

Chapter 3 Selections



1

Motivations

If you assigned a negative value for radius in Listing 2.2, `ComputeAreaWithConsoleInput.java`, the program would print an invalid result. If the radius is negative, you don't want the program to compute the area. How can you deal with this situation?



2

The boolean Type and Operators

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**.

```
boolean b = (1 > 2) ;
```



3

Relational Operators

| Java Operator | Mathematics Symbol | Name | Example (radius is 5) | Result |
|---------------|--------------------|--------------------------|-----------------------------|--------------------|
| < | < | less than | <code>radius < 0</code> | <code>false</code> |
| <= | ≤ | less than or equal to | <code>radius <= 0</code> | <code>false</code> |
| > | > | greater than | <code>radius > 0</code> | <code>true</code> |
| >= | ≥ | greater than or equal to | <code>radius >= 0</code> | <code>true</code> |
| == | = | equal to | <code>radius == 0</code> | <code>false</code> |
| != | ≠ | not equal to | <code>radius != 0</code> | <code>true</code> |



4

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.



5

A Simple Math Learning Tool

Listing 3.1 AdditionQuiz.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() / 10 % 10);

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

        System.out.print(
            "What is " + number1 + " + " + number2 + "? ");

        int answer = input.nextInt();

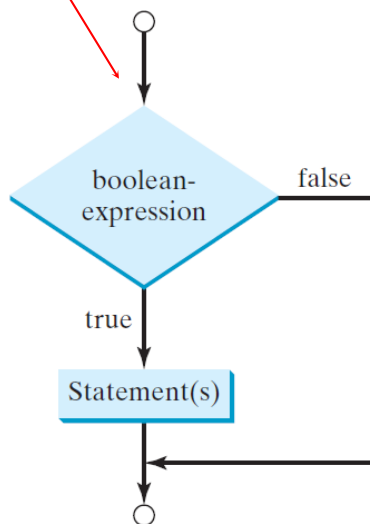
        System.out.println(
            number1 + " + " + number2 + " = " + answer + " is " +
            (number1 + number2 == answer));
    }
}
```



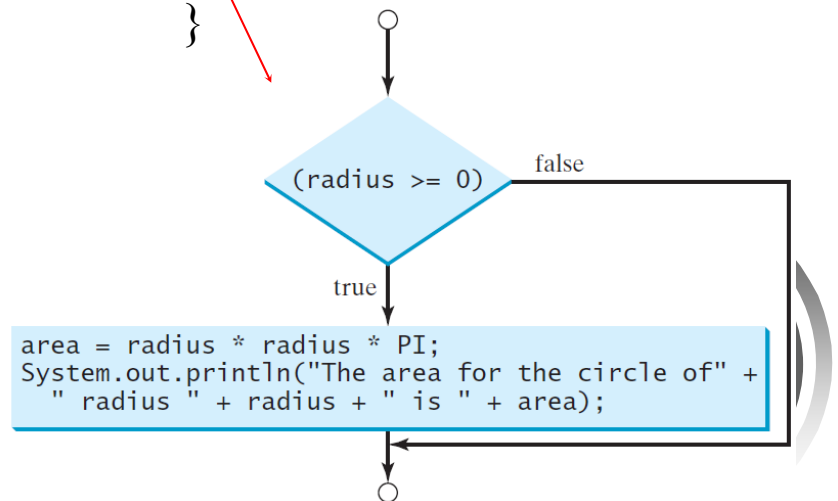
6

One-way if Statements

```
if (boolean-expression) {  
    statement(s);  
}
```



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



7

Note

```
if i > 0 {  
    System.out.println("i is positive");  
}
```

(a) Wrong

```
if (i > 0) {  
    System.out.println("i is positive");  
}
```

(b) Correct

```
if (i > 0) {  
    System.out.println("i is positive");  
}
```

(a)

Equivalent

```
if (i > 0)  
    System.out.println("i is positive");
```

(b)



8

Simple if Demo

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.



9

Simple if Demo

Listing 3.2 SimpleIfDemo.java

```
import java.util.Scanner;

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

        if (number % 5 == 0)
            System.out.println("HiFive");

