2b

Control Statements: Part 1

OBJECTIVES

In this lecture you will learn:

- To use basic problem-solving techniques.
- To develop algorithms through the process of top-down, stepwise refinement.
- To use the `if` and `if…else` selection statements to choose among alternative actions.
- To use the `while` repetition statement to execute statements in a program repeatedly.
- To use counter-controlled repetition and sentinel-controlled repetition.
- To use the assignment, increment and decrement operators.
- The primitive data types.

Outline

2b.2 Algorithms

- **Algorithms**
  - **The actions to execute**
  - **The order in which these actions execute**
- **Program control**
  - **Specifies the order in which actions execute in a program**

2b.3 Pseudocode

- **Pseudocode**
  - **An informal language similar to English**
  - **Helps programmers develop algorithms**
  - **Does not run on computers**
  - **Should contain input, output and calculation actions**
  - **Should not contain variable declarations**

2b.4 Control Structures

- **Sequential execution**
  - **Statements are normally executed one after the other in the order in which they are written**
- **Transfer of control**
  - **Specifying the next statement to execute that is not necessarily the next one in order**
  - **Can be performed by the `goto` statement**
    - **Structured programming eliminated `goto` statements**

2b.4 Control Structures (Cont.)

- **Bohm and Jacopini's research**
  - **Demonstrated that `goto` statements were unnecessary**
  - **Demonstrated that all programs could be written with three control structures**
    - **The sequence structure,**
    - **The selection structure and**
    - **The repetition structure**

2b.4 Control Structures (Cont.)

- **UML activity diagram (www.uml.org)**
  - **Models the workflow (or activity) of a part of a software system**
  - **Action-state symbols (rectangles with their sides replaced with outward-curving arcs)**
    - **represent action expressions specifying actions to perform**
  - **Diamonds**
    - **Decision symbols (explained in Section 2b.5)**
    - **Merge symbols (explained in Section 2b.7)**

2b.4 Control Structures (Cont.)

- **Small circles**
  - **Solid circle represents the activity's initial state**
  - **Solid circle surrounded by a hollow circle represents the activity's final state**
- **Transition arrows**
  - **Indicate the order in which actions are performed**
- **Notes (rectangles with the upper-right corners folded over)**
  - **Explain the purposes of symbols (like comments in Java)**
  - **Are connected to the symbols they describe by dotted lines**

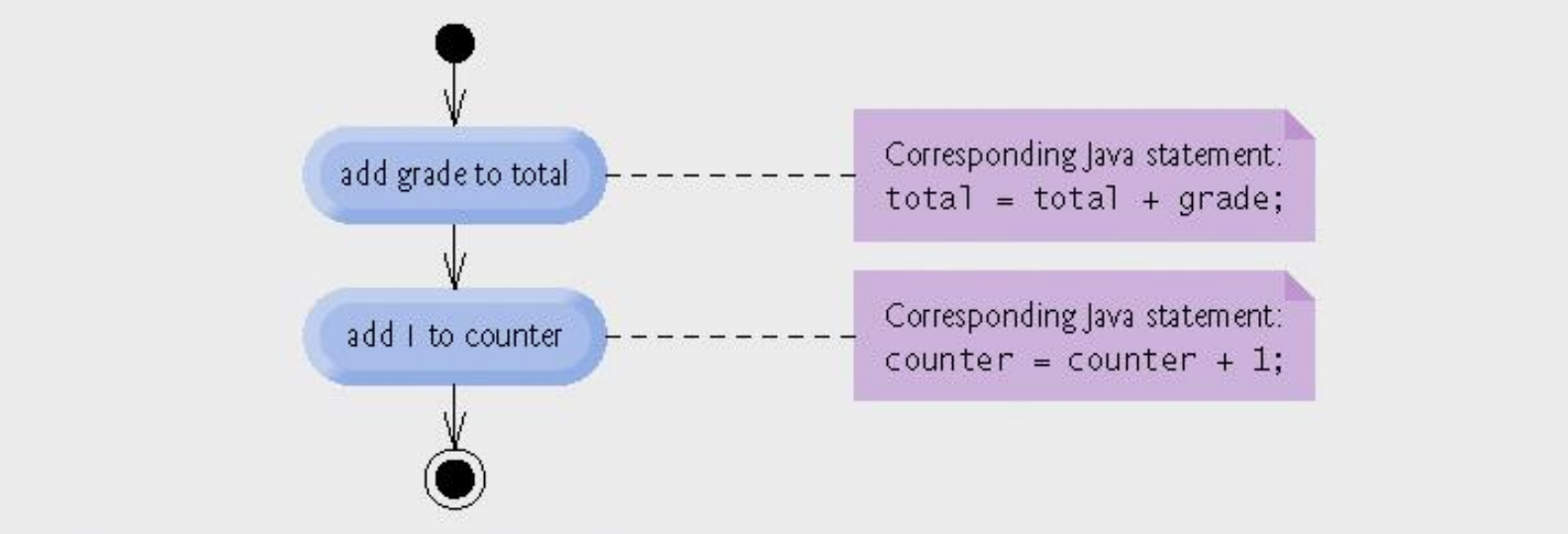

Fig. 2b.1 | Sequence structure activity diagram.

2b.4 Control Structures (Cont.)

- **Selection Statements**
  - **`if` statement**
    - **Single-selection statement**
  - **`if`...`else` statement**
    - **Double-selection statement**
  - **`switch` statement**
    - **Multiple-selection statement**

2b.4 Control Structures (Cont.)

- **Repetition statements**
  - **Also known as looping statements**
  - **Repeatedly performs an action while its loop-continuation condition remains true**
  - **`while` statement**
    - **Performs the actions in its body zero or more times**
  - **`do`...`while` statement**
    - **Performs the actions in its body one or more times**
  - **`for` statement**
    - **Performs the actions in its body zero or more times**

2b.4 Control Structures (Cont.)

