

Java Programming, 9e

Chapter 6

Looping





Objectives

- Describe the loop structure
- Create `while` loops
- Use shortcut arithmetic operators
- Create `for` loops
- Create `do...while` loops
- Nest loops
- Improve loop performance



Learning About the Loop Structure (1 of 3)

- **Loop**

- A structure that allows repeated execution of a block of statements

- **Loop body**

- A block of statements
- Executed repeatedly

- **Iteration**

- One execution of any loop



Learning About the Loop Structure (2 of 3)

- Three types of loops
 - `while`
 - The loop-controlling Boolean expression is the first statement
 - `for`
 - A concise format in which to execute loops
 - `do...while`
 - The loop-controlling Boolean expression is the last statement



Learning About the Loop Structure (3 of 3)

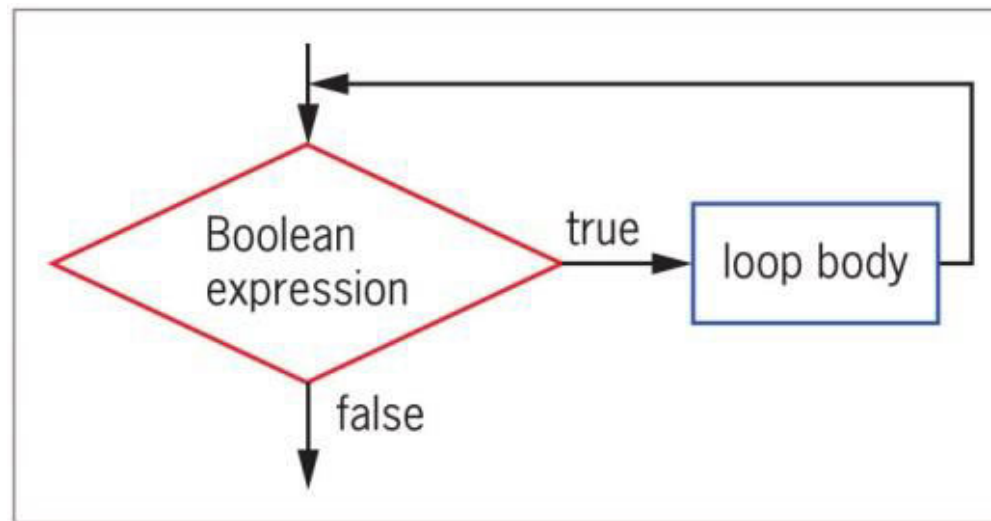


Figure 6-1 Flowchart of a loop structure



Creating while Loops

- **while loop**

- Executes a body of statements continually
 - As long as the Boolean expression that controls entry into the loop continues to be `true`
- Consists of:
 - The keyword `while`
 - Followed by a Boolean expression within parentheses
 - Followed by the body of the loop; can be a single statement or a block of statements surrounded by curly braces
- **Definite loop (counted loop):** programmer knows exact number of iterations
- **Indefinite loop:** programmer cannot predict number of iterations



Writing a Definite `while` Loop (1 of 6)

- Initialize the **loop control variable**
 - The variable whose value determines whether loop execution continues
- While the loop control variable does not pass a limiting value, the program continues to execute the body of the `while` loop



Writing a Definite while Loop (2 of 6)