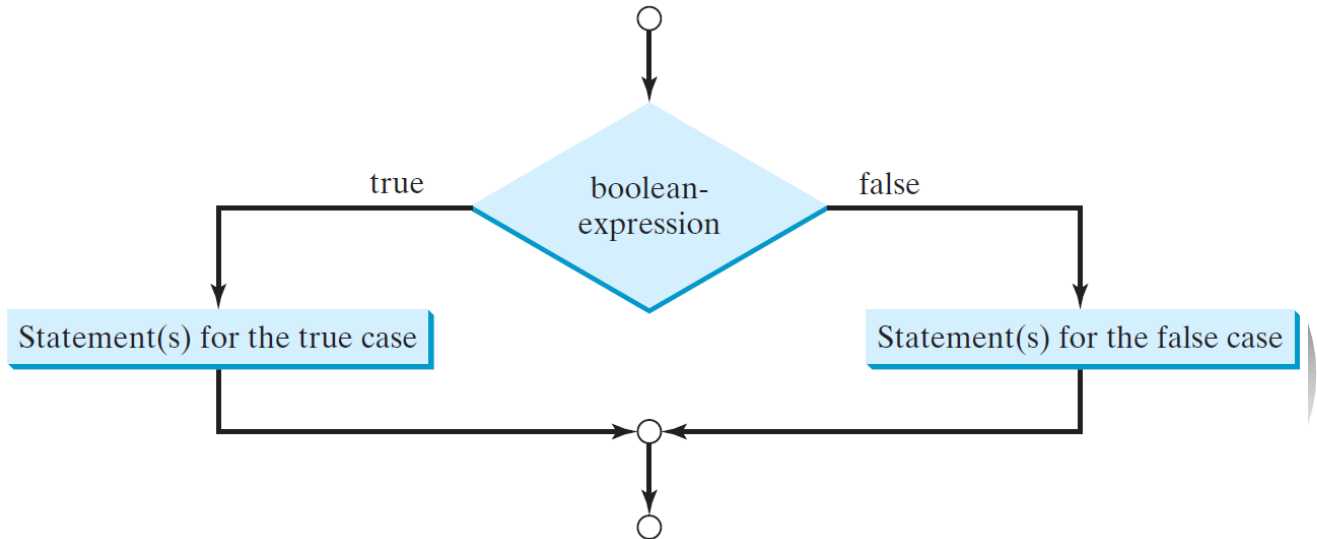
        if (number % 2 == 0)
            System.out.println("HiEven");
    }
}
```



10

The Two-way if Statement

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



11

if-else Example

```
if (radius >= 0) {  
    area = radius * radius * 3.14159;  
  
    System.out.println("The area for the "  
        + "circle of radius " + radius +  
        " is " + area);  
}  
else {  
    System.out.println("Negative input");  
}
```



12

Multiple Alternative if Statements