- **Java has three kinds of control structures**
  - **Sequence statement,**
  - **Selection statements (three types) and**
  - **Repetition statements (three types)**
  - **All programs are composed of these control statements**
    - **Control-statement stacking**
      - **All control statements are single-entry/single-exit**
    - **Control-statement nesting**

2b.5 `if` Single-Selection Statement

- **`if` statements**
  - **Execute an action if the specified condition is `true`**
  - **Can be represented by a decision symbol (diamond) in a UML activity diagram**
    - **Transition arrows out of a decision symbol have guard conditions**
      - **Workflow follows the transition arrow whose guard condition is true**

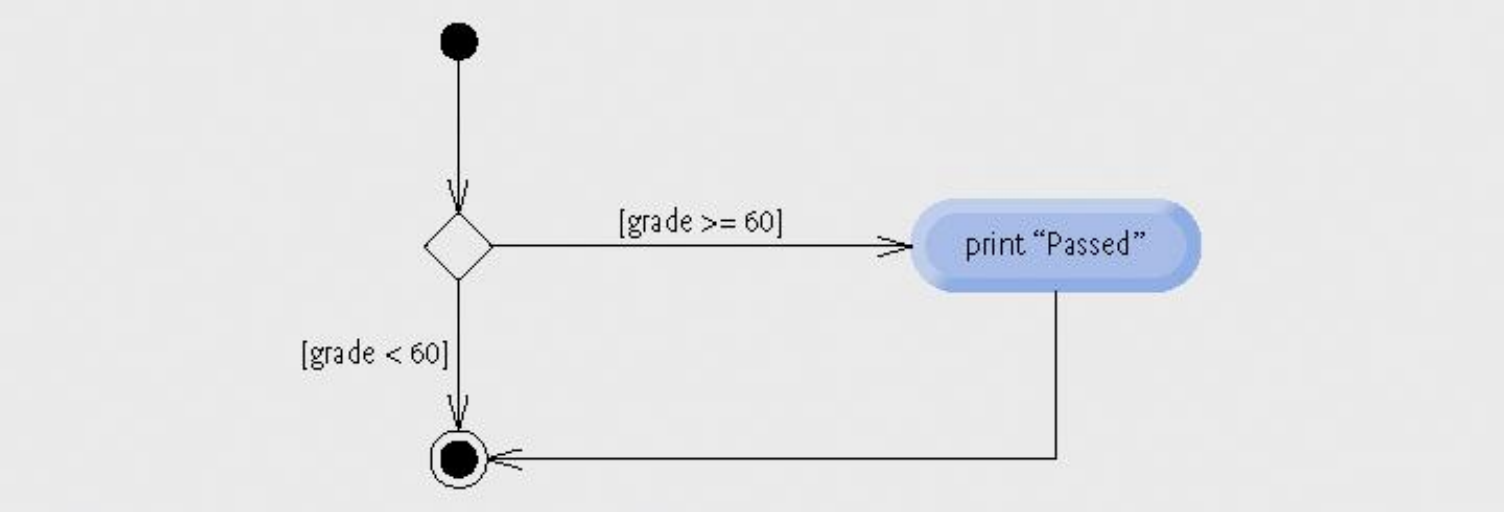

Fig. 2b.2 | `if` single-selection statement UML activity diagram.

2b.6 `if…else` Double-Selection Statement

- **`if…else` statement**
  - **Executes one action if the specified condition is `true` or a different action if the specified condition is `false`**
- **Conditional Operator (`? :`)**
  - **Java's only ternary operator (takes three operands)**
  - **`? :` and its three operands form a conditional expression**
    - **Entire conditional expression evaluates to the second operand if the first operand is `true`**
    - **Entire conditional expression evaluates to the third operand if the first operand is `false`**

Good Programming Practice 2b.1

Indent both body statements of an `if…else` statement.

Good Programming Practice 2b.2

If there are several levels of indentation, each level should be indented the same additional amount of space.

Good Programming Practice 2b.3

Conditional expressions are more difficult to read than `if…else` statements and should be used to replace only simple `if…else` statements that choose between two values.

