Introduction to Java and Programs, and Elementary Programming

Introduction to Programming and Computational Problem Solving - 2

CSE 8B

Lecture 2
Announcements

• Assignment 1 will be released today
  – Due Oct 6, 11:59 PM

• Reading:
  – Liang
    • Chapters 1 and 2
Programs

- Computer programs (i.e., software) are instructions to the computer
- You tell a computer what to do through programs
- Computers do not understand human languages, so you need to use computer languages to communicate with them
- Programs are written using programming languages
Programming languages

• Machine language
• Assembly language
• High-level language
Programming languages

• Machine language
  – Machine language is a set of primitive instructions built into every computer
  – The instructions are in the form of binary code, so you must enter binary codes for various instructions
  – Programming with native machine language is a tedious process, and the programs are highly difficult to read and modify
  – For example, to add two numbers, you might write an instruction in binary like this:
    1101101010011010
Programming languages

• Assembly language
  – Assembly languages were developed to make programming easy (CSE 30 and ECE 30 are “easy”)
  – Since the computer cannot understand assembly language, a program called assembler is used to convert assembly language programs into machine code
  – For example, to add two numbers, you might write an instruction in assembly code like this:
    \[ \text{ADDF3 R1, R2, R3} \]
Programming languages

• High-level language
  – High-level languages are English-like and easy to learn and program
    • For example, the following is a high-level language statement that computes the area of a circle with radius 5:
      
      ```
      area = 5 * 5 * 3.1415;
      ```
Interpreting/Compiling source code

• A program written in a high-level language is called a source program or source code.
• Because a computer cannot understand a source program, a source program must be translated into machine code for execution.
• The translation can be done using another programming tool called an interpreter or a compiler.
Interpreting source code

• An interpreter reads one statement from the source code, translates it to the machine code or virtual machine code, and then executes it right away
• A statement from the source code may be translated into several machine instructions
Compiling source code

- A compiler translates the entire source code into a machine-code file, and the machine-code file is then executed.
Java

• Java is a high-level language
• Java is a general purpose programming language
• Java can be used to develop standalone applications
• Java can be used to develop applications for web servers
Java

- The compiler of Java is called javac
  - Java source code is compiled into the Java Virtual Machine (JVM) code called bytecode
- The interpreter of Java is called java
  - The bytecode is machine-independent and can run on any machine that has a Java interpreter, which is part of the JVM (write once, run anywhere)
Developing, compiling, and running Java programs

Source code (developed by the programmer)

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

Bytecode (generated by the compiler for JVM to read and interpret)

```
... Method Welcome()
  0 aload_0 ...

Method void main(java.lang.String[])
  0 getstatic #2 ...
  3 ldc #3 <String "Welcome to Java!">
  5 invokevirtual #4 ...
  8 return
```

Create/Modify Source Code

Saved on the disk

Source Code

Compile Source Code e.g., javac Welcome.java

If compile errors occur

Stored on the disk

Bytecode

Run Bytecode e.g., java Welcome

Result

"Welcome to Java" is displayed on the console

Welcome to Java!

If runtime errors or incorrect result
Programming errors

• Syntax errors
  – Detected by the compiler

• Runtime errors
  – Causes the program to abort

• Logic errors
  – Produces incorrect result
Anatomy of a Java program

• Class name
• Main method
• Statements
• Statement terminator
• Reserved words
• Comments
• Blocks
Class name

• Every Java program must have at least one class
• Each class has a name
• Naming convention: capitalize the first letter of each word in the name class (e.g., ComputeArea)
• This class name is Welcome

```java
// This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
Main method

• This line defines the main method
• In order to run a class, the class must contain a method named main
• The program is executed from the main method

```java
// This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
Statement

• A statement represents an action or a sequence of actions
• This is a statement to display the greeting “Welcome to Java!”

```java
// This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
Statement terminator

• Every statement in Java ends with a semicolon

```
// This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
Reserved words

• Reserved words or keywords are words that have a specific meaning to the compiler and cannot be used for other purposes in the program
• For example, when the compiler sees the word class, it understands that the word after class is the name for the class

```java
// This program prints Welcome to Java!
public class Welcome {
    public static void main(String[] args) {
        System.out.println("Welcome to Java!");
    }
}
```
Blocks

- A pair of braces in a program forms a block that groups components of a program

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

- Class block
- Method block
Blocks

• Two different block styles

```java
public class Test {
    public static void main(String[] args) {
        System.out.println("Block Styles");
    }
}
```

```java
public class Test {
    public static void main(String[] args) {
        System.out.println("Block Styles");
    }
}
```

