Java Review
Selim Aksoy
Bilkent University
Department of Computer Engineering
saksoy@cs.bilkent.edu.tr

Java
- Java Basics
- Java Program Statements
  - Conditional statements
  - Repetition statements (loops)
- Writing Classes in Java
  - Class definitions
  - Encapsulation and Java modifiers
  - Method declaration, invocation, and parameter passing
  - Method overloading

Programming Rules of Thumb
- Learn program patterns of general utility (branching, loops, etc.) and use relevant patterns for the problem at hand
- Seek inspiration by systematically working test data by hand and ask yourself: “what am I doing?”
- Declare variables for each piece of information you maintain when working problem by hand
- Decompose problem into manageable tasks
- Remember the problem’s boundary conditions
- Validate your program by tracing it on test data with known output

Introduction to Objects
- An object represents something with which we can interact in a program
- An object provides a collection of services that we can tell it to perform for us
- The services are defined by methods in a class that defines the object
- A class represents a concept, and an object represents the embodiment of a class
- A class can be used to create multiple objects

Java Program Structure
- In the Java programming language:
  - A program is made up of one or more classes
  - A class contains one or more methods
  - A method contains program statements
  - Attributes/properties correspond to fields (or variables)
  - Behaviors/operations correspond to methods
  - A Java application always contains a method called main
Variables
- A variable is a name for a location in memory.
- A variable must be declared by specifying the variable’s name and the type of information that it will hold.

```java
int total;
int count, temp, result;
```

Multiple variables can be created in one declaration.

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

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Storage</th>
<th>Min Value</th>
<th>Max Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>8 bits</td>
<td>-128</td>
<td>127</td>
</tr>
<tr>
<td>short</td>
<td>16 bits</td>
<td>-32,768</td>
<td>32,767</td>
</tr>
<tr>
<td>int</td>
<td>32 bits</td>
<td>-2,147,483,648</td>
<td>2,147,483,647</td>
</tr>
<tr>
<td>long</td>
<td>64 bits</td>
<td>&lt; -9 x 10^30</td>
<td>&gt; 9 x 10^30</td>
</tr>
<tr>
<td>float</td>
<td>32 bits</td>
<td>+/- 3.4 x 10^38 with 7 significant digits</td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>64 bits</td>
<td>+/- 1.7 x 10^308 with 15 significant digits</td>
<td></td>
</tr>
</tbody>
</table>

Arithmetic Expressions
- An expression is a combination of one or more operands and their operators.
- Arithmetic expressions use the operators:
  - Addition (+)
  - Subtraction (-)
  - Multiplication (*)
  - Division (/)
  - Remainder (%) (no ^ operator)
- If either or both operands associated with an arithmetic operator are floating point, the result is a floating point.

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

<table>
<thead>
<tr>
<th></th>
<th>equal?</th>
<th>4</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 / 3</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>8 / 12</td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>equal?</th>
<th>2</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 % 3</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8 % 12</td>
<td></td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

String Concatenation
- The string concatenation operator (+) is used to append one string to the end of another.
- The plus operator (+) is also used for arithmetic addition.
- The function that the + operator performs depends on the type of the information on which it operates:
  - If at least one operand is a string, it performs string concatenation.
  - If both operands are numeric, it adds them.
- The + operator is evaluated left to right.
- Parentheses can be used to force the operation order.
Data Conversions

- In Java, data conversions can occur in three ways:
  - Assignment conversion
  - Arithmetic promotion
  - Casting
- Assignment conversion occurs when a value of one type is assigned to a variable of another.
  - Only widening conversions can happen via assignment.
- Arithmetic promotion happens automatically when operators in expressions convert their operands.

Casting is the most powerful, and dangerous, technique for conversion.