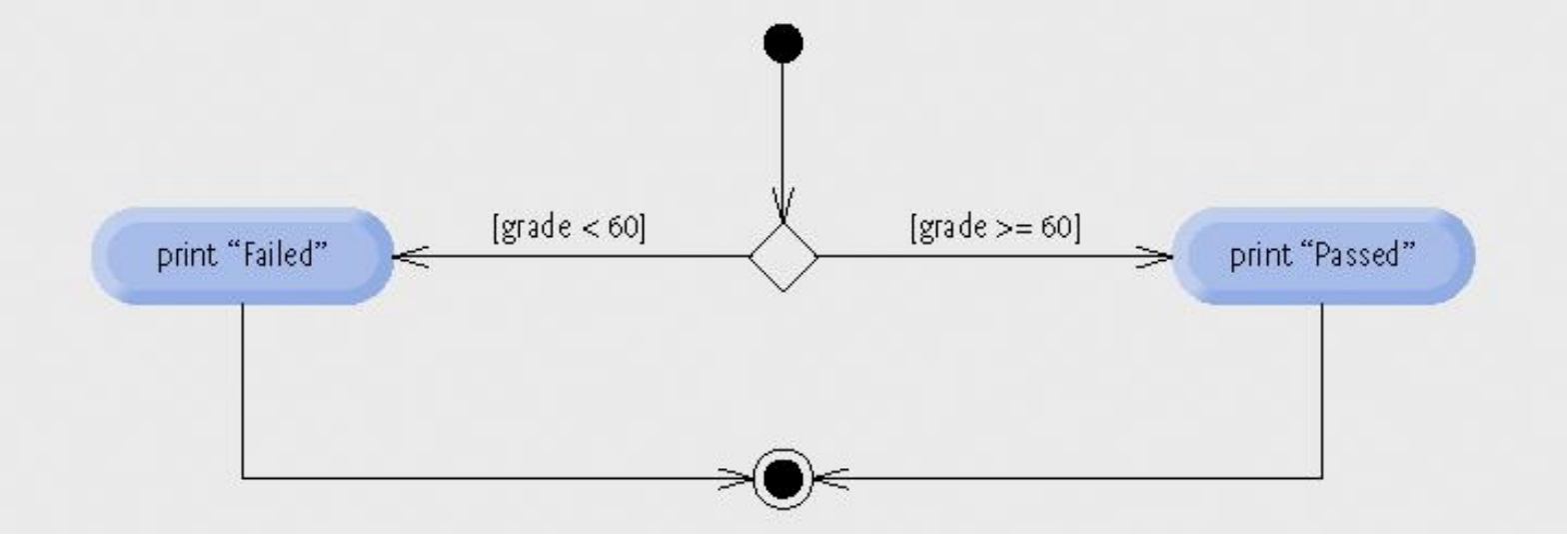

Fig. 2b.3 | `if`…else double-selection statement UML activity diagram.

2b.6 `if`…`else` Double-Selection Statement (Cont.)

- **Nested `if`…`else` statements**
  - **`if`…`else` statements can be put inside other `if`…`else` statements**
- **Dangling-`else` problem**
  - **`else`s are always associated with the immediately preceding `if` unless otherwise specified by braces `{ }`**
- **Blocks**
  - **Braces `{ }` associate statements into blocks**
  - **Blocks can replace individual statements as an `if` body**

2b.6 `if…else` Double-Selection Statement (Cont.)

- **Logic errors**
  - **Fatal logic errors cause a program to fail and terminate prematurely**
  - **Nonfatal logic errors cause a program to produce incorrect results**
- **Empty statements**
  - **Represented by placing a semicolon (`;`) where a statement would normally be**
  - **Can be used as an `if` body**

Common Programming Error 2b.1

Forgetting one or both of the braces that delimit a block can lead to syntax errors or logic errors in a program.

Good Programming Practice 2b.4

Always using braces in an `if...else` (or other) statement helps prevent their accidental omission, especially when adding statements to the `if`-part or the `else`-part at a later time. To avoid omitting one or both of the braces, some programmers type the beginning and ending braces of blocks before typing the individual statements within the braces.

Common Programming Error 2b.2

Placing a semicolon after the condition in an `if` or `if...else` statement leads to a logic error in single-selection `if` statements and a syntax error in double-selection `if...else` statements (when the `if`-part contains an actual body statement).

2b.7 `while` Repetition Statement

- **`while` statement**
  - **Repeats an action while its loop-continuation condition remains true**
  - **Uses a merge symbol in its UML activity diagram**
    - **Merges two or more workflows**
    - **Represented by a diamond (like decision symbols) but has:**
      - **Multiple incoming transition arrows,**
      - **Only one outgoing transition arrow and**
      - **No guard conditions on any transition arrows**

Common Programming Error 2b.3

Not providing, in the body of a `while` statement, an action that eventually causes the condition in the `while` to become false normally results in a logic error called an *infinite loop*, in which the loop never terminates.

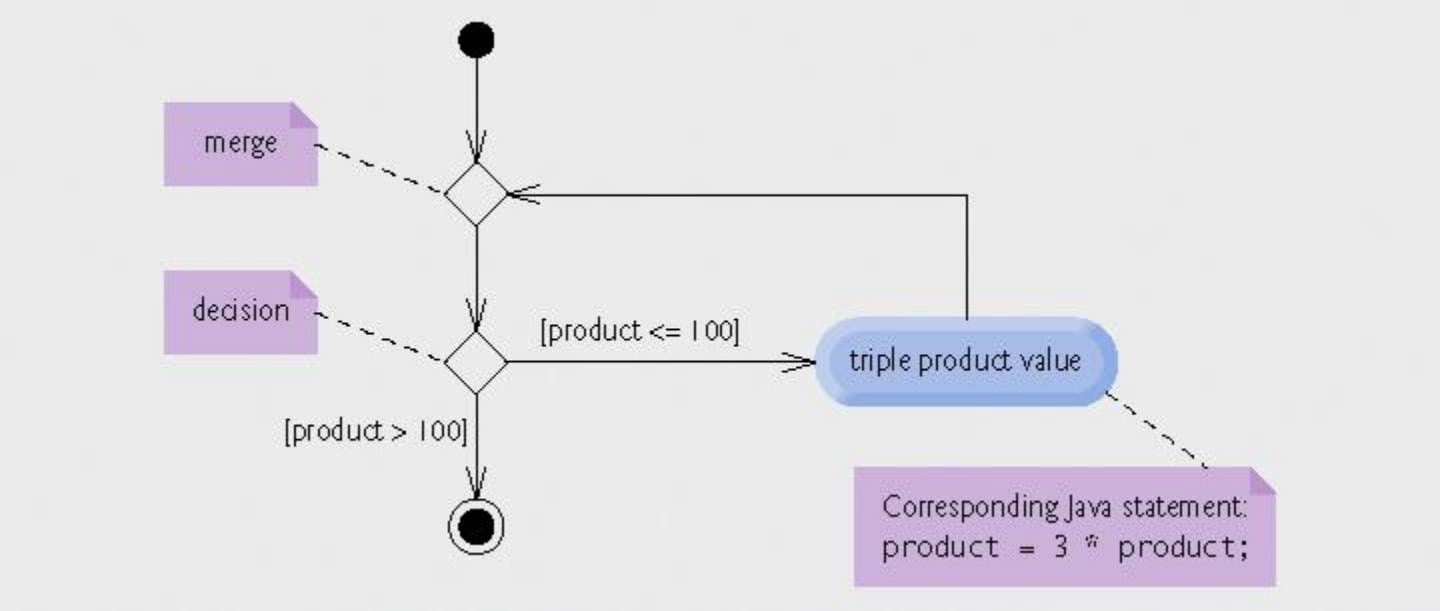

Fig. 2b.4 | `while` repetition statement UML activity diagram.

