Conditionals and Loops

• Now we will examine programming statements that allow us to:
  – make decisions
  – repeat processing steps in a loop

• Chapter 5 focuses on:
  – boolean expressions
  – the if and if-else statements
  – comparing data
  – while loops
  – iterators
  – more drawing techniques
  – more GUI components
Flow Control

LET A = a loaf of bread
LET T = a toaster
LET P = a plate
LET B = some butter
LET M = some margarine
FOR every friend (F) eating toast{
   LET S = cut slice from A
   move S to T
   turn on T
   WHILE T is not finished{
      talk to F
   }
}
Outline

Boolean Expressions
The if Statement
Comparing Data
The while Statement
Iterators
The ArrayList Class
Determining Event Sources
Check Boxes and Radio Buttons
Flow of Control

• Unless specified otherwise, the order of statement execution through a method is linear: one after another

• Some programming statements allow us to make decisions and perform repetitions

• These decisions are based on boolean expressions (also called conditions) that evaluate to true or false

• The order of statement execution is called the flow of control
Conditional Statements

• A *conditional statement* lets us choose which statement will be executed next

• They are sometimes called *selection statements*

• Conditional statements give us the power to make basic decisions

• The Java conditional statements are the:
  – *if* and *if-else* statement
  – *switch* statement

• We'll explore the switch statement in Chapter 6
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 (=)
Boolean Expressions

• An if statement with its boolean condition:

\[
\text{if (sum > MAX)} \\
\quad \text{delta = sum - MAX;}
\]

• First, the condition is evaluated: the value of sum is either greater than the value of MAX, or it is not

• If the condition is true, the assignment statement is executed; if it isn't, it is skipped

• See Age.java
import java.util.Scanner;

public class Age {
    // Reads the user's age and prints comments accordingly.
    public static void main (String[] args) {
        final int MINOR = 21;

        Scanner scan = new Scanner (System.in);

        System.out.print ("Enter your age: ");
        int age = scan.nextInt();

        continue
continue

    System.out.println ("You entered: " + age);

    if (age < MINOR)
        System.out.println ("Youth is a wonderful thing. Enjoy.");

    System.out.println ("Age is a state of mind.");
}
```
Sample Run

Enter your age: 47
You entered: 47
Age is a state of mind.

System.out.println ("You entered: " + age);

if (age < MINOR)
    System.out.println ("Youth is a wonderful thing. Enjoy.");

System.out.println ("Age is a state of mind.");
}
}

Another Sample Run

Enter your age: 12
You entered: 12
Youth is a wonderful thing. Enjoy.
Age is a state of mind.
```
Quiz

• What is the value of x, a, and b after the execution of the following statements?

```java
int x=1, a=2, b=3;
if (x < 0)
b=5;
a= b*2;
x=4;
```
Quiz

What is the value of x, a, and b after the execution of the following statements?

```java
int x=1, a=2, b=3;
if (x < 0)
    b=5;  // this statement is not executed
a= b*2;
x=4;
```

x is 4
a is 6
b is 3
Logical Operators

• Boolean expressions can also 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)
Logical NOT

• The logical NOT operation is also called logical negation or logical complement

• If some boolean condition $a$ is true, then $!a$ is false; if $a$ is false, then $!a$ is true

• Logical expressions can be shown using a truth table:

<table>
<thead>
<tr>
<th>$a$</th>
<th>$!a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
</tr>
</tbody>
</table>
Quiz

- What is the value of x, a, and b after the execution of the following statements?

```c
int x=0, a=2, b=3;
if (!(x >1))
b=5;
a= b*2;
x=4;
```
Quiz

• What is the value of x, a, and b after the execution of the following statements?

```cpp
int x=0, a=2, b=3;
if (!(x >1))
b=5; // this statement is executed
a= b*2;
x=4;

x is 4
a is 10
b is 5
```
Logical AND and Logical OR

• The *logical AND* expression

\[ a \ \&\& \ b \]

is true if both \( a \) and \( b \) are true, and false otherwise.

• The *logical OR* expression

\[ a \ \|\| \ b \]

is true if \( a \) or \( b \) or both are true, and false otherwise.
Logical AND and Logical OR

- A truth table shows all possible true-false combinations of the terms

- Since `&&` and `||` each have two operands, there are four possible combinations of conditions `a` and `b`

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
<td>a &amp;&amp; b</td>
<td>a</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
</tbody>
</table>
Logical Operators

• Expressions that use logical operators can form complex conditions

\[
\text{if (total < MAX+5 && !found)}
\]

\[
\text{System.out.println ("Processing..."));}
\]

• All \textbf{logical operators} have lower precedence than the \textbf{relational operators}

• The \texttt{!} operator has higher precedence than \&\& and | |
Quiz

• Are the two following Boolean expressions equivalent? Assume that \( a \) and \( b \) are Boolean variables.

1) \(! (a \land b)\)

2) \(!a \land b\)
Quiz

• Are the two following Boolean expressions equivalent? Assume that a and b are Boolean variables.

1) !(a && b)
2) !a && b

NO, the first is always true except when a and b are true. The second is true only when a is false and b is true.
Boolean Expressions

- Specific expressions can be evaluated using truth tables

<table>
<thead>
<tr>
<th>total &lt; MAX</th>
<th>found</th>
<th>!found</th>
<th>total &lt; MAX &amp;&amp; !found</th>
</tr>
</thead>
<tbody>
<tr>
<td>false</td>
<td>false</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>false</td>
<td>true</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>true</td>
<td>false</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>true</td>
<td>true</td>
<td>false</td>
<td>false</td>
</tr>
</tbody>
</table>
Quiz

• Assuming that $c_1$ and $c_2$ are boolean variables, create a truth table for the expression:

$$(c_1 \land \neg c_2) \lor (\neg c_1 \land c_2)$$
**Quiz**

- Assuming that $c_1$ and $c_2$ are **boolean** variables, create a truth table for the expression:

  $$(c_1 \land \neg c_2) \lor (\neg c_1 \land c_2)$$

| $c_1$ | $c_2$ | $\neg c_1$ | $\neg c_2$ | $c_1 \land \neg c_2$ | $\neg c_1 \land c_2$ | $c_1 \land \neg c_2$ || $\neg c_1 \land c_2$ |
|------|------|------------|------------|---------------------|---------------------|---------------------|---------------------|
| true | true | false      | false      | false               | false               | false               | false               |
| true | false| false      | true       | true               | false               | true               | true               |
| false| true | true       | false      | false               | true               | true               | true               |
| false| false| true       | true       | false               | false               | false               | false               |
Short-Circuited Operators