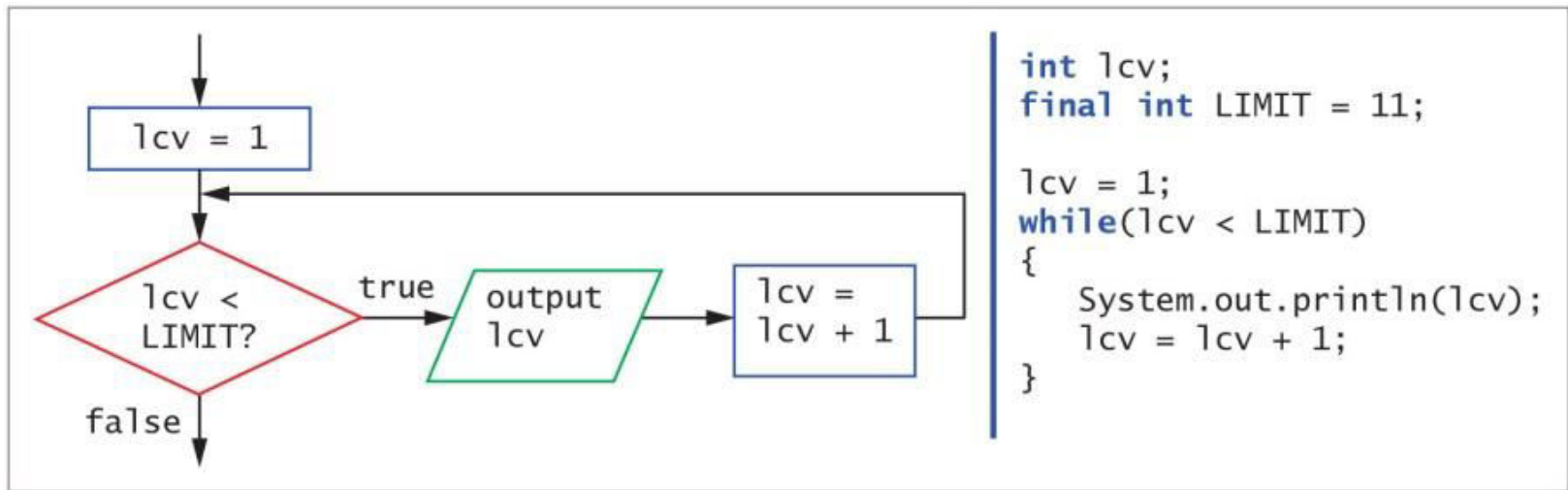


Figure 6-2 A while loop that displays the integers 1 through 10



Writing a Definite `while` Loop (3 of 6)

- Write a definite loop (cont'd.)
 - The body of the loop must include a statement that alters the loop control variable
- **Infinite loop**
 - A loop that never ends
 - Can result from a mistake in the `while` loop
 - Do not write intentionally



Writing a Definite while Loop (4 of 6)

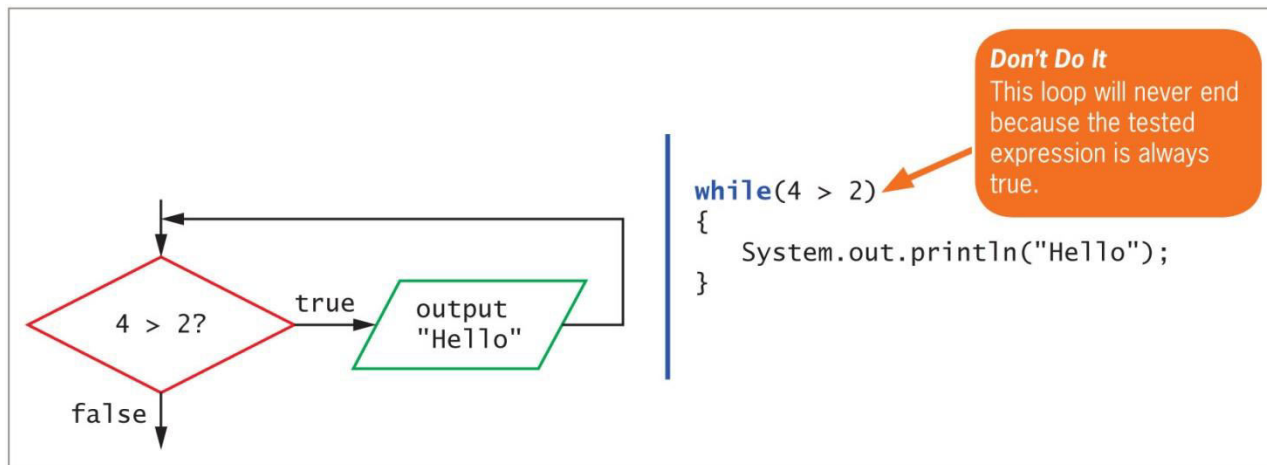


Figure 6-3 A loop that displays *Hello* infinitely



Writing a Definite `while` Loop (5 of 6)

- Suspect an infinite loop when:
 - The same output is displayed repeatedly
 - The screen remains idle for an extended period of time
- To exit an infinite loop, press and hold Ctrl, then press C or Break



Writing a Definite while Loop (6 of 6)

