STUDENT OUTLINE

Lesson 8 – Structured Programming, Control Structures, if-else Statements, Pseudocode

INTRODUCTION: This lesson is the first of four covering the standard control structures of a high-level language. Using such control structures requires the creation of simple to complex Boolean statements that evaluate to true or false. After covering the relational and logical operators available in Java, the remainder of this lesson will present the **if-else** control structure.

The key topics for this lesson are:

A. Structured Programming
B. Control Structures
C. Algorithm Development and Pseudocode
D. Relational Operators
E. Logical Operators
F. Precedence and Associativity of Operators
G. The **if-else** Statements
H. Compound Statements
I. Nested **if-else** Statements
J. Conditional Operator
K. Boolean Identifiers

VOCABULARY:

STRUCTURED PROGRAMMING	CONTROL STRUCTURE
ALGORITHM	ITERATION
LOGICAL OPERATOR	PSEUDOCODE
IF-ELSE	RELATIONAL OPERATOR
STEPWISE REFINEMENT	COMPOUND STATEMENT
CONDITIONAL OPERATOR	BOOLEAN IDENTIFIER

DISCUSSION:

A. Structured Programming

1. Up to this point in your study of computer science and Java, you have created programs that used only sequential execution. So far most programs have consisted of a sequence of lines that are executed once, line-by-line. As we add the power of loops and selection, we need to use these tools in a disciplined manner.

2. In the early days of programming (1960's), the approach to writing software was relatively primitive and ineffective. Much of the code was written with **`goto`** statements that transferred program control to another part of the code. Tracing this type of code was an exercise in jumping from one spot to another, leaving behind a trail of lines similar to spaghetti. The term

"spaghetti code" comes from trying to trace code linked together with **`goto`** statements.

3. The research of Bohm and Jacopini[1] has led to the rules of structured programming. Here are five tenets of structured programming. There are only three necessary control structures needed to write programs: sequence, selection, and iteration.

   a. No **`goto`** statements are to be used in writing code.
   b. All programs can be written in terms of three control structures: sequence, selection, and iteration.
   c. Each control structure has one entrance point and one exit point. We will sometimes allow for multiple exit points from a control structure using the **`break`** statement.
   d. Control structures may be stacked (sequenced) one after the other.
   e. Control structures may be nested inside other control structures.

4. The control structures of Java encourage structured programming. Staying within the guidelines of structured programming has led to great productivity gains in the field of software engineering.

B. Control Structures

See Handout H.A.8.2, *Control Structures in Java.*

1. There are only three necessary control structures needed to write programs: sequence, selection, and iteration.

2. Sequence refers to the line-by-line execution as used in your programs so far. The program enters the sequence, does each step, and exits the sequence.

3. Selection is the control structure that allows choice among different directions. Java provides different levels of selection:

   - One-way selection with an **`if`** structure
   - Two-way selection with an **`if-else`** structure
   - Multiple selection with a **`switch`** structure

4. Iteration refers to looping. JAVA provides three loop structures:

   - **`while`** loops
   - **`do-while`** loops
   - **`for`** loops

5. Of the seven control structures, the **`if-else`** and **`while`** loop are the most flexible and powerful for problem-solving. The other control structures have

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[1] Bohm, C., and G. Jacopini, "Flow Diagrams, Turing Machines, and Languages with Only Two Formation Rules, "*Communications of the ACM*, Vol. 9, No. 5, May 1966, pp. 336-371."

their place, but **if-else** and **while** are the most common control structures used in Java code.

6. The diagrams in H.A.8.2, *Control Structures in Java*, are flowcharts that describe the flow of program control. A statement rectangle in any control structure can be a simple line or even another control structure. A statement can also be a compound statement that consists of multiple statements.

C. Algorithm Development and Pseudocode

1. An algorithm is a solution to a problem. Computer scientists are in the problem-solving business. They use techniques of structured programming to develop solutions to problems. Algorithms will range from the easier "finding the average of two numbers" to the more difficult "visiting all the subdirectories on a hard disk, searching for a file."

2. A major task of the implementation stage is the conversion of rough designs into refined algorithms that can then be coded in the implementation language of choice.

3. Pseudocode refers to a rough-draft outline of an answer, written in English-like terms. We will probably use phrases and words that are close to programming languages, but avoid using any specific language. Once the pseudocode has been developed, translation into code occurs more easily than if we had skipped this pseudocode stage.

4. Stepwise refinement is the process of gradually developing a more detailed description of an algorithm. Problem solving in computer science involves overall development of the sections of a program, expanding each section with more detail, later working out the individual steps of an algorithm using pseudocode, then finally writing a code solution.