• The processing of && and || is “short-circuited”

• If the left operand is sufficient to determine the result, the right operand is not evaluated

    if (count != 0 && total/count > MAX)
    System.out.println ("Testing.");

• This type of processing should be used carefully
Quiz

• What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (count > 1 || ++base > count)
    count--;
```
Quiz

• What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (count > 1 || ++base > count)
    count--;
```

count is 1
base is 0
Quiz

• What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (++base > count || count > 1)
    count--;```

Quiz

• What is the value of count and base after the execution of the following statements

```c
int count=2, base=0;
if (++base > count || count > 1)
    count--;
```

count is 1
base is 1
Quiz

What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (++base > count && --count > 1)
    count--;```

Quiz

• What is the value of count and base after the execution of the following statements?

```c
int count=2, base=0;
if (++base > count && --count > 1)
    count--;

count is 2
base is 1
```
The if Statement

• Let's now look at the `if` statement in more detail
• The `if` statement has the following syntax:

```
if ( condition )
statement;
```

- The `condition` must be a boolean expression. It must evaluate to either true or false.
- `if` is a Java reserved word.

If the `condition` is true, the `statement` is executed. If it is false, the `statement` is skipped.
Logic of an if statement

Flowchart

condition evaluated

true

false

statement
Indention

• The statement controlled by the `if` statement is **indented** to indicate that relationship.

• The use of a consistent indentation style makes a program easier to read and understand.

• The **compiler ignores indentation**, which can lead you to make (logical) errors if the indentation is not correct.

"Always code as if the person who ends up maintaining your code will be a violent psychopath who knows where you live."

-- Martin Golding
Quick Check

What do the following statements do?

```java
if (total != stock + warehouse)
    inventoryError = true;
```

```java
if (found || !done)
    System.out.println("Ok");
```
Quick Check

What do the following statements do?

if (total != stock + warehouse)
inventoryError = true;

Sets the boolean variable to true if the value of total is not equal to the sum of stock and warehouse

if (found || !done)
System.out.println("Ok");

Prints "Ok" if found is true or done is false
The if-else Statement

• An *else clause* can be added to an *if* statement to make an *if-else statement*

  ```java
  if ( condition )
      statement1;
  else
      statement2;
  ```

• If the *condition* is true, *statement1* is executed; if the condition is false, *statement2* is executed

• One or the other will be executed, but not both

• See *Wages.java*
import java.text.NumberFormat;
import java.util.Scanner;

public class Wages
{
    //-----------------------------------------------------------------
    //  Reads the number of hours worked and calculates wages.
    //-----------------------------------------------------------------
    public static void main (String[] args)
    {
        final double RATE = 8.25;  // regular pay rate
        final int STANDARD = 40;   // standard hours in a work week

        Scanner scan = new Scanner (System.in);

        double pay = 0.0;

        continue
continue

    System.out.print ("Enter the number of hours worked: ");
    int hours = scan.nextInt();

    System.out.println ();

    // Pay overtime at "time and a half"
    if (hours > STANDARD)
        pay = STANDARD * RATE + (hours-STANDARD) * (RATE * 1.5);
    else
        pay = hours * RATE;

    NumberFormat fmt = NumberFormat.getCurrencyInstance();
    System.out.println ("Gross earnings: " + fmt.format(pay));
}
System.out.print("Enter the number of hours worked: ");
int hours = scan.nextInt();
System.out.println();

// Pay overtime at "time and a half"
if (hours > STANDARD)
    pay = STANDARD * RATE + (hours-STANDARD) * (RATE * 1.5);
else
    pay = hours * RATE;

NumberFormat fmt = NumberFormat.getCurrencyInstance();
System.out.println("Gross earnings: "+fmt.format(pay));
Logic of an if-else statement

- The condition is evaluated.
  - If true, execute statement1.
  - If false, execute statement2.
Flowcharts

for(A;B;C)  
D;

A

B  
\[\text{FALSE}\]
\[\text{TRUE}\]

D

C

...
Flowchart Symbols

- Beginning or ending of a program or sub-process. They usually contain the word "Start" or "End", or another phrase signaling the start or end of a process, such as "submit inquiry" or "receive product".

- Set of operations that change value, form, or location of data.

- Set of operations that change value, form, or location of data.

- Input and output of data, as in entering data or displaying results.
Exercise

• Draw the flowchart of a simple algorithm that will output EVEN/ODD depending on the parity of the input integer.
Solution

Start

Input N

Remainder = N modulo 2

Remainder = 0?

YES

Answer = EVEN

NO

Answer = ODD

Output Answer

End
Quiz

What is printing the program described in this flowchart?
Syntax Diagram

If Statement

- if
- (Expression)
- )
- Statement
- else
- Statement

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The Coin Class

• Let's look at an example that uses a class that represents a coin that can be flipped

• Instance data is used to indicate which face (heads or tails) is currently showing

• See CoinFlip.java
• See Coin.java
public class CoinFlip {
    // ----------------------------------
    //   Creates a Coin object, flips it, and prints the results.
    // ----------------------------------
    public static void main (String[] args) {
        Coin myCoin = new Coin();

        myCoin.flip();

        System.out.println (myCoin);

        if (myCoin.isHeads())
            System.out.println ("You win.");
        else
            System.out.println ("Better luck next time.");
    }
}
public class CoinFlip
{
    // Creates a Coin object, flips it, and prints the results.
    public static void main (String[] args)
    {
        Coin myCoin = new Coin();

        myCoin.flip();

