



Programming Logic and Design

Ninth Edition

Chapter 5

Looping



Objectives

- In this chapter, you will learn about:
 - The advantages of looping
 - Using a loop control variable
 - Nested loops
 - Avoiding common loop mistakes
 - Using a for loop
 - Using a posttest loop
 - Characteristics shared by all structured loops
 - Common loop applications
 - Similarities and differences between selections and loops

Appreciating the Advantages of Looping

- Looping makes computer programming efficient and worthwhile
- Write one set of instructions to operate on multiple, separate sets of data
 - Less time required for design and coding
 - Fewer errors
 - Shorter compile time
- Loop: a structure that repeats actions while some condition continues

Appreciating the Advantages of Looping (continued -1)

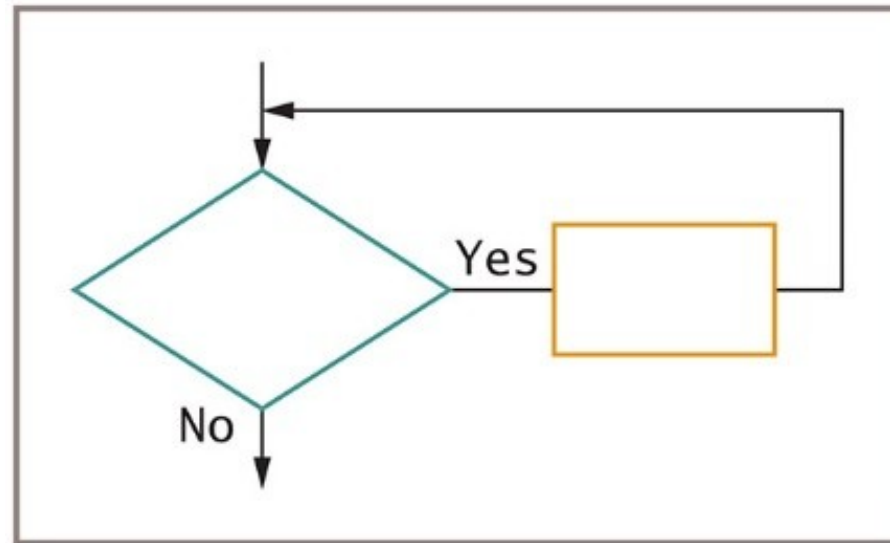


Figure 5-1 The loop structure

Appreciating the Advantages of Looping

(continued -2)

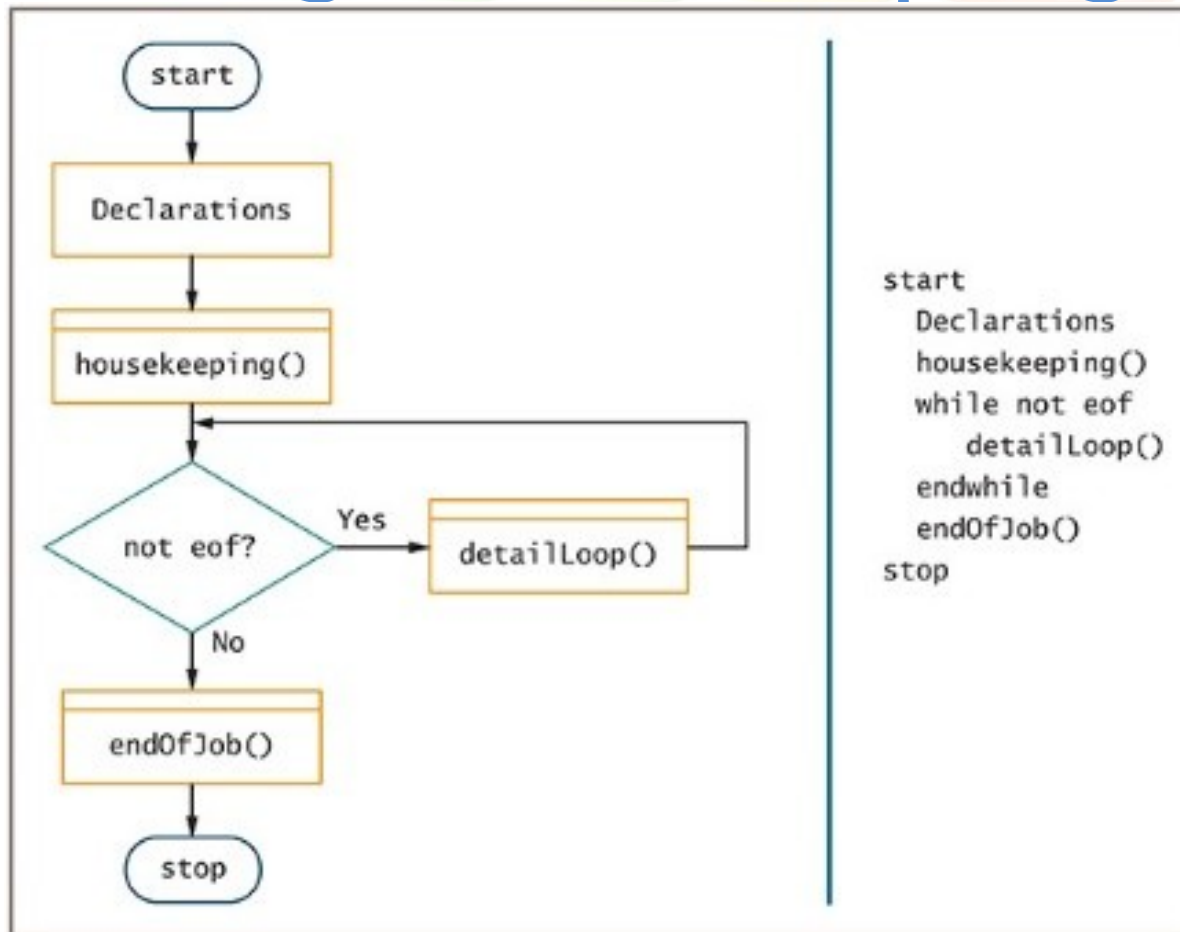


Figure 5-2 The mainline logic common to many business programs

Using a Loop Control Variable

- As long as a condition remains true, the statements in a `while` loop's body execute
- Control number of repetitions
 - **Loop control variable** initialized before entering loop
 - Loop control variable tested
 - Body of loop must alter value of loop control variable
- Repetitions controlled by:
 - Counter – used to create a definite counter-controlled loop
 - Sentinel value – used to create an indefinite

Using a Definite Loop with a Counter

- **Definite loop**
 - Executes a predetermined number of times
- **Counter-controlled loop** or **counted loop**
 - Program counts loop repetitions
- Loop control variables altered by:
 - **Incrementing**
 - **Decrementing**
- **Counter**
 - Any numeric variable that counts the number of times an event has occurred, usually starts with 0

Using a Definite Loop with a Counter

(continued -1)

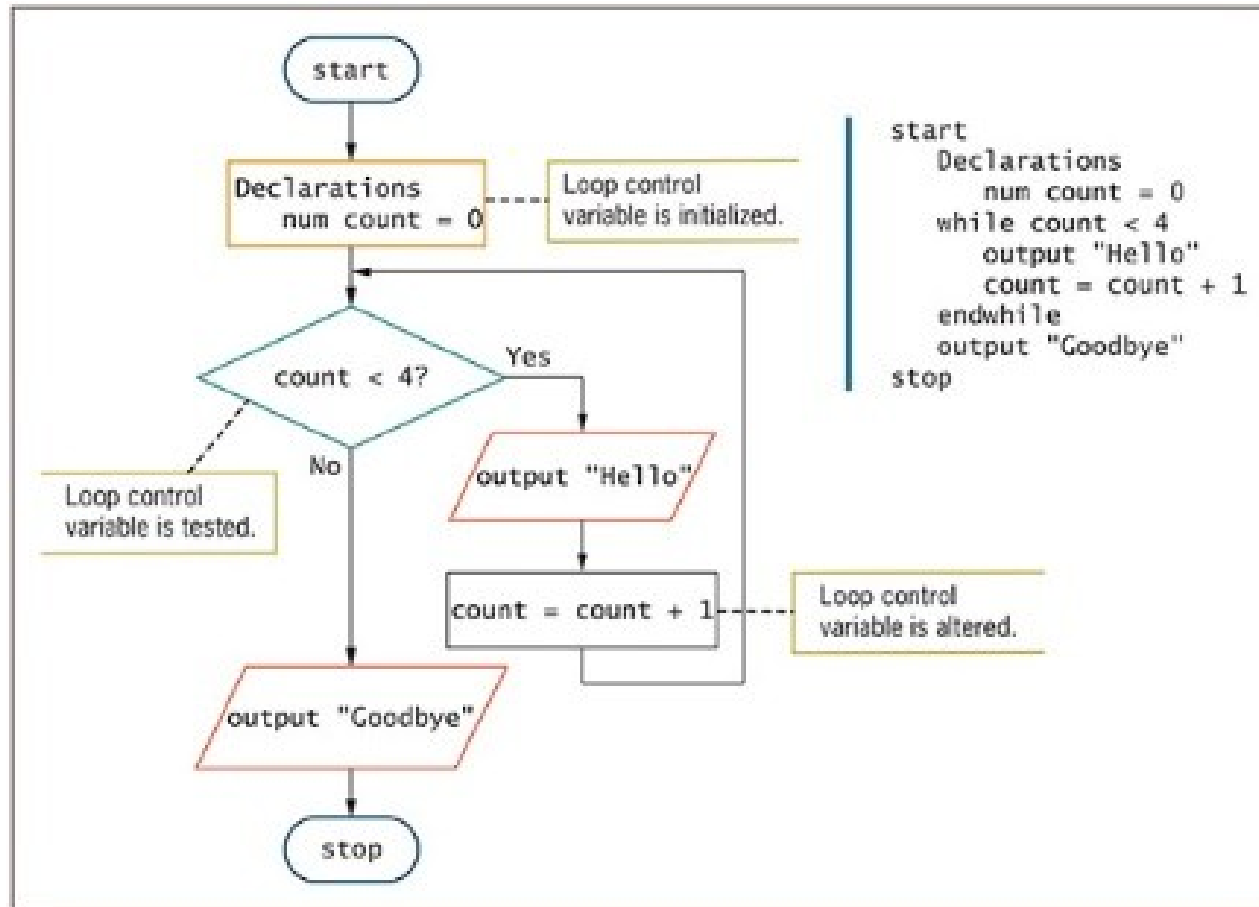


Figure 5-3 A counted while loop that outputs Hello four times

Using an Indefinite Loop with a Sentinel Value

- **Indefinite loop**
 - Performed a different number of times each time the program executes
 - The user decides how many times the loop executes

