Chapter 3
Selections

3.1 Introduction

- Java provides selections that let you choose actions with two or more alternative courses.
- Selection statements use conditions. Conditions are Boolean expressions.
- Java has several types of selection statements:
  - if Statements, if … else statements, nested if statements
  - switch Statements
  - Conditional Expressions

3.2 boolean Data Type

- 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.

**TABLE 3.1 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>

- Examples
  ```java
  System.out.println(1 < 2); // Displays true
  
  boolean b = (1 > 2);
  System.out.println("b is " + b); // Displays b is false
  ```
3.3 Problem: A Simple Math Learning Tool

- This example creates a program to let a first grader practice additions. The program randomly generates two single-digit integers number1 and number2 and displays a question such as “What is 7 + 9?” to the student. After the student types the answer, the program displays a message to indicate whether the answer is true or false.
- LISTINT 3.1 AdditionQuiz.java

```java
import java.util.Scanner;

public class AdditionQuiz {
    public static void main(String[] args) {
        int number1 = (int)(System.currentTimeMillis() % 10);
        int number2 = (int)(System.currentTimeMillis() * 7 % 10);

        // Create a Scanner
        Scanner input = new Scanner(System.in);

        System.out.print("What is " + number1 + " + " + number2 + "? ");
        int answer = input.nextInt();

        System.out.println(number1 + " + " + number2 + " = " + answer + " is " +
                           (number1 + number2 == answer));
    }
}
```

What is 1 + 7? 8
1 + 7 = 8 is true

What is 4 + 8? 9
4 + 8 = 9 is false
3.4 if Statements

- Java has several types of selection statements:
  - *if* Statements, *if ... else* statements, *nested if* statements
  - *switch* Statements
  - Conditional Expressions

3.4.1 One-Way if Statements

```java
if (booleanExpression) {
    statement(s);
}    // execution flow chart is shown in Figure (A)
```

Example
```java
if (radius >= 0) {
    area = radius * radius * PI;
    System.out.println("The area for the circle of radius " +
                      radius + " is " + area);
} // if the Boolean expression evaluates to T, the statements in the
// block are executed as shown in figure (B)
```

![Diagram of if statement](image)

**FIGURE 3.1** An if statement executes statements if the Boolean Expression evaluates as true
• **Note:**
  o The Boolean expression is enclosed in **parentheses** for all forms of the if statement. Thus, the outer parentheses in the previous if statements are required.
  o The braces can be omitted if they enclose a **single** statement.

![Diagram showing the difference between outer parentheses required and braces omitted for a single statement.]

- Write a program that prompts the user to enter an integer. If the number is a multiple of 5, print HiFive. If the number is divisible by 2, print HiEven.
- **LISTING 3.2 SimpleIfDemo.java**

```java
import java.util.Scanner;

public class SimpleIfDemo {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);
        System.out.println("Enter an integer: ");
        int number = input.nextInt();

        if (number % 5 == 0)
            System.out.println("HiFive");
        if (number % 2 == 0)
            System.out.println("HiEven");
    }
}
```

<table>
<thead>
<tr>
<th>Enter an integer: 4</th>
<th>HiEven</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter an integer: 30</td>
<td>HiFive HiEven</td>
</tr>
</tbody>
</table>
3.5 Problem: Guessing Birthdays

- The program can guess your birth date.

Note: 19 is 10011 in binary. 7 is 111 in binary. 23 is 11101 in binary

<table>
<thead>
<tr>
<th>Set1</th>
<th>Set2</th>
<th>Set3</th>
<th>Set4</th>
<th>Set5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 3 5 7</td>
<td>1 3 6 7</td>
<td>4 5 6 7</td>
<td>8 9 10 11</td>
<td>16 17 18 19</td>
</tr>
<tr>
<td>9 11 13 15</td>
<td>10 11 14 15</td>
<td>12 13 14 15</td>
<td>12 13 14 15</td>
<td>20 21 22 23</td>
</tr>
<tr>
<td>17 19 21 23</td>
<td>18 19 22 23</td>
<td>20 21 22 23</td>
<td>24 25 26 27</td>
<td>24 25 26 27</td>
</tr>
<tr>
<td>25 27 29 31</td>
<td>26 27 30 31</td>
<td>28 29 30 31</td>
<td>28 29 30 31</td>
<td>28 29 30 31</td>
</tr>
</tbody>
</table>