        System.out.println (myCoin);

        if (myCoin.isHeads())
            System.out.println ("You win.");
        else
            System.out.println ("Better luck next time.");
    }
}
/**
 * Represents a coin with two sides that can be flipped.
 */

class Coin {
    private final int HEADS = 0;
    private final int TAILS = 1;
    private int face;

    public Coin () {
        flip();
    }
}

continue
public void flip ()
{
    face = (int) (Math.random() * 2);
}

public boolean isHeads ()
{
    return (face == HEADS);
}
public String toString()
{
    String faceName;

    if (face == HEADS)
        faceName = "Heads";
    else
        faceName = "Tails";

    return faceName;
}
Indentation Revisited

• Remember that indentation is for the human reader, and is ignored by the compiler

```java
if (depth >= UPPER_LIMIT)
    delta = 100;
else
    System.out.println("Reseting Delta");
    delta = 0;
```

• Despite what the indentation implies, `delta` will be set to 0 no matter what
Quiz

Consider the following code that will assign a letter grade of 'A', 'B', 'C', 'D', or 'F' depending on a student's test score.

```cpp
if (score >= 90) grade = 'A';
if (score >= 80) grade = 'B';
if (score >= 70) grade = 'C';
if (score >= 60) grade = 'D';
else grade = 'F';
```

A) This code will work correctly in all cases
B) This code will work correctly only if grade >= 60
C) This code will work correctly only if grade < 60
D) This code will work correctly only if grade < 70
E) This code will not work correctly under any circumstances
Quiz

Consider the following code that will assign a letter grade of 'A', 'B', 'C', 'D', or 'F' depending on a student's test score.

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

A) This code will work correctly in all cases
B) This code will work correctly only if grade >= 60
C) This code will work correctly only if grade < 60
D) **This code will work correctly only if grade < 70**
E) This code will not work correctly under any circumstances
Block Statements

• Several statements can be grouped together into a *block statement* delimited by braces

• A *block statement* can be used wherever a *statement* is called for in the Java syntax rules

```java
if (total > MAX)
{
    System.out.println ("Error!!");
    errorCount++;
}
```
Block Statements

• The `if` clause, or the `else` clause, or both, could govern block statements

```java
if (total > MAX)
{
    System.out.println ("Error!!");
    errorCount++;
}
else
{
    System.out.println ("Total: " + total);
    current = total*2;
}
```

• See `Guessing.java`
import java.util.*;

public class Guessing {
  // Plays a simple guessing game with the user.

  public static void main (String[] args) {
    final int MAX = 10;
    int answer, guess;

    Scanner scan = new Scanner(System.in);
    Random generator = new Random();

    answer = generator.nextInt(MAX) + 1;
    continue
continue

System.out.print("I'm thinking of a number between 1 and " + MAX + ". Guess what it is: ");

guess = scan.nextInt();

if (guess == answer)
    System.out.println("You got it! Good guessing!");
else
{
    System.out.println("That is not correct, sorry.");
    System.out.println("The number was " + answer);
}
}
Sample Run

I'm thinking of a number between 1 and 10. Guess what it is: 6
That is not correct, sorry.
The number was 9

```java
if (guess == answer)
    System.out.println("You got it! Good guessing!");
else
{
    System.out.println("That is not correct, sorry.");
    System.out.println("The number was " + answer);
}
```
Nested if Statements

• The statement executed as a result of an if or else clause could be another if statement

• These are called nested if statements

• Example:

```java
if (age < 21)
    if (age > 2)
        System.out.println("age is larger than" + " 2 and smaller than 21");
```
Nested if Statements

- An `else` clause is **matched to the last unmatched if** (no matter what the indentation implies)

```java
if (age < 21)
    if (age > 2)
        System.out.println("age is larger than" +
                        " 2 and smaller than 21");
    else
        System.out.println("age is " +
                        "smaller than 21");

- Braces can be used to specify the `if` statement to which an `else` clause belongs.
Quiz

• What is printing the algorithm described in the flowchart below, given 3 numbers (A, B and C) as input:

```
START

READ A, B, C

IS B>C?

IS A>B?

IS A>C?

PRINT B

PRINT C

PRINT A

END
```
// Demonstrates the use of nested if statements.

import java.util.Scanner;

public class MinOfThree
{
    public static void main (String[] args)
    {
        int num1, num2, num3, min = 0;

        Scanner scan = new Scanner (System.in);

        System.out.println ("Enter three integers: ");
        num1 = scan.nextInt();
        num2 = scan.nextInt();
        num3 = scan.nextInt();

        continue
    }
}
continue

    if (num1 < num2)
        if (num1 < num3)
            min = num1;
        else  //matches the last unmatched if
            min = num3;
    else
        if (num2 < num3)
            min = num2;
        else
            min = num3;

    System.out.println("Minimum value: "+ min);
  }
}
```java
if (num1 < num2)
    if (num1 < num3)
        min = num1;
    else
        min = num3;
else
    if (num2 < num3)
        min = num2;
    else
        min = num3;

System.out.println("Minimum value: "+min);
```
Quiz

• What happens in the MinOfThree program if two or more of the values are equal? If exactly two of the values are equal, does it matter whether the equal values are lower or higher than the third?
Quiz

• What happens in the MinOfThree program if two or more of the values are equal? If exactly two of the values are equal, does it matter whether the equal values are lower or higher than the third?

If two or more values are equal, the program still prints the lowest value.
Quiz

• What output is produced by the following code fragment given the assumptions below

