Chapter 2
Introduction to Java Applications

Yepang LIU
liuyp1@sustech.edu.cn

Outline

- First glance of Java programs
- Java's primitive types (基本数据类型)
- Arithmetic computation (算术运算)
- Evaluation order of arithmetic expressions (算术表达式求值顺序)
- Decision-making statements (决策/条件语句)

Our First Java Program

```
// Text-printing program
public class Welcome1 {
    // main method begins the execution of Java application
    public static void main(String[] args) {
        System.out.println("Welcome to Java Programming!");
    }
}
```

`Welcome1` prints the following text in the command window (console):

```
Welcome to Java Programming!
```

Comments

```
// Text-printing program
```

- `//` indicates that the line is a comment.
- Comments help document programs to improve their readability.
- Compiler ignores comments.

Traditional comments begin with `/*` and end with `*/`. They can be spread over several lines

```
/* This is a traditional comment. It
   can be split over multiple lines */
```

Traditional vs. End-of-Line Comments

- Traditional comments do not nest (嵌套), the first */ after the first /* will terminate the comment

```
/*
  /* comment 1 */
     comment 2 */
```

Syntax Error (语法错误)

- End-of-line comments can contain anything

```
// /* this comment is okay */
```

Class Declaration

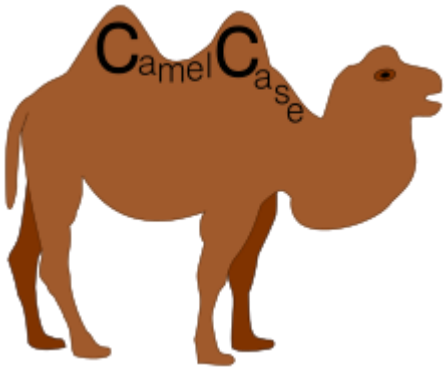
```
public class Welcome1
```

- Every Java program consists of at least one class (类) that you define
- The class keyword introduces a class declaration and is immediately followed by the class name
- Keywords are reserved for use by Java and are always spelled with all lowercase letters (we will see more later)

Identifiers

- A name in a Java program is called an **identifier**, which is used for identification purpose.
  - `"Welcome1"` is an identifier. It is the name for the class we just defined.
- The only allowed characters in Java identifiers are **a to z, A to Z, 0 to 9, $** and _ (underscore).
- Identifiers can't start with digits, e.g., **123name** is invalid.

Class Names



- By convention, class names begin with a capital letter and capitalize the first letter of each word they include (upper camel case, 大驼峰式命名法)

- Java is case sensitive—uppercase and lowercase letters are distinct (not in comments). "`Name`" and "`name`" are different identifiers.

The Braces

- A left brace { begins the declaration of every class and method
- A corresponding right brace } ends the declaration of each class and method
- Code between braces should be indented (good practice)

```
public class Welcome1 {
    public static void main(String[] args) {
        System.out.println("Welcome to Java Programming!");
    }
}
```

The `main` method

```
public static void main(String[] args) {
        System.out.println("Welcome to Java Programming!");
}
```

- Starting point of Java applications
- A method groups code that collectively achieves a functionality
- Parentheses after the identifier `main` enclose formal parameters (形式参数)
- Java class declarations normally contain one or more methods
- Keyword `void` indicates that this method will not return any data

The `main` method body

- Enclosed in left and right braces
- The statement in the method instructs the computer to print the string of characters contained between the double quotation marks

```
public static void main(String[] args) {
        System.out.println("Welcome to Java Programming!");
}
```

The System.out Object

```
System.out.println("Welcome to Java Programming!");
```

- System.out is the standard output object that allows Java applications to display strings in the command window
- `System.out.println` method
  - Displays (or prints) a line of text in the command window
  - The string in the parentheses is the actual argument (实际参数) to the method
  - Positions the output cursor at the beginning of the next line in the command window

Compile `Welcome1.java`

- Type the following command in the command line interface to compile the program

```
javac Welcome1.java
```

- If the program contains no syntax errors, the command creates a **`Welcome1.class`** file (known as the class file) containing the platform-independent Java bytecodes that represent the application

Execute `Welcome1`

- To execute the program, type `java Welcome1`
- The command launches the JVM, which loads the `.class` file for class `Welcome1` and executes the program
- The `.class` file-name extension is omitted from the command; otherwise, JVM will not execute the program.