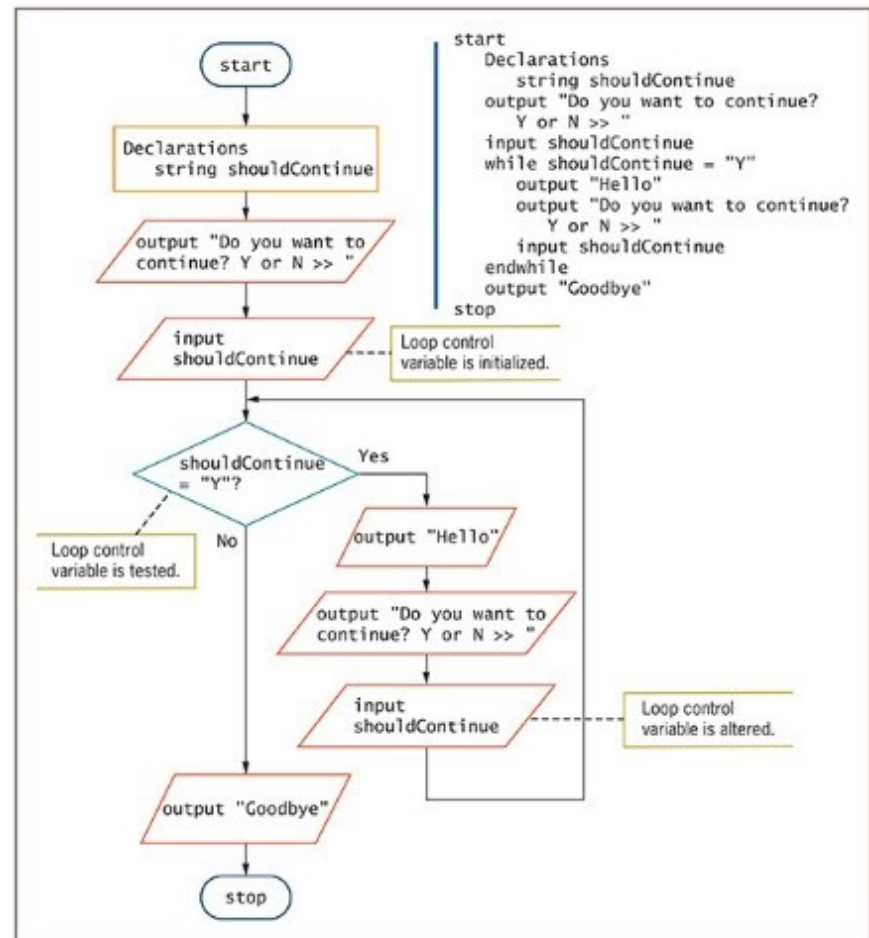


Figure 5-4 An indefinite while loop that displays Hello as long as the user wants to continue

Using an Indefinite Loop with a Sentinel Value (continued -1)

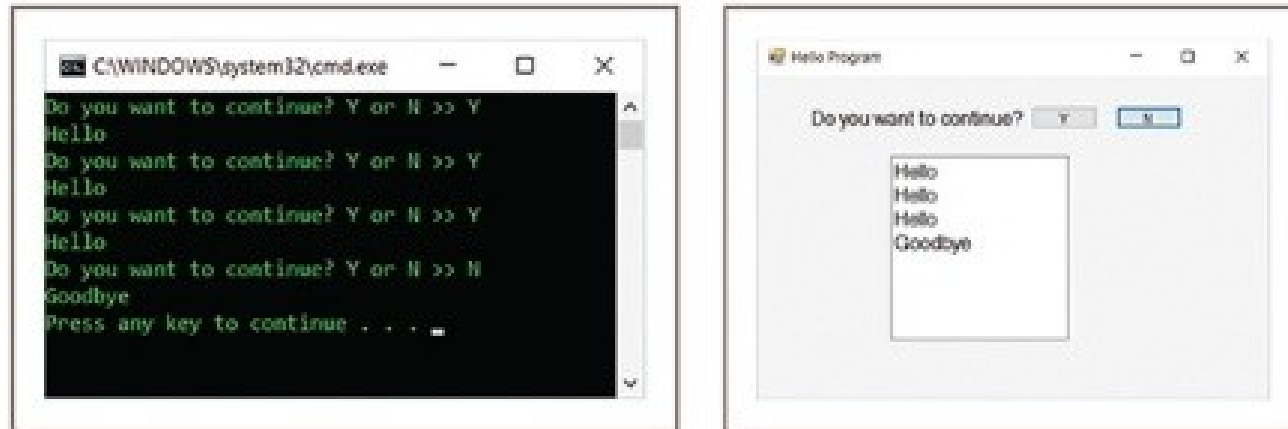


Figure 5-5 Typical executions of the program in Figure 5-4 in two environments

Understanding the Loop in a Program's Mainline Logic

- Three steps should occur in every properly functioning loop:
 - Provide a starting value for the variable that will control the loop
 - Test the loop control variable to determine whether the loop body executes
 - Alter the loop control variable within the loop

Understanding the Loop in a Program's Mainline Logic

(continued -1)

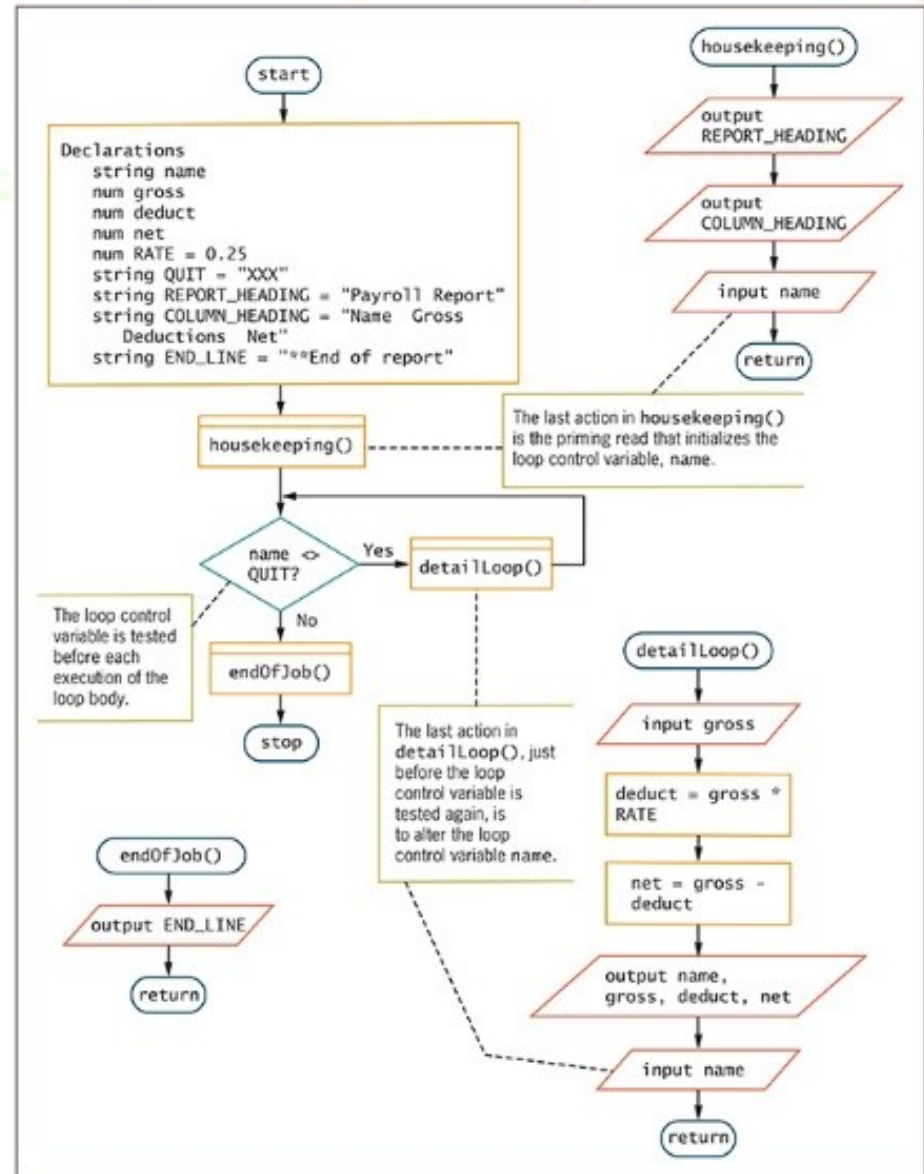


Figure 5-6 A payroll program showing how the loop control variable is used



Nested Loops

- **Nested loops:** loops within loops
- **Outer loop:** the loop that contains the other loop
- **Inner loop:** the loop that is contained
- Needed when values of two (or more) variables repeat to produce every combination of values

Nested Loops (continued -1)

Chapter 1 Quiz

Part 1

1. _____

2. _____

3. _____

Part 2

1. _____

2. _____

3. _____

Part 3

1. _____

2. _____

3. _____

Part 4

1. _____

2. _____

3. _____

Part 5

1. _____

2. _____

3. _____

Extra Credit Quiz

Part 1

1. _____

2. _____

3. _____

Part 2

1. _____

2. _____

3. _____

Part 3

1. _____

2. _____

3. _____

Part 4

1. _____

2. _____

3. _____

Part 5

1. _____

2. _____

3. _____

Make-up Quiz

Part 1

1. _____

2. _____

3. _____

Part 2

1. _____

2. _____

3. _____

Part 3

1. _____

2. _____

3. _____

Part 4

1. _____

2. _____

3. _____

Part 5

1. _____

2. _____

3. _____

Figure 5-7 Quiz answer sheets

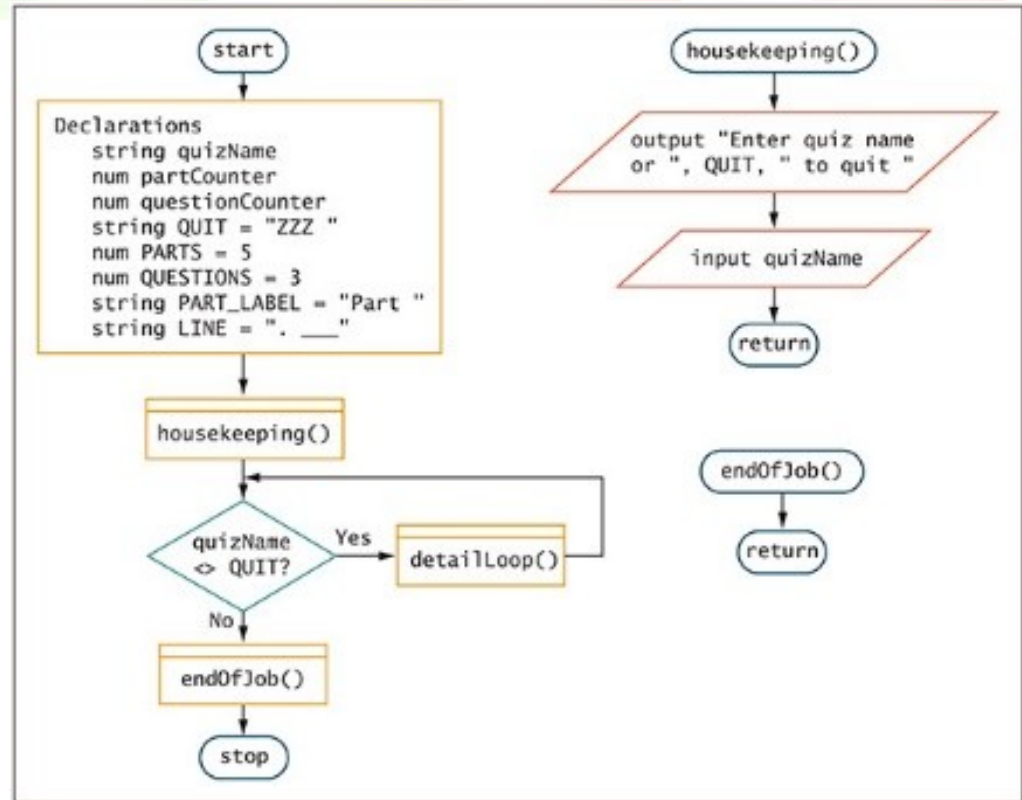


Figure 5-8 Flowchart and pseudocode for AnswerSheet program (continues)