- Both widening and narrowing conversions can be accomplished by explicitly casting a value.
- To cast, the type is put in parentheses in front of the value being converted.
- For example, if `total` and `count` are integers, but we want a floating point result when dividing them, we can cast `total`:
  \[
  \text{result} = \frac{\text{total}}{\text{count}}
  \]

Creating Objects

- A variable holds either a primitive type or a reference to an object.
- A class name can be used as a type to declare an object reference variable.
- `String title;`
- No object is created with this declaration.
- An object reference variable holds the address of an object.
- The object itself must be created separately.

Generally, we use the `new` operator to create an object.

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

Creating an object is called instantiation.

- An object is an instance of a particular class.

Conditional Statements

- A conditional statement lets us choose which statement will be executed next.
- Therefore they are sometimes called selection statements.
- Conditional statements give us the power to make basic decisions.
- Java's conditional statements are the `if` statement, the `if-else` statement, and the `switch` statement.

The if Statement

- The if statement has the following syntax:
  \[
  \text{if (condition)}
  \]
  \[
  \text{statement1;}
  \]
  \[
  \text{else}
  \]
  \[
  \text{statement2;}
  \]

- If the condition is true, `statement1` is executed.
- If it is false, `statement2` is executed.
Boolean Expressions

A condition often uses one of Java's equality operators or relational operators, which all return boolean results:

- `==` equal to
- `!=` not equal to
- `<` less than
- `>` greater than
- `<=` less than or equal to
- `>=` greater than or equal to

Note the difference between the equality operator (==) and the assignment operator (=).

Logical Operators

- Boolean expressions can use the following logical operators:
  - `!` Logical NOT
  - `&&` Logical AND
  - `||` Logical OR

- They all take boolean operands and produce boolean results
- Logical NOT is a unary operator (it operates on one operand)
- Logical AND and logical OR are binary operators (each operates on two operands)

Repetition Statements

- Repetition statements allow us to execute a statement multiple times
- Often they are referred to as loops
- Like conditional statements, they are controlled by boolean expressions
- Java has three kinds of repetition statements:
  - the while loop
  - the do loop
  - the for loop
- The programmer should choose the right kind of loop for the situation

The while Statement

The while statement has the following syntax:

```
while (condition) statement;
```

- `while` is a reserved word
- If the condition is true, the statement is executed
- Then the condition is evaluated again
- The statement is executed repeatedly until the condition becomes false

Example

```java
public class Counter {
    public static void main(String[] args) {
        final int LIMIT = 5;
        int count = 1;
        while (count <= LIMIT) {
            System.out.println(count);
            count = count + 1;
        }
        System.out.println("Done");
    }
}
```

The do Statement

The do statement has the following syntax:

```
do while (condition) statement;
```

- The statement is executed once initially, and then the condition is evaluated
- The statement is executed repeatedly until the condition becomes false
The do Statement

- A do loop is similar to a while loop, except that the condition is evaluated after the body of the loop is executed. Therefore the body of a do loop will execute at least once.

Example

```java
public class Counter2 {
    public static void main(String[] args) {
        final int LIMIT = 5;
        int count = 0;
        do {
            count = count + 1;
            System.out.println(count);
        } while (count < LIMIT);
        System.out.println("Done");
    }
}
```

Comparing while and do

```
while loop
  condition and used: true
  statement
  condition: true
  do loop
  condition and used: true
  statement
  condition: false
```

The for Statement

- The for statement has the following syntax:

```
for (initialization; condition; increment) {
    statement;
}
```

- A for loop is functionally equivalent to the following while loop structure:

```
initialization;
while (condition) {
    statement;
    increment;
}
```

Logic of a for loop

```
initialization
condition and used: true
statement
condition: true
increment
condition: false
```
The for Statement
- Like a while loop, the condition of a for statement is tested prior to executing the loop body.
- Therefore, the body of a for loop will execute zero or more times.
- It is well suited for executing a loop a specific number of times that can be determined in advance.