See Handout H.A.8.3, *Pseudocode and Algorithm Development.*

5. The handout, H.A.8.3, *Pseudocode and Algorithm Development*, will present a thorough example of this process. You should read this now.

D. Relational Operators

1. A relational operator is a binary operator that compares two values. The following symbols are used in Java as relational operators:

<	less than
>	greater than
<=	less than or equal to
>=	greater than or equal to
==	equal to
!=	not equal to

2. A relational operator is used to compare two values, resulting in a relational expression. For example:

```
number > 16          grade == 'F'         passing >= 60
```

3. The result of a relational expression is a **`boolean`** value, **`true`** or **`false`**.

4. When character data is compared, the ASCII code values are used to determine the answer. The following expressions result in the answers given:

`'A' < 'B'`	evaluates as **`true`**, (65 < 66)
`'d' < 'a'`	evaluates as **`false`**, (100 < 97)
`'t' < 'X'`	evaluates as **`false`**, (116 < 88)

In the last example, you must remember that upper case letters come first in the ASCII collating sequence; the lower case letters follow after and consequently have larger ASCII values than do upper case ('A' = 65, 'a' = 97).

E. Logical Operators

1. The three logical operators of programming are AND, OR, and NOT. These operators are represented by the following symbols in Java:

AND	&&
OR	|| (two vertical bars)
NOT	!

2. The && (and) operator requires both operands (values) to be true for the result to be true.

T and T = **`true`**
T and F = **`false`**
F and T = **`false`**
F and F = **`false`**

3. The following are Java examples of using the && (and) operator.

```
( (2 < 3) && (3.5 > 3.0) )  evaluates as true
( (1 == 0) && (2 != 3) )    evaluates as false
```

The && operator performs short-circuit evaluation in Java. If the first half of an && statement is false, the operator immediately returns false without evaluating the second half.

4. The || (or) operator requires only one operand (value) to be true for the result to be true.

```
T or T = true
T or F = true
F or T = true
F or F = false
```

5. The following is a Java example of using the `||` (or) operator.

```
( (2+3 < 10) || (21 > 19) )
```
evaluates as true

The `||` operator also performs short-circuit evaluation in Java. If the first half of an `||` statement is true, the operator immediately returns true without evaluating the second half.

6. The `!` operator is a unary operator that changes a **`boolean`** value to its opposite.

! false = true
! true = false

F. Precedence and Associativity of Operators

1. Introducing two new sets of operators (relational and logical) adds to the complexity of operator precedence in Java. An abbreviated precedence chart is included here.

Operator	Associativity
`!` unary `-` `++` `--`	right to left
`*` `/` `%`	left to right
`+` `-`	left to right
`<` `<=` `>` `>=`	left to right
`==` `!=`	left to right
`&&` (and)	left to right
`||` (or)	left to right
`=` `+=` `-=` `*=` `/=`	right to left

Table 8-1 Precedence and Associativity of Operators

2. Because the logical operators have low precedence in Java, parentheses are not needed to maintain the correct order of solving problems. However, they can be used to make complex expressions more readable.

```
((2 + 3 < 10) && (75 % 12 != 12))    // easier to read
(2 + 3 < 10 && 75 % 12 != 12)        // harder to read
```

G. The **`if-else`** Statements

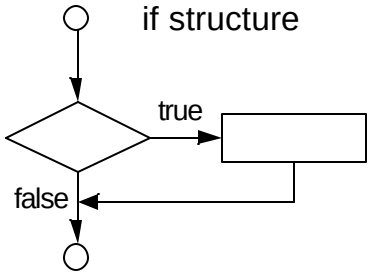
1. The general syntax of the **`if-else`** statement is as follows:

```
if (expression)
   statement1;
else
   statement2;
```

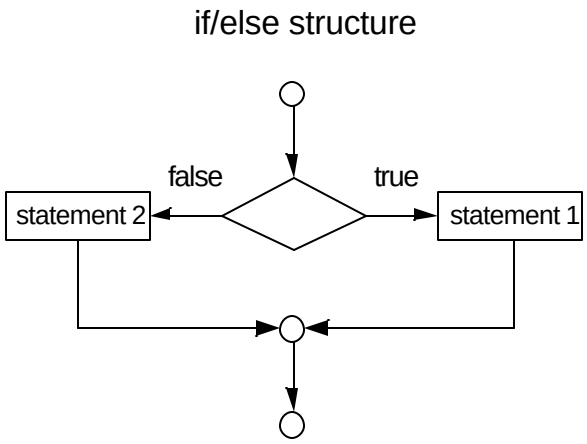
2. **`if`** statements may omit the **`else`** option if it results in one-way selection.

```
if (expression)
   statement1;
```

   If the expression is non-zero, statement is executed, otherwise nothing is executed. The following flowchart illustrates the flow of control.