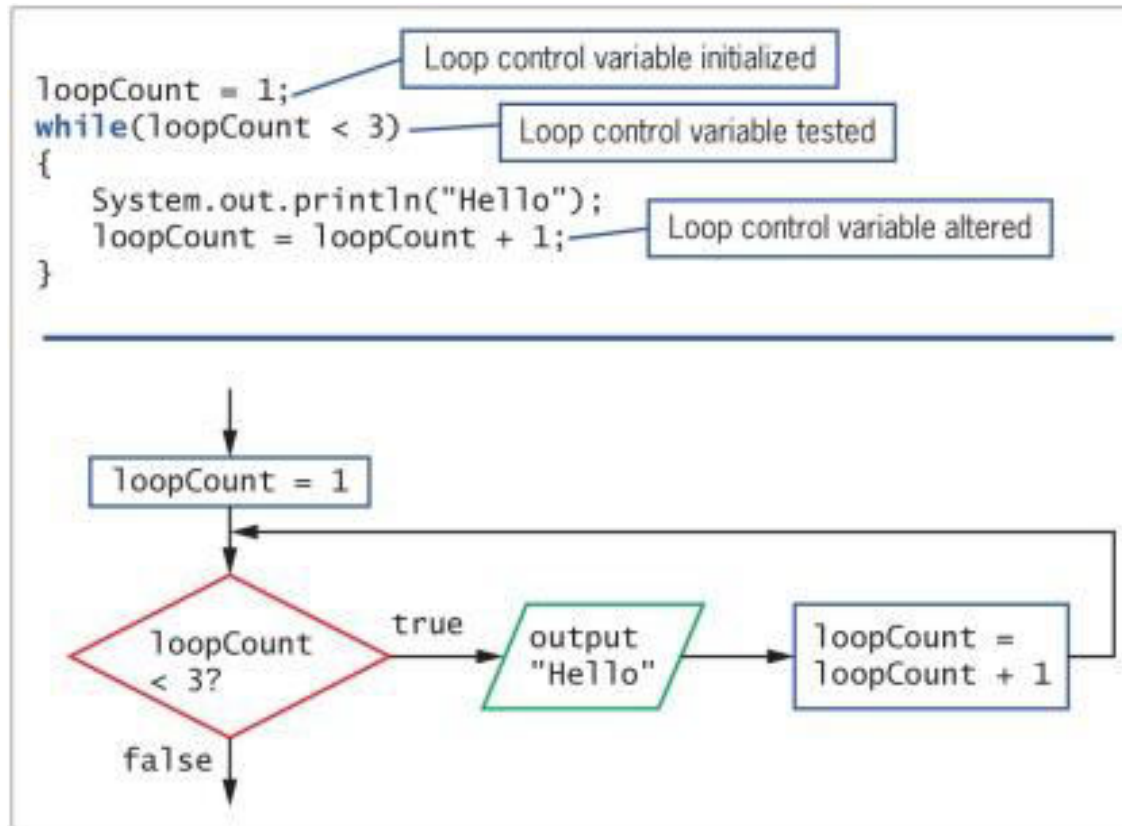


Figure 6-4 A while loop that displays *Hello* twice



Pitfall: Failing to Alter the Loop Control Variable Within the Loop Body (1 of 2)

- Prevent the `while` loop from executing infinitely
 - The named loop control variable is initialized to a starting value
 - The loop control variable is tested in the `while` statement
 - If the test expression is `true`, the body of the `while` statement takes action
 - Alters the value of the loop control variable
 - The test of the `while` statement must eventually evaluate to `false`



Pitfall: Failing to Alter the Loop Control Variable Within the Loop Body (2 of 2)