Example
```java
//********************************************************************
//  Counter3.java       Author: Lewis/Loftus
//
//  Demonstrates the use of a for loop.
//********************************************************************
public class Counter3
{
  //-----------------------------------------------------------------
  //  Prints integer values from 1 to a specific limit.
  //-----------------------------------------------------------------
  public static void main (String[] args)
  {
    final int LIMIT = 5;
    for (int count=1; count <= LIMIT; count++)
      System.out.println (count);
    System.out.println ("Done");
  }
}
```

Choosing a Loop Structure
- When you can't determine how many times you want to execute the loop body, use a while statement or a do statement.
  - If it might be zero or more times, use a while statement.
  - If it will be at least once, use a do statement.
- If you can determine how many times you want to execute the loop body, use a for statement.

The switch Statement
- The general syntax of a switch statement is:
  ```java
  switch (expression)
  {
    case value1: statement-list1; break;
    case value2: statement-list2; break;
    case value3: statement-list3; break;
    case ... 
  }
  ```
- The expression of a switch statement must result in an integral type, meaning an int or char.
- It cannot be a boolean value, a floating point value (float or double), a byte, a short, or a long.
- The implicit boolean condition in a switch statement is equality - it tries to match the expression with a value.
- You cannot perform relational checks with a switch statement.

Comparing Strings
- Remember that a character string in Java is an object.
- The equals method can be called with strings to determine if two strings contain exactly the same characters in the same order.
- The String class also contains a method called compareTo to determine if one string comes before another in lexicographic order (based on the Unicode character set).
- This is not strictly alphabetical when uppercase and lowercase characters are mixed.
Comparing Float Values

- We also have to be careful when comparing two floating point values (float or double) for equality.
- You should rarely use the equality operator (==) when comparing two floats.
- In many situations, you might consider two floating point numbers to be “close enough” even if they aren’t exactly equal.
- Therefore, to determine the equality of two floats, you may want to use the following technique:

```java
if (Math.abs(f1 - f2) < 0.00001)
    System.out.println("Essentially equal.");
```

Increment and Decrement

- The increment and decrement operators are arithmetic and operate on one operand.
- The increment operator (++) adds one to its operand.
- The decrement operator (--) subtracts one from its operand.
- The statement `count++` is functionally equivalent to `count = count + 1;`.

Assignment Operators

- There are many assignment operators, including the following:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Example</th>
<th>Equivalent To</th>
</tr>
</thead>
<tbody>
<tr>
<td>+=</td>
<td>x += y</td>
<td>x = x + y</td>
</tr>
<tr>
<td>-=</td>
<td>x -= y</td>
<td>x = x - y</td>
</tr>
<tr>
<td>*=</td>
<td>x *= y</td>
<td>x = x * y</td>
</tr>
<tr>
<td>/=</td>
<td>x /= y</td>
<td>x = x / y</td>
</tr>
<tr>
<td>%=</td>
<td>x %= y</td>
<td>x = x % y</td>
</tr>
</tbody>
</table>

Objects and Classes

- An object has:
  - state - descriptive characteristics
  - behaviors - what it can do (or what can be done to it)
- A class is the model or pattern from which objects are created.
- For example, consider a coin that can be flipped so that it’s face shows either “heads” or “tails”.
- The state of the coin is its current face (heads or tails).
- The behavior of the coin is that it can be flipped.

Encapsulation

- We can take one of two views of an object:
  - internal - the variables the object holds and the methods that make the object useful
  - external - the services that an object provides and how the object interacts
- Any changes to the object's state (its variables) should be made only by that object's methods.
- We should make it difficult, if not impossible, to access an object's variables other than via its methods.
- The user, or client, of an object can request its services, but it should not have to be aware of how those services are accomplished.

Encapsulation

- An encapsulated object can be thought of as a black box.
- Its inner workings are hidden to the client, which invokes only the interface methods.
Visibility Modifiers

- In Java, we accomplish encapsulation through the appropriate use of visibility modifiers.
- A modifier is a Java reserved word that specifies particular characteristics of a method or data value.
- Members of a class that are declared with public visibility can be accessed from anywhere (public variables violate encapsulation).
- Members of a class that are declared with private visibility can only be accessed from inside the class.