Nested Loops (continued-2)

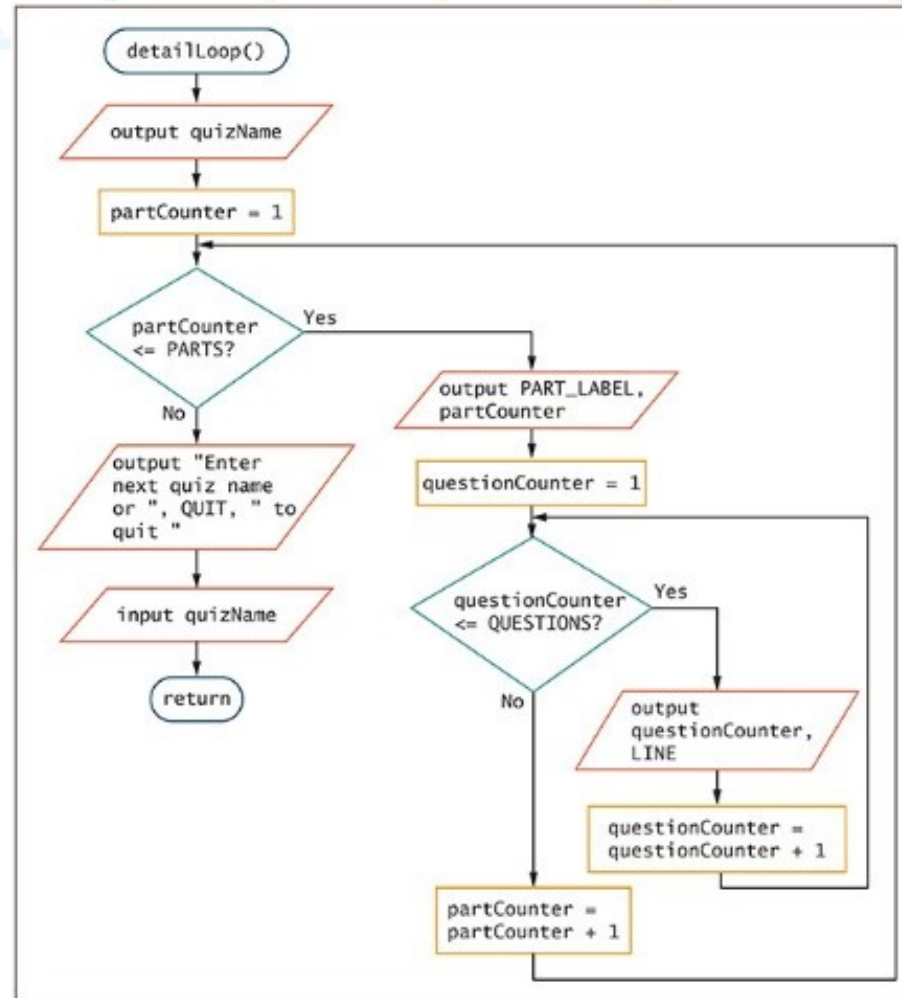


Figure 5-8 Flowchart and pseudocode for AnswerSheet program (continues)

Nested Loops (continued -3)

(continued)

```
start
  Declarations
    string quizName
    num partCounter
    num questionCounter
    string QUIT = "ZZZ "
    num PARTS = 5
    num QUESTIONS = 3
    string PART_LABEL = "Part "
    string LINE = ". ____"
  housekeeping()
  while quizName <> QUIT
    detailLoop()
  endwhile
  endOfJob()
stop

housekeeping()
  output "Enter quiz name or ", QUIT, " to quit "
  input quizName
  return

detailLoop()
  output quizName
  partCounter = 1
  while partCounter <= PARTS
    output PART_LABEL, partCounter
    questionCounter = 1
    while questionCounter <= QUESTIONS
      output questionCounter, LINE
      questionCounter = questionCounter + 1
    endwhile
    partCounter = partCounter + 1
  endwhile
  output "Enter next quiz name or ", QUIT, " to quit "
  input quizName
  return

endOfJob()
return
```

Figure 5-8 Flowchart and pseudocode for AnswerSheet program

Nested Loops (continued -4)

- **Nested Loop facts:**
 - Nested loops never overlap. An inner loop is always completely contained within an outer loop
 - An inner loop goes through all of its iterations each time its outer loop goes through just one iteration
 - The total number of iterations executed by a nested loop is the number of inner loop iterations times the number of outer loop iterations

Avoiding Common Loop Mistakes

- Mistake: failing to initialize the loop control variable
 - Example: get name statement removed
 - Value of name unknown or garbage
 - Program may end before any labels printed
 - 100 labels printed with an invalid name

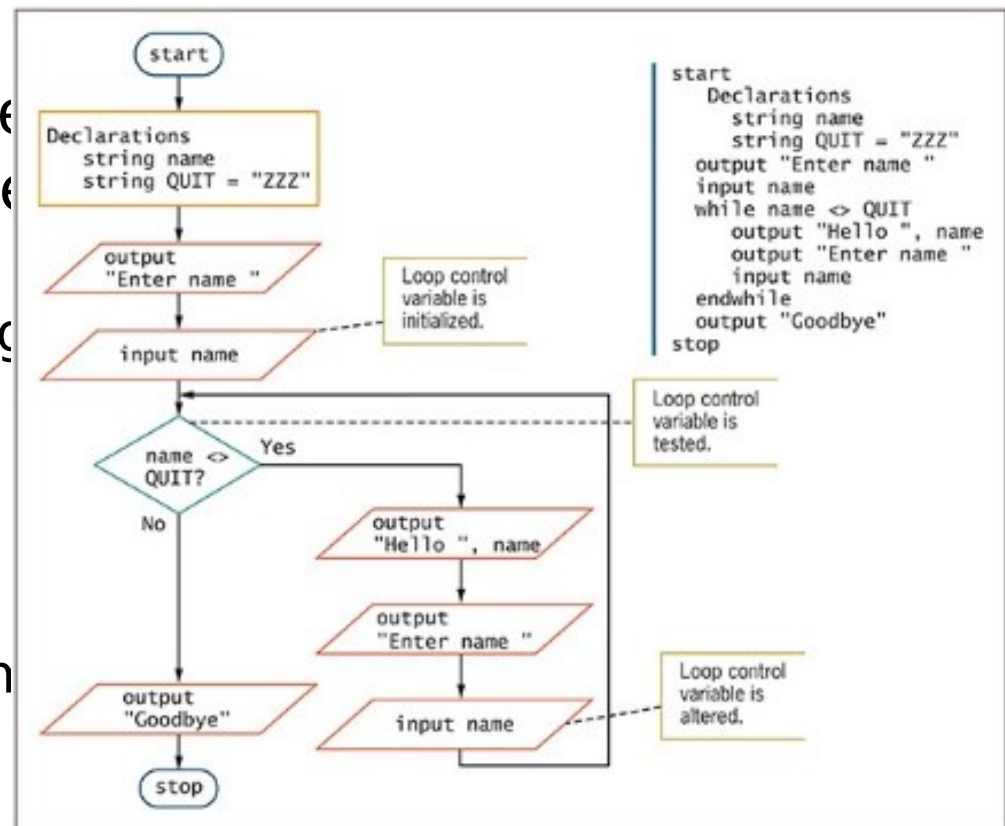


Figure 5-9 Correct logic for greeting program

Avoiding Common Loop Mistakes

(continued -1)

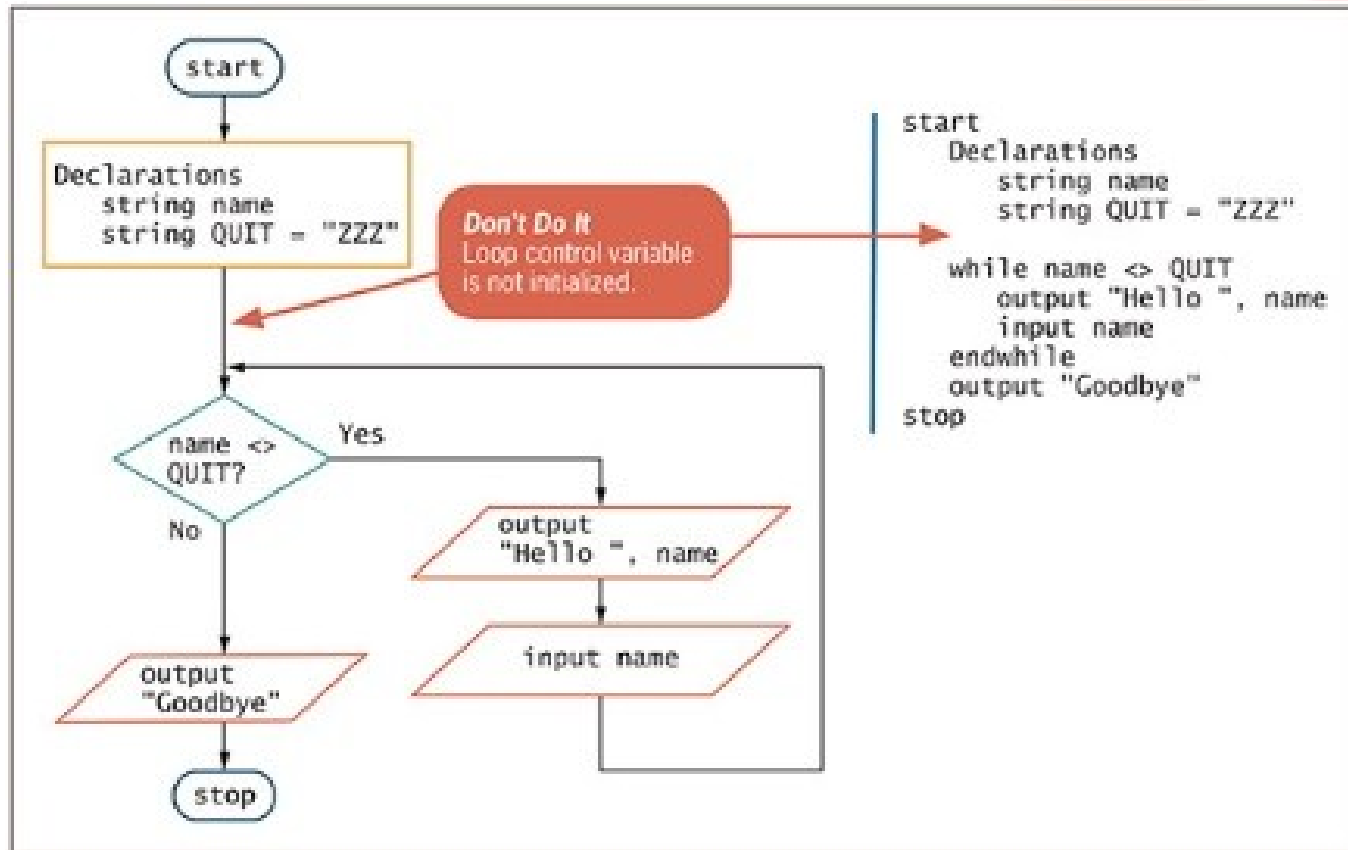


Figure 5-10 Incorrect logic for greeting program because the loop control variable initialization is missing