3. The full **`if-else`** statement allows for two-way control. If the value of the expression is true, statement1 is executed. If the value of the expression equals false, the **`else`** option results in statement2 being executed. The following flowchart from handout, H.A.8.2, illustrates the flow of control.



4. The expression being tested must always be placed in parentheses. This is a common source of syntax errors.

H. Compound Statements

1. The statement executed in a control structure can be a block of statements, grouped together into a single compound statement.

2. A compound statement is created by enclosing any number of single statements by braces as shown in the following example:

```
if (expression)
{
  statement1;
  statement2;
  statement3;
}
else
{
  statement4;
  statement5;
  statement6;
}
```

I. Nested **if-else** Statements

1. The statement inside of an **if** or **else** option can be another **if-else** statement. Placing an **if-else** inside another is known as nested **if-else** constructions. For example:

```
if (expression1)
  if (expression2)
    statement1;
  else
    statement2;
else
  statement3;
```

2. The **else** option will be paired with the nearest unpaired **if**. `statement2` is the alternative action of the inner **if**, while `statement3` is the alternative action of the outer **if**.

3. The above example has three possible different outcomes as shown in the following chart:

expression 1	expression2	statement executed
true	**true**	statement1
true	**false**	statement2
false	**true**	statement3
false	**false**	statement3

4. Caution must be shown when using **else** statements inside of nested **if-else** structures. For example:

```
if (expression1)
  if (expression2)
    statement1;
else
  statement2;
```

Indentation is ignored by the compiler, hence it will pair the **else** statement with the inner **if**. If you want the **else** to get paired with the outer **if** as the indentation indicates, you need to add braces:

```
if (expression1)
{
  if (expression2)
    statement1;
}
else
  statement2;
```

The braces allow the else statement to be paired with the outer **if**.

5. Another alternative to the example in Section 4. makes use of the && operator. A pair of nested **if** statements can be coded as a single compound && statement.

```
if (expression1 && expression2)
  statement1;
else
  statement2;
```

6. The most common and effective use of nested **if-else** statements is called an **if-else** chain. See the following formatting styles:

Formatting style 1

```
if (expression1)
   statement1;
else
   if (expression2)
      statement2;
   else
      if (expression3)
         statement3;
      else
         statement4;
```

Formatting style 2

```
if (expression1)
   statement1;
else if (expression2)
   statement2;
else if (expression3)
   statement3;
else
   statement4;
```

Notice that each successive **`if-else`** statement is buried deeper in the overall structure. `statement4` will only be executed if the first three expressions are **`false`**.

7. Formatting style 1 lines up the **`if`** with its counterpart **`else`** keyword. This makes it easy to check syntax but the indentation can get rather deep. Formatting style 2 is a more compact version but you need to be careful about which **`else`** statement belongs to which **`if`**. Formatting style 1 is more appropriate if the statements are compound statements. Formatting style 2 is appropriate if the statements are single-line statements.

8. The advantage of such an **`if-else`** chain is efficiency in execution. If a **`true`** value is encountered at any level, that statement is executed and the rest of the structure is ignored.

9. Consider the following example of determining the type of triangle given the three sides `A`, `B`, and `C`.

```
if ( (A == B) && (B == C) )
  System.out.println("Equilateral triangle");
else  if ( (A == B) || (B == C) || (A == C) )
  System.out.println("Isosceles triangle");
else
  System.out.println("Scalene triangle");
```

   If an equilateral triangle is encountered, the rest of the code is ignored. Such a chain is best constructed by placing the most demanding case at the top and the least demanding case at the bottom.

J. Conditional Operator (optional)

1. Java provides an alternate method of coding an **`if-else`** statement using the conditional operator. This operator is the only ternary operator in Java, as it requires three operands. The general syntax is:

```
(condition) ? statement1 : statement2;
```

2. If the condition is true, `statement1` is executed. If the condition is false, `statement2` is executed.

3. This is appropriate in situations where the conditions and statements are fairly compact.

```
int max(int a, int b)  // returns the larger of two integers
{
  (a > b) ? return a  :  return b;
}
```

K. Boolean Identifiers

1. The execution of **`if-else`** statements depends on the value of the Boolean expression. We can use **`boolean`** variables to write code that is easier to read.