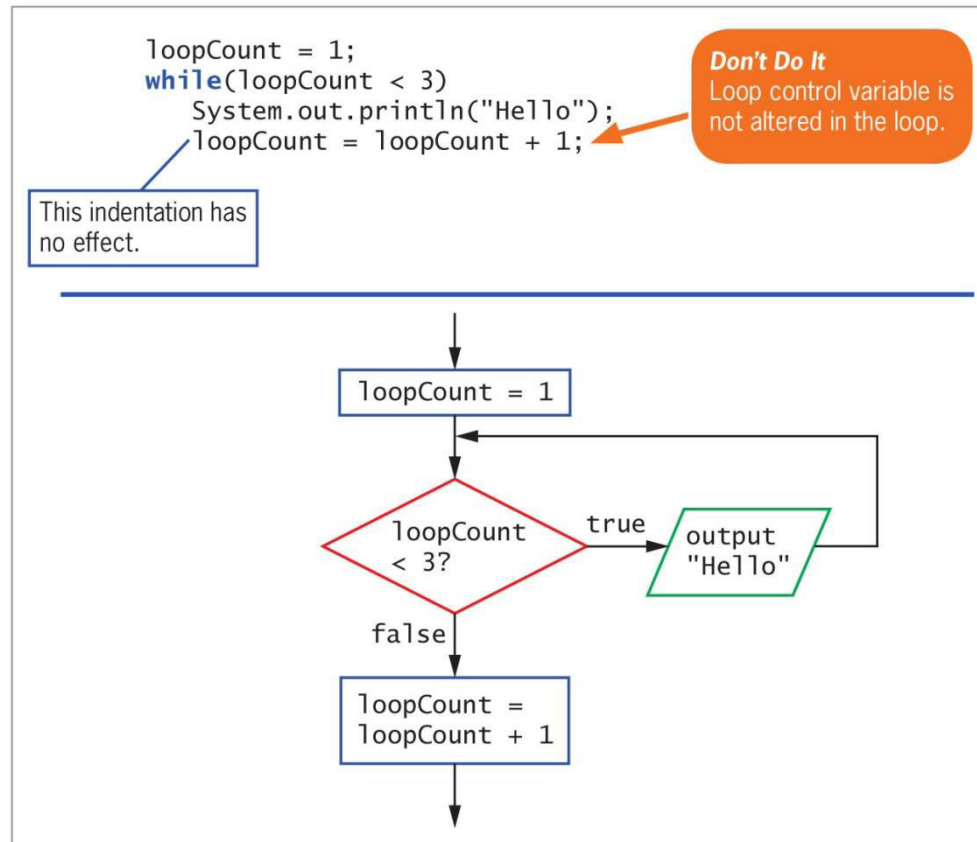


Figure 6-5 A `while` loop that displays *Hello* infinitely because `loopCount` is not altered in the loop body



Pitfall: Unintentionally Creating a Loop with an Empty Body (1 of 2)

- Loop control variable
 - A variable that is altered and stored with a new value

```
loopCount = loopCount + 1
```

 - The equal sign assigns a value to the variable on the left
 - The variable should be altered within the body of the loop
- **Empty body**
 - A body with no statements
 - Caused by misplaced semicolons



Pitfall: Unintentionally Creating a Loop with an Empty Body (2 of 2)