Modifying Welcome1.java

```
// Print a line of text with multiple statements
public class Welcome2 {
    public static void main(String[] args) {
        System.out.print("Welcome to ");
        System.out.print("Java Programming!");
    }
}
```

Class Welcome2 uses two statements to produce the same output as class Welcome1

```
Welcome to Java Programming!
```

The System.out.print() method

- System.out's method print displays a string

- Unlike the method println, print does not position the output cursor at the beginning of the next line in the command window (it simply prints the string)

```
System.out.print("Welcome to ");
System.out.print("Java Programming!");
```

Continue the modification

```
// Print multiple lines of text using a single statement
public class Welcome3 {
    public static void main(String[] args) {
        System.out.println("Welcome\nto\nJava\nProgramming!");
    }
}
```

`Welcome3` prints the following text on the console:

```
Welcome
to
Java
Programming!
```

The newline character \n

- Newline characters instruct `System.out`'s `print` and `println` methods to position the output cursor at the beginning of the next line in the command window

- Newline characters are white-space characters, which represent horizontal or vertical space in typography and do not correspond to visible marks

```
System.out.println("Welcome\nto\nJava\nProgramming!");
```

Escape character

- The backslash (\) is an escape character (转义字符, a case of metacharacters), which invokes an alternative interpretation on subsequent characters

- Backslash \ is combined with the next character to form an escape sequence (转义序列)

- The escape sequence \n represents the newline character

Common Escape Sequences

Sequence	Description
`\n`	Newline. Position the cursor at the beginning of the next line.
`\t`	Horizontal tab. Move the cursor to the next tab stop.
`\r`	Carriage return. Position the cursor at the beginning of the current line (do not advance to the next line). Any characters output after the carriage return overwrite the characters previously output on that line.
`\\`	Used to print a backslash character.
`\"`	Used to print a double-quote character. `System.out.println("\"in quotes\"");` displays `"in quotes"`

Displaying text with `printf`

```
// Print multiple lines with printf
public class Welcome4 {
    public static void main(String[] args) {
        System.out.printf("%s\n%s\n", "Welcome to",
                          "Java Programming!");
    }
}
```

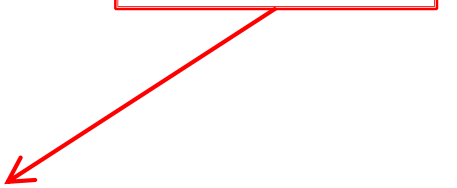
`Welcome4` prints the following text on the console:

```
Welcome to
Java Programming!
```

The printf method

- printf displays "formatted" data

```
System.out.printf("%s\n%s\n", "Welcome to",
                  "Java Programming!");
```



- It takes a format string (格式字符串) as an argument.
- The format specifiers (格式说明符) begin with a percent sign (%) and are followed by a character that represents the data type (e.g., %s is a placeholder for a string)

Tabulating output with `printf`

radius	perimeter	area
1	6.2832	3.1416
2	12.5664	12.5664
3	18.8496	28.2743
4	25.1327	50.2655

How to generate beautiful tables using `printf`?

Here is the magic code

```
double pi = Math.PI;
System.out.printf("%-20s%-20s%-20s\n", "radius", "perimeter", "area");
System.out.printf("%-20d%-20.4f%-20.4f\n", 1, 2*pi*1, pi*1*1);
System.out.printf("%-20d%-20.4f%-20.4f\n", 2, 2*pi*2, pi*2*2);
System.out.printf("%-20d%-20.4f%-20.4f\n", 3, 2*pi*3, pi*3*3);
System.out.printf("%-20d%-20.4f%-20.4f\n", 4, 2*pi*4, pi*4*4);
```

Please decode the format strings by yourself.