Avoiding Common Loop Mistakes

(continued -2)

- Mistake: neglecting to alter the loop control variable
 - Remove get name instruction from outer loop
 - User never enters a name after the first one
 - Inner loop executes infinitely
- Always incorrect to create a loop that cannot terminate

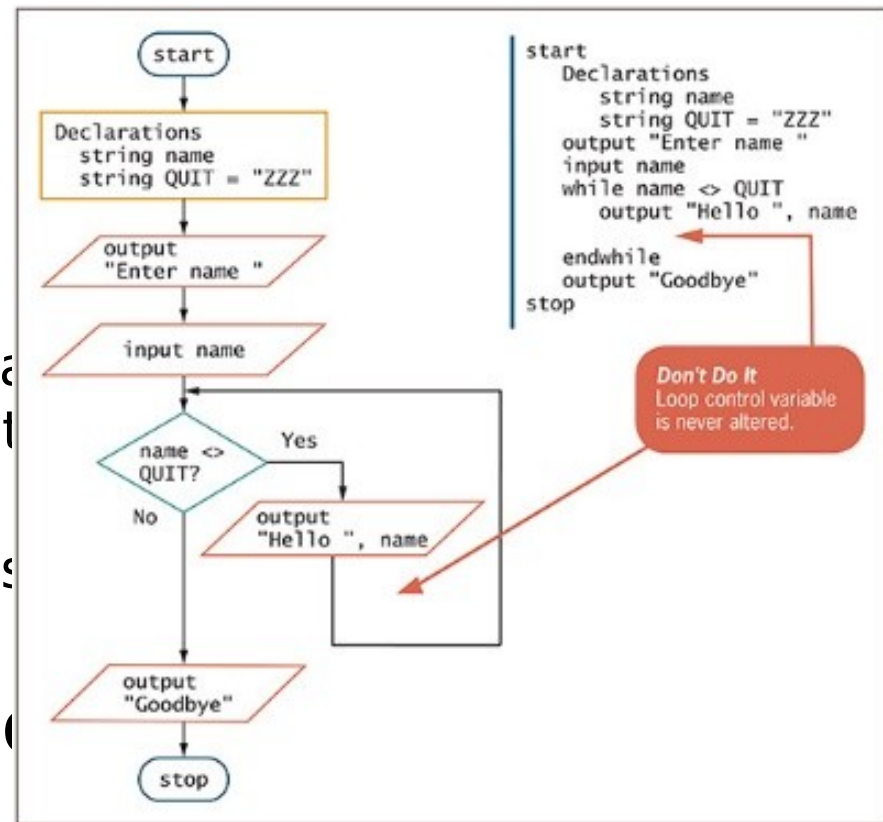


Figure 5-11 Incorrect logic for greeting program because the loop control variable is not altered

Avoiding Common Loop Mistakes

(continued -3)

- Mistake: using the wrong comparison when testing loop control variable
 - Programmers must use correct comparison
 - Seriousness depends on actions performed within a loop
 - Overcharge insurance customer by one month
 - Overbook a flight on airline application
 - Dispense extra medication to patients in pharmacy

Avoiding Common Loop Mistakes

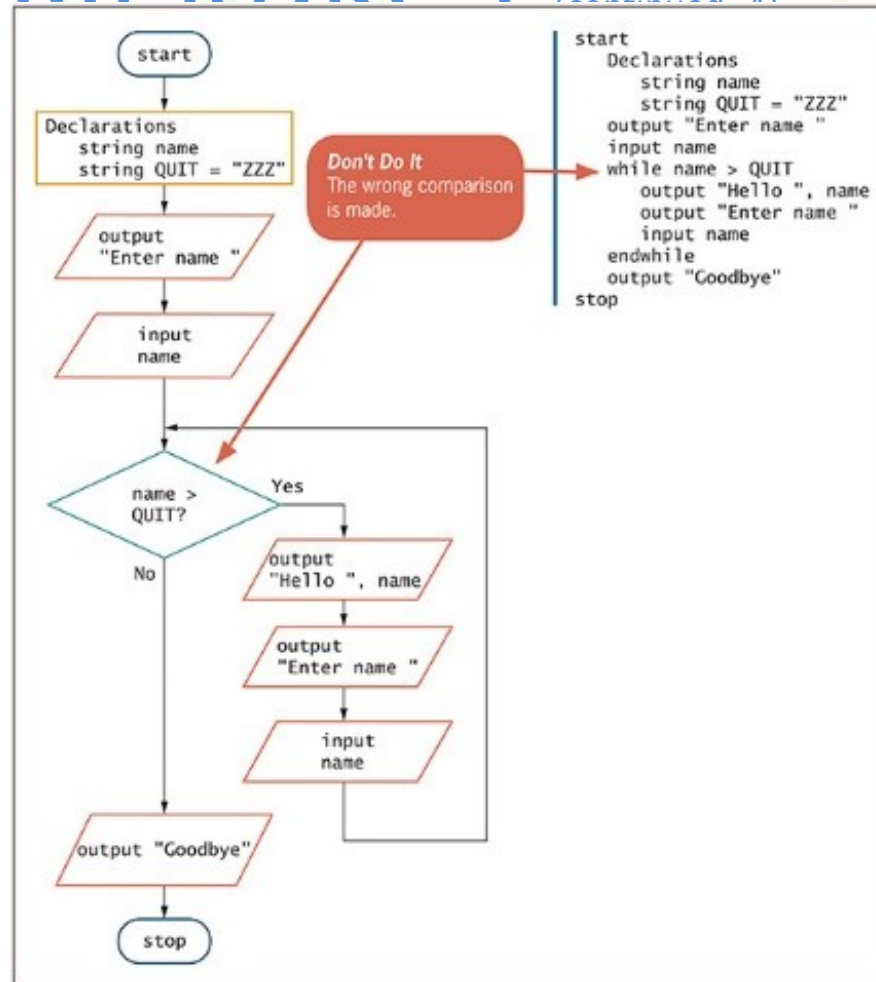


Figure 5-12 Incorrect logic for greeting program because the wrong test is made with the loop control variable

Avoiding Common Loop Mistakes

(continued -5)

- Mistake: including statements inside the loop that belong outside the loop
 - Example: discount every item by 30 percent
 - Inefficient because the same value is calculated 100 separate times for each price that is entered
 - Move outside the loop for efficiency

Avoiding Common Loop Mistakes

(continued -6)

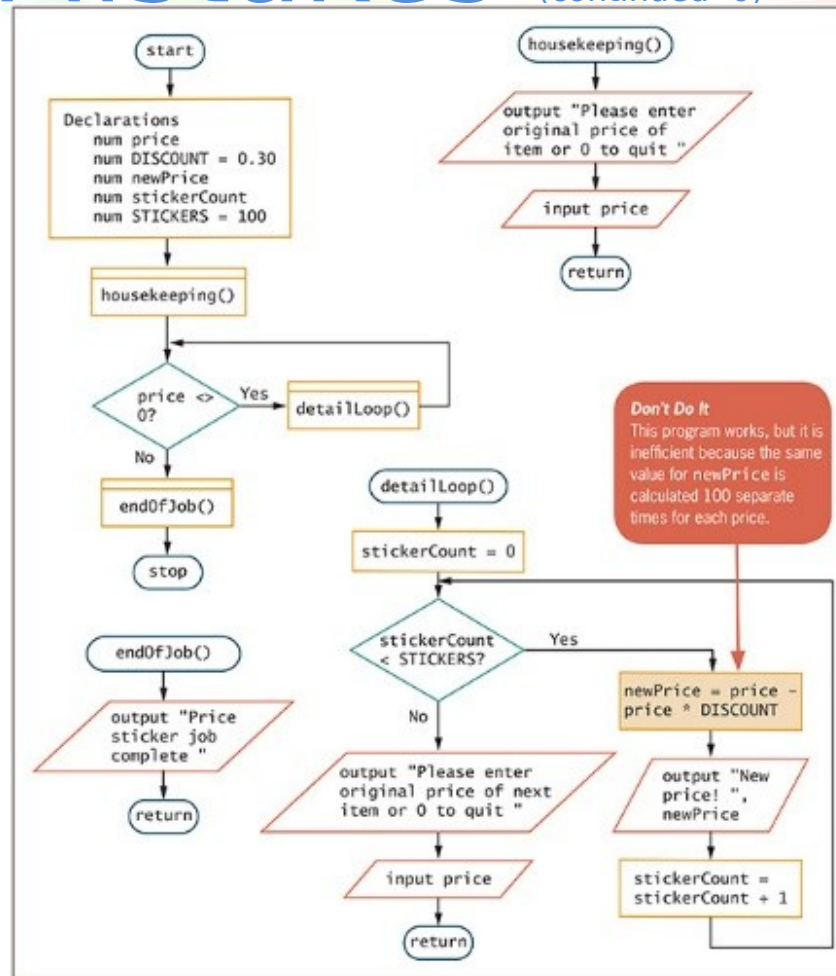


Figure 5-13 Inefficient way to produce 100 discount price stickers for differently priced items (continues)

Avoiding Common Loop Mistakes

(continued)

```
start
  Declarations
    num price
    num DISCOUNT = 0.30
    num newPrice
    num stickerCount
    num STICKERS = 100
  housekeeping()
  while price <> 0
    detailLoop()
  endwhile
  endOfJob()
stop

housekeeping()
  output "Please enter original price of item or 0 to quit "
  input price
  return

detailLoop()
  stickerCount = 0
  while stickerCount < STICKERS
    newPrice = price - price * DISCOUNT
    output "New price! ", newPrice
    stickerCount = stickerCount + 1
  endwhile
  output "Please enter original price of
  next item or 0 to quit "
  input price
  return

endOfJob()
  output "Price sticker job complete"
  return
```

Don't Do It

This program works, but it is inefficient because the same value for newPrice is calculated 100 separate times for each price.

