  |
| true  | true  | true  |

Example

(2 > 3) || (5 > 5) is false, because (2 > 3) and (5 > 5) are both false.

(3 > 2) || (5 > 5) is true, because (3 > 2) is true.

TABLE 2.10 Truth Table for Operator ^

<table>
<thead>
<tr>
<th>p1</th>
<th>p2</th>
<th>p1 ^ p2</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>false</td>
</tr>
</tbody>
</table>

Example

(2 > 3) ^ (5 > 1) is true, because (2 > 3) is false and (5 > 1) is true.

(3 > 2) ^ (5 > 1) is false, because both (3 > 2) and (5 > 1) are true.

• Examples

```java
int num = 2;
System.out.println("Is " + num + " divisible by 2 and 3? " +
    ((num % 2 == 0) && (num % 3 == 0)));
System.out.println("Is " + num + " divisible by 2 or 3? " +
    ((num % 2 == 0) || (num % 3 == 0)));
System.out.println("Is " + num + " divisible by 2 or 3, but not both? " +
    ((num % 2 == 0) ^ (num % 3 == 0)));

Is 2 divisible by 2 and 3? false
Is 2 divisible by 2 or 3? true
Is 2 divisible by 2 or 3, but not both? true
```

2.10.1 Unconditional vs. Conditional Boolean Operators

&&: conditional (short-circuit) AND operator
&: unconditional AND operator
||: conditional (short-circuit) OR operator
|: unconditional OR operator

exp1  &&  exp2
(1 < x)  &&  (x < 100)

(1 < x)  &  (x < 100)

If x is 1, what is x after this expression?
(x > 1)  &  (x++ < 10)  ➔ x = 2
(1 > x)  &&  (1 > x++)  ➔ x = 1

How about
(1 == x) | (10 > x++)?
(1 == x) || (10 > x++)?

- **Tip:** Avoid using the & and |. For example:

  \[(x != 0) \& (100 / x < 10)\]

  \(\Rightarrow\) runtime error if \(x\) is 0

- **Note:** The & and | operators can also apply to bitwise operations. See Appendix G

- **Note:** A Boolean value, however, **cannot** be cast into a value of other types, nor can a value of other types be cast into a Boolean value.

- **Note:** true and false are literals, just like a number such as 10, so they are not keywords, but you **cannot** use them as identifiers, just as you cannot use 10 as an identifier.

### 2.11 Operator Precedence & Associativity

How to evaluate?

\[
3 + 4 * 4 > 5 * (4 + 3) - 1
\]

- The precedence rule defines precedence for operators as shown below.
- If operators with the same precedence are next to each other, their associativity determines the order of evaluation.
- All binary operators except assignment operators are **left-associative**. For example:

  \[a - b + c - d\]

  is equivalent to \((a - b) + c - d\)

  Assignment operators are **right-associative**. Therefore, the expression

  \[a = b += c = 5\]

  is equivalent to \(a = (b += (c = 5))\)

- **Operator Precedence Chart (Table 2.11)**

  var++, var--
  +, - (Unary plus and minus), ++var,--var
  (type) Casting
  ! (Not)
  *, /, % (Multiplication, division, and modulus)
  +, - (Binary addition and subtraction)
  <, <=, >, >= (Comparison)
  ==, != (Equality)
  & (Unconditional AND)
  ^ (Exclusive OR)
  | (Unconditional OR)
  && (Conditional AND) Short-circuit AND
  || (Conditional OR) Short-circuit OR
  =, +=, -=, *=, /=, %= (Assignment operator)
Applying the operator precedence and associativity rule, the expression $3 + 4 \times 4 > 5 \times (4 + 3) - 1$ is evaluated as follows:

$$3 + 4 \times 4 > 5 \times (4 + 3) - 1$$

1. inside parentheses first
2. multiplication
3. multiplication
4. addition
5. subtraction
6. greater than

false

2.12 Operand Evaluation Order

- The precedence and associativity rules specify the order of the operators, but do not specify the order in which the operands of a binary operator are evaluated. Operands are evaluated from **left to right** in Java.
  
- *The left-hand operand of a binary operator is evaluated before any part of the right-hand operand is evaluated.*
  
- *If no operands have side effects that change the value of a variable, the order of operand evaluation is irrelevant. Interesting cases arise when operands do have a side effect.*
  
- For example, $x$ becomes 1 in the following code, because $a$ is evaluated to 0 before $++a$ is evaluated to 1.

  ```java
  int a = 0;
  int x = a + (++a);
  ```

- But $x$ becomes 2 in the following code, because $++a$ is evaluated to 1, then $a$ is evaluated to 1.

  ```java
  int a = 0;
  int x = ++a + a;
  ```

- *The order for evaluating operands takes precedence over the operator precedence rule.*
  
- $;++a$ has higher precedence than $(+)$, but since it is a left-hand operand of the addition $(+)$, it is evaluated before any part of its right hand operand.
  