```java
if (num1 < num2)
    System.out.println("red ");
if ((num1 + 5) < num2)
    System.out.println("white ");
else
    System.out.println("blue ");
System.out.println("yellow ");
```

a) num1=2, num2=10  
b) num1=10, num2=2  
c) num1=2, num2=2
Quiz

• What output is produced by the following code fragment given the assumptions below

if (num1 < num2)
    System.out.println("red ");
if ((num1 + 5) < num2)
    System.out.println("white ");
else
    System.out.println("blue ");
System.out.println("yellow ");

a) num1=2, num2=10 → red white yellow
b) num1=10, num2=2 → blue yellow
c) num1=2, num2=2 → blue yellow
Outline

Boolean Expressions

The if Statement

Comparing Data

The while Statement

Iterators

The ArrayList Class

Determining Event Sources

Check Boxes and Radio Buttons
Comparing Data

• When comparing data using boolean expressions, it's important to understand the nuances of certain data types

• Let's examine some key situations:
  – Comparing floating point values for equality
  – Comparing characters
  – Comparing strings (alphabetical order)
  – Comparing object vs. comparing object references
Comparing Float Values

• You should rarely use the equality operator (==) when comparing two floating point values (float or double)

• Two floating point values are equal only if their underlying binary representations match exactly

• Computations often result in slight differences that may be irrelevant

• In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal
Comparing Float Values

• To determine the equality of two floats, use the following technique:

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

• If the difference between the two floating point values is less than the tolerance, they are considered to be equal

• The tolerance could be set to any appropriate level, such as 0.000001
Exercise

• Write a method called floatEquals that accepts three floating-point values as parameters. The method should return true if the first two parameters are equal within the tolerance of the third parameter.
public boolean floatEquals(double float1, double float2, double tolerance) {
    return (Math.abs(float1 - float2) <= tolerance);
}
Comparing Characters

• As we've discussed, Java character data is based on the Unicode character set

• Unicode establishes a particular **numeric value** for each character, and therefore an **ordering**

• We can use relational operators on character data based on this ordering (\(<\), \(>\), \(==\), \(>=\), \(<=\), \(!=\))

• For example, the character \('+\)' is less \(<\) than the character \('J'\) because it comes before it in the Unicode character set

• Appendix C provides an overview of Unicode
Comparing Characters

• In Unicode, the digit characters (0-9) are contiguous and in order

• Likewise, the uppercase letters (A-Z) and lowercase letters (a-z) are contiguous and in order

<table>
<thead>
<tr>
<th>Characters</th>
<th>Unicode Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 9</td>
<td>48 through 57</td>
</tr>
<tr>
<td>A – Z</td>
<td>65 through 90</td>
</tr>
<tr>
<td>a – z</td>
<td>97 through 122</td>
</tr>
</tbody>
</table>
Quiz

Is this snippet syntactically correct? If yes, what is going to be printed?

```java
if ('a' > 'b')
    System.out.println(true);
else
    System.out.println(false);
```
Quiz

Is this snippet syntactically correct? If yes, what is going to be printed?

```java
if ('a' > 'b')
    System.out.println(true);
else
    System.out.println(false);
```

YES it is correct and will print:
false
Comparing Objects

• The == operator can be applied to objects – it returns **true** if the two **references** are **aliases** of each other

• The **equals** method is defined for all objects, but unless we **redefine** it when we write a class, it has the **same semantics** as the == operator

• It has been **redefined** in the **String** class to compare the characters in the two strings

• When you write a class, you can redefine the **equals** method to return true under whatever conditions are appropriate
Exercise

• What this code is printing? Is printing always the same code (at every execution)?

Coin coin1, coin2, coin3;
coin1 = new Coin();
coin2 = coin1;
coin3 = new Coin();
System.out.println(coin1 == coin3);
System.out.println(coin1 == coin2);
Solution

• What this code is printing? Is printing always the same code (at every execution)?

Coin coin1, coin2, coin3;
coin1 = new Coin();
coin2 = coin1;
coin3 = new Coin();
System.out.println(coin1 == coin3);
System.out.println(coin1 == coin2);
false
true
Exercise

• Define a viable `equals` method for the class `Coin`
Exercise

• Define a viable `equals` method for the class `Coin`

```java
public boolean equals(Coin coin) {
    return face == coin.face;
}
```

Almost correct! See next slides.
Comparing Strings

• Remember that in Java a character string 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 `equals` method returns a boolean result

```java
if (name1.equals(name2))
    System.out.println("Same name");
```
Comparing Strings

• We cannot use the relational operators to compare strings ('<=' or '->')

• The String class contains the compareTo method for determining if one string comes before another – *but it returns an integer!*

• A call to `name1.compareTo(name2)`
  
  – returns zero if `name1` and `name2` are equal (contain the same characters)
  – returns a negative value if `name1` is less than `name2`
  – returns a positive value if `name1` is greater than `name2`
Comparing Strings

Because comparing characters and strings is based on a character set, it is called a *lexicographic ordering*

```java
int result = name1.compareTo(name2);
if (result < 0)
    System.out.println (name1 + " comes first");
else
    if (result == 0)
        System.out.println ("Same name");
    else
        System.out.println (name2 + " comes first");
```
Lexicographic Ordering

• Lexicographic ordering is not strictly alphabetical when uppercase and lowercase characters are mixed.

• For example, the string "Great" comes before the string "fantastic" because all of the uppercase letters come before all of the lowercase letters in Unicode.

• Also, short strings come before longer strings with the same prefix (lexicographically).

• Therefore "book" comes before "bookcase".
Quiz

• Write an `compareTo` method for the `Die` class of section 4.2

• A call to `die1.compareTo(die2)`
  – returns zero if `die1` and `die2` are equal (show the same face)
  – returns a negative value if the `faceValue` of `die1` is smaller than the `faceValue` of `die2`
  – returns a positive value in the other cases
Quiz

• Write an `compareTo` method for the `Die` class of section 4.2

• A call to `die1.compareTo(die2)`
  – returns zero if `die1` and `die2` are equal (show the same face)
  – returns a negative value if the `faceValue` of `die1` is smaller than the `faceValue` of `die2`
  – returns a positive value in the other cases

```java
public int compareTo(Die die) {
    return faceValue - die.faceValue;
}
```
Quiz

• Write an equals method for the Die class of section 4.2
Quiz

• Write an equals method for the Die class of section 4.2

```java
public boolean equals(Die die) {
    if (faceValue == die.faceValue)
        return true;
    return false;
}
```

```java
public boolean equals(Die die) {
    return (faceValue == die.faceValue);
}
```
Quiz

• Write an equals method for the Die class of section 4.2

• Actually the previous solutions are not OK because the parameter of equals must be of type Object

```java
public boolean equals(Object die) {
    if (die.getClass() == getClass())
        return faceValue == (((Die) die).faceValue);
    return false;
}
```
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Boolean Expressions
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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: *while, do, and for loops*

• The *do* and *for* loops are discussed in Chapter 6
The while Statement

• A *while statement* has the following syntax:

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

• If the *condition* is true, the *statement* is executed

• Then the condition is *evaluated again*, and if it is still true, the statement is *executed again*

• The statement is executed repeatedly until the condition becomes false
Logic of a while Loop

- Condition evaluated
- True
- False
- Statement
The while Statement

• An example of a while statement:

```java
int count = 1;
while (count <= 5) {
    System.out.println (count);
    count++;
}
```

• If the condition of a while loop is false initially, the statement is never executed

• Therefore, the body of a while loop will execute zero or more times
Sentinel Values

- Let's look at some examples of loop processing
- A loop can be used to maintain a *running sum*
- A *sentinel value* is a special input value that represents the end of input
- See *Average.java*
import java.text.DecimalFormat;
import java.util.Scanner;

public class Average
{
    public static void main (String[] args)
    {
        int sum = 0, value, count = 0;
        double average;

        Scanner scan = new Scanner (System.in);

        System.out.print ("Enter an integer (0 to quit): ");
        value = scan.nextInt();

        continue
    }
}
continue

```java
while (value != 0)  // sentinel value of 0 to terminate loop
{
    count++;  
    sum += value; 
    System.out.println("The sum so far is "+sum);

    System.out.print("Enter an integer (0 to quit): ");
    value = scan.nextInt();
}
```

continue
continue

    System.out.println ();

    if (count == 0)
        System.out.println ("No values were entered.");
    else
        {
            average = (double)sum / count;

            DecimalFormat fmt = new DecimalFormat ("0.###");
            System.out.println ("The average is " + fmt.format(average));
        }
    }
}
```
continue
System.out.println();
if (count == 0)
    System.out.println("No values were entered.");
else {
    average = (double)sum / count;
    DecimalFormat fmt = new DecimalFormat("0.###");
    System.out.println("The average is "+fmt.format(average));
}
```
Quiz

• Modify the code of the previous example so that 0 can be entered as any other integer, i.e., will not stop the input.

• Hint: use another non numeric "sentinel" and use hasNextInt() method of Scanner (it returns true if the input is an integer).
System.out.print("Enter an integer ("q" to quit): ");
while (scan.hasNextInt())
{
    value = scan.nextInt();
    count++;
    sum += value;
    System.out.println("The sum so far is " + sum);
    System.out.print("Enter an integer ("q" to quit): ");
}

Input Validation

• A loop can also be used for *input validation*, making a program more *robust*

• It's generally a good idea to verify that input is valid (in whatever sense) when possible

• See [WinPercentage.java](WinPercentage.java)
import java.text.NumberFormat;
import java.util.Scanner;

public class WinPercentage
{
    // Computes the percentage of games won by a team.
    public static void main (String[] args)
    {  
        final int NUM_GAMES = 12;
        int won;
        double ratio;

        Scanner scan = new Scanner (System.in);

        System.out.print ("Enter the number of games won (0 to "
                        + NUM_GAMES + "): ");
        won = scan.nextInt();
continue

while (won < 0 || won > NUM_GAMES)
{
    System.out.print("Invalid input. Please reenter: ");
    won = scan.nextInt();
}

ratio = (double)won / NUM_GAMES;

NumberFormat fmt = NumberFormat.getPercentInstance();

System.out.println();
System.out.println("Winning percentage: "+ fmt.format(ratio));
}
```java
while (won < 0 || won > NUM_GAMES) {
    System.out.print("Invalid input. Please reenter: ");
    won = scan.nextInt();
}
ratio = (double)won / NUM_GAMES;
NumberFormat fmt = NumberFormat.getPercentInstance();
System.out.println();
System.out.println("Winning percentage: "+fmt.format(ratio));
```
Exercise

• What output is produced by the following code fragment?

```java
int num = 1, max = 20;
while (num < max)
{
    if (num%2 == 0)
        System.out.println(num);
    num++;
}
```
What is going on here?

• An example of an "strange" loop:

```java
int count = 1;
while (count <= 25) {
    System.out.println (count);
    count = count - 1;
}
```

• This loop will continue executing until interrupted (Control-C) or until an underflow error occurs
Infinite Loops

• The body of a while loop eventually must make the condition false

• If not, it is called an infinite loop, which will execute until the user interrupts the program

• This is a common logical error

• You should always double check the logic of a program to ensure that your loops will terminate normally
Nested Loops

• Similar to nested `if` statements, loops can be nested as well
• That is, the body of a loop can contain another loop
• For each iteration of the outer loop, the inner loop iterates completely
• See `PalindromeTester.java`
//********************************************************************
//  PalindromeTester.java       Author: Lewis/Loftus
//
//  Demonstrates the use of nested while loops.
//********************************************************************

import java.util.Scanner;

public class PalindromeTester
{
    //-----------------------------------------------------------------
    //  Tests strings to see if they are palindromes.
    //-----------------------------------------------------------------
    public static void main (String[] args)
    {
        String str, another = "y";
        int left, right;

        Scanner scan = new Scanner (System.in);

        while (another.equalsIgnoreCase("y")) // allows y or Y
        {
            System.out.println ("Enter a potential palindrome:");
            str = scan.nextLine();

            left = 0;
            right = str.length() - 1;

            continue
        }
    }
}
```java
continue

while (str.charAt(left) == str.charAt(right) && left < right) {
    left++;
    right--;
}

System.out.println();

if (left < right) {
    System.out.println("That string is NOT a palindrome.");
} else {
    System.out.println("That string IS a palindrome.");
}

System.out.println();
System.out.print("Test another palindrome (y/n)? ");
another = scan.nextLine();
```
Sample Run

Enter a potential palindrome: radar

That string IS a palindrome.

Test another palindrome (y/n)? y
Enter a potential palindrome: able was I ere I saw elba

That string IS a palindrome.

Test another palindrome (y/n)? y
Enter a potential palindrome: abracadabra

That string is NOT a palindrome.

Test another palindrome (y/n)? n
Quick Check

How many times will the string "Here" be printed?

```java
count1 = 1;
while (count1 <= 10)
{
    count2 = 1;
    while (count2 < 20)
    {
        System.out.println ("Here");
        count2++;
    }
    count1++;
}
```
Quick Check

How many times will the string "Here" be printed?

count1 = 1;
while (count1 <= 10)
{
    count2 = 1;
    while (count2 < 20)
    {
        System.out.println ("Here");
        count2++;
    }
    count1++;
}

10 * 19 = 190
Quick Check

If x is an int where x = 1, what will x be after the following loop terminates?