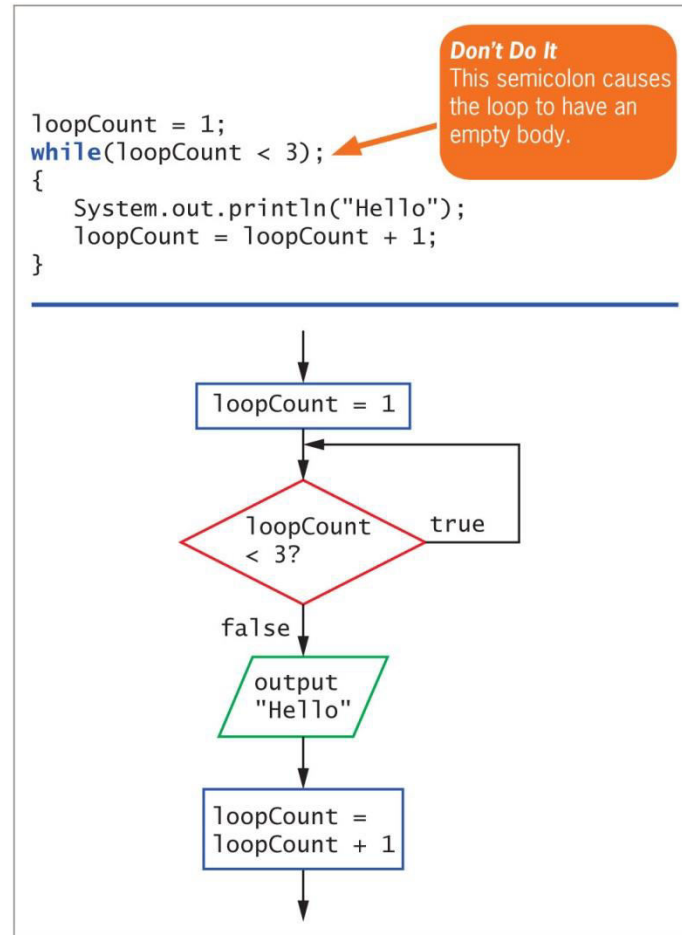


Figure 6-6 A while loop that loops infinitely with no output because the loop body is empty



Altering a Definite Loop's Control Variable (1 of 2)

- **Incrementing** the variable
 - Alter the value of the loop control variable by adding 1
- **Decrementing** the variable
 - Subtract 1 from the loop control variable
- **Clearer and best method**
 - Start the loop control variable at 0 or 1
 - Increment by 1 each time through the loop
 - Stop when the loop control variable reaches the limit



Altering a Definite Loop's Control Variable

(2 of 2)

```
loopCount = 3;  
while(loopCount > 1)  
{  
    System.out.println("Hello");  
    loopCount = loopCount - 1;  
}
```

Figure 6-7 A `while` loop that displays *Hello* twice, decrementing the `loopCount` variable in the loop body



Writing an Indefinite `while` Loop (1 of 2)

- **Event-controlled loop**
 - Altered by user input
 - Controlled by the user
 - Executed any number of times



Writing an Indefinite while Loop (2 of 2)

```
import java.util.Scanner;
public class BankBalance
{
    public static void main(String[] args)
    {
        double balance;
        int response;
        int year = 1;
        final double INT_RATE = 0.03;
        Scanner keyboard = new Scanner(System.in);
        System.out.print("Enter initial bank balance > ");
        balance = keyboard.nextDouble();
        System.out.println("Do you want to see next year's balance?");
        System.out.print("Enter 1 for yes");
        System.out.print(" or any other number for no >> ");
        response = keyboard.nextInt();
        while(response == 1)
        {
            balance = balance + balance * INT_RATE;
            System.out.println("After year " + year + " at " + INT_RATE +
                " interest rate, balance is $" + balance);
            year = year + 1;
            System.out.println("\nDo you want to see the balance " +
                "at the end of another year?");
            System.out.print("Enter 1 for yes");
            System.out.print(" or any other number for no >> ");
            response = keyboard.nextInt();
        }
    }
}
```

Figure 6-8 The BankBalance application



Validating Data (1 of 2)

- **Validating data**

- Ensure a value falls within a specified range
- Use indefinite loops to validate input data
- If a user enters incorrect data, the loop repeats

- **Priming read (priming input)**

- Input retrieved before the loop is entered
- Within a loop, the last statement retrieves the next input value and checks the value before the next entrance of the loop



Validating Data (2 of 2)

```
import java.util.Scanner;
public class EnterSmallValue
{
    public static void main(String[] args)
    {
        int userEntry;
        final int LIMIT = 3;
        Scanner input = new Scanner(System.in);
        System.out.print("Please enter an integer no higher than " +
            LIMIT + " > ");
        userEntry = input.nextInt();
        while(userEntry > LIMIT)
        {
            System.out.println("The number you entered was too high");
            System.out.print("Please enter an integer no higher than " +
                LIMIT + " > ");
            userEntry = input.nextInt();
        }
        System.out.println("You correctly entered " + userEntry);
    }
}
```

The while statement controls the loop

The loop body is between the curly braces.

Figure 6-10 The EnterSmallValue application



Using Shortcut Arithmetic Operators (1 of 5)

- **Accumulating**

- Repeatedly increasing a value by some amount
- Java provides shortcuts for incrementing and accumulating
 - `+=` add and assign operator**
 - `-=` subtract and assign operator**
 - `*=` multiply and assign operator**
 - `/=` divide and assign operator**
 - `%=` remainder and assign operator**



Using Shortcut Arithmetic Operators (2 of 5)

- **Prefix increment operator** and **postfix increment operator**

`++someValue, someValue++`

- Use only with variables
- Unary operators
 - Use with one value
- Increase a variable's value by 1
 - No difference between operators (unless other operations are in the same expression)