2. For example, the **`boolean`** variable `done` could be used to write code that is more English-like.

   Instead of

```
if (done == true)
  System.out.println("We are done!");
```

   we can write

```
if (done)
  System.out.println("We are done!");
```

3. Using Boolean identifiers with conditional loops allows a separation of solving expressions from thinking about program control. Here is an example solution using the **`while`** control structure (to be covered in the next lesson), presented in a blend of Java and pseudocode:

```
boolean done = false;

while (!done)
 // do some code that could change the value of done
```

4. Where appropriate you are encouraged to use **`boolean`** variables to aid in program flow and readability.

SUMMARY/ REVIEW: Control structures are a fundamental part of high level languages. Fluency in any high level language only comes with practice. You will need to practice control structures in Java as well as all other aspects of the language.

ASSIGNMENT: Lab Exercise, L.A.8.1, *IRS*

LAB EXERCISE

IRS

Background:

Federal income tax rates can be calculated using tax rate schedules. The following are tax rates for two out of the four categories used by the IRS in 2001:

Schedule X - Single

If your taxable income is:

over -	but not over -	your tax is	of the amount over -
$ 0	$ 27,050	15 %	$ 0
27,050	65,550	$ 4,057.50 + 27.5 %	27,050
65,550	136,750	$ 14,645.00 + 30.5 %	65,550
136,750	297,350	$ 36,361.00 + 35.5 %	136,750
297,350	---------	$ 93,374.00 + 39.1 %	297,350

Schedule Y-1 - Married filing jointly

If your taxable income is:

over -	but not over -	your tax is	of the amount over -
$ 0	$ 45,200	15 %	$ 0
45,200	109,250	$ 6,780.00 + 27.5 %	45,200
109,250	166,500	$ 24,393.75 + 30.5 %	109,250
166,500	297,350	$ 41,855.00 + 35.5 %	166,500
297,350	---------	$ 88,306.00 + 39.1 %	297,350

To test your understanding, follow this example of a single person with taxable income of $68,000:
Tax is 14645 + 0.305*(68000-65550) = 14645+745.25 = $15392.25

Assignment:

1. Write a program that:

   a. Prompts the user for the following information:

      Filing status : single or married
      Taxable income

   b. Calculates and prints

      Filing status

Taxable income
Federal tax

2. Your program should be written using proper modular design and parameter passing. Use the handout H.A.8.1 as a model. Your instructor will give you more guidelines if you have questions.

3. Example run output:

   Single
   Taxable income = $ 35,125
   Federal tax = $ 6,630.50

Instructions:

1. Complete the working program to the screen and verify the calculations. Use the values given above.

2. Print your source code first, then the run output below it.

3. Use these values for your run output:

   Single, $15,500

   Single, $100,000

   Married, $50,000

   Married, $125,000

PROGRAMMING POINTERS, LESSON 8

Syntax/correctness issues

8-1 The statement of a control structure can be a single statement, a compound statement marked out with braces {}, or the empty statement that consists of a semicolon (;).

8-2 The condition for a control structure must be placed within parentheses ().

8-3 Be careful when setting up an equality (==) comparison. A very common mistake is the use of the assignment operator (=) when equality was intended. Here is a suggestion, when using comparisons that involve a variable and a value (`x == 2`), reverse the order (`2 == x`) to avoid the subtle error of writing `x = 2`.

Formatting suggestions

8-4 Use consistent indentation when formatting control structures. Indentation implies hierarchy or subordination - which statements belong to which control structure. I suggest three blank spaces per indent.

8-5 When writing expressions with logical and relational operators, add white space around each operator to make the expression more readable. For example:

((*number* <= 10) && (*total* <= 1000)) instead of ((*number*<=10)&&(*total*<=1000))

Software engineering

8-6 Use pseudocode to develop your solution to a problem. Then convert your pseudocode to Java code.

8-7 Programs and subprograms can be broken down into three stages: initialization, processing, and output. When writing a method or an entire program consider this approach:

1. Initialize some variables
2. Solve some processing problem, this usually involves developing an algorithm
3. Return some output to either the screen or to the calling statement of the function.

8-8 The && operator is also a short-circuit operator in Java. If the first operand of an && expression is false, the second condition is not evaluated. Consequently you should write the expression most likely to be false as the first half of an && expression.