2b.8 Formulating Algorithms: Counter-Controlled Repetition

- **Counter-controlled repetition**
  - **Use a counter variable to count the number of times a loop is iterated**
- **Integer division**
  - **The fractional part of an integer division calculation is truncated (thrown away)**

```
1     Set total to zero
2     Set grade counter to one
3
4     While grade counter is less than or equal to ten
5         Prompt the user to enter the next grade
6         Input the next grade
7         Add the grade into the total
8         Add one to the grade counter
9
10    Set the class average to the total divided by ten
11    Print the class average
```

Fig. 2b.5 | Pseudocode algorithm that uses counter-controlled repetition to solve the class-average problem.

```java
// Fig. 4.6: GradeBook.java
// GradeBook class that solves class-average problem using
// counter-controlled repetition.
import java.util.Scanner; // program uses class Scanner

public class GradeBook
{
   private String courseName; // name of course this GradeBook represents

   // constructor initializes courseName
   public GradeBook( String name )
   {
      courseName = name; // initializes courseName
   } // end constructor

   // method to set the course name
   public void setCourseName( String name )
   {
      courseName = name; // store the course name
   } // end method setCourseName

   // method to retrieve the course name
   public String getCourseName()
   {
      return courseName;
   } // end method getCourseName

```

•GradeBook.java
(1 of 3)

Assign a value to instance variable **courseName**

Declare method **setCourseName**

Declare method **getCourseName**

```
28    // display a welcome message to the GradeBook user
29    public void displayMessage()
30    {
31       // getCourseName gets the name of the course
32       System.out.printf( "Welcome to the grade book for\n%s!\n\n",
33          getCourseName() );
34    } // end method displayMessage
35
36    // determine class average based on 10 grades entered by user
37    public void determineClassAverage()
38    {
39       // create Scanner to obtain input from command window
40       Scanner input = new Scanner( System.in );
41
42       int total; // sum of grades entered by user
43       int gradeCounter; // number of the grade to be entered next
44       int grade; // grade value entered by user
45       int average; // average of grades
46
47       // initialization phase
48       total = 0; // initialize total
49       gradeCounter = 1; // initialize loop counter
50
```

Declare method **`displayMessage`**

Declare method **`determineClassAverage`**

Declare and initialize **`Scanner`** variable **`input`**

Declare local **`int`** variables **`total`**, **`gradeCounter`**, **`grade`** and **`average`**

•GradeBook.java
(2 of 3)

```
51       // processing phase
52       while ( gradeCounter <= 10 ) // loop 10 times
53       {
54          System.out.print( "Enter grade: " ); // prompt
55          grade = input.nextInt(); // input next grade
56          total = total + grade; // add grade to total
57          gradeCounter = gradeCounter + 1; // increment counter by 1
58       } // end while
59
60       // termination phase
61       average = total / 10; // integer division yields integer result
62
63       // display total and average of grades
64       System.out.printf( "\nTotal of all 10 grades is %d\n", total );
65       System.out.printf( "Class average is %d\n", average );
66    } // end method determineClassAverage
67
68 } // end class GradeBook
```

`while` loop iterates as long as **`gradeCounter <= 10`**

Increment the counter variable **`gradeCounter`**

Calculate average grade

Display results

•GradeBook.java
(3 of 3)

Good Programming Practice 2b.5

Separate declarations from other statements in methods with a blank line for readability.

Software Engineering Observation 2b.1

Experience has shown that the most difficult part of solving a problem on a computer is developing the algorithm for the solution. Once a correct algorithm has been specified, the process of producing a working Java program from the algorithm is normally straightforward.

Common Programming Error 2b.4

Using the value of a local variable before it is initialized results in a compilation error. All local variables must be initialized before their values are used in expressions.

Error-Prevention Tip 2b.1

Initialize each counter and total, either in its declaration or in an assignment statement. Totals are normally initialized to 0. Counters are normally initialized to 0 or 1, depending on how they are used (we will show examples of when to use 0 and when to use 1).

•GradeBook Test.java

```
1  // Fig. 4.7: GradeBookTest.java
2  // Create GradeBook object and invoke its determineClassAverage method.
3
4  public class GradeBookTest
5  {
6     public static void main( String args[] )
7     {
8        // create GradeBook object myGradeBook and
9        // pass course name to constructor
10       GradeBook myGradeBook = new GradeBook(
11          "CS101 Introduction to Java Programming" );
12
13       myGradeBook.displayMessage(); // display welcome message
14       myGradeBook.determineClassAverage(); // find average of 10 grades
15    } // end main
16
17 } // end class GradeBookTest
```

Create a new **GradeBook** object

Pass the course's name to the **GradeBook** constructor as a **string**

Call **GradeBook**'s **determineClassAverage** method

```
Welcome to the grade book for
CS101 Introduction to Java Programming!

Enter grade: 67
Enter grade: 78
Enter grade: 89
Enter grade: 67
Enter grade: 87
Enter grade: 98
Enter grade: 93
Enter grade: 85
Enter grade: 82
Enter grade: 100

Total of all 10 grades is 846
Class average is 84
```

Common Programming Error 2b.5

Assuming that integer division rounds (rather than truncates) can lead to incorrect results. For example, 7 ÷ 4, which yields 1.75 in conventional arithmetic, truncates to 1 in integer arithmetic, rather than rounding to 2.

2b.9 Formulating Algorithms: Sentinel-Controlled Repetition

- **Sentinel-controlled repetition**
  - **Also known as indefinite repetition**
  - **Use a sentinel value (also known as a signal, dummy or flag value)**
    - **A sentinel value cannot also be a valid input value**

2b.9 Formulating Algorithms: Sentinel-Controlled Repetition (Cont.)