```
if (score >= 90.0)
    System.out.print("A");
else
    if (score >= 80.0)
        System.out.print("B");
    else
        if (score >= 70.0)
            System.out.print("C");
        else
            if (score >= 60.0)
                System.out.print("D");
            else
                System.out.print("F");
```

(a)

Equivalent

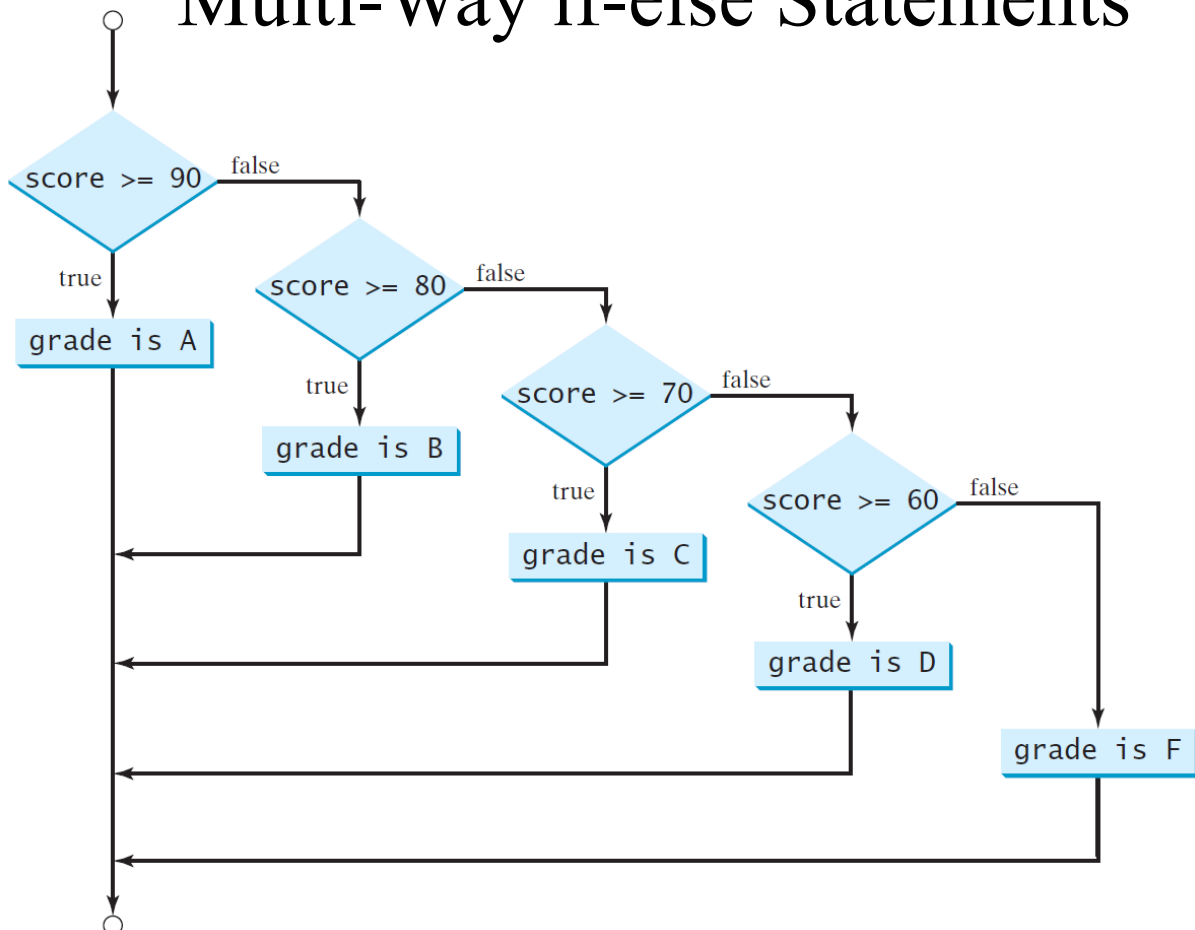
This is better

```
if (score >= 90.0)
    System.out.print("A");
else if (score >= 80.0)
    System.out.print("B");
else if (score >= 70.0)
    System.out.print("C");
else if (score >= 60.0)
    System.out.print("D");
else
    System.out.print("F");
```

(b)

13

Multi-Way if-else Statements



14

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if (score >= 90.0)
```

```
    System.out.print("A");  
else if (score >= 80.0)  
    System.out.print("B");  
else if (score >= 70.0)  
    System.out.print("C");  
else if (score >= 60.0)  
    System.out.print("D");  
else  
    System.out.print("F");
```



15

Trace if-else statement

Suppose score is 70.0

The condition is false

```
if (score >= 90.0)
```

```
    System.out.print("A");  
else if (score >= 80.0)  
    System.out.print("B");  
else if (score >= 70.0)  
    System.out.print("C");  
else if (score >= 60.0)  
    System.out.print("D");  
else  
    System.out.print("F");
```



16

Trace if-else statement

Suppose score is 70.0

The condition is true

```
if (score >= 90.0)
    System.out.print("A");
else if (score >= 80.0)
    System.out.print("B");
else if (score >= 70.0)
    System.out.print("C");
else if (score >= 60.0)
    System.out.print("D");
else
    System.out.print("F");
```



17

Trace if-else statement

Suppose score is 70.0

grade is C

```
if (score >= 90.0)
    System.out.print("A");
else if (score >= 80.0)
    System.out.print("B");
else if (score >= 70.0)
    System.out.print("C");
else if (score >= 60.0)
    System.out.print("D");
else
    System.out.print("F");
```



18

Trace if-else statement

Suppose score is 70.0

Exit the if statement

```
if (score >= 90.0)
    System.out.print("A");
else if (score >= 80.0)
    System.out.print("B");
else if (score >= 70.0)
    System.out.print("C");
else if (score >= 60.0)
    System.out.print("D");
else
    System.out.print("F");
```



19

Note

The else clause matches the most recent if clause in the same block.