(expression1 && expression2)

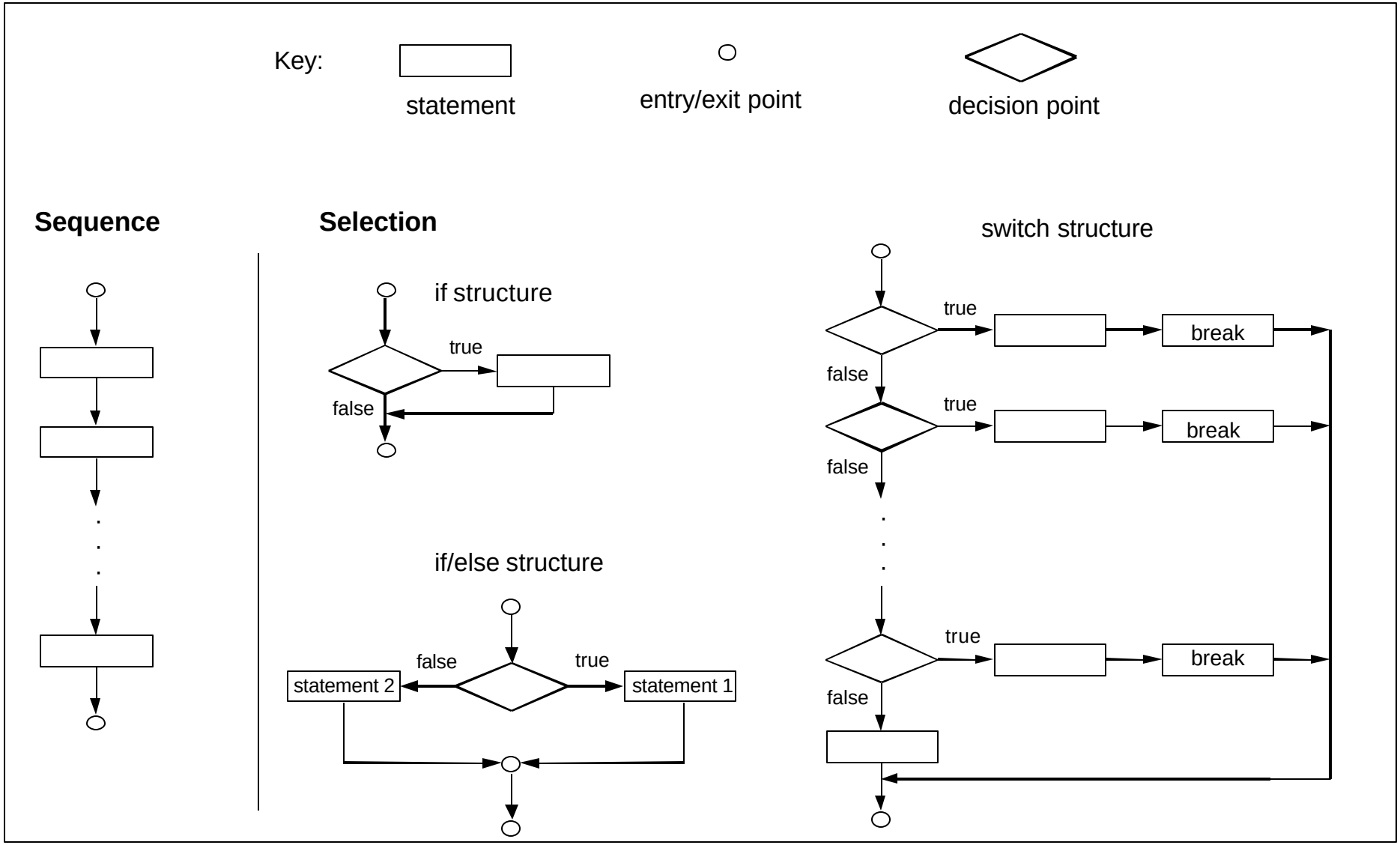
If expression1 is false, the && operator will ignore processing expression2.

8-9 The || operator is also an efficient operator. You should put the expression most likely to be true as the first condition of an || expression.

(expression1 || expression2)

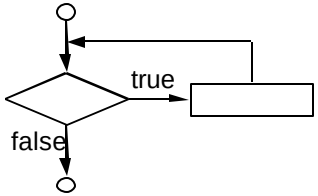
If expression1 is true, the || operator will ignore processing expression2.

CONTROL STRUCTURES IN JAVA

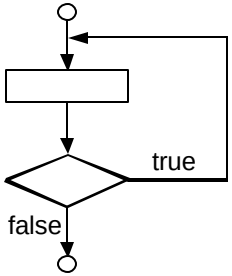


Repetition