Check out the self-study materials on Blackboard or visit the link below.

https://www.cs.colostate.edu/~cs160/.Summer16/resources/Java_printf_method_quick_reference.pdf

Outline

- First glance of Java programs
- Java's primitive types
- Arithmetic computation
- Evaluation order of arithmetic expressions
- Decision-making statements

Data types

- All programs are composed of data and operations on the data.
- A data type tells the computer how the programmer intends to use the data
  - What is the meaning of the data (a sequence of bits)?
  - What operations can be done on the data?
  - How to store the data in memory?
- Computers only know about a few types of data: numbers, booleans, characters (strings), arrays, structures (objects)

Primitive data types

- Complex data types are built from primitive data types, which are built-in and basic to a language implementation
- Java has eight primitive types
  - Integral types: byte, short, int, long
  - Floating-point types: float, double
  - The boolean data type
  - The char data type

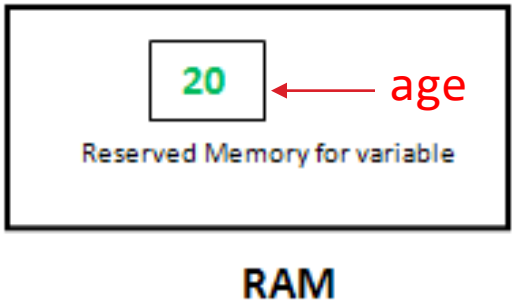
Integral data types (Integers)

Type	Size	Range
byte	8 bits	-128 to +127
short	16 bits	-32,768 to +32,767
int	32 bits	(about) -2 billion to +2 billion
long	64 bits	(about) -10E18 to +10E18

Example: `int age = 20;`

Meaning of `int age = 20;`

- The statement tells the computer to
  - Allocate space in memory to hold data of `int` type
  - Give the memory location a name “age”, such as we can refer to the data stored in the location using the name in the program (we say we created a **variable** named `age`)
  - Store the value 20 to the allocated space



https://www.geeksforgeeks.org/variables-in-java/

Floating-Point Numbers

- Computers represent **real numbers** (numbers that can contain a fractional part) using complex standard, such as the most popular IEEE Floating-Point Standard
- The term "*floating point*" is derived from the fact that there is no fixed number of digits before and after the decimal point; that is, the decimal point can float.
- There are also fixed-point representations: the number of digits before and after the decimal point is set (they can only handle a smaller range of numbers)

https://www.webopedia.com/TERM/F/floating_point_number.html

Floating-Point Numbers

Type	Size	Range
float	32 bits	-3.4E+38 to +3.4E+38
double	64 bits	-1.7E+308 to 1.7E+308

Example:

- `double pi = 3.1415926;`
- `float f = 234.5f;`

The value 234.5 by default is of type double, so f is needed to tell the compiler this is a value of float type

The precision of double and float

- The `double` type: double-precision floating-point number
  - A double has approximately 16 decimal digits
- The `float` type: single-precision floating-point number
  - A float has approximately 7 decimal digits

```
float f = 1.2345678990922222f; // 16 decimal digits
double d = 1.22222222222222222; // 20 decimal digits
System.out.println("f = " + f + "\t" + "d = " + d);
```

```
f = 1.2345679       d = 1.2222222222222223
```

Think about this

- **Why computers cannot store real numbers of infinite precisions (such as the irrational number π)?**

- It would otherwise require infinite memory (resources are finite in computers). This is why the built-in primitive types can only represent a range of values.