- **Top-down, stepwise refinement**
  - **Top: a single statement that conveys the overall function of the program**
  - **First refinement: multiple statements using only the sequence structure**
  - **Second refinement: commit to specific variables, use specific control structures**

Common Programming Error 2b.6

Choosing a sentinel value that is also a legitimate data value is a logic error.

Software Engineering Observation 2b.2

Each refinement, as well as the top itself, is a complete specification of the algorithm—only the level of detail varies.

Software Engineering Observation 2b.3

Many programs can be divided logically into three phases: an initialization phase that initializes the variables; a processing phase that inputs data values and adjusts program variables (e.g., counters and totals) accordingly; and a termination phase that calculates and outputs the final results.

Error-Prevention Tip 2b.2

When performing division by an expression whose value could be zero, explicitly test for this possibility and handle it appropriately in your program (e.g., by printing an error message) rather than allow the error to occur

```
1     Initialize total to zero
2     Initialize counter to zero
3
4     Prompt the user to enter the first grade
5     Input the first grade (possibly the sentinel)
6
7     While the user has not yet entered the sentinel
8         Add this grade into the running total
9         Add one to the grade counter
10        Prompt the user to enter the next grade
11        Input the next grade (possibly the sentinel)
12
13    If the counter is not equal to zero
14        Set the average to the total divided by the counter
15        Print the average
16    else
17        Print "No grades were entered"
```

Fig. 2b.8 | Class-average problem pseudocode algorithm with sentinel-controlled repetition.

Software Engineering Observation 2b.4

Terminate the top-down, stepwise refinement process when you have specified the pseudocode algorithm in sufficient detail for you to convert the pseudocode to Java. Normally, implementing the Java program is then straightforward.

Software Engineering Observation 2b.5

Some experienced programmers write programs without ever using program-development tools like pseudocode. They feel that their ultimate goal is to solve the problem on a computer and that writing pseudocode merely delays the production of final outputs. Although this method may work for simple and familiar problems, it can lead to serious errors and delays in large, complex projects.

```java
// Fig. 4.9: GradeBook.java
// GradeBook class that solves class-average program using
// sentinel-controlled repetition.
import java.util.Scanner; // program uses class Scanner

public class GradeBook
{
   private String courseName; // name of course this GradeBook represents

   // constructor initializes courseName
   public GradeBook( String name )
   {
      courseName = name; // initializes courseName
   } // end constructor

   // method to set the course name
   public void setCourseName( String name )
   {
      courseName = name; // store the course name
   } // end method setCourseName

   // method to retrieve the course name
   public String getCourseName()
   {
      return courseName;
   } // end method getCourseName

```

•GradeBook.java
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Assign a value to instance variable **courseName**

Declare method **setCourseName**

Declare method **getCourseName**

```
28    // display a welcome message to the GradeBook user
29    public void displayMessage()
30    {
31       // getCourseName gets the name of the course
32       System.out.printf( "Welcome to the grade book for\n%s!\n\n",
33          getCourseName() );
34    } // end method displayMessage
35
36    // determine the average of an arbitrary number of grades
37    public void determineClassAverage()
38    {
39       // create Scanner to obtain input from command window
40       Scanner input = new Scanner( System.in );
41
42       int total; // sum of grades
43       int gradeCounter; // number of grades entered
44       int grade; // grade value
45       double average; // number with decimal point for average
46
47       // initialization phase
48       total = 0; // initialize total
49       gradeCounter = 0; // initialize loop counter
50
51       // processing phase
52       // prompt for input and read grade from user
53       System.out.print( "Enter grade or -1 to quit: " );
54       grade = input.nextInt();
55
```

Declare method **displayMessage**

Declare method **determineClassAverage**

Declare and initialize **Scanner** variable **input**

Declare local **int** variables **total**, **gradeCounter** and **grade** and **double** variable **average**

•GradeBook.java
(2 of 3)

```
56       // loop until sentinel value read from user
57       while ( grade != -1 )
58       {
59          total = total + grade; // add grade to total
60          gradeCounter = gradeCounter + 1; // increment counter
61
62          // prompt for input and read next grade from user
63          System.out.print( "Enter grade or -1 to quit: " );
64          grade = input.nextInt();
65       } // end while
66
67       // termination phase
68       // if user entered at least one grade...
69       if ( gradeCounter != 0 )
70       {
71          // calculate average of all grades entered
72          average = (double) total / gradeCounter;
73
74          // display total and average (with two digits of precision)
75          System.out.printf( "\nTotal of the %d grades entered is %d\n",
76             gradeCounter, total );
77          System.out.printf( "Class average is %.2f\n", average );
78       } // end if
79       else // no grades were entered, so output appropriate message
80          System.out.println( "No grades were entered" );
81    } // end method determineClassAverage
82
83 } // end class GradeBook
```

`while` loop iterates as long as **`grade !=`** the sentinel value, **`-1`**

•GradeBook.java
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Calculate average grade using **`(double)`** to perform explicit conversion

Display average grade

Display **"No grades were entered"** message

Good Programming Practice 2b.6

In a sentinel-controlled loop, the prompts requesting data entry should explicitly remind the user of the sentinel value.

Common Programming Error 2b.7

Omitting the braces that delimit a block can lead to logic errors, such as infinite loops. To prevent this problem, some programmers enclose the body of every control statement in braces even if the body contains only a single statement.

2b.9 Formulating Algorithms: Sentinel-Controlled Repetition (Cont.)