```c
while (x < 100)
    x *= 2;
```
Quick Check

If x is an int where x = 1, what will x be after the following loop terminates?

```java
while (x < 100)
    x *= 2;
```

x=128
Outline

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Iterators

• An *iterator* is an object that allows you to process a collection of items one at a time

• It lets you step through each item in turn and process it as needed

• An iterator has a `hasNext` method that returns true if there is at least one more item to process

• The `next` method returns the next item

• Iterator objects are defined using the `Iterator` interface, which is discussed further in Chapter 7
Iterators

• Several classes in the Java standard class library are iterators

• The Scanner class is an iterator
  – the hasNext method returns true if there is more data to be scanned
  – the next method returns the next scanned token as a string

• The Scanner class also has variations on the hasNext method for specific data types (such as hasNextInt)
Iterators

• The fact that a Scanner is an iterator is particularly helpful when reading input from a file

• Suppose we wanted to read and process a list of URLs stored in a file

• One scanner can be set up to read each line of the input until the end of the file is encountered

• Another scanner can be set up for each URL to process each part of the path

• See URLDissector.java

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import java.util.Scanner;
import java.io.*;

public class URLDissector
{
    //-----------------------------------------------------------------
    // Reads urls from a file and prints their path components.
    //-----------------------------------------------------------------
    public static void main (String[] args) throws IOException
    {
        String url;
        Scanner fileScan, urlScan;

        fileScan = new Scanner(new File("urls.inp"));

        continue
continue

    // Read and process each line of the file
    while (fileScan.hasNext())
    {
        url = fileScan.nextLine();
        System.out.println("URL: " + url);

        urlScan = new Scanner(url);
        urlScan.useDelimiter("/");

        // Print each part of the url
        while (urlScan.hasNext())
            System.out.println("   " + urlScan.next());

        System.out.println();
    }
Sample Run

URL: www.google.com
    www.google.com

URL: www.linux.org/info/gnu.html
    www.linux.org
    info
    gnu.html

URL: thelyric.com/calendar/
    thelyric.com
    calendar

URL: www.cs.vt.edu/undergraduate/about
    www.cs.vt.edu
    undergraduate
    about

URL: youtube.com/watch?v=EHCRImwwRGLs
    youtube.com
    watch?v=EHCRImwwRGLs
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The ArrayList Class

- An ArrayList object stores a list of objects, and is often processed using a loop.

- The ArrayList class is part of the java.util package.

- You can reference each object in the list using a numeric index.

- An ArrayList object grows and shrinks as needed, adjusting its capacity as necessary.
The ArrayList Class

• Index values of an ArrayList begin at 0 (not 1):

  0   "Bashful"
  1   "Sleepy"
  2   "Happy"
  3   "Dopey"
  4   "Doc"

• Elements can be inserted and removed

• The indexes of the elements adjust accordingly
ArrayList Methods

• Some `ArrayList` methods:

  ```java
  boolean add (E obj)
  void add (int index, E obj)
  Object remove (int index)
  Object get (int index)
  boolean isEmpty()
  int size()
  ```
The ArrayList Class

• The type of object stored in the list is established when the `ArrayList` object is created:

```java
ArrayList<String> names = new ArrayList<String>();
ArrayList<Book> list = new ArrayList<Book>();
```

• This makes use of Java generics, which provide additional type checking at compile time

• An `ArrayList` object cannot store primitive types, but that's what wrapper classes are for

• See `Beatles.java`
import java.util.ArrayList;

public class Beatles
{
    public static void main (String[] args)
    {
        ArrayList<String> band = new ArrayList<String>();

        band.add ("Paul");
        band.add ("Pete");
        band.add ("John");
        band.add ("George");
    
    continue
}
System.out.println (band);
int location = band.indexOf ("Pete");
band.remove (location);

System.out.println (band);
System.out.println ("At index 1: " + band.get(1));
band.add (2, "Ringo");

System.out.println ("Size of the band: " + band.size());
int index = 0;
while (index < band.size())
{
    System.out.println (band.get(index));
    index++;
}
}
System.out.println (band);
int location = band.indexOf ("Pete");
band.remove (location);
System.out.println (band);
System.out.println ("At index 1: "+ band.get(1));
band.add (2, "Ringo");
System.out.println ("Size of the band: "+ band.size());
int index = 0;
while (index < band.size())
{
    System.out.println (band.get(index));
    index++;
}
}
Why Generics

• A generic type is a generic class or interface that is parameterized over types
• Stronger type checking
• Elimination of casting

```java
ArrayList list = new ArrayList();
list.add("hello");
String s = (String) list.get(0);

ArrayList<String> list = new ArrayList<String>();
list.add("hello");
String s = list.get(0); // no cast
```

• Enabling programmers to implement generic algorithms.
Example

• Here we do not use generic class

```java
public class Box {
    private Object object;

    public void set(Object newObject) {
        object = newObject;
    }

    public Object get() {
        return object;
    }
}
```

• Since its methods accept or return an Object, you are free to pass in whatever you want

• There is no way to verify, at compile time, how the class is used.
A Generic Version

• A *generic class* is defined with the following format:

```java
class name<T1, T2, ..., Tn> { /* ... */ }
```

- All occurrences of `Object` are replaced by `T`
- A type variable can be any non-primitive type you specify: any class type, any interface type, any array type, or even another type variable.