- Rule of Evaluating an Expression:
  - Rule 1: Evaluate whatever sub-expressions you can possibly evaluate from left to right.
  - Rule 2: The operators are applied according to their precedence, as shown in Table 2.11.
Rule 3: The associativity rule applies for two operators next to each other with the same precedence.

- Applying the rule, the expression $3 + 4 \cdot 4 > 5 \cdot (4 + 3) - 1$ is evaluated as follows:

```
3 + 4 * 4 > 5 * (4 + 3) - 1
```

1. $4 \cdot 4$ is the first sub-expression that can be evaluated from left.
2. $3 + 16$ is evaluated now.
3. $4 + 3$ is now the leftmost subexpression that should be evaluated.
4. $5 \cdot 7$ is evaluated now.
5. $35 - 1$ is evaluated now.
6. $19 > 34$ is evaluated now.

### 2.13 The String Type

- The char type only represents one character. To represent a string of characters, use the data type called String. For example,

```
String message = "Welcome to Java";
```

- String is actually a predefined class in the Java library just like the System class and JOptionPane class.
- The String type is not a primitive type. It is known as a reference type. Any Java class can be used as a reference type for a variable.
- Reference data types will be thoroughly discussed in Chapter 6, “Classes and Objects.” For the time being, you just need to know how to declare a String variable, how to assign a string to the variable, and how to concatenate strings.

### String Concatenation

- The plus sign (+) is the concatenation operator if one of the operands is a string.
- If one of the operands is a non-string (e.g. a number), the non-string value is converted into a string and concatenated with the other string.

```java
// Three strings are concatenated
String message = "Welcome " + "to " + "Java";
message += " and Java is fun"; // message = Welcome to Java and Java is fun

// String Chapter is concatenated with number 2
String s = "Chapter" + 2; // s becomes Chapter2

// String Supplement is concatenated with character B
String s1 = "Supplement" + 'B'; // s becomes SupplementB
```
i = 1; j = 3;
System.out.println("i + j is " + i + j); → i + j is 13
System.out.println("i + j is " + (i + j)); → i + j is 4

2.14 Getting Input from Input Dialog Boxes

```java
String string = JOptionPane.showInputDialog(null, "Prompt Message", "Dialog Title", JOptionPane.QUESTION_MESSAGE);
```

```java
String string = JOptionPane.showInputDialog(null, x, y, JOptionPane.QUESTION_MESSAGE));
```

where \(x\) is a string for the prompting message and \(y\) is a string for the title of the input dialog box.

- **Note:** There are several ways to use the showInputDialog method. For the time being, you only need to know two ways to invoke it.
  One is to use a statement as shown in the example:

```java
String string = JOptionPane.showInputDialog(null, x, y, JOptionPane.QUESTION_MESSAGE));
```

where \(x\) is a string for the prompting message, and \(y\) is a string for the title of the input dialog box.

The other is to use a statement like this:

```java
JOptionPane.showMessageDialog(x);
```

where \(x\) is a string for the prompting message.

2.14.1 Converting String to Numbers

Converting Strings to Integers
• The input returned from the input dialog box is a **string**. If you enter a numeric value such as 123, it returns “123”. To obtain the input as a number, you have to convert a string into a number.

• To convert a string into an **int** value, you can use the **static parseInt** method in the **Integer** class as follows:

  ```java
  int intValue = Integer.parseInt(intString);
  ```

  where **intString** is a numeric string such as “123”.

### Converting Strings to Doubles

• To convert a string into a **double** value, you can use the **static parseDouble** method in the **Double** class as follows:

  ```java
  double doubleValue = Double.parseDouble(doubleString);
  ```

  where **doubleValue** is a numeric string such as “123.45”.

### Example Page 55:

• This program first prompts the user to enter a year as an **int** value and checks if it is a leap year, it then prompts you to enter a **double** value and checks if it is positive.

• A year is a leap year if it is divisible by 4 but not by 100, or it is divisible by 400.

  ```java
  ((year % 4 == 0) && (year % 100 != 0)) || (year % 400 == 0)
  ```

  // InputDialogDemo.java: Entering input from input dialog boxes

  ```java
  import javax.swing.JOptionPane;
  public class InputDialogDemo {
    public static void main(String args[]) {
      // Prompt the user to enter a year
      String yearString = JOptionPane.showInputDialog(null,
        "Enter a year:", "Example 2.2 Input (int)",
        JOptionPane.QUESTION_MESSAGE);

      // Convert the string into an int value
      int year = Integer.parseInt(yearString);

      // Check if the year is a leap year
      boolean isLeapYear =
        ((year % 4 == 0) && (year % 100 != 0)) || (year % 400 == 0);

      // Display the result in a message dialog box
      JOptionPane.showMessageDialog(null,
        year + " is a leap year? " + isLeapYear,
        "Example 2.2 Output (int)",
        JOptionPane.INFORMATION_MESSAGE);

      // Prompt the user to enter a double value
      String doubleString = JOptionPane.showInputDialog(null,
        "Enter a double value:", "Example 2.2 Input (double)"");
  }
  ```
2.17 Formatting Output (JDK 1.5 Feature)

- Use the new JDK 1.5 printf statement.

```java
System.out.printf(format, item);
```

Where `format` is a string that may consist of substrings and format specifiers. A format `specifier` specifies how an item should be displayed. An item may be a numeric value, character, boolean value, or a string. Each specifier begins with a percent sign.