Data Scope

- The scope of data is the area in a program in which that data can be used (referenced).
- Data declared at the class level can be used by all methods in that class.
- Data declared within a block (enclosed within { and }, if statements, loops) can be used only in that block.

Example

```java
import java.text.NumberFormat;

public class Account {
    private NumberFormat fmt = NumberFormat.getCurrencyInstance();
    private final double RATE = 0.035;  // interest rate of 3.5%
    private long acctNumber;
    private double balance;
    private String name;

    public Account (String owner, long account, double initial) {
        name = owner;
        acctNumber = account;
        balance = initial;
    }

    public double deposit (double amount) {
        if (amount < 0) {  // deposit value is negative
            System.out.println();
            System.out.println("Error: Deposit amount is invalid.");
            System.out.println(acctNumber + "  " + fmt.format(amount));
        } else
            balance = balance + amount;
        return balance;
    }

    public double withdraw (double amount, double fee) {
        amount += fee;
        if (amount < 0) {  // withdraw value is negative
            System.out.println();
            System.out.println("Error: Withdraw amount is invalid.");
            System.out.println("Account: " + acctNumber);
            System.out.println("Requested: " + fmt.format(amount));
        } else if (amount > balance) {  // withdraw value exceeds balance
            System.out.println();
            System.out.println("Error: Insufficient funds.");
            System.out.println("Account: " + acctNumber);
            System.out.println("Requested: " + fmt.format(amount));
            System.out.println("Available: " + fmt.format(balance));
        } else
            balance = balance - amount;
        return balance;
    }

    public double addInterest () {
        balance += (balance * RATE);
        return balance;
    }

    public double getBalance () {
        return balance;
    }

    public long getAccountNumber () {
        return acctNumber;
    }

    public String toString () {
        return acctNumber + "  " + name + "  " + fmt.format(balance);
    }
}
```
Example

```java
public class Banking {
    // Creates some bank accounts and requests various services.
    public static void main (String[] args) {
        Account acct1 = new Account("Ted Murphy", 72354, 102.56);
        Account acct2 = new Account("Jane Smith", 69713, 40.00);
        Account acct3 = new Account("Edward Demsey", 93757, 759.32);
        acct1.deposit(25.85);
        double smithBalance = acct2.deposit(500.00);
        System.out.println("Smith balance after deposit: " + smithBalance);
        System.out.println("Smith balance after withdrawal: " + acct2.withdraw(430.75, 1.50));
        acct3.withdraw(800.00, 0.0);  // exceeds balance
        acct1.addInterest();
        acct2.addInterest();
        acct3.addInterest();
        System.out.println();
        System.out.println(acct1);
        System.out.println(acct2);
        System.out.println(acct3);
    }
}
```

Method Header and Body

```
return type method name parameter list
```

char calc (int num1, int num2, String message) {
int sum = num1 + num2;
char result = message.charAt(sum);
return result;
}

The return expression must be consistent with the return type

The return Statement

- The return type of a method indicates the type of value that the method sends back to the calling location
- A method that does not return a value has a void return type
- A return statement specifies the value that will be returned
  
  ```java
  return expression;
  ```

Constructors Revisited

- Recall that a constructor is a special method that is used to initialize a newly created object
- When writing a constructor, remember that:
  - it has the same name as the class
  - it does not return a value
  - it has no return type, not even void
  - it typically sets the initial values of instance variables
- The programmer does not have to define a constructor for a class

Overloading Methods

- Method overloading is the process of using the same method name for multiple methods
- The signature of each overloaded method must be unique
- The signature includes the number, type, and order of the parameters
- The compiler determines which version of the method is being invoked by analyzing the parameters
- The return type of the method is not part of the signature

Overloading Methods

```
Version 1
float tryMe (int x) {
    return x + .375;
}
Version 2
float tryMe (int x, float y) {
    return x*y;
}
```

Invocation

```
result = tryMe (25, 4.32)
```
Object Relationships

- Some use associations occur between objects of the same class.
- For example, we might add two Rational number objects together as follows:
  \[ r3 = r1.add(r2); \]
- One object (r1) is executing the method and another (r2) is passed as a parameter.