LISTING 3.3 GuessBirthday.java

```java
import java.util.Scanner;

public class GuessBirthday {
    public static void main(String[] args) {
        String set1 =
            " 1  3  5  7
            9 11 13 15
           17 19 21 23
           25 27 29 31"
            +"; 

        String set2 =
            " 2  3  6  7
            10 11 14 15
           18 19 22 23
           26 27 30 31"
            +"; 

        String set3 =
            " 4  5  6  7
            12 13 14 15
           20 21 22 23
           28 29 30 31"
            +"; 

        String set4 =
            " 8  9 10 11
            12 13 14 15
           24 25 26 27
           28 29 30 31"
            +"; 

        String set5 =
            "16 17 18 19"
            +";

        Set1
        Set2
        Set3
        Set4
        Set5

        String set1 =
            " 1  3  5  7" +
            " 9 11 13 15" +
            "17 19 21 23" +
            "25 27 29 31";

        String set2 =
            " 2  3  6  7" +
            "10 11 14 15" +
            "18 19 22 23" +
            "26 27 30 31";

        String set3 =
            " 4  5  6  7" +
            "12 13 14 15" +
            "20 21 22 23" +
            "28 29 30 31";

        String set4 =
            " 8  9 10 11" +
            "12 13 14 15" +
            "24 25 26 27" +
            "28 29 30 31";

        String set5 =
            "16 17 18 19"
            +";

        int birthday = 19;
        boolean result;

        System.out.println("Is your birthday in Set1? "+result);
        System.out.println("Is your birthday in Set2? "+result);
        System.out.println("Is your birthday in Set3? "+result);
        System.out.println("Is your birthday in Set4? "+result);
        System.out.println("Is your birthday in Set5? "+result);

        System.out.println("Your birthday is "+birthday);
    }
}
```

Is your birthday in Set1?
1 3 5 7
9 11 13 15
17 19 21 23
25 27 29 31
Enter 0 for No and 1 for Yes: 1

Is your birthday in Set2?
2 3 6 7
10 11 14 15
18 19 22 23
26 27 30 31
Enter 0 for No and 1 for Yes: 1

Is your birthday in Set3?
4 5 6 7
12 13 14 15
20 21 22 23
28 29 30 31
Enter 0 for No and 1 for Yes: 0

Is your birthday in Set4?
8 9 10 11
12 13 14 15
24 25 26 27
28 29 30 31
Enter 0 for No and 1 for Yes: 0

Is your birthday in Set5?
16 17 18 19
20 21 22 23
24 25 26 27
28 29 30 31
Enter 0 for No and 1 for Yes: 1

Your birthday is 19!
int day = 0;

// Create a Scanner
Scanner input = new Scanner(System.in);

// Prompt the user to answer questions
System.out.print("Is your birthday in Set1?\n");
System.out.print(set1);
System.out.print("\nEnter 0 for No and 1 for Yes: ");
int answer = input.nextInt();

if (answer == 1)
    day += 1;

// Prompt the user to answer questions
System.out.print("\nIs your birthday in Set2?\n");
System.out.print(set2);
System.out.print("\nEnter 0 for No and 1 for Yes: ");
answer = input.nextInt();

if (answer == 1)
    day += 2;

// Prompt the user to answer questions
System.out.print("\nIs your birthday in Set3?\n");
System.out.print(set3);
System.out.print("\nEnter 0 for No and 1 for Yes: ");
answer = input.nextInt();

if (answer == 1)
    day += 4;

// Prompt the user to answer questions
System.out.print("\nIs your birthday in Set4?\n");
System.out.print(set4);
System.out.print("\nEnter 0 for No and 1 for Yes: ");
answer = input.nextInt();

if (answer == 1)
    day += 8;

// Prompt the user to answer questions
System.out.print("\nIs your birthday in Set5?\n");
System.out.print(set5);
System.out.print("\nEnter 0 for No and 1 for Yes: ");
answer = input.nextInt();

if (answer == 1)
    day += 16;

System.out.println("\nYour birthday is " + day + "!");
3.6 Two-Way if Statements

```java
if (booleanExpression) {
    statement(s)-for-the-true-case;
} else {
    statement(s)-for-the-false-case;
}
```

FIGURE 3.3 An if … else executes statements for the true case if the Boolean expression evaluations are true; otherwise, statements for the false case are executed.