- **Unary cast operator**
  - **Creates a temporary copy of its operand with a different data type**
    - **example: `(double)` will create a temporary floating-point copy of its operand**
  - **Explicit conversion**
- **Promotion**
  - **Converting a value (e.g. `int`) to another data type (e.g. `double`) to perform a calculation**
  - **Implicit conversion**

Common Programming Error 2b.8

The cast operator can be used to convert between primitive numeric types, such as `int` and `double`, and between related reference types (as we discuss in Chapter 10, Object-Oriented Programming: Polymorphism). Casting to the wrong type may cause compilation errors or runtime errors.

```
1  // Fig. 4.10: GradeBookTest.java
2  // Create GradeBook object and invoke its determineClassAverage method.
3
4  public class GradeBookTest
5  {
6     public static void main( String args[] )
7     {
8        // create GradeBook object myGradeBook and
9        // pass course name to constructor
10       GradeBook myGradeBook = new GradeBook(
11          "CS101 Introduction to Java Programming" );
12
13       myGradeBook.displayMessage(); // display welcome message
14       myGradeBook.determineClassAverage(); // find average of grades
15    } // end main
16
17 } // end class GradeBookTest
```

```
Welcome to the grade book for
CS101 Introduction to Java Programming!

Enter grade or -1 to quit: 97
Enter grade or -1 to quit: 88
Enter grade or -1 to quit: 72
Enter grade or -1 to quit: -1

Total of the 3 grades entered is 257
Class average is 85.67
```

Create a new **GradeBook** object

Pass the course's name to the **GradeBook** constructor as a **string**

Call **GradeBook**'s **determineClassAverage** method

•GradeBookTest.java

2b.10 Formulating Algorithms: Nested Control Statements

- **Control statements can be nested within one another**
  - **Place one control statement inside the body of the other**

```
1  Initialize passes to zero
2  Initialize failures to zero
3  Initialize student counter to one
4
5  While student counter is less than or equal to 10
6     Prompt the user to enter the next exam result
7     Input the next exam result
8
9     If the student passed
10       Add one to passes
11    Else
12       Add one to failures
13
14    Add one to student counter
15
16 Print the number of passes
17 Print the number of failures
18
19 If more than eight students passed
20    Print "Raise tuition"
```

Fig. 2b.11 | Pseudocode for examination-results problem.

```
1  // Fig. 4.12: Analysis.java
2  // Analysis of examination results.
3  import java.util.Scanner; // class uses class Scanner
4
5  public class Analysis
6  {
7     public void processExamResults
8     {
9        // create Scanner to obtain input from command window
10       Scanner input = new Scanner( System.in );
11
12       // initializing variables in declarations
13       int passes = 0; // number of passes
14       int failures = 0; // number of failures
15       int studentCounter = 1; // student counter
16       int result; // one exam result (obtains value from user)
17
18       // process 10 students using counter-controlled loop
19       while ( studentCounter <= 10 )
20       {
21          // prompt user for input and obtain value from user
22          System.out.print( "Enter result (1 = pass, 2 = fail): " );
23          result = input.nextInt();
24
```

Declare **`processExamResults`**' local variables

`while` loop iterates as long as **`studentCounter <= 10`**

- **Analysis.java** (1 of 2)

```
25          // if...else nested in while
26          if ( result == 1 )          // if result 1,
27             passes = passes + 1;     // increment passes;
28          else                        // else result is not 1, so
29             failures = failures + 1; // increment failures
30
31          // increment studentCounter so loop eventually terminates
32          studentCounter = studentCounter + 1;
33       } // end while
34
35       // termination phase; prepare and display results
36       System.out.printf( "Passed: %d\nFailed: %d\n", passes, failures );
37
38       // determine whether more than 8 students passed
39       if ( passes > 8 )
40          System.out.println( "Raise Tuition" );
41    } // end method processExamResults
42
43 } // end class Analysis
```

Determine whether this student passed or failed and increment the appropriate variable

Determine whether more than eight students passed the exam

•Analysis.java
(2 of 2)

Error-Prevention Tip 2b.3

Initializing local variables when they are declared helps the programmer avoid any compilation errors that might arise from attempts to use uninitialized data. While Java does not require that local variable initializations be incorporated into declarations, it does require that local variables be initialized before their values are used in an expression.

```
1  // Fig. 4.13: AnalysisTest.java
2  // Test program for class Analysis.
3
4  public class AnalysisTest
5  {
6     public static void main( String args[] )
7     {
8        Analysis application = new Analysis(); // create Analysis object
9        application.processExamResults(); // call method to process results
10    } // end main
11
12 } // end class AnalysisTest
```

Create an Analysis object

•**AnalysisTest.java**

```
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 2
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Passed: 9
Failed: 1
Raise Tuition
```

More than 8 students passed the exam

```
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 2
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 2
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 2
Enter result (1 = pass, 2 = fail): 2
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Passed: 6
Failed: 4
```

2b.11 Compound Assignment Operators

- **Compound assignment operators**
  - **An assignment statement of the form:**
    variable = variable operator expression ;
    where *operator* is `+`, `-`, `*`, `/` or `%` can be written as:
    variable operator= expression ;
  - **example: `c = c + 3 ;` can be written as `c += 3 ;`**
    - **This statement adds `3` to the value in variable `c` and stores the result in variable `c`**

Assignment operator	Sample expression	Explanation	Assigns
Assume: `int c = 3, d = 5, e = 4, f = 6, g = 12;`			
`+=`	`c += 7`	`c = c + 7`	10 to `c`
`-=`	`d -= 4`	`d = d - 4`	1 to `d`
`*=`	`e *= 5`	`e = e * 5`	20 to `e`
`/=`	`f /= 3`	`f = f / 3`	2 to `f`
`%=`	`g %= 9`	`g = g % 9`	3 to `g`

Fig. 2b.14 | Arithmetic compound assignment operators.

2b.12 Increment and Decrement Operators

- **Unary increment and decrement operators**
  - **Unary increment operator (++) adds one to its operand**
  - **Unary decrement operator (−−) subtracts one from its operand**
  - **Prefix increment (and decrement) operator**
    - **Changes the value of its operand, then uses the new value of the operand in the expression in which the operation appears**
  - **Postfix increment (and decrement) operator**
    - **Uses the current value of its operand in the expression in which the operation appears, then changes the value of the operand**

Good Programming Practice 2b.7

Unlike binary operators, the unary increment and decrement operators should be placed next to their operands, with no intervening spaces.