Example

```java
public class RationalNumbers {
  public static void main(String[] args) {
    Rational r1 = new Rational(6, 8);
    Rational r2 = new Rational(1, 3);
    System.out.println("r1: "+r1);
    System.out.println("r2: "+r2);
    System.out.println("r1 + r2: "+r1.add(r2));
    System.out.println("r1 - r2: "+r1.subtract(r2));
    System.out.println("r1 * r2: "+r1.multiply(r2));
    System.out.println("r1 / r2: "+r1.divide(r2));
    System.out.println("r1 and r2 are equal: "+r1.equals(r2));
  }
}
```

Example

```java
public class Rational {
  private int numerator;
  private int denominator;

  public Rational(int numerator, int denominator) {
    this.numerator = numerator;
    this.denominator = denominator;
  }

  public int getNumerator ()
  return numerator;

  public int getDenominator ()
  return denominator;

  public String toString ()
  return "Rational (" + getNumerator () + ", " + getDenominator () + ");";

  public Rational reduce () {
    int common = getGCD (getNumerator (), getDenominator ());
    return new Rational (getNumerator () / common, getDenominator () / common);
  }

  public boolean isPositive ()
  return numerator > 0;

  public Rational int sign ()
  return getNumerator () * (numerator < 0 ? -1 : 1); // Make the numerator "store" the sign

  public int getGCD (int a, int b)
  if (b == 0) return a;
  return getGCD (b, a % b);
}
```

Example

```java
private void multiply (Rational op2)
long commonDenominator = denominator * op2.getDenominator ();
long numerator1 = numerator * op2.getNumerator ();
Rational r5 = new Rational (sum, commonDenominator);
}
```
Example

```java
public class Address {
    private String streetAddress, city, state;
    private long zipCode;

    //-----------------------------------------------------------------
    // Sets up this Address object with the specified data.
    //-----------------------------------------------------------------
    public Address (String street, String town, String st, long zip) {
        streetAddress = street;
        city = town;
        state = st;
        zipCode = zip;
    }

    //-----------------------------------------------------------------
    // Returns this Address object as a string.
    //-----------------------------------------------------------------
    public String toString() {
        String result = streetAddress + "\n";
        result += city + ", " + state + "  " + zipCode;
        return result;
    }
}
```

Example

```java
public class Student {
    private String firstName, lastName;
    private Address homeAddress, schoolAddress;

    //-----------------------------------------------------------------
    // Sets up this Student object with the specified initial values.
    //-----------------------------------------------------------------
    public Student (String first, String last, Address home, Address school) {
        firstName = first;
        lastName = last;
        homeAddress = home;
        schoolAddress = school;
    }

    //-----------------------------------------------------------------
    // Returns this Student object as a string.
    //-----------------------------------------------------------------
    public String toString() {
        String result = firstName + " " + lastName + "\n";
        result += "Home Address:\n" + homeAddress + "\n";
        result += "School Address:\n" + schoolAddress;
        return result;
    }
}
```

Example

```java
public class StudentBody {
    //-----------------------------------------------------------------
    // Creates some Address and Student objects and prints them.
    //-----------------------------------------------------------------
    public static void main (String[] args) {
        Address school = new Address ("800 Lancaster Ave.", "Villanova", "PA", 19085);
        Address jHome = new Address ("21 Jump Street", "Lynchburg", "VA", 24551);
        Student john = new Student ("John", "Smith", jHome, school);
        Address mHome = new Address ("123 Main Street", "Euclid", "OH", 44132);
        Student marsha = new Student ("Marsha", "Jones", mHome, school);
        System.out.println (john);
        System.out.println (marsha);
    }
}
```