**TABLE 2.12 Frequently Used Specifiers**

<table>
<thead>
<tr>
<th>Specifier</th>
<th>Output</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>%b</td>
<td>a boolean value</td>
<td>true or false</td>
</tr>
<tr>
<td>%c</td>
<td>a character</td>
<td>'a'</td>
</tr>
<tr>
<td>%d</td>
<td>a decimal integer</td>
<td>200</td>
</tr>
<tr>
<td>%f</td>
<td>a floating-point number</td>
<td>45.460000</td>
</tr>
<tr>
<td>%e</td>
<td>a number in standard scientific notation</td>
<td>4.556000e+01</td>
</tr>
<tr>
<td>%s</td>
<td>a string</td>
<td>&quot;Java is cool&quot;</td>
</tr>
</tbody>
</table>

```java
int count = 5;
double amount = 45.56;
System.out.printf("count is %2d %4.2f", count, amount);
```

displays
```
count is  5 45.56
```

- Items must match the specifiers in order, on number, and in exact type. By default, a floating-point value is displayed with 6 digits after the decimal points.

2.18 Programming Style and Documentation

- Programming Style deals with what programs look like.
- Documentation is the body of explanatory remarks and comments pertaining to a program.
• Programming style and documentation are as important as coding. They make the programs easy to read.

2.18.1 Appropriate Comments and Comments Style

• Include a summary at the beginning of the program to explain what the program does, its key features, its supporting data structures, and unique techniques it uses.
• In a long program, you should also include comments that introduce each major step and explain anything that is difficult to read.
• Make your comments concise to they do not crowd the program or make it difficult to read.
• Include your name, class section, date, instruction, and a brief description at the beginning of the program.

2.18.2 Naming Conventions

• Use lowercase for variables and methods. If a name consists of several words, concatenate all in one, use lowercase for the first word, and capitalize the first letter of each subsequent word in the name. Ex: showInputDialog.
• Choose meaningful and descriptive names. For example, the variables radius and area, and the method computeArea.
• Capitalize the first letter of each word in the class name. For example, the class name ComputeArea.
• Capitalize all letters in constants. For example, the constant PI.
• Do not use class names that are already used in Java library. For example, the constants PI and MAX_VALUE.

2.18.3 Proper Indentation andSpacing Lines

• Indentation is used to illustrate the structural relationships between program’s components or statements.
• Indent two spaces in each subcomponent more than the structure which it is nested.
• Use a single space on both sides of a binary operator.

    boolean b = 3 + 4 * 4 > 5 * (4 + 3)

• Use a blank line to separate segments of the code.

2.18.4 Block Styles

• A block is a group of statements surrounded by braces. Use end-of-line style for braces or next-line style.
2.19 Programming Errors

2.19.1 Syntax Errors “Compilation Error”
- Errors that occur during compilation are called syntax errors or compilation errors.
- Syntax errors result from errors in code construction, such as mistyping a keyword, omitting some necessary punctuation, or using an opening brace without a corresponding closing brace.
- These errors are easily detected, because the compiler tells you where they are and the reasons for them.

```java
public class ShowSyntaxErrors {
    public static void main(String[] args) {
        i = 30;
        System.out.println(i+4);
    }
}
```

2.19.2 Runtime Errors
- Runtime errors are errors that cause a program to terminate abnormally.
- Runtime errors occur while an application is running where the environment detects an operation that is impossible to carry out.
- For instance, an input error occurs when the user enters an unexpected input value that the program can’t handle. To prevent input errors, the program should prompt the user to enter the correct type of values.
- Another example of a run time error is division by zero.

```java
public class ShowRuntimeErrors {
    public static void main(String[] args) {
        int i = 1 / 0;
    }
}
```

2.19.3 Logic Errors
- Logic errors occur when a program doesn’t perform the way it was intended to.
For example, the program doesn’t have syntax or runtime errors, but it does not print the correct result.

```java
// ShowLogicErrors.java: The program contains a logic error
import javax.swing.JOptionPane;

public class ShowLogicErrors {
    public static void main(String[] args) {
        // Add number1 to number2
        int number1 = 3;
        int number2 = 3;
        number2 += number1 + number2;
        System.out.println("number2 is " + number2);
    }
}
```

2.20 Debugging

- Finding logic errors “bugs” is challenging and the process of finding and correcting errors is called debugging.
- You can hand-trace the program or you can insert print statements in order to show the values of the variables or the execution flow of the program.
- For a large, complex program, the most effective approach for debugging is to use a debugger utility.