Next-line style

End-of-line style
# Special symbols

<table>
<thead>
<tr>
<th>Character</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>{}</td>
<td>Opening and closing braces</td>
<td>Denotes a block to enclose statements.</td>
</tr>
<tr>
<td>()</td>
<td>Opening and closing parentheses</td>
<td>Used with methods.</td>
</tr>
<tr>
<td>[]</td>
<td>Opening and closing brackets</td>
<td>Denotes an array.</td>
</tr>
<tr>
<td>//</td>
<td>Double slashes</td>
<td>Precedes a comment line.</td>
</tr>
<tr>
<td>&quot; &quot;</td>
<td>Opening and closing quotation marks</td>
<td>Enclosing a string (i.e., sequence of characters).</td>
</tr>
<tr>
<td>;</td>
<td>Semicolon</td>
<td>Marks the end of a statement.</td>
</tr>
</tbody>
</table>
Identifiers

- Identifiers are the names that identify the elements such as classes, methods, and variables in a program
- An identifier is a sequence of characters that consist of letters, digits, underscores (_), and dollar signs ($)
- An identifier must start with a letter, an underscore (_), or a dollar sign ($)
- An identifier cannot start with a digit
- An identifier cannot be a reserved word
  - List of reserved words
    - Liang, Appendix A
    - https://docs.oracle.com/javase/tutorial/java/nutsandbolts/_keywords.html
- An identifier cannot be true, false, or null
- An identifier can be of any length
Variables

• Variables are used to represent values that may be changed in the program

```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);
```
Declaring variables

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
Assignment statements

x = 1;          // Assign 1 to x
radius = 1.0;    // Assign 1.0 to radius
a = 'A';        // Assign 'A' to a
Declaring and initializing in one step

```java
int x = 1;
double radius = 1.0;
char a = 'A';
```
Named constants

• Naming convention: capitalize all letters in constants, and use underscores to connect words

```java
final datatype CONSTANTNAME = VALUE;
final double PI = 3.14159;
final int MAX_VALUE = 3;
```
Variable and method names

• Naming convention: Use lowercase. If the 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
  
  — For example, the variables radius and area, and the method computeArea.
# Numerical data types

<table>
<thead>
<tr>
<th>Name</th>
<th>Range</th>
<th>Storage Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>(-2^7 \text{ to } 2^7 - 1) (-128 to 127)</td>
<td>8-bit signed</td>
</tr>
<tr>
<td>short</td>
<td>(-2^{15} \text{ to } 2^{15} - 1) (-32768 to 32767)</td>
<td>16-bit signed</td>
</tr>
<tr>
<td>int</td>
<td>(-2^{31} \text{ to } 2^{31} - 1) (-2147483648 to 2147483647)</td>
<td>32-bit signed</td>
</tr>
<tr>
<td>long</td>
<td>(-2^{63} \text{ to } 2^{63} - 1) (\text{(i.e., } -9223372036854775808 \text{ to } 9223372036854775807))</td>
<td>64-bit signed</td>
</tr>
</tbody>
</table>
| float  | Negative range: \(-3.4028235E+38 \text{ to } -1.4E-45\)  
Positive range: \(1.4E-45 \text{ to } 3.4028235E+38\) | 32-bit IEEE 754 |
| double | Negative range: \(-1.7976931348623157E+308 \text{ to } -4.9E-324\)  
Positive range: \(4.9E-324 \text{ to } 1.7976931348623157E+308\) | 64-bit IEEE 754 |
Number literals

• A literal is a constant value that appears directly in the program

```java
int i = 34;
long x = 1000000;
double d = 5.0 + 1.0;
```

34, 1000000, 5.0, and 1.0 are literals
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 \(-2^{31}\) (equals -2147483648) to \(2^{31}-1\) (equals 2147483647)
• To denote an integer literal of the long type, append it with the letter L or l
  – L is preferred because l (lowercase L) can easily be confused with 1 (the digit one)
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
Scientific notation

• 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
## Numeric operations

<table>
<thead>
<tr>
<th>Name</th>
<th>Meaning</th>
<th>Example</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Addition</td>
<td>34 + 1</td>
<td>35</td>
</tr>
<tr>
<td>-</td>
<td>Subtraction</td>
<td>34.0 - 0.1</td>
<td>33.9</td>
</tr>
<tr>
<td>*</td>
<td>Multiplication</td>
<td>300 * 30</td>
<td>9000</td>
</tr>
<tr>
<td>/</td>
<td>Division</td>
<td>1.0 / 2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>%</td>
<td>Remainder</td>
<td>20 % 3</td>
<td>2</td>
</tr>
</tbody>
</table>
double vs float

• The double type values are more accurate than the float type values
  – For example,

```java
System.out.println("1.0 / 3.0 is " + 1.0 / 3.0);
```

displays \texttt{1.0 / 3.0 is 0.3333333333333333}

16 digits

```java
System.out.println("1.0F / 3.0F is " + 1.0F / 3.0F);
```

displays \texttt{1.0F / 3.0F is 0.33333334}

7 digits
Floating-point accuracy

• Calculations involving floating-point numbers are approximated because these numbers are not stored with complete accuracy