The `boolean` data type

- Represents one bit of information (the real size in memory depends on language implementations, could be 8 bits)
- Has only two possible values: `true` and `false`
- Often used as simple flags for tracking program conditions

Example: `boolean testResult = true;`

The char data type

- Represents a single 16-bit Unicode character
- Ranges from ‘\u0000’ to ‘\uffff’: 65536 characters, covering characters of most modern languages and a large number of symbols

```
char c1 = 'a';
```

```
char c2 = '\u5357';
char c3 = '\u79d1';
char c4 = '\u5927';
System.out.printf("%c %c %c", c2, c3, c4);
```

Prints: 南 科 大

Outline

- First glance of Java programs
- Java's primitive types
- Arithmetic computation
- Evaluation order of arithmetic expressions
- Decision-making statements

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Import declaration

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

- Helps the compiler locate a class that is used in this program
- In Java, related classes are grouped into packages
- java.util package provides commonly-used library classes. These classes are collectively called Java class library, or Java Application Programming Interface (Java API)

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Variable declaration statement

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

- Variable is a storage location, where a value can be stored for use in a program, paired with a symbolic name (an identifier)
- Variables must be declared with a name and a type before use
- A variable's **name** enables the program to access the value of the variable in memory
- A variable's **type** specifies what kind of information is stored at that location in memory

Variable declaration statement

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

- The Scanner class enables a program to read input data
- The data can come from different sources, such as the keyboard or a file on disk
- Standard input object, System.in, enables a program to read input data typed by the user

Variable declaration statement

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

- The new keyword creates an object (we will talk more later)
- The assignment operator = assigns the value on its right to the operand on its left. Here, the input variable will point to the scanner object.

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Declare variables of int type and initialize them

Same as `int number1 = 0, number2 = 0, sum = 0;`

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Read the first number from user

Receiving input with Scanner

```
System.out.print("Enter the first integer:"); // prompt
number1 = input.nextInt(); // read number from user
```

- Prompt is a message that directs the user to take a specific action
- `System` is a class, why we don't import it like `Scanner`? Because it belongs to the `java.lang` package, which is imported by default
- `Scanner` method `nextInt` obtains an integer from the user. The program waits until the user types the number on the keyboard and press the Enter key to submit the number (the method is blocking).

Receiving input with Scanner

```
System.out.print("Enter the first integer:"); // prompt
number1 = input.nextInt(); // read number from user
```

- The result of the call to method `nextInt` will be assigned to the variable `number1` by the assignment operator =
- Note that `number1`'s initial value 0 will be replaced by the new value from `input.nextInt()`

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Read the second number from user

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Addition operation

```
sum = number1 + number2;
```

An expression

- The computer reads / loads the values of `number1` and `number2` from memory, adds the two values and stores the result to the memory location represented by `sum`
- Expressions: Portions of statements that contain calculations

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Formatted output

```
System.out.printf("Sum is %d\n", sum);
```

- Format specifier %d is a placeholder for an int value
- The letter ‘d’ stands for “decimal integer”

Adding two integers

```
import java.util.Scanner;
public class Addition {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1 = 0;
        int number2 = 0;
        int sum = 0;
        System.out.print("Enter the first integer: ");
        number1 = input.nextInt();
        System.out.print("Enter the second integer: ");
        number2 = input.nextInt();
        sum = number1 + number2;
        System.out.printf("Sum is %d\n", sum);
        input.close();
    }
}
```

Close the scanner after use (good practice)

A sample execution

```
> java Addition


Enter the first integer: 72
Enter the second integer: 34
Sum is 106
```

Arithmetic operators

Java has five binary arithmetic operators (they operate on two operands)

Operator	Use	Description
+	op1 + op2	Adds op1 and op2; also used to concatenate strings
-	op1 - op2	Subtracts op2 from op1
*	op1 * op2	Multiplies op1 by op2
/	op1 / op2	Divides op1 by op2
%	op1 % op2	Computes the remainder of dividing op1 by op2

Examples

- `int x = 3; int y = 2; int z = x / y;`
- Integer division yields an integer quotient. The fractional part is simply discarded (z gets the value 1)

- `int a = 10; int b = 3; int c = a % b;`
- c gets the value 1 (the remainder of dividing 10 by 3 is 1)