Figure 5-13 Inefficient way to produce 100 discount price stickers for differently priced items

Avoiding Common Loop Mistakes

(continued -8)

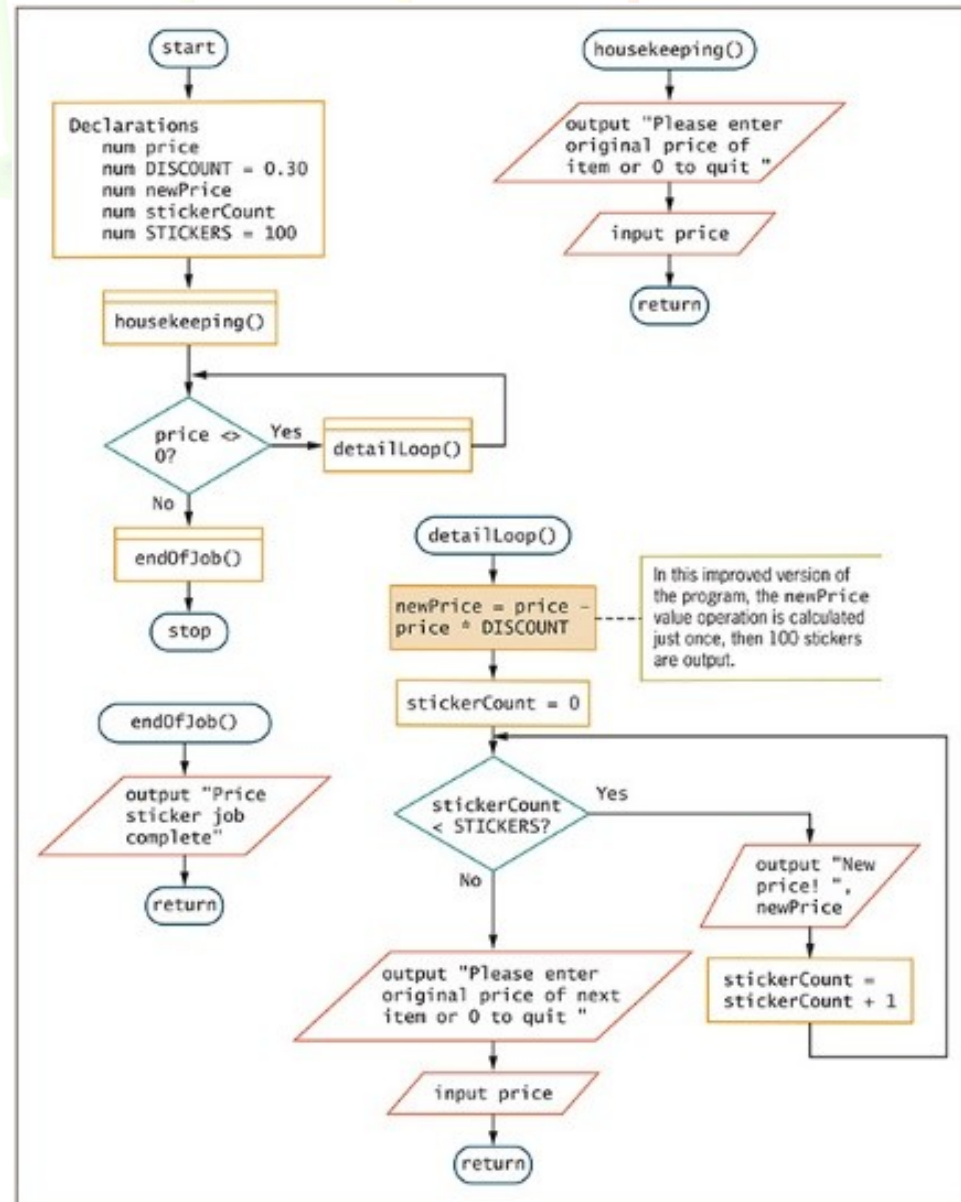


Figure 5-14 Improved discount sticker-making program (continues)

Avoiding Common Loop Mistakes

(continued -9)

(continued)

```
start
  Declarations
    num price
    num DISCOUNT = 0.30
    num newPrice
    num stickerCount
    num STICKERS = 100
  housekeeping()
  while price <> 0
    detailLoop()
  endwhile
  endOfJob()
stop

housekeeping()
  output "Please enter original price of item or 0 to quit "
  input price
  return

detailLoop()
  newPrice = price - price * DISCOUNT -----
  stickerCount = 0
  while stickerCount < STICKERS
    output "New price! ", newPrice
    stickerCount = stickerCount + 1
  endwhile
  output "Please enter original price of next item or 0 to quit "
  input price
  return

endOfJob()
  output "Price sticker job complete"
  return
```

In this improved version of the program, the newPrice value operation is calculated just once, then 100 stickers are output.

Figure 5-14 Improved discount sticker-making program

Using a for Loop

- **for statement** or **for loop** is a definite loop
- Provides three actions in one structure:
 - Initializes
 - Tests
 - Alters

```
count = 0
while count <= 3
    output "Hello"
    count = count + 1
endwhile
```

```
for count = 0 to 3 step 1
    output "Hello"
endfor
```

Figure 5-15 Comparable while and for statements that each output *Hello* four times

Using a for Loop (continued -1)

- Example

```
for count = 0 to 3 step 1
    output "Hello"
endfor
```

- Initializes count variable to 0
- Checks count variable against the limit value 3
- If evaluation is true, for statement body prints the word “Hello”
- Increases count by 1 using a **step value**



Using a for Loop (continued -2)

- **Step value:** the amount by which a loop control variable changes
 - Can be positive or negative (incrementing or decrementing the loop control variable)
 - Default step value is 1
 - Programmer specifies a step value when each pass through the loop changes the loop control variable by a value other than 1



Using a for Loop (continued -3)

- while statement could be used in place of for statement
- **Pretest loop:** the loop control variable is tested before each iteration
 - for loops and while loops are pretest loops



Using a Posttest Loop

- **Posttest loop:** the loop control variable is tested after each iteration
- In a **posttest loop**, the loop body executes at least one time because the loop control variable is not tested until after the first iteration.
 - **do-while loop** is a posttest loop
- Example
 - do**
 - pay a bill
 - while** more bills remain to be paid

Using a Posttest Loop (continued -1)

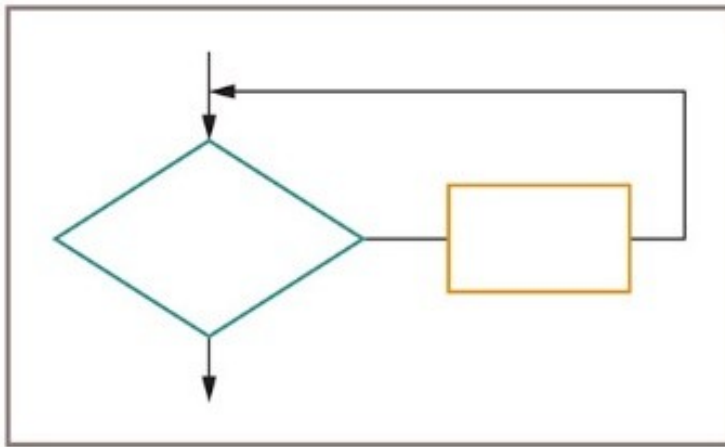


Figure 5-16 The while loop, which is a pretest

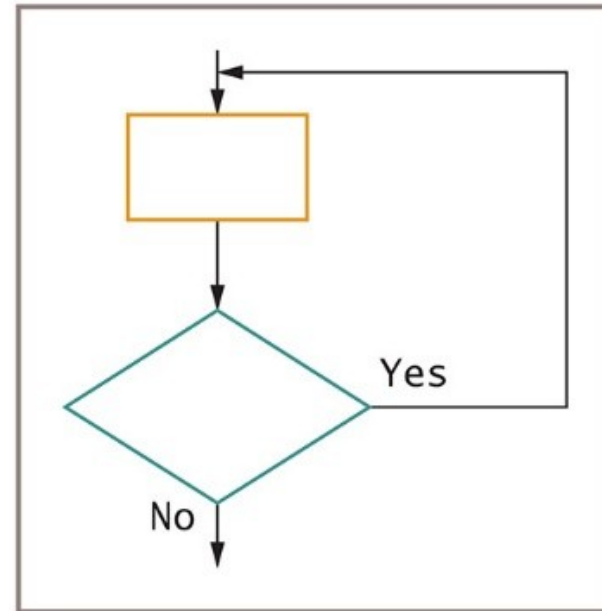


Figure 5-17 Structure of a do-while loop, which is a posttest loop

Using a Posttest Loop

(continued -2)

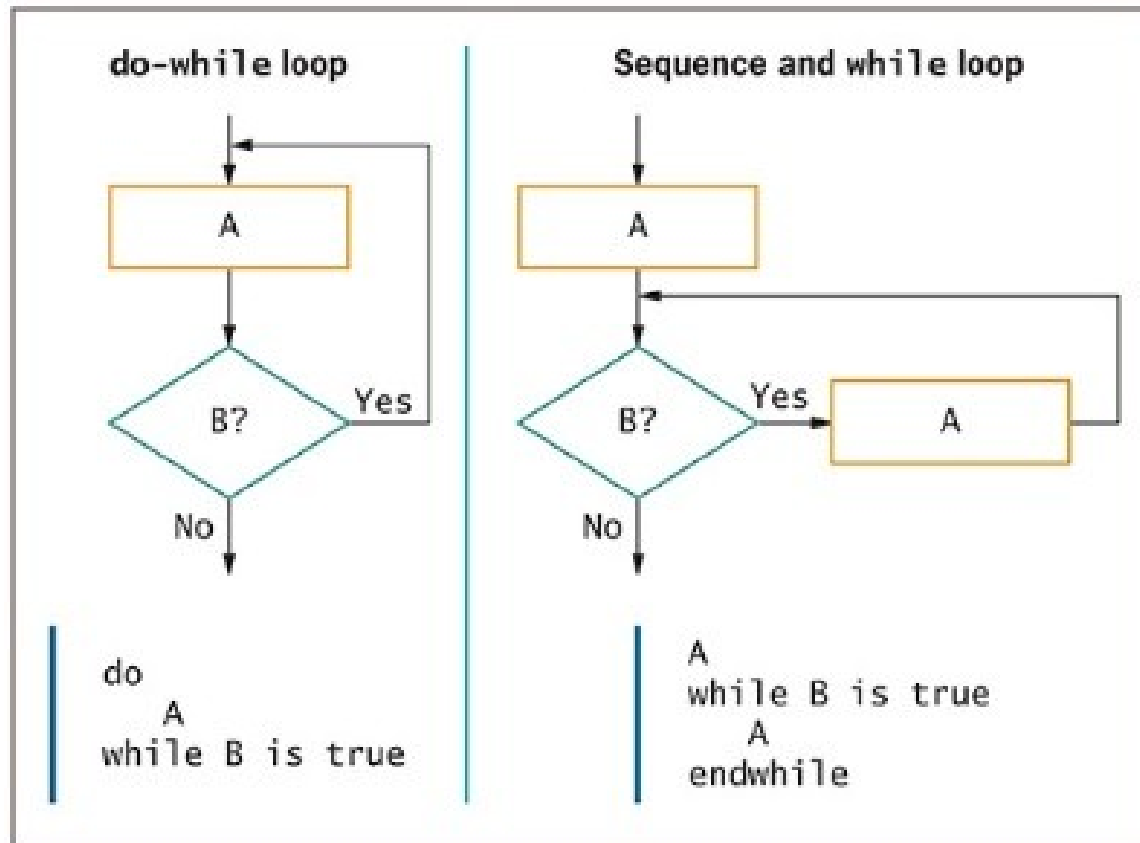


Figure 5-18 Flowchart and pseudocode for do-while loop and while loop that do the same thing