Using Shortcut Arithmetic Operators (3 of 5)

```
int value;  
value = 24;  
++value; // Result: value is 25  
value = 24;  
value++; // Result: value is 25  
value = 24;  
value = value + 1; // Result: value is 25  
value = 24;  
value += 1; // Result: value is 25
```

Figure 6-13 Four ways to add 1 to a value



Using Shortcut Arithmetic Operators (4 of 5)

- **Prefix increment operator** and **postfix increment operator** (cont'd.)
 - **Prefix ++**
 - The result is calculated and stored
 - Then the variable is used
 - **Postfix ++**
 - The variable is used
 - Then the result is calculated and stored
- **Prefix and postfix decrement operators**
 - `--someValue`
 - `someValue--`
- Similar logic to increment operators



Using Shortcut Arithmetic Operators (5 of 5)

```
public class PrefixPostfixDemo
{
    public static void main(String[] args)
    {
        int myNumber, answer;
        myNumber = 17;
        System.out.println("Before incrementing, myNumber is " +
            myNumber);
        answer = ++myNumber;
        System.out.println("After prefix increment, myNumber is " +
            myNumber);
        System.out.println(" and answer is " + answer);
        myNumber = 17;
        System.out.println("Before incrementing, myNumber is " +
            myNumber);
        answer = myNumber++;
        System.out.println("After postfix increment, myNumber is " +
            myNumber);
        System.out.println(" and answer is " + answer);
    }
}
```

Figure 6-14 The PrefixPostfixDemo application



Creating a `for` Loop (1 of 4)

- **`for` loop**

- Used when a definite number of loop iterations is required
- One convenient statement indicates:
 - The starting value for the loop control variable
 - The test condition that controls loop entry
 - The expression that alters the loop control variable



Creating a for Loop (2 of 4)

```
for(val = 1; val < 11; ++val)
{
    System.out.println(val);
}

val = 1;
while(val < 11)
{
    System.out.println(val);
    ++val;
}
```

Figure 6-18 A for loop and a while loop that display the integers 1 through 10



Creating a `for` Loop (3 of 4)

- Unconventional `for` loops
 - Initialization of more than one variable
 - Place commas between separate statements
 - Performance of more than one test using AND or OR operators
 - Decrementing or performance of some other task
 - Altering more than one value
- You can leave one or more portions of a `for` loop empty
 - Two semicolons are still required as placeholders



Creating a `for` Loop (4 of 4)

- Use the same loop control variable in all three parts of a `for` statement
- To pause a program:
 - Use the `for` loop that contains no body (**do-nothing** loop)

```
for(x = 0; x < 100000; ++x);
```
 - Or use the built-in `sleep()` method



Learning How and When to Use a do...while Loop (1 of 3)

- **do...while loop**

- As a **pretest loop**:

- Checks the value of the loop control variable before loop body

- As a **posttest loop**

- Checks the value of the loop control variable
 - At the bottom of the loop
 - After one repetition has occurred
 - Performs a task at least one time
 - You are never required to use this type of loop
 - Use curly braces to block the statement
 - Even with a single statement



Learning How and When to Use a do...while Loop (2 of 3)