• For example,
  
  System.out.println(1.0 - 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
  – Calculations with integers yield a precise integer result
Integer division

• Warning: resulting fractional part (i.e., values after the decimal point) are truncated, *not rounded*
  – For example $5 \div 2$ yields an integer 2
Remainder operator

• Example: an even number % 2 is always 0 and an odd number % 2 is always 1
  – You can use this property to determine whether a number is even or odd

• Example: If today is Saturday and you and your friends are going to meet in 10 days. What day is in 10 days? You can find that day is Tuesday using the following expression.

Saturday is the 6th day in a week

\[(6 + 10) \% 7 \text{ is 2}\]

A week has 7 days

The 2nd day in a week is Tuesday

After 10 days
# Augmented assignment operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Name</th>
<th>Example</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>+=</td>
<td>Addition assignment</td>
<td><code>i += 8</code></td>
<td><code>i = i + 8</code></td>
</tr>
<tr>
<td>-=</td>
<td>Subtraction assignment</td>
<td><code>i -= 8</code></td>
<td><code>i = i - 8</code></td>
</tr>
<tr>
<td>*=</td>
<td>Multiplication assignment</td>
<td><code>i *= 8</code></td>
<td><code>i = i * 8</code></td>
</tr>
<tr>
<td>/=</td>
<td>Division assignment</td>
<td><code>i /= 8</code></td>
<td><code>i = i / 8</code></td>
</tr>
<tr>
<td>%=</td>
<td>Remainder assignment</td>
<td><code>i %= 8</code></td>
<td><code>i = i % 8</code></td>
</tr>
</tbody>
</table>
# Increment and decrement operators

<table>
<thead>
<tr>
<th>Operator</th>
<th>Name</th>
<th>Description</th>
<th>Example (assume (i = 1))</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>++\text{var}</code></td>
<td>preincrement</td>
<td>Increment \text{var} by 1, and use the new \text{var} value in the statement</td>
<td>\text{int } j = ++i; \quad // j is 2, i is 2</td>
</tr>
<tr>
<td><code>\text{var}++</code></td>
<td>postincrement</td>
<td>Increment \text{var} by 1, but use the original \text{var} value in the statement</td>
<td>\text{int } j = i++; \quad // j is 1, i is 2</td>
</tr>
<tr>
<td><code>--\text{var}</code></td>
<td>predecrement</td>
<td>Decrement \text{var} by 1, and use the new \text{var} value in the statement</td>
<td>\text{int } j = --i; \quad // j is 0, i is 0</td>
</tr>
<tr>
<td><code>\text{var}--</code></td>
<td>postdecrement</td>
<td>Decrement \text{var} by 1, and use the original \text{var} value in the statement</td>
<td>\text{int } j = i--; \quad // j is 1, i is 0</td>
</tr>
</tbody>
</table>
Conversion rules

• 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`
Type casting

Implicit casting

```java
double d = 3; (type widening)
```

Explicit casting

```java
int i = (int)3.0; (type narrowing)
int i = (int)3.9; (fraction part is truncated, not rounded!)
```

range increases

byte, short, int, long, float, double
Reading numbers from the console

1. Create a Scanner object

   Scanner input = new Scanner(System.in);

2. Use the method nextDouble() to obtain to a double value. For example,

   System.out.print("Enter a double value: ");
   Scanner input = new Scanner(System.in);
   double d = input.nextDouble();
## Reading numbers from the console

Scanner input = new Scanner(System.in);
int value = input.nextInt();

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>nextByte()</code></td>
<td>reads an integer of the <code>byte</code> type.</td>
</tr>
<tr>
<td><code>nextShort()</code></td>
<td>reads an integer of the <code>short</code> type.</td>
</tr>
<tr>
<td><code>nextInt()</code></td>
<td>reads an integer of the <code>int</code> type.</td>
</tr>
<tr>
<td><code>nextLong()</code></td>
<td>reads an integer of the <code>long</code> type.</td>
</tr>
<tr>
<td><code>nextFloat()</code></td>
<td>reads a number of the <code>float</code> type.</td>
</tr>
<tr>
<td><code>nextDouble()</code></td>
<td>reads a number of the <code>double</code> type.</td>
</tr>
</tbody>
</table>
Explicit import and implicit Import

• At top of source file

```java
import java.util.Scanner; // Explicit Import

import java.util.*; // Implicit import
```
Next Lecture

• Selections
• Mathematical functions, characters, and strings
• Reading:
  – Liang
    • Chapters 3 and 4