- if...else Example

```java
if (radius >= 0) {
    area = radius * radius * PI;
    System.out.println("The area for the "+ "circle of radius "+ radius + "is " + area);
} else {
    System.out.println("Negative input"); // braces may be omitted
}
```

Note: If radius >= 0 is true, area is computed and displayed; if it is false, the message “Negative input” is printed.

- Using the if … else statement, you can rewrite the following code for determining whether a number is even or odd, as follows:

```java
if (number % 2 == 0) {
    System.out.println(number + " is even.");
} else {
    System.out.println(number + " is odd.");
}
```

// rewriting the code using else

```java
if (number % 2 == 0) {
    System.out.println(number + " is even.");
} else {
    System.out.println(number + " is odd.");
}
```

Note: This is more efficient because whether number % 2 is 0 is tested only once.
3.7 Nested if Statements

• The statement in an if or if ... else statement can be any legal Java statement, including another if or if ... else statement. The inner if statement is said to be nested inside the outer if statement.

• The inner if statement can contain another if statement.

• There is no limit to the depth of the nesting.

```java
if (i > k) {
    if (j > k)
        System.out.println("i and j are greater than k");
} else
    System.out.println("i is less than or equal to k");
// the if (j > k) is nested inside the if (i > k)
```

• The nested if statement can be used to implement multiple alternatives.

```java
if (score >= 90)
    grade = ‘A’;
else
    if (score >= 80)
        grade = ‘B’;
    else
        if (score >= 70)
            grade = ‘C’;
        else
            if (score >= 60)
                grade = ‘D’;
            else
                grade = ‘F’;
```

• The preceding if statement is equivalent to the following preferred format because it is easier to read:

```java
if (score >= 90)
    grade = ‘A’;
else if (score >= 80)
    grade = ‘B’;
else if (score >= 70)
    grade = ‘C’;
else if (score >= 60)
    grade = ‘D’;
else
    grade = ‘F’;
```
**Tip**

- Often new Programmers write that assigns a test condition to a Boolean variable like the code in (a).

```
if (number % 2 == 0)
    even = true;
else
    even = false;
```

(b)  

```
boolean even = number % 2 == 0;
```

- The code can be simplified by assigning the test value directly to the variable, as shown in (b).
3.8 Common Errors in Selection Statements

- **Common Error 1: Forgetting Necessary Braces**

  if (radius >= 0)  
  area = radius * radius * PI;  
  System.out.println("The area " + " is " + area);

  if (radius >= 0){  
  area = radius * radius * PI;  
  System.out.println("The area " + " is " + area);  
  }

  (a) Wrong  
  (b) Correct

- **Common Error 2: Wrong Semicolon at the if Line**
  - Adding a semicolon at the end of an if clause is a common mistake.
  - This mistake is hard to find, because it is not a compilation error or a runtime error, it is a logic error.
  - This error often occurs when you use the next-line block style.

  if (radius >= 0)  
  {  
  area = radius * radius * PI;  
  System.out.println("The area " + " is " + area);  
  }

  if (radius >= 0) {  
  area = radius * radius * PI;  
  System.out.println("The area " + " is " + area);  
  }

  (a)  
  (b)

- **Common Error 3: Redundant Testing of Boolean Values**
  - To test whether a Boolean variable is true or false in a test condition, it is redundant to use the equality comparison operator like this:

  if (even == true)  
  System.out.println("It is even.");

  if (even)  
  System.out.println("It is even.");

  (a)  
  (b)

**Caution**
- What’s wrong with the following?

  if (even == true)  
  System.out.println("It is even.");

  This statement does not have syntax errors. It assigns true to even so that even is always true.
Common Error 4: Dangling else Ambiguity

- The else clause matches the most recent unmatched if clause in the same block. For example, the following statement:

```java
int i = 1; int j = 2; int k = 3;
if (i > j)
    if (i > k)
        System.out.println("A");
else
    System.out.println("B");
```

is equivalent to:

```java
int i = 1; int j = 2; int k = 3;
if (i > j)
    if (i > k)
        System.out.println("A");
else
    System.out.println("B");
```

- Nothing is printed from the preceding statement because the compiler ignores indentation. To force the else clause to match the first if clause, you must add a pair of braces:

```java
int i = 1; int j = 2; int k = 3;
if (i > j) {
    if (i > k)
        System.out.println("A");
} else
    System.out.println("B");
```

This statement prints B.
This example creates a program to teach a first grade child how to learn subtractions. The program randomly generates two single-digit integers number1 and number2 with number1 > number2 and displays a question such as “What is 9 – 2?” to the student, as shown in the figure. After the student types the answer in the input dialog box, the program displays a message dialog box to indicate whether the answer is correct.