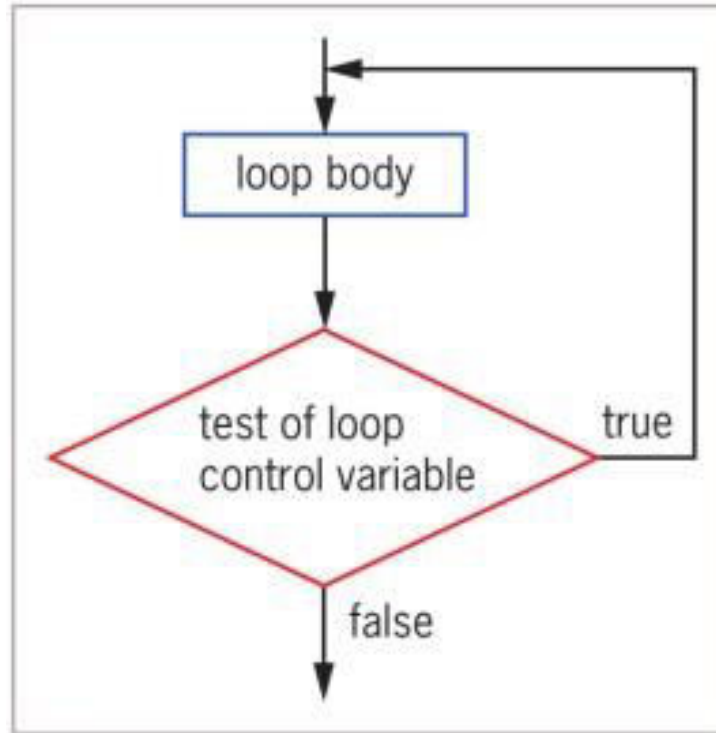


Figure 6-22 General structure of a do...while loop



Learning How and When to Use a do...while Loop (3 of 3)

```
import java.util.Scanner;
public class BankBalance2
{
    public static void main(String[] args)
    {
        double balance;
        int response;
        int year = 1;
        final double INT_RATE = 0.03;
        Scanner keyboard = new Scanner(System.in);
        System.out.print("Enter initial bank balance > ");
        balance = keyboard.nextDouble();
        keyboard.nextLine();
        do
        {
            balance = balance + balance * INT_RATE;
            System.out.println("After year " + year + " at " + INT_RATE +
                " interest rate, balance is $" + balance);
            year = year + 1;
            System.out.println("\nDo you want to see the balance " +
                "at the end of another year?");
            System.out.println("Enter 1 for yes");
            System.out.print(" or any other number for no >> ");
            response = keyboard.nextInt();
        } while(response == 1);
    }
}
```

The keyword do starts the loop.

The loop control variable is tested after the loop body executes.

Figure 6-23 A do...while loop for the BankBalance2 application



Learning About Nested Loops (1 of 2)

- **Inner loop** and **outer loop**

- An inner loop must be entirely contained in an outer loop
- Loops can never overlap

- To print three mailing labels for each of 20 customers:

```
for(customer = 1; customer <= 20; ++customer)
    for(color = 1; color <= 3; ++color)
        outputLabel ();
```



Learning About Nested Loops (2 of 2)