Recognizing the Characteristics Shared by Structured Loop

- All structured loops have these characteristics:
 - The loop-controlling evaluation must provide either the entry to or exit from the structure
 - The loop-controlling evaluation provides the only entry to or exit from the structure
- Some languages support a **do-until loop**, which is a posttest loop that iterates until the loop controlling evaluation is false

Recognizing the Characteristics Shared by Structured Loop

(continued -1)

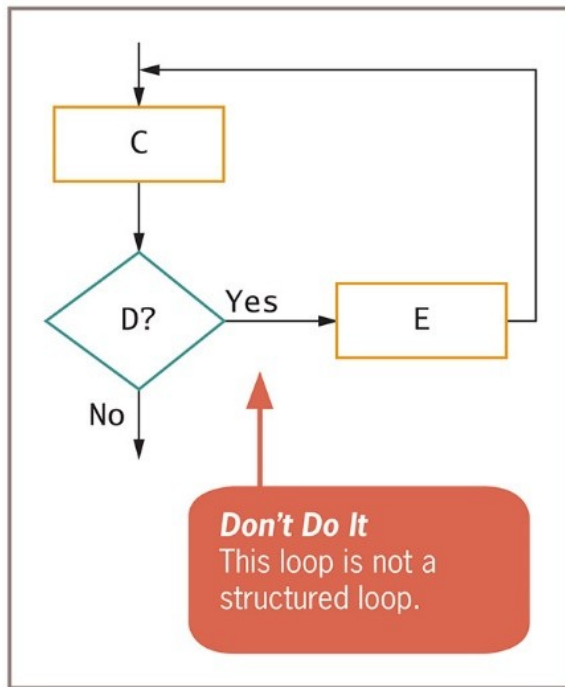


Figure 5-19 Unstructured loop

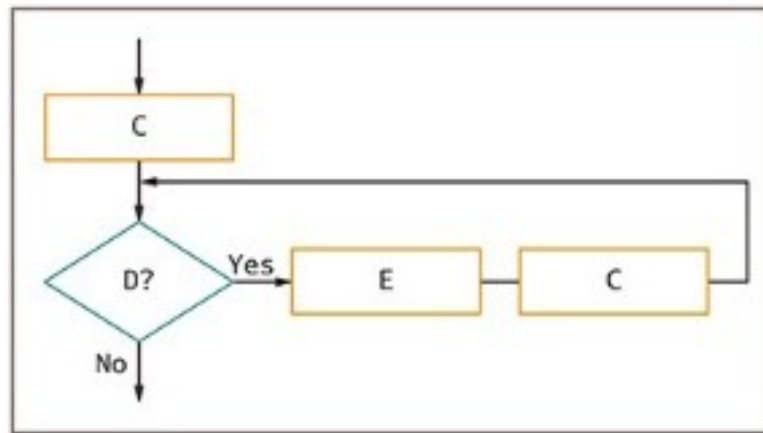


Figure 5-20 Sequence and structured loop that accomplish the same tasks as Figure 5-19



Common Loop Applications

- Using a loop to accumulate totals
 - Examples
 - Business reports often include totals
 - List of real estate sold and total value
- **Accumulator:** variable that gathers values
 - Similar to a counter
 - Counter increments by 1
 - Accumulator increments by some value

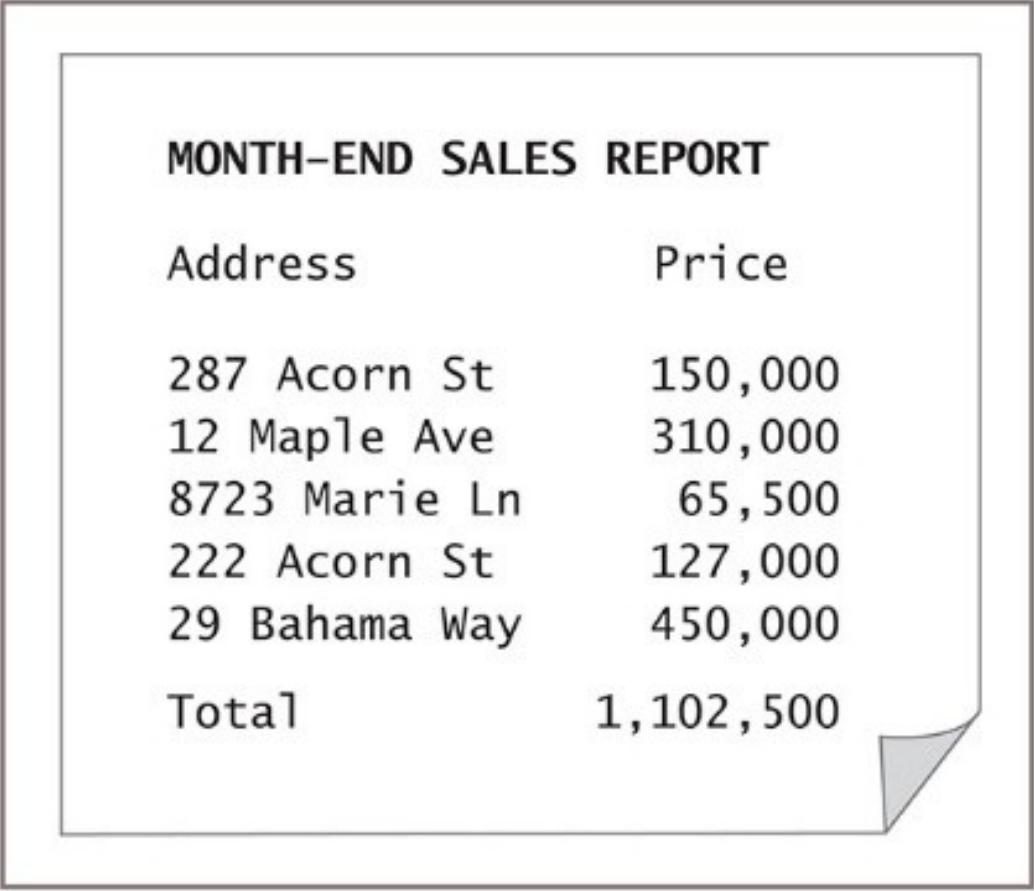
Common Loop Applications

(continued -1)

- Accumulators require three actions
 - Initialize the accumulator to 0
 - Accumulators are altered: once for every data set processed
 - At the end of processing, accumulators are output
- **Summary reports**
 - Contain only totals with no detail data
 - Loops are processed but detail information is not printed

Common Loop Applications

(continued -2)

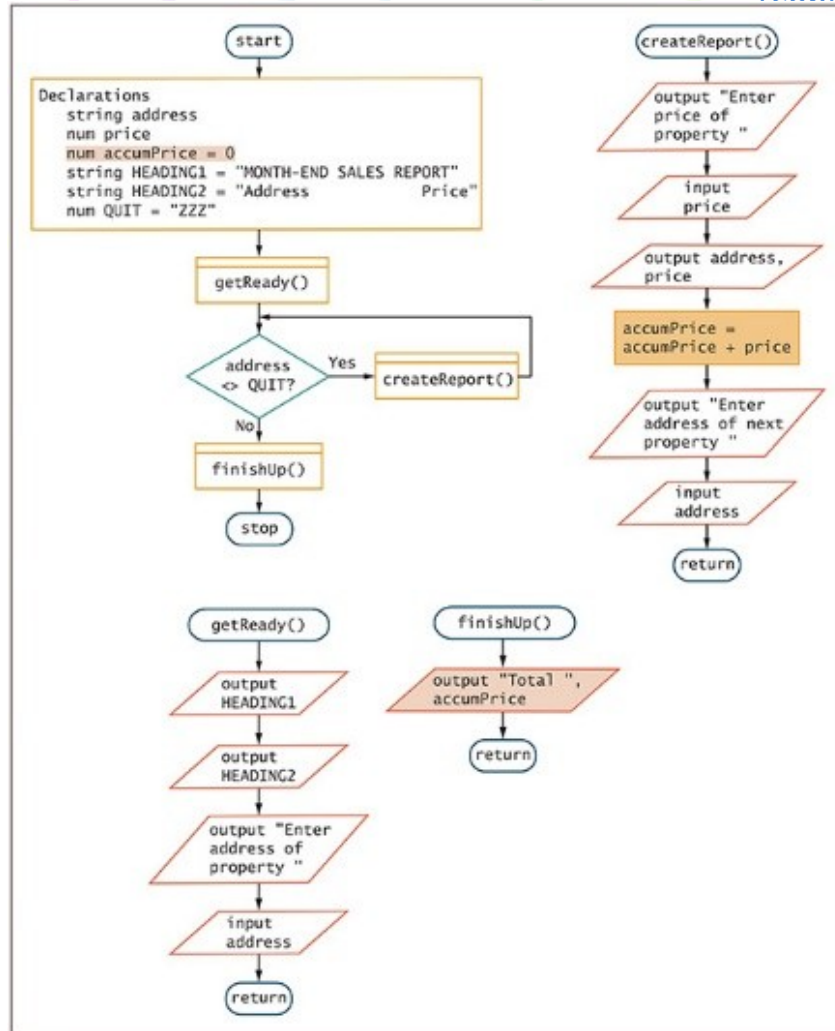


MONTH-END SALES REPORT	
Address	Price
287 Acorn St	150,000
12 Maple Ave	310,000
8723 Marie Ln	65,500
222 Acorn St	127,000
29 Bahama Way	450,000
Total	1,102,500

Figure 5-21 Month-end real estate sales report

Common Loop Applications

(continued -3)



(continued)

```

start
  Declarations
    string address
    num price
    num accumPrice = 0
    string HEADING1 = "MONTH-END SALES REPORT"
    string HEADING2 = "Address Price"
    num QUIT = "ZZZ"
  getReady()
  while address <> QUIT
    createReport()
  endwhile
  finishUp()
stop

getReady()
  output HEADING1
  output HEADING2
  output "Enter address of property "
  input address
  return

createReport()
  output "Enter price of property "
  input price
  output address, price
  accumPrice = accumPrice + price
  output "Enter address of next property "
  input address
  return

finishUp()
  output "Total ", accumPrice
  return
    
```

Figure 5-22 Flowchart and pseudocode for real estate sales report program

Figure 5-22 Flowchart and pseudocode for real estate sales report program (continues)

Common Loop Applications

(continued -4)

- Using a loop to validate data
 - **Defensive programming**: preparing for all possible errors before they occur
 - When prompting a user for data, no guarantee that data is valid
 - **Validate data**: make sure data falls in acceptable ranges (month values between 1 and 12)
 - **GIGO**: Garbage in, garbage out
 - Unvalidated input will result in erroneous output