LISTING 3.4 SubtractionQuiz.java

```java
import java.util.Scanner;

public class SubtractionQuiz {  
    public static void main(String[] args) {  
        // 1. Generate two random single-digit integers
        int number1 = (int)(Math.random() * 10);
        int number2 = (int)(Math.random() * 10);

        // 2. If number1 < number2, swap number1 with number2
        if (number1 < number2) {
            int temp = number1;
            number1 = number2;
            number2 = temp;
        }

        // 3. Prompt the student to answer “what is number1 - number2?”
        System.out.print("What is " + number1 + " - " + number2 + "? ");
        Scanner input = new Scanner(System.in);
        int answer = input.nextInt();

        // 4. Grade the answer and display the result
        if (number1 - number2 == answer)
            System.out.println("You are correct!");
        else
            System.out.println("Your answer is wrong.\n" + number1 + " - " + number2 + " should be " + (number1 - number2));
    }
}
```

What is 6 - 6? 0
You are correct!

What is 9 - 2? 5
Your answer is wrong.
9 - 2 should be 7
3.10 Problem: Computing Body Mass Index (Page 84)

- Body Mass Index (BMI) is a measure of health on weight. It can be calculated by taking your weight in kilograms and dividing by the square of your height in meters. The interpretation of BMI for people 16 years or older is as follows:

<table>
<thead>
<tr>
<th>BMI</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>below 16</td>
<td>serious underweight</td>
</tr>
<tr>
<td>16-18</td>
<td>underweight</td>
</tr>
<tr>
<td>18-24</td>
<td>normal weight</td>
</tr>
<tr>
<td>24-29</td>
<td>overweight</td>
</tr>
<tr>
<td>29-35</td>
<td>seriously overweight</td>
</tr>
<tr>
<td>above 35</td>
<td>gravely overweight</td>
</tr>
</tbody>
</table>

- LISTING 3.5 ComputeBMI.java

```java
import java.util.Scanner;

public class ComputeAndInterpretBMI {
    public static void main(String[] args) {
        Scanner input = new Scanner(System.in);

        // Prompt the user to enter weight in pounds
        System.out.print("Enter weight in pounds: ");
        double weight = input.nextDouble();

        // Prompt the user to enter height in inches
        System.out.print("Enter height in inches: ");
        double height = input.nextDouble();

        final double KILOGRAMS_PER_POUND = 0.45359237; // Constant
        final double METERS_PER_INCH = 0.0254; // Constant

        // Compute BMI
        double weightInKilograms = weight * KILOGRAMS_PER_POUND;
        double heightInMeters = height * METERS_PER_INCH;
        double bmi = weightInKilograms / (heightInMeters * heightInMeters);

        // Display result
        System.out.printf("Your BMI is %5.2f\n", bmi);
        if (bmi < 16)
            System.out.println("You are seriously underweight");
        else if (bmi < 18)
            System.out.println("You are underweight");
        else if (bmi < 24)
            System.out.println("You are normal weight");
        else if (bmi < 29)
            System.out.println("You are overweight");
        else if (bmi < 35)
            System.out.println("You are seriously overweight");
        else
            System.out.println("You are gravely overweight");
    }
}
```

Enter weight in pounds: 146
Enter height in inches: 70
Your BMI is 20.95
You are normal weight
3.11 Problem: Computing Taxes (Page 85)

- The US federal personal income tax is calculated based on the filing status and taxable income. There are four filing statuses: single filers, married filing jointly, married filing separately, and head of household. The tax rates for 2009 are shown below.