Operator	Called	Sample expression	Explanation
++	prefix increment	++a	Increment a by 1, then use the new value of a in the expression in which a resides.
++	postfix increment	a++	Use the current value of a in the expression in which a resides, then increment a by 1.
--	prefix decrement	--b	Decrement b by 1, then use the new value of b in the expression in which b resides.
--	postfix decrement	b--	Use the current value of b in the expression in which b resides, then decrement b by 1.

Fig. 2b.15 | Increment and decrement operators.

```
1  // Fig. 4.16: Increment.java
2  // Prefix increment and postfix increment operators.
3
4  public class Increment
5  {
6     public static void main( String args[] )
7     {
8        int c;
9
10       // demonstrate postfix increment operator
11       c = 5; // assign 5 to c
12       System.out.println( c );   // print 5
13       System.out.println( c++ ); // print 5 then postincrement
14       System.out.println( c );   // print 6
15
16       System.out.println(); // skip a line
17
18       // demonstrate prefix increment operator
19       c = 5; // assign 5 to c
20       System.out.println( c );   // print 5
21       System.out.println( ++c ); // preincrement then print 6
22       System.out.println( c );   // print 6
23
24    } // end main
25
26 } // end class Increment
```

```
5
5
6

5
6
6
```

Postincrementing the `c` variable

Preincrementing the `c` variable

•Increment.java

Common Programming Error 2b.9

Attempting to use the increment or decrement operator on an expression other than one to which a value can be assigned is a syntax error. For example, writing `++(x + 1)` is a syntax error because `(x + 1)` is not a variable.

Operators						Associativity	Type
++	--					right to left	unary postfix
++	--	+	-	(*type*)		right to left	unary prefix
*	/	%				left to right	Multiplicative
+	-					left to right	Additive
<	<=	>	>=			left to right	Relational
==	!=					left to right	Equality
?:						right to left	Conditional
=	+=	-=	*=	/=	%=	right to left	assignment

Fig. 2b.17 | Precedence and associativity of the operators discussed so far.

2b.13 Primitive Types

- **Java is a strongly typed language**
  - **All variables have a type**
- **Primitive types in Java are portable across all platforms that support Java**

Portability Tip 2b.1

Unlike C and C++, the primitive types in Java are portable across all computer platforms that support Java. Thanks to this and Java's many other portability features, a programmer can write a program once and be certain that it will execute on any computer platform that supports Java. This capability is sometimes referred to as *WORA* (Write Once, Run Anywhere).

2b.14 (Optional) GUI and Graphics Case Study: Creating Simple Drawings

- **Java's coordinate system**
  - **Defined by x-coordinates and y-coordinates**
    - **Also known as horizontal and vertical coordinates**
    - **Are measured along the x-axis and y-axis**
  - **Coordinate units are measured in pixels**
- **`Graphics` class from the `java.awt` package**
  - **Provides methods for drawing text and shapes**
- **`JPanel` class from the `javax.swing` package**
  - **Provides an area on which to draw**

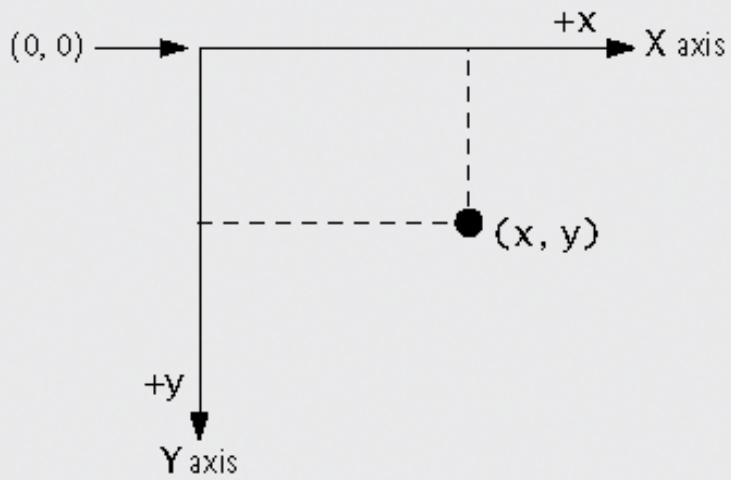


Fig. 2b.18 | Java coordinate system. Units are measured in pixels.

2b.14 (Optional) GUI and Graphics Case Study: Creating Simple Drawings (Cont.)

- **Inheriting**
  - **`extends` keyword**
  - **The subclass inherits from the superclass**
    - **The subclass has the data and methods that the superclass has as well as any it defines for itself**

```
1  // Fig. 4.19: DrawPanel.java
2  // Draws two crossing lines on a panel.
3  import java.awt.Graphics;
4  import javax.swing.JPanel;
5
6  public class DrawPanel extends JPanel
7  {
8     // draws an X from the corners of the panel
9     public void paintComponent( Graphics g )
10    {
11       // call paintComponent to ensure the panel displays correctly
12       super.paintComponent( g );
13
14       int width = getWidth(); // total width
15       int height = getHeight(); // total height
16
17       // draw a line from the upper-left to the lower-right
18       g.drawLine( 0, 0, width, height );
19
20       // draw a line from the lower-left to the upper-right
21       g.drawLine( 0, height, width, 0 );
22    } // end method paintComponent
23 } // end class DrawPanel
```

Import the **`java.awt.Graphics`** and the **`javax.swing.JPanel`** classes

The **`DrawPanel`** class extends the **`JPanel`** class

•DrawPanel.java

Declare the **`paintComponent`** method

Retrieve the **`JPanel`**'s width and height

Draw the two lines

2b.14 (Optional) GUI and Graphics Case Study: Creating Simple Drawings (Cont.)