Outline

- First glance of Java programs
- Java's primitive types
- Arithmetic computation
- Evaluation order of arithmetic expressions
- Decision-making statements

Evaluation order

- An arithmetic expression may contain multiple operators and operands (e.g., `1 + 2 * 5`)

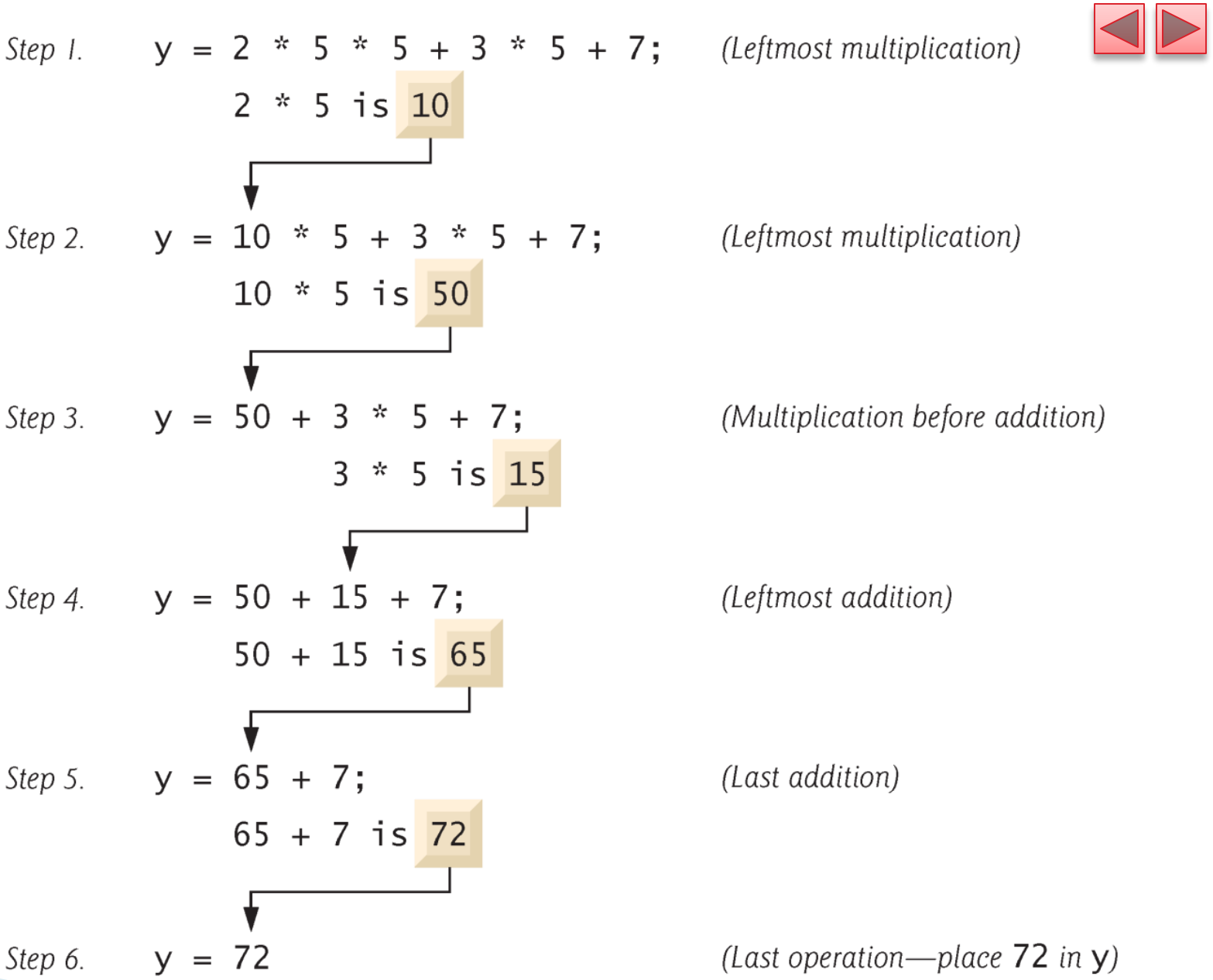
- The order in which the operators get evaluated depends on their precedence (优先级) and associativity (结合性)

Precedence of operators

- Precedence specifies the priority of an operator
- *, / and % operators have the same level of precedence
- + and – have the same level of precedence
- *, / and % have higher precedence than + and –
- So, in expression 1 + 2 * 5, the multiplication operator will be applied first.