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

(a)

Equivalent

This is better
with correct
indentation

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

(b)



20

Note, cont.

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

```
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.



21

Common Errors

Adding a semicolon at the end of an if clause is a common mistake.

```
if (radius >= 0); ← Wrong
{
    area = radius*radius*PI;
    System.out.println(
        "The area for the circle of radius " +
        radius + " is " + area);
}
```

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.



22

TIP

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

(a)

Equivalent

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

(b)



23

CAUTION

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

(a)

Equivalent

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

(b)



24

Problem: An Improved Math Learning Tool

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 \geq number2 and displays a question such as “What is 9 – 2?” to the student. After the student types the answer, the program displays whether the answer is correct.



25

An Improved Math Learning Tool

Listing 3.3 SubtractionQuiz.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;
        }
    }
}
```




26

SubtractionQuiz.java

```
// 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.");
    System.out.println(number1 + " - " + number2 +
        " should be " + (number1 - number2));
}
}
```



27

Logical Operators

| Operator | Name | Description |
|----------|--------------|---------------------|
| ! | not | logical negation |
| && | and | logical conjunction |
| | or | logical disjunction |
| ^ | exclusive or | logical exclusion |

28

Truth Table for Operator !

| p | !p | Example (assume age = 24, weight = 140) |
|-------|-------|-------------------------------------------------------------|
| true | false | !(age > 18) is false, because (age > 18) is true. |
| false | true | !(weight == 150) is true, because (weight == 150) is false. |

29

Truth Table for Operator &&

| p ₁ | p ₂ | p ₁ && p ₂ | Example (assume age = 24, weight = 140) |
|----------------|----------------|----------------------------------|----------------------------------------------------------------------------------------------|
| false | false | false | (age <= 18) && (weight < 140) is false, because both conditions are both false. |
| false | true | false | |
| true | false | false | (age > 18) && (weight > 140) is false, because (weight > 140) is false. |
| true | true | true | (age > 18) && (weight >= 140) is true, because both (age > 18) and (weight >= 140) are true. |

30

Truth Table for Operator ||

| p ₁ | p ₂ | p ₁ p ₂ | Example (assume age = 24, weight = 140) |
|----------------|----------------|----------------------------------|--------------------------------------------------------------------------------------------------|
| false | false | false | |
| false | true | true | (age > 34) (weight <= 140) is true, because (age > 34) is false, but (weight <= 140) is true. |
| true | false | true | (age > 14) (weight >= 150) is false, because (age > 14) is true. |
| true | true | true | |

31

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.

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

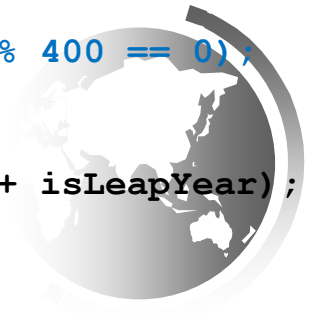


32

Determining Leap Year?

Listing 3.7 LeapYear.java

```
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);  
    }  
}
```



33

Problem: Body Mass Index

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:

| BMI | Interpretation |
|-------------------|----------------|
| BMI < 18.5 | Underweight |
| 18.5 ≤ BMI < 25.0 | Normal |
| 25.0 ≤ BMI < 30.0 | Overweight |
| 30.0 ≤ BMI | Obese |



34

Body Mass Index

Listing 3.4 ComputeAndInterpretBMI.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
```



35

Body Mass Index

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

        // Display result
        System.out.println("BMI is " + bmi);
        if (bmi < 18.5)
            System.out.println("Underweight");
        else if (bmi < 25)
            System.out.println("Normal");
        else if (bmi < 30)
            System.out.println("Overweight");
        else
            System.out.println("Obese");
    }
}
```



36

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 matches 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.



37

Lottery

Listing 3.8 Lottery.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;
```




38

Lottery

(Cont...)