**TABLE 3.2 2009 U.S. Federal Personal Tax Rates**

<table>
<thead>
<tr>
<th>Marginal Tax Rate</th>
<th>Single</th>
<th>Married Filing Jointly or Qualified Widow(er)</th>
<th>Married Filing Separately</th>
<th>Head of Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>$0 – $8,350</td>
<td>$0 – $16,700</td>
<td>$0 – $33,350</td>
<td>$0 – $11,950</td>
</tr>
<tr>
<td>15%</td>
<td>$8,351 – $33,950</td>
<td>$16,701 – $67,900</td>
<td>$33,351 – $33,950</td>
<td>$11,951 – $40,500</td>
</tr>
<tr>
<td>28%</td>
<td>$82,251 – $171,550</td>
<td>$137,051 – $208,550</td>
<td>$137,051 – $208,550</td>
<td>$117,451 – $190,200</td>
</tr>
<tr>
<td>35%</td>
<td>$372,951+</td>
<td>$372,951+</td>
<td>$186,476+</td>
<td>$372,951+</td>
</tr>
</tbody>
</table>

```java
import java.util.Scanner;

public class ComputeTax {
    public static void main(String[] args) {
        // Create a Scanner
        Scanner input = new Scanner(System.in);

        // Prompt the user to enter filing status
        System.out.print("(0-single filer, 1-married jointly, \n" +
                        "2-married separately, 3-head of household) \n" +
                        "Enter the filing status: ");
        int status = input.nextInt();

        // Prompt the user to enter taxable income
        System.out.print("Enter the taxable income: ");
        double income = input.nextDouble();

        // Compute tax
        double tax = 0;

        if (status == 0) { // Compute tax for single filers
            if (income <= 8350)
                tax = income * 0.10;
            else if (income <= 33950)
                tax = 8350 * 0.10 + (income - 8350) * 0.15;
            else if (income <= 82250)
                tax = 8350 * 0.10 + (33950 - 8350) * 0.15 +
                        (income - 33950) * 0.25;
            else if (income <= 171550)
```
tax = 8350 * 0.10 + (33950 - 8350) * 0.15 +
(82250 - 33950) * 0.25 + (income - 82250) * 0.28;
else if (income <= 372950)
tax = 8350 * 0.10 + (33950 - 8350) * 0.15 +
(82250 - 33950) * 0.25 + (171550 - 82250) * 0.28 +
(income - 171550) * 0.35;
else
tax = 8350 * 0.10 + (33950 - 8350) * 0.15 +
(82250 - 33950) * 0.25 + (171550 - 82250) * 0.28 +
(372950 - 171550) * 0.33 + (income - 372950) * 0.35;
}
else if (status == 1) { // Compute tax for married file jointly
  // Left as exercise
}
else if (status == 2) { // Compute tax for married separately
  // Left as exercise
}
else if (status == 3) { // Compute tax for head of household
  // Left as exercise
}
else {
  System.out.println("Error: invalid status");
  System.exit(0);
}

  // Display the result
System.out.println("Tax is " + (int)(tax * 100) / 100.0);
}

(0-single filer, 1-married jointly,
2-married separately, 3-head of household)
Enter the filing status: 0
Enter the taxable income: 40000
Tax is 6187.5
3.12 Logical Operators

- Logical operators, also known as Boolean operators, operate on Boolean values to create a new Boolean value.

**TABLE 3.3 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>

- Examples

  && (and)   (1 < x) && (x < 100)

  || (or)    (lightsOn) || (isDayTime)

  !   (not)   !(isStopped)

**TABLE 3.4 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 3.5 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 3.6 Truth Table for Operator ||**

| p1        | p2        | p1 || p2 | Example                           |
|-----------|-----------|--------|-----------------------------------|
| false     | false     | false  | (2 > 3) || (5 > 5) is false, because (2 > 3) and (5 > 5) are both false. |
| false     | true      | true   |                                  |
| true      | false     | true   | (3 > 2) || (5 > 5) is true, because (3 > 2) is true. |
| true      | true      | true   |                                  |
TABLE 3.7 Truth Table for Operator ^

<table>
<thead>
<tr>
<th>p1</th>
<th>p2</th>
<th>p1 ^ p2</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>false</td>
<td>false</td>
<td>(2 &gt; 3) ^ (5 &gt; 1) is true, because (2 &gt; 3) is false and (5 &gt; 1) is true.</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>true</td>
<td>(3 &gt; 2) ^ (5 &gt; 1) is false, because both (3 &gt; 2) and (5 &gt; 1) are true.</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>true</td>
<td></td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>false</td>
<td></td>
</tr>
</tbody>
</table>