```java
public class Box<T> {
   // T stands for "Type"
   private T t;
   public void set(T tIn) {
      t = tIn; }
   public T get() {
      return t;
   }
}
```
Instantiating a Generic Class

• To create a parameterized type of `Box<T>`, you supply an actual type argument for the formal type parameter `T`:

  ```java
  Box<Integer> intBox = new Box<>();
  Box<String> strBox = new Box<String>();
  ```

• If the actual type argument is omitted, you create a raw type of `Box<T>`:

  ```java
  Box rawBox = new Box();
  ```

• `Box` is the raw type of the generic type `Box<T>`.
Assignment

• Raw types show up in legacy code because lots of API classes (such as the Collections classes) were not generic prior to JDK 5.0.

• For backward compatibility, assigning a parameterized type to its raw type is allowed:

```
Box<String> stringBox = new Box<>();
Box rawBox = stringBox; // OK
```

• But if you assign a raw type to a parameterized type, you get a warning:

```
Box rawBox = new Box();
    // rawBox is a raw type of Box<T>
Box<Integer> intBox = rawBox;
    // warning: unchecked conversion
```
Invoking Methods

• You also get a warning if you use a raw type to invoke generic methods defined in the corresponding generic type:

```java
Box<String> stringBox = new Box<>();
Box rawBox = stringBox;
rawBox.set(8);
// warning: unchecked invocation to set(T)
```
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Determining Event Sources

• Recall that interactive GUIs require establishing a relationship between components and the listeners that respond to component events

• One listener object can be used to listen to two different components

• The source of the event can be determined by using the `getSource` method of the event passed to the listener

• See `LeftRight.java`
• See `LeftRightPanel.java`
import javax.swing.JFrame;

public class LeftRight {
  //------------------------------------------------------------
  //  Creates the main program frame.
  //------------------------------------------------------------
  public static void main (String[] args) {
    JFrame frame = new JFrame ("Left Right");
    frame.setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);

    frame.getContentPane().add(new LeftRightPanel());

    frame.pack();
    frame.setVisible(true);
  }
}
import javax.swing.JFrame;

public class LeftRight {
    // Creates the main program frame.
    public static void main (String[] args) {
        JFrame frame = new JFrame ("Left Right");
        frame.setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);

        frame.getContentPane().add(new LeftRightPanel());

        frame.pack();
        frame.setVisible(true);
    }
}
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class LeftRightPanel extends JPanel {
    private JButton left, right;
    private JLabel label;
    private JPanel buttonPanel;

    continue
continue

// Constructor: Sets up the GUI.
// -----------------------------------------------------------------
public LeftRightPanel ()
{
  left = new JButton ("Left");
  right = new JButton ("Right");

  ButtonListener listener = new ButtonListener();
  left.addActionListener (listener);
  right.addActionListener (listener);

  label = new JLabel ("Push a button");

  buttonPanel = new JPanel();
  buttonPanel.setPreferredSize (new Dimension(200, 40));
  buttonPanel.setBackground (Color.blue);
  buttonPanel.add (left);
  buttonPanel.add (right);

  setPreferredSize (new Dimension(200, 80));
  setBackground (Color.cyan);
  add (label);
  add (buttonPanel);
}

continue
continue

//*****************************************************************
// Represents a listener for both buttons.
//*****************************************************************
private class ButtonListener implements ActionListener {
   //--------------
   // Determines which button was pressed and sets the label
   // text accordingly.
   //--------------
   public void actionPerformed (ActionEvent event) {
      if (event.getSource() == left)
         label.setText("Left");
      else
         label.setText("Right");
   }
}
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Check Boxes

- A check box is a button that can be toggled on or off
- It is represented by the JCheckBox class
- Unlike a push button, which generates an action event, a check box generates an ItemEvent whenever it changes state
- The ItemListener interface is used to define item event listeners
- A check box calls the itemStateChanged method of the listener when it is toggled

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Check Boxes

• Let's examine a program that uses check boxes to determine the style of a label's text string

• It uses the **Font** class, which embodies a character font's:
  – family name (such as Times or Courier)
  – style (bold, italic, or both)
  – font size

• See **StyleOptions.java**
• See **StyleOptionsPanel.java**
import javax.swing.JFrame;

public class StyleOptions {
    // Creates and presents the program frame.
    public static void main (String[] args) {
        JFrame frame = new JFrame ("Style Options");
        frame.setDefaultCloseOperation (JFrame.EXIT_ON_CLOSE);
        StyleOptionsPanel panel = new StyleOptionsPanel();
        frame.getContentPane().add (panel);
        frame.pack();
        frame.setVisible(true);
    }
}
import javax.swing.JFrame;

public class StyleOptions {

    // Creates and displays the program frame.

    public static void main(String[] args) {
        JFrame frame = new JFrame("Style Options");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        StyleOptionsPanel panel = new StyleOptionsPanel();
        frame.getContentPane().add(panel);
        frame.pack();
        frame.setVisible(true);
    }
}
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class StyleOptionsPanel extends JPanel
{
    private JLabel saying;
    private JCheckBox bold, italic;

    continue
// Sets up a panel with a label and some check boxes that control the style of the label's font.

public StyleOptionsPanel() {
    saying = new JLabel("Say it with style!");
    saying.setFont(new Font("Helvetica", Font.PLAIN, 36));

    bold = new JCheckBox("Bold");
    bold.setBackground(Color.cyan);
    italic = new JCheckBox("Italic");
    italic.setBackground(Color.cyan);

    StyleListener listener = new StyleListener();
    bold.addItemListener(listener);
    italic.addItemListener(listener);

    add(saying);
    add(bold);
    add(italic);

    setBackground(Color.cyan);
    setPreferredSize(new Dimension(300, 100));
}
private class StyleListener implements ItemListener
{

   public void itemStateChanged (ItemEvent event)
   {
      int style = Font.PLAIN;

      if (bold.isSelected())
         style = Font.BOLD;

      if (italic.isSelected())
         style += Font.ITALIC;

      saying.setFont (new Font ("Helvetica", style, 36));
   }
}
Radio Buttons

• A group of radio buttons represents a set of mutually exclusive options – only one can be selected at any given time.

• When a radio button from a group is selected, the button that is currently "on" in the group is automatically toggled off.

• To define the group of radio buttons that will work together, each radio button is added to a ButtonGroup object.

• A radio button generates an action event.
Radio Buttons

- Let's look at a program that uses radio buttons to determine which line of text to display

- See QuoteOptions.java
- See QuoteOptionsPanel.java
import javax.swing.JFrame;

public class QuoteOptions {
    // Creates and presents the program frame.
    public static void main (String[] args) {
        JFrame frame = new JFrame("Quote Options");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        QuoteOptionsPanel panel = new QuoteOptionsPanel();
        frame.getContentPane().add(panel);
        frame.pack();
        frame.setVisible(true);
    }
}
import javax.swing.JFrame;

public class QuoteOptions {
    // Creates and presents the program frame.
    public static void main(String[] args) {
        JFrame frame = new JFrame("Quote Options");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        QuoteOptionsPanel panel = new QuoteOptionsPanel();
        frame.getContentPane().add(panel);
        frame.pack();
        frame.setVisible(true);
    }
}
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class QuoteOptionsPanel extends JPanel {
    private JLabel quote;
    private JRadioButton comedy, philosophy, carpentry;
    private String comedyQuote, philosophyQuote, carpentryQuote;

    // Sets up a panel with a label and a set of radio buttons
    // that control its text.

    public QuoteOptionsPanel() {
        comedyQuote = "Take my wife, please.";
        philosophyQuote = "I think, therefore I am.";
        carpentryQuote = "Measure twice. Cut once.";

        quote = new JLabel (comedyQuote);
        quote.setFont (new Font ("Helvetica", Font.BOLD, 24));
continue

comedy = new JRadioButton ("Comedy", true);
comedy.setBackground (Color.green);
philosophy = new JRadioButton ("Philosophy");
philosophy.setBackground (Color.green);
carpentry = new JRadioButton ("Carpentry");
carpentry.setBackground (Color.green);

ButtonGroup group = new ButtonGroup();
group.add (comedy);
group.add (philosophy);
group.add (carpentry);

QuoteListener listener = new QuoteListener();
comedy.addActionListener (listener);
philosophy.addActionListener (listener);
carpentry.addActionListener (listener);

add (quote);
add (comedy);
add (philosophy);
add (carpentry);

setBackground (Color.green);
setPreferredSize (new Dimension(300, 100));
private class QuoteListener implements ActionListener
{
  // Sets the text of the label depending on which radio
  // button was pressed.
  public void actionPerformed (ActionEvent event)
  {
    Object source = event.getSource();

    if (source == comedy) 
      quote.setText (comedyQuote);
    else
      if (source == philosophy)
        quote.setText (philosophyQuote);
      else
        quote.setText (carpentryQuote);
  }
}
Summary

• Chapter 5 focused on:
  – boolean expressions
  – the if and if-else statements
  – comparing data
  – while loops
  – iterators
  – more drawing techniques
  – more GUI components
Exercises

• What is wrong with the following code fragment? Rewrite it so that it produces correct output.