```
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");
}
```



39

Problem: Computing Taxes

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.

| <i>Marginal Tax Rate</i> | <i>Single</i> | <i>Married Filing Jointly or Qualifying Widow(er)</i> | <i>Married Filing Separately</i> | <i>Head of Household</i> |
|------------------------------|-----------------------|-----------------------------------------------------------|----------------------------------|--------------------------|
| 10% | \$0 – \$8,350 | \$0 – \$16,700 | \$0 – \$8,350 | \$0 – \$11,950 |
| 15% | \$8,351 – \$33,950 | \$16,701 – \$67,900 | \$8,351 – \$33,950 | \$11,951 – \$45,500 |
| 25% | \$33,951 – \$82,250 | \$67,901 – \$137,050 | \$33,951 – \$68,525 | \$45,501 – \$117,450 |
| 28% | \$82,251 – \$171,550 | \$137,051 – \$208,850 | \$68,526 – \$104,425 | \$117,451 – \$190,200 |
| 33% | \$171,551 – \$372,950 | \$208,851 – \$372,950 | \$104,426 – \$186,475 | \$190,201 – \$372,950 |
| 35% | \$372,951+ | \$372,951+ | \$186,476+ | \$372,951+ |

40

Problem: Computing Taxes, cont.

```
if (status == 0) {
    // Compute tax for single filers
}
else if (status == 1) {
    // Compute tax for married file jointly
    // or qualifying widow(er)
}
else if (status == 2) {
    // Compute tax for married file separately
}
else if (status == 3) {
    // Compute tax for head of household
}
else {
    // Display wrong status
}
```



41

Computing Taxes

Listing 3.5 ComputeTax.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 or " +
            "qualifying widow(er), 2-married separately, 3-head of " +
            "household) 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;
```

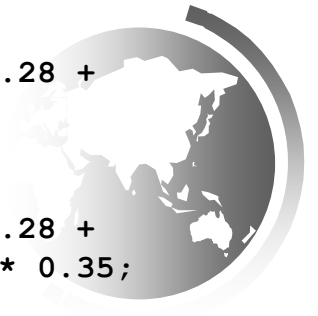


42

Computing Taxes

(Cont.)

```
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) * 0.33;
    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;
}
```




43

Computing Taxes

(Cont.)

```
else if (status == 1) { // Compute tax for married file jointly
    // Left as exercise in Programming Assignment #03
}
else if (status == 2) { // Compute tax for married separately
    // Left as exercise in Programming Assignment #03
}
else if (status == 3) { // Compute tax for head of household
    // Left as exercise in Programming Assignment #03
}
else {
    System.out.println("Error: invalid status");
    System.exit(1);
}

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



44

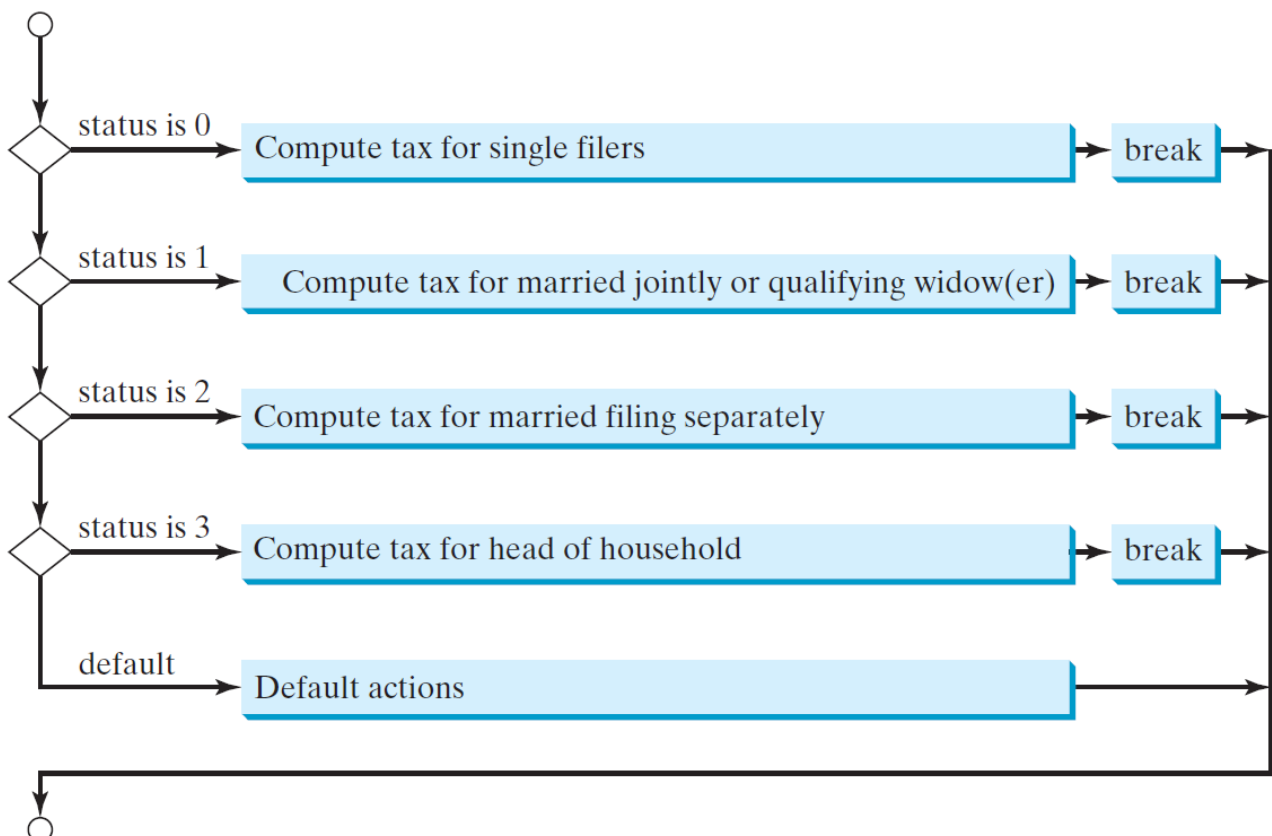
switch Statements