Common Loop Applications

(continued -5)

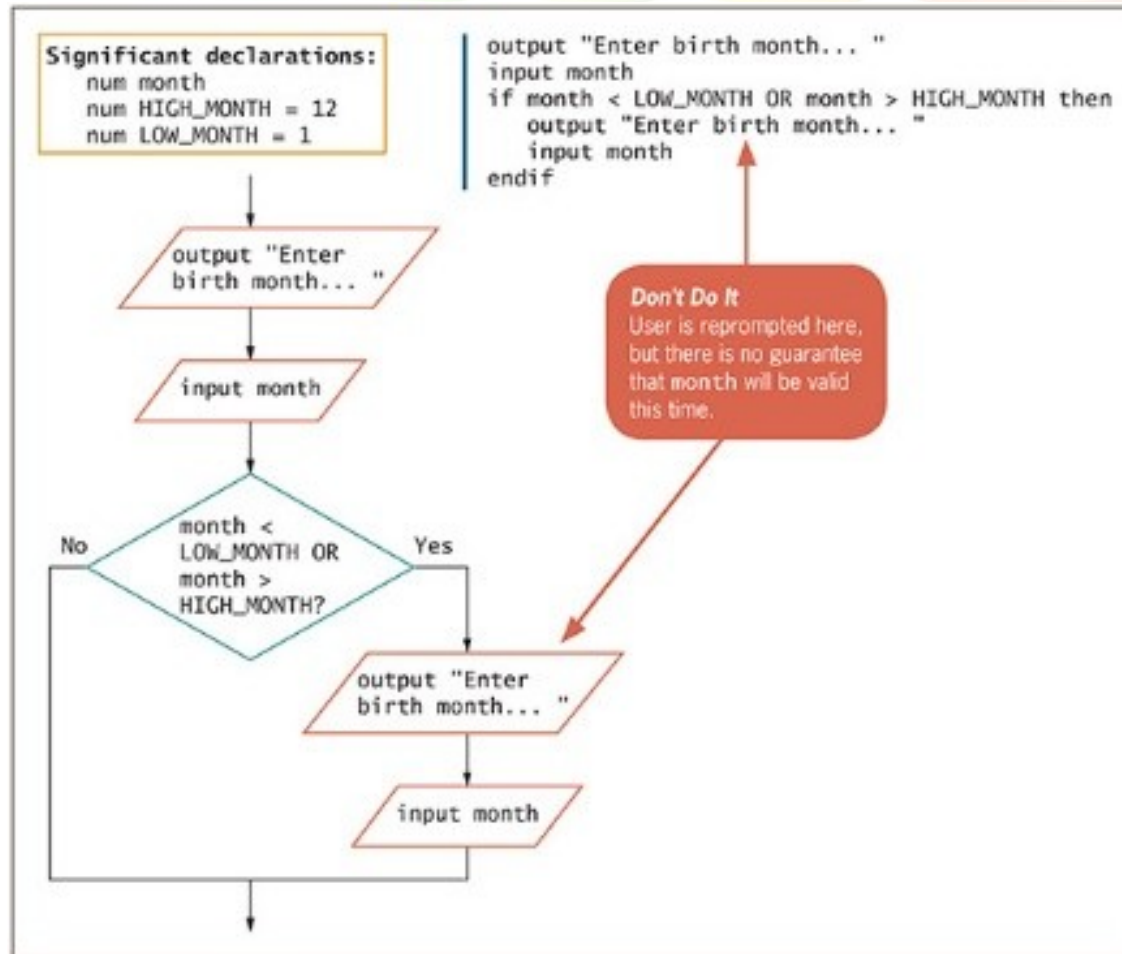


Figure 5-23 Reprompting a user once after an invalid month is entered

Common Loop Applications

(continued -6)

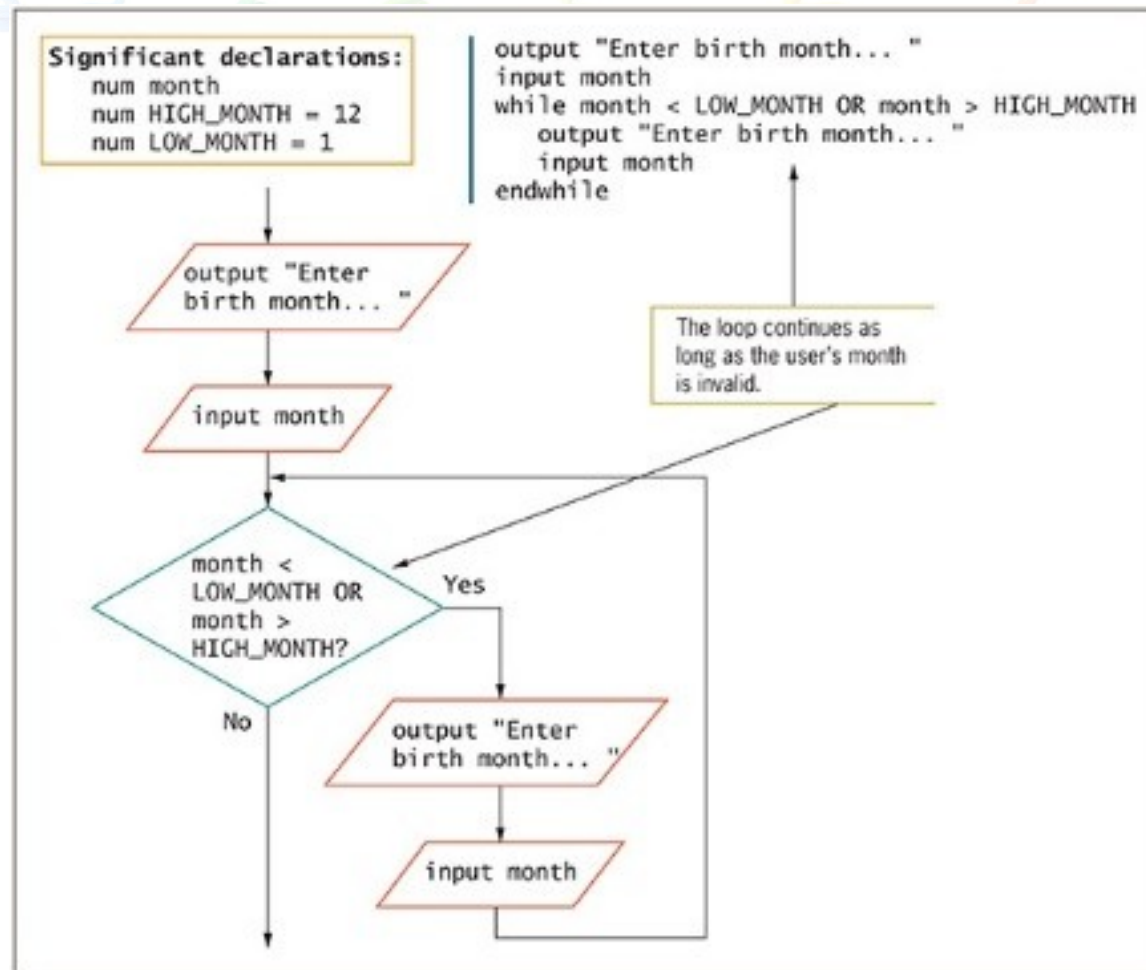


Figure 5-24 Reprompting a user continuously after an invalid month is entered

Common Loop Applications

(continued -7

- Limiting a reprompting loop
 - Reprompting can be frustrating to a user if it continues indefinitely
 - Maintain a count of the number of reprompts
 - **Forcing** a data item means:
 - Override incorrect data by setting the variable to a specific value

Common Loop Applications

(continued -8)

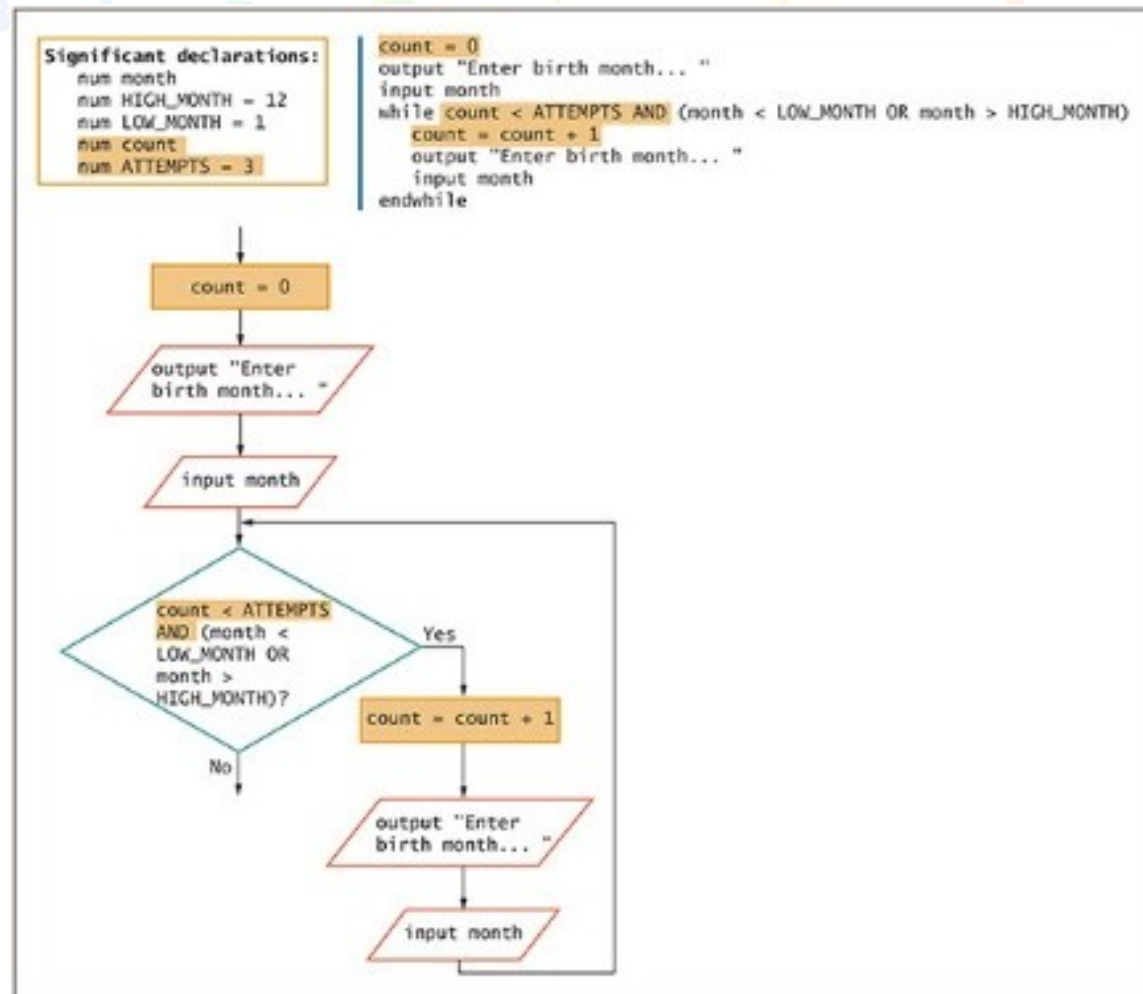


Figure 5-25 Limiting user reprompts

Common Loop Applications

(continued -9)