- LISTING 3.7 TestBooleanOperators.java

```java
import java.util.Scanner;

public class TestBooleanOperators {
    public static void main(String[] args) {
        // Create a Scanner
        Scanner input = new Scanner(System.in);

        // Receive an input
        System.out.print("Enter an integer: ");
        int number = input.nextInt();

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

Enter an integer: 18
Is 18 divisible by 2 and 3? true
Is 18 divisible by 2 or 3? true
Is 18 divisible by 2 or 3, but not both? false
3.13 Problem: Determining Leap Year

- This program first prompts the user to enter a year as an int value and checks if it is a leap year.
- A year is a leap year if it is divisible by 4 but not by 100, or it is divisible by 400.

\[(\text{year} \mod 4 == 0 && \text{year} \mod 100 != 0) || (\text{year} \mod 400 == 0)\]

- LISTING 3.8 LeapYear.java

```java
import java.util.Scanner;

public class LeapYear {
    public static void main(String args[]) {
        // Create a Scanner
        Scanner input = new Scanner(System.in);
        System.out.print("Enter a year: ");
        int year = input.nextInt();

        // 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
        System.out.println(year + " is a leap year? " + isLeapYear);
    }
}
```

Enter a year: 2008
2008 is a leap year? true

Enter a year: 2002
2002 is a leap year? false
3.14 Problem: Lottery

- Write a program that randomly generates a lottery of a two-digit number, prompts the user to enter a two-digit number, and determines whether the user wins according to the following rule:
  - If the user input matches the lottery in **exact order**, the award is $10,000.
  - If the user input match all the digits in the lottery, the award is $3,000.
  - If one digit in the user input matches a digit in the lottery, the award is $1,000.

- **LISTING 3.9 LeapYear.java**

```java
import java.util.Scanner;

public class Lottery {
    public static void main(String[] args) {
        // Generate a lottery
        int lottery = (int)(Math.random() * 100);

        // Prompt the user to enter a guess
        Scanner input = new Scanner(System.in);
        System.out.print("Enter your lottery pick (two digits): ");
        int guess = input.nextInt();

        // Get digits from lottery
        int lotteryDigit1 = lottery / 10;
        int lotteryDigit2 = lottery % 10;

        // Get digits from guess
        int guessDigit1 = guess / 10;
        int guessDigit2 = guess % 10;

        System.out.println("The lottery number is " + lottery);

        // Check the guess
        if (guess == lottery)
            System.out.println("Exact match: you win $10,000");
        else if (guessDigit2 == lotteryDigit1 && guessDigit1 == lotteryDigit2)
            System.out.println("Match all digits: you win $3,000");
        else if (guessDigit1 == lotteryDigit1 || guessDigit1 == lotteryDigit2
                  || guessDigit2 == lotteryDigit1 || guessDigit2 == lotteryDigit2)
            System.out.println("Match one digit: you win $1,000");
        else
            System.out.println("Sorry, no match");
    }
}
```

Enter your lottery pick (two digits): 45
The lottery number is 12
Sorry, no match

Enter your lottery pick (two digits): 23
The lottery number is 34
Match one digit: you win $1,000
3.15 switch Statements

- One can write a `switch` statement to replace a nested `if` statement. For example,

```
switch (status) {
    case 0:  compute taxes for single filers;
             break;
    case 1:  compute taxes for married file jointly;
             break;
    case 2:  compute taxes for married file separately;
             break;
    case 3:  compute taxes for head of household;
             break;
    default: System.out.println("Errors: invalid status");
             System.exit(0);
} // checks if status matches the values 0, 1, 2, or 3 respectively.
```

FIGURE 3.5 The switch statement checks all cases and executes the statement in matched cases

The `switch` Statement Rules:
- The `switch-expression` must yield a value of `char`, `byte`, `short`, or `int` type and must always be enclosed in parentheses.
- The `value1`... and `valueN` must have the same data type as the value of the `switch-expression`. `value1`... and `valueN` are constant expressions, meaning that they cannot contain variables in the expression, such as `1 + x`.
- When the value in a `case` statement matches the value of the `switch-expression`, the statements starting from this case are executed until either a `break` statement or the end of the `switch` statement is reached.
• The keyword **break** is optional. The **break** statement *immediately ends* the **switch** statement.

• The **default** case, which is optional, can be used to perform actions when **none** of the specified cases matches the **switch-expression**.

• The cases statements are checked in **sequential** order, but the **order** of the cases (including the default case) **does not** matter. However, it is a good programming style to follow the logical sequence of the cases and place the default case at the end.

**Caution**

• **Do not** forget to use a **break** statement when one is needed. For example, the following code prints character a **three times** if ch is ‘a’:

```java
switch (ch) {
    case 'a': System.out.println(ch);
    case 'b': System.out.println(ch);
    case 'c': System.out.println(ch);
}
```
3.16 Conditional Expressions

- Conditional expressions are in different style, which no explicit if in the statement. The syntax is shown below:

  \[ \text{BooleanExpression} ? \text{expression1} : \text{expression2}; \]

  The result of this conditional expression \text{expression1} if \text{BooleanExpression} is true; otherwise the result is \text{expression2}.

- For example:

  ```java
  if (x > 0)
  y = 1
  else
  y = -1;
  ```

  is equivalent to

  ```java
  y = (x > 0) ? 1 : -1;
  ```

- For example:

  ```java
  if (num % 2 == 0)
  System.out.println(num + "is even");
  else
  System.out.println(num + "is odd");
  ```

  is equivalent to

  ```java
  System.out.println((num % 2 == 0)? num + "is even" : num + "is odd");
  ```

- For example:

  ```java
  Max = (num1 > num2)? num1 : num2;
  ```

**Note**

- The symbols \( ? \) and \( : \) appear together in a **conditional expression**. They form a condition operator. The operator is called a **ternary** operator because it uses three operands.
3.17 Formatting Console Output

- Use printf statement to format the output.

```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 3.8 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 %d %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.

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

display

count is  5 and amount is 45.560000

- Creating Formatted Strings

  `String.format(format, item1, item2, ..., itemk)`

- Example

  ```java
  String s = String.format("count is %d and amount is %f", 5, 45.56);
  ```
### 3.18 Operator Precedence and 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:

  \[
a \text{ – } b + c \text{ – } d \text{ is equivalent to } ((a \text{ – } b) + c) \text{ – } d
\]

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

\[
a = b += c = 5 \text{ is equivalent to } a = (b += (c = 5))
\]

**TABLE 3.10 Operator Precedence Chart**

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>var++, var--</td>
<td>Increment and decrement</td>
</tr>
<tr>
<td>+, - (Unary plus and minus), ++var,--var</td>
<td>Unary addition and subtraction</td>
</tr>
<tr>
<td>(type) Casting</td>
<td>Type casting</td>
</tr>
<tr>
<td>! (Not)</td>
<td>Logical negation</td>
</tr>
<tr>
<td>*, /, % (Multiplication, division, and modulus)</td>
<td>Multiplication and division</td>
</tr>
<tr>
<td>+, - (Binary addition and subtraction)</td>
<td>Binary addition and subtraction</td>
</tr>
<tr>
<td>&lt;, &lt;=, &gt;, &gt;= (Comparison)</td>
<td>Comparison operators</td>
</tr>
<tr>
<td>==, != (Equality)</td>
<td>Equality operator</td>
</tr>
<tr>
<td>^ (Exclusive OR)</td>
<td>Exclusive OR</td>
</tr>
<tr>
<td>&amp; (Unconditional AND)</td>
<td>Unconditional AND</td>
</tr>
<tr>
<td></td>
<td>(Unconditional OR)</td>
</tr>
<tr>
<td>&amp;&amp; (Conditional AND)</td>
<td>Conditional AND (short-circuit)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>=, +=, -=, *=, /=, %= (Assignment operator)</td>
<td>Assignment operators</td>
</tr>
</tbody>
</table>

- **Example**

  Applying the operator precedence and associativity rule, the expression \(3 + 4 * 4 > 5 * (4 + 3) - 1\) is evaluated as follows:

\[
\begin{align*}
3 + 4 * 4 & > 5 * (4 + 3) - 1 \\
3 + 4 & * 4 > 5 * 7 - 1 \\
3 & + 16 > 5 * 7 - 1 \\
3 & + 16 > 35 - 1 \\
19 & > 35 - 1 \\
19 & > 34
\end{align*}
\]

\[
false
\]

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