```
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(1);  
}
```



45

switch Statement Flow Chart



46

Trace switch statement

Suppose day is 2:

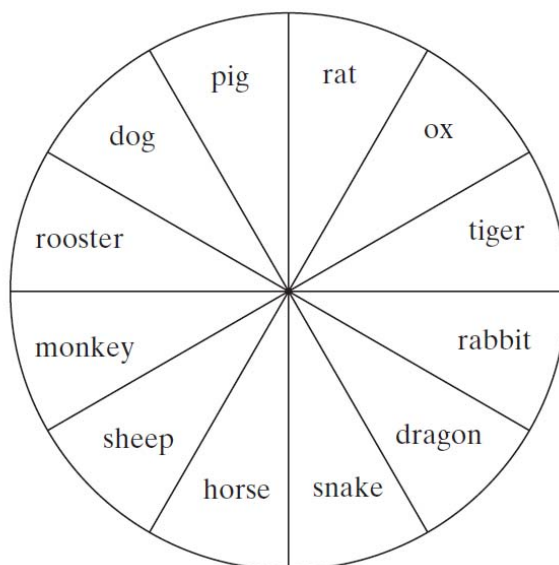
```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```



47

Problem: Chinese Zodiac

Write a program that prompts the user to enter a year and displays the animal for the year.



year % 12 = {

- 0: monkey
- 1: rooster
- 2: dog
- 3: pig
- 4: rat
- 5: ox
- 6: tiger
- 7: rabbit
- 8: dragon
- 9: snake
- 10: horse
- 11: sheep



48

Chinese Zodiac

Listing 3.0 ChineseZodiac.java

```
import java.util.Scanner;

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

        System.out.print("Enter a year: ");
        int year = input.nextInt();

        switch (year % 12) {
            case 0: System.out.println("monkey"); break;
            case 1: System.out.println("rooster"); break;
            case 2: System.out.println("dog"); break;
            case 3: System.out.println("pig"); break;
            case 4: System.out.println("rat"); break;
            case 5: System.out.println("ox"); break;
            case 6: System.out.println("tiger"); break;
            case 7: System.out.println("rabbit"); break;
            case 8: System.out.println("dragon"); break;
            case 9: System.out.println("snake"); break;
            case 10: System.out.println("horse"); break;
            case 11: System.out.println("sheep"); break;
        }
    }
}
```



49

Conditional Operators

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



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



50