- The `JPanel` class
  - Every `JPanel` has a `paintComponent` method
    - `paintComponent` is called whenever the system needs to display the `JPanel`
  - `getWidth` and `getHeight` methods
    - Return the width and height of the `JPanel`, respectively
  - `drawLine` method
    - Draws a line from the coordinates defined by its first two arguments to the coordinates defined by its second two arguments

2b.14 (Optional) GUI and Graphics Case Study: Creating Simple Drawings (Cont.)

- **`JFrame` class from the `javax.swing` package**
  - **Allows the programmer to create a window**
  - **`setDefaultCloseOperation` method**
    - **Pass `JFrame.EXIT_ON_CLOSE` as its argument to set the application to terminate when the user closes the window**
  - **`add` method**
    - **Attaches a `JPanel` to the `JFrame`**
  - **`setSize` method**
    - **Sets the width (first argument) and height (second argument) of the `JFrame`**

```
1  // Fig. 4.20: DrawPanelTest.java
2  // Application to display a DrawPanel.
3  import javax.swing.JFrame;
4
5  public class DrawPanelTest
6  {
7     public static void main( String args[] )
8     {
9        // create a panel that contains our drawing
10       DrawPanel panel = new DrawPanel();
11
12       // create a new frame to hold the panel
13       JFrame application = new JFrame();
14
15       // set the frame to exit when it is closed
16       application.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
17
18       application.add( panel );// add the panel to the frame
19       application.setSize( 250, 250 ); // set the size of the frame
20       application.setVisible( true );// make the frame visible
21    } // end main
22 } // end class DrawPanelTest
```

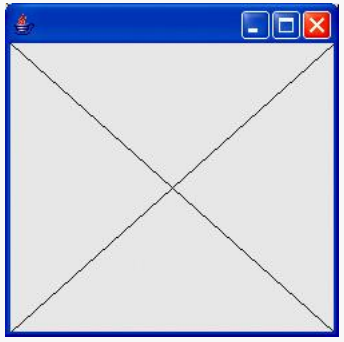
Import the **JFrame** class from the **javax.swing** package

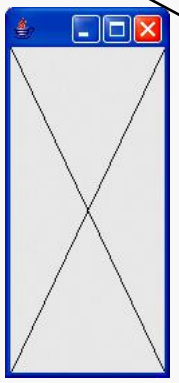
Create **DrawPanel** and **JFrame** objects

Set the application to terminate when the user closes the window

Add the **DrawPanel** to the **JFrame**

Set the size of and display the **JFrame**





•DrawPanel Test.java

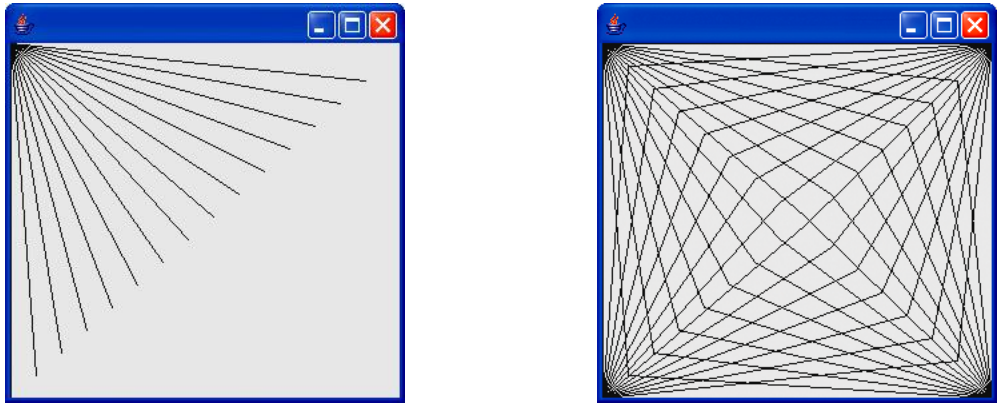


Fig. 2b.21 | Lines fanning from a corner.

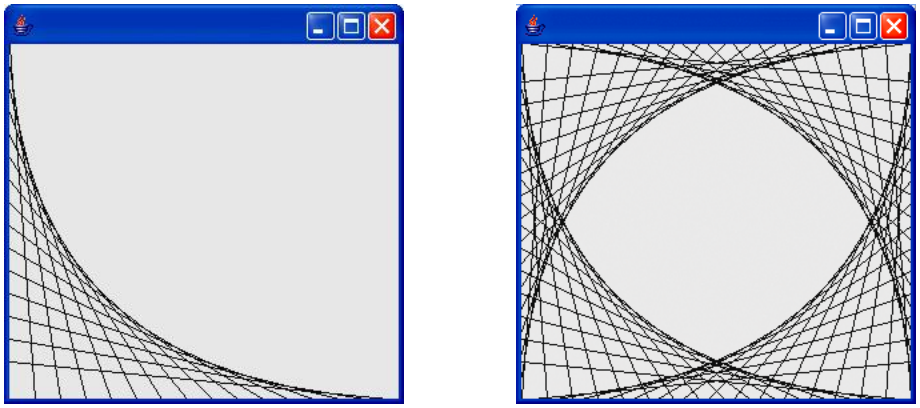


Fig. 2b.22 | Line art with loops and drawLine.

Class	Descriptive words and phrases
ATM	user is authenticated
BalanceInquiry	account number
Withdrawal	account number amount
Deposit	account number amount
BankDatabase	[no descriptive words or phrases]
Account	account number PIN Balance
Screen	[no descriptive words or phrases]
Keypad	[no descriptive words or phrases]
CashDispenser	begins each day loaded with 500 $20 bills
DepositSlot	[no descriptive words or phrases]

Fig. 2b.23 | Descriptive words and phrases from the ATM requirements.

Software Engineering Observation 2b.6

At early stages in the design process, classes often lack attributes (and operations). Such classes should not be eliminated, however, because attributes (and operations) may become evident in the later phases of design and implementation.