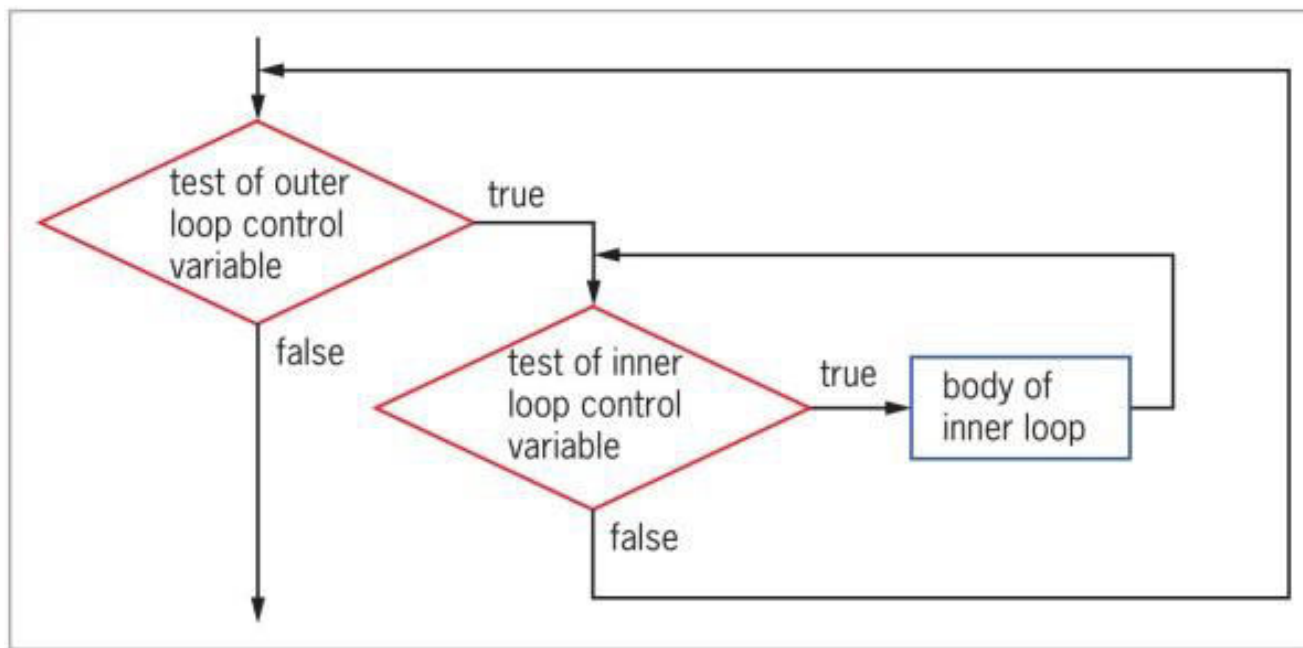


Figure 6-25 Nested loops



Improving Loop Performance

- Make sure a loop does not include unnecessary operations or statements
- Consider the order of evaluation for short-circuit operators
- Make comparisons to zero (0)
- Employ loop fusion to combine loops



Avoiding Unnecessary Operations

- Do not use unnecessary operations or statements:
 - Within a loop's tested expression
 - Within the loop body

- Avoid:

```
while (x < a + b)
// loop body
```

- Instead use:

```
int sum = a + b;
while(x < sum)
// loop body
```



Considering the Order of Evaluation of Short-Circuit Operators

- Short-circuit evaluation
 - Each part of an AND or an OR expression is evaluated only as much as necessary to determine the value of the expression
- Important to consider the number of evaluations that take place
 - When a loop might execute many times



Comparing to Zero (1 of 2)

- Making a comparison to zero (0) is faster than making a comparison to any other value
- To improve loop performance, compare the loop control variable to zero (0)
- Do-nothing loop
 - Performs no actions other than looping



Comparing to Zero (2 of 2)

```
import java.time.*;
public class CompareLoopTimes
{
    public static void main(String[] args)
    {
        int startTime, endTime;
        final int REPEAT = 100_000;
        final int FACTOR = 1_000_000;
        LocalDateTime now;
        now = LocalDateTime.now();
        startTime = now.getNano();
        for(int x = 0; x <= REPEAT; ++x)
            for(int y = 0; y <= REPEAT; ++y); ——— Nested do-nothing loop
        now = LocalDateTime.now();
        endTime = now.getNano();
        System.out.println("Time for loops starting from 0: " +
            ((endTime - startTime) / FACTOR) + " milliseconds");
        now = LocalDateTime.now();
        startTime = now.getNano();
        for(int x = REPEAT; x >= 0; --x)
            for(int y = REPEAT; y >= 0; --y); ——— Nested do-nothing loop
        now = LocalDateTime.now();
        endTime = now.getNano();
        System.out.println("Time for loops ending with 0: " +
            ((endTime - startTime) / FACTOR) + " milliseconds");
    }
}
```

Figure 6-29 The CompareLoopTimes application



Employing Loop Fusion

- **Loop fusion**
 - A technique of combining two loops into one
 - Will not work in every situation



Don't Do It

- Don't insert a semicolon at the end of a `while` clause
- Don't forget to block multiple statements that should execute in a loop
- Don't make the mistake of checking for invalid data using a decision instead of a loop
- Don't ignore subtleties in the boundaries used to stop loop performance
- Don't repeat steps within a loop that could just as well be placed outside the loop



Summary (1 of 3)

- The loop structure allows repeated execution of a block of statements
 - Infinite loop
 - Definite loop
 - Nest loop
- You must change the loop control variable within the looping structure
- Use the `while` loop to execute statements while some condition is `true`



Summary (2 of 3)

- Execute the `while` loop
 - Initialize the loop control variable, test in the `while` statement, and alter the loop control variable
- Prefix `++` and postfix `++`
 - Increase a variable's value by 1
 - The variable is used
 - The result is calculated and stored
- Unary operators
 - Use with one value



Summary (3 of 3)

- Binary operators
 - Operate on two values
- Shortcut operators `+=`, `-=`, `*=`, and `/=`
 - Perform operations and assign the result in one step
- `for` loop
 - Initializes, tests, and increments in one statement
- `do...while` loop
 - Tests a Boolean expression after one repetition
- Improve loop performance
 - Do not include unnecessary operations or statements