Associativity of operators

- In case there are multiple operators of the same precedence in an expression, their evaluation order is determined by their associativity
- If an expression contains multiple *, / and % operators, they are applied from the left to right
- If an expression contains multiple + and - operators, they are also applied from the left to right



Parentheses in expressions

- In Java, parentheses operator () has the highest level of precedence
- In expression (1 + 2) * 3, the addition will be done first because of the parentheses

- Parentheses have left associativity.
- In expression (1 + 2) * (3 + 4), 1 + 2 will be done first

- In case of nested parentheses, the expression in the innermost set of parentheses is evaluated first: ((a + b) * c)

There is a complete table of Java operator precedence on Blackboard

Outline

- First glance of Java programs
- Java's primitive types
- Arithmetic computation
- Evaluation order of arithmetic expressions
- Decision-making statements

Conditional expressions

- An expression that can be true or false

- Conditional expressions involve two types of operators:
  - Equality operators (相同运算符): ==, !=
  - Relational operators (关系运算符): >, <, >=, <=

Standard algebraic equality or relational operator	Java equality or relational operator	Sample Java condition	Meaning of Java condition
Equality operators			
=	==	x == y	x is equal to y
≠	!=	x != y	x is not equal to y
Relational operators			
>	>	x > y	x is greater than y
<	<	x < y	x is less than y
≥	>=	x >= y	x is greater than or equal to y
≤	<=	x <= y	x is less than or equal to y

Precedence and associativity

- Relational operators <, <=, >, >= have the same level of precedence. They are associated from left to right.
- Equality operators ==, != have the same level of precedence. They are associated from left to right.
- Relational and equality operators have lower precedence than the five binary arithmetic operators
- In expression 1 + 3 != 5 * 3, multiplication will be done first, then addition, the inequality check will be done at last

Decision-making statements

- `if` selection statement allows a program to make a decision based on a condition's value

```
if (condition) actions;
```

- In the above statement, the actions will be performed only if `condition` evaluates to `true`

Example

```
import java.util.Scanner;
public class Comparison {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        int number1, number2;

        System.out.print("Enter first integer: ");
        number1 = input.nextInt();

        System.out.print("Enter second integer: ");
        number2 = input.nextInt();

        if(number1 == number2)
            System.out.printf("%d == %d\n", number1, number2);
        if(number1 != number2)
            System.out.printf("%d != %d\n", number1, number2);

        input.close();
    }
}
```

Sample executions

```
> java Comparison

Enter first integer: 72
Enter second integer: 34
72 != 34
```

```
> java Comparison

Enter first integer: 25
Enter second integer: 25
25 == 25
```

Appendix – Terms

- Comment 注释 End-of-line comments 行末注释 Syntax error 语法错误
- String 字符串 Command window 命令窗口 Argument 参数 Cursor 光标
- Console 控制台 White-space characters 空白字符 Escape character 转义字符
- Carriage return 回车 Format string 格式字符串 Format specifier 格式说明符
- Primitive types 基本数据类型 Floating-point number 浮点数
- Decimal digits 小数位数 Unicode 万国码
- Standard input/output 标准输入输出 Assignment operator 赋值运算/操作符
- Prompt 提示符 Binary arithmetic operator 二元算术操作符
- Precedence 优先级 Associativity 结合性 Nested parentheses 嵌套的圆括号
- Equality operator 相同运算符 Relational operator 关系运算符