- Validating a data type
 - Validating data requires a variety of methods
 - `isNumeric()` or similar method
 - Provided with the language translator you use to write your programs
 - Black box
 - `isChar()` or `isWhitespace()` or `isUpper()`
 - Accept user data as strings
 - Use built-in methods to convert to correct data types

Common Loop Applications

(continued -10)

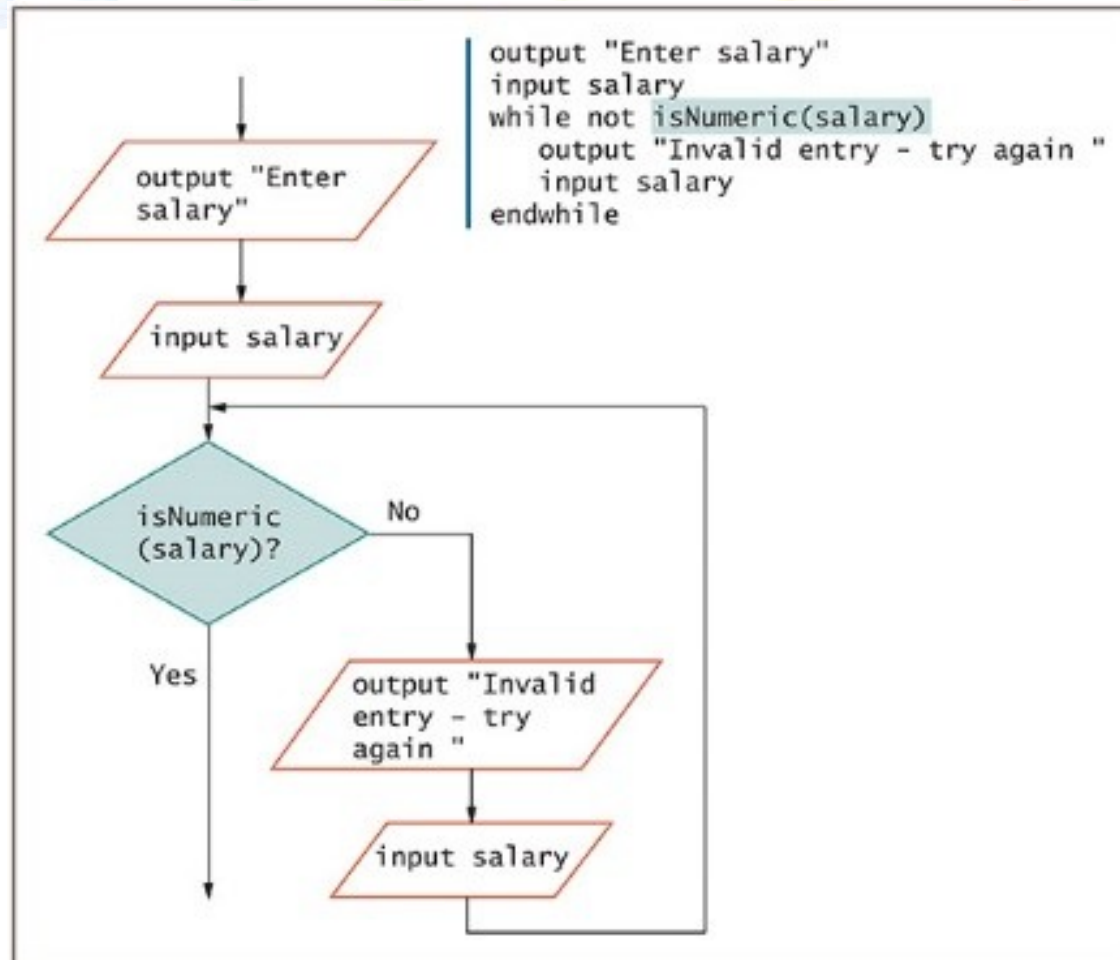


Figure 5-26 Checking data for correct type

Common Loop Applications

(continued -11)

- Validating reasonableness and consistency of data
 - Many data items can be checked for reasonableness
 - Good defensive programs try to foresee all possible inconsistencies and errors

Common Loop Applications

(continued -12)

- **Comparing Selection and Loops**
- Selection Structure
 - The two logical paths (True and False) join together
- Loop Structure
 - One of the logical branches returns to the same decision

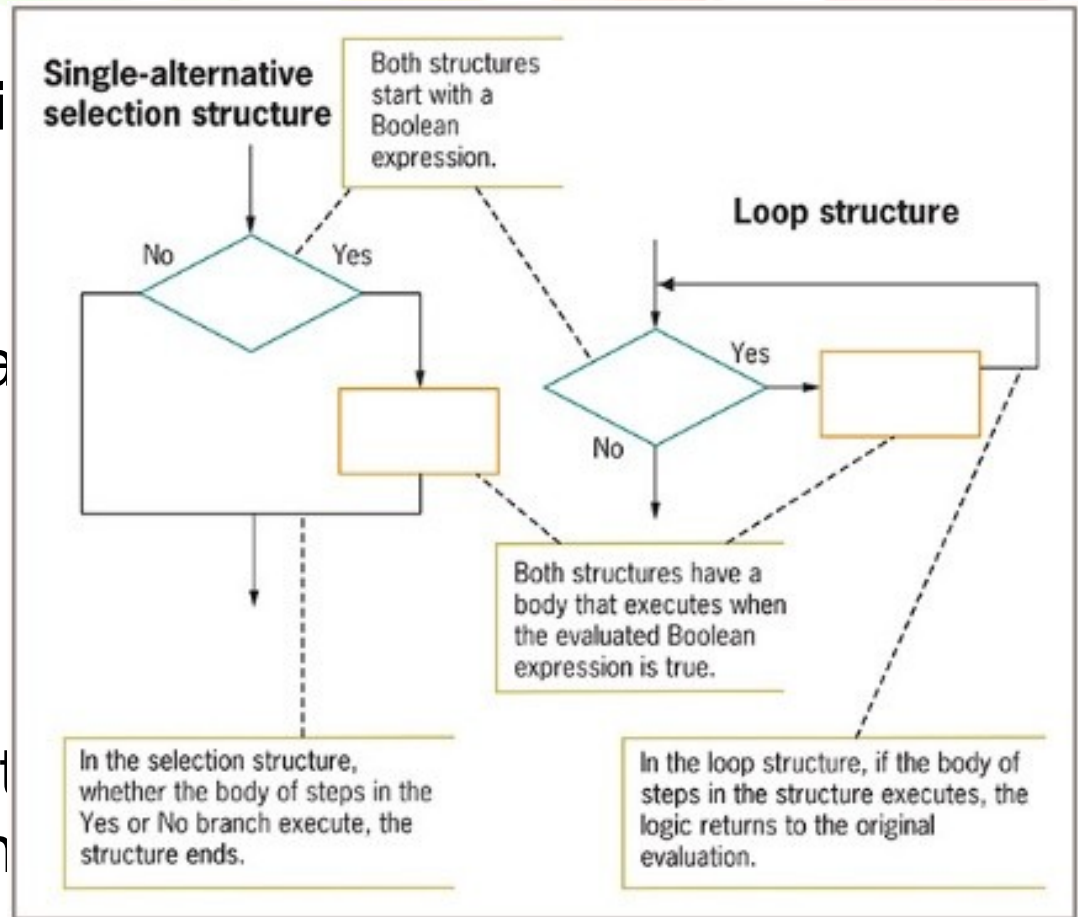
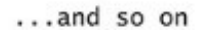


Figure 5-27 Comparing a selection and a loop

(continued -13)



Common Loop Applications

(continued -14)

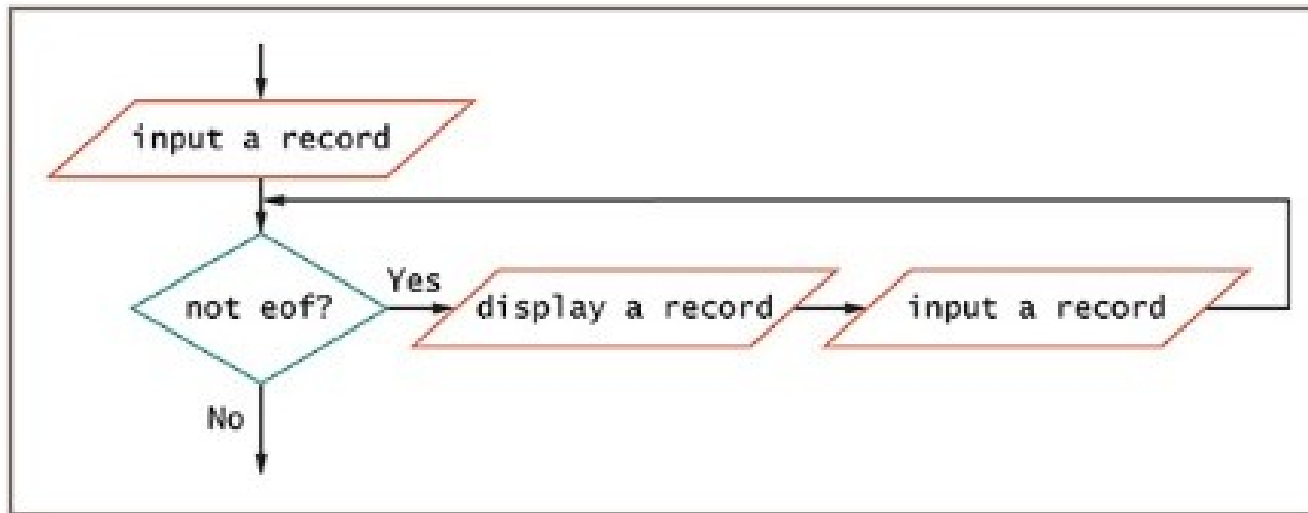


Figure 5-29 Efficient and structured logic for getting and displaying employee records



Summary

- Loops write one set of instructions that operate on multiple, separate sets of data
- Three steps must occur in every loop
 - Initialize the loop control variable
 - Compare the variable to some value
 - Alter the variable that controls the loop
- Nested loops: loops within loops
- Nested loops maintain two individual loop control variables
 - Alter each at the appropriate time

Summary (continued -1)

- Common mistakes made by programmers
 - Neglecting to initialize the loop control variable
 - Neglecting to alter the loop control variable
 - Using the wrong comparison with the loop control variable
 - Including statements inside the loop that belong outside the loop
- Most computer languages support a for loop
 - for loop used when the number of iterations is known
- In a posttest loop, the loop body executes at least one time because the loop control



Summary

(continued -2)

- Loops are used to accumulate totals in business reports and to reprompt users for valid data
- In the selection structure the two logical paths that emerge from a test join together following their actions
- In the loop structure, the paths that emerge from the test do not join together, instead, one of the paths eventually returns to the same test