```java
if (total == MAX)
if (total < sum)
    System.out.println("total == MAX and < sum.");
else
    System.out.println("total is not equal to MAX");
```

• What is wrong with the following code fragment? Will this code compile if it is part of an otherwise valid program? Explain.

```java
if (length = MIN_LENGTH)
    System.out.println("The length is minimal.");
```
Exercise

• What output is produced by the following code fragment?

```java
int limit = 100, num1 = 15, num2 = 40;
if (limit <= limit){
    if (num1 == num2)
        System.out.println("lemon");
    System.out.println("lime");
}
System.out.println("grape");
```

• What output is produced by the following code fragment?

```java
int num = 1, max = 20;
while (num < max) {
    System.out.println(num);
    num += 4;
}
```
Exercise

• Write a method called isAlpha that accepts a character parameter and returns true if that character is either an uppercase or lowercase alphabetic letter.
public boolean isAlpha (char ch)
{
    return ( (ch >= 'a' && ch <= 'z') ||
            (ch >= 'A' && ch <= 'Z') );
}
Exercises

• Write a method called `maxOfTwo` that accepts two integer parameters and returns the larger of the two.

• Write a method called `larger` that accepts two floating-point parameters (of type double) and returns true if the first parameter is greater than the second, and false otherwise.
Solution

public int maxOfTwo(int num1, int num2)
{
    int result = num1;
    if (num2 > num1)
        result = num2;
    return result;
}

public boolean larger(double num1, double num2)
{
    return (num1 > num2);
}
Exercise

- Suppose that the variables $a$, $b$, $c$, and $t$ are all of the same numeric primitive type. Show that the following code reassigns to $a$, $b$, and $c$ their original values but in ascending order:

```java
if (a > b) { t = a; a = b; b = t; }
if (a > c) { t = a; a = c; c = t; }
if (b > c) { t = b; b = c; c = t; }
```
Exercise

• Draw the flowchart of the Euclid’s algorithm for finding the GCD

**English-language description**

Compute the greatest common divisor of two nonnegative integers $p$ and $q$ as follows: If $q$ is 0, the answer is $p$. If not, divide $p$ by $q$ and take the remainder $r$. The answer is the greatest common divisor of $q$ and $r$.

**Java-language description**

```java
public static int gcd(int p, int q) {
    if (q == 0) return p;
    int r = p % q;
    return gcd(q, r);
}
```

Euclid’s algorithm
Solution

1. Start
2. Read a, b
3. c = b
4. b = a % b
5. a = c
6. If b ≠ 0 then:
   - True: Print a
   - False: Stop
Exercise

• Write a Flight class that describes a flight of an airline, for a particular type of airplane, from an origin to a destination and a distance (int)
• Write an appropriate constructor (sets all the instance data)
• Write a method that compute the time of the flight in hours:mins (String) of the flight depending on the distance and the airplane type (Fast, 1000km/h, Slow 600 km/h)
• Write a FlightTest class that creates three flights and print their flight times (implement a toString method for the class Flight).
public class Flight {
    private String airline, origin, destination, type;
    private int flightNumber, distance, speed;

    public Flight(String airlineInit, String originInit, String destinationInit, int flightNumberInit, String typeInit, int distanceInit) {
        airline = airlineInit;
        origin = originInit;
        destination = destinationInit;
        flightNumber = flightNumberInit;
        distance = distanceInit;
        type = typeInit;
        if (type.equals("fast"))
            speed = 1000;
        else if (type.equals("slow"))
            speed = 600;
        else
            speed = 800;
    }

    public String timeFlight() {
        return "" + distance / speed + ":" + (int)((double)(distance % speed) / speed) * 60;
    }
}
public class FlightTest {

    public static void main(String[] args) {
        Flight f2 = new Flight("Delta", "Philadelphia", "London", 212, "slow", 5000);
        Flight f3 = new Flight("Continental", "Atlanta", "Chicago", 822, "average", 750);

        System.out.println(f1);
        System.out.println(f2);
        System.out.println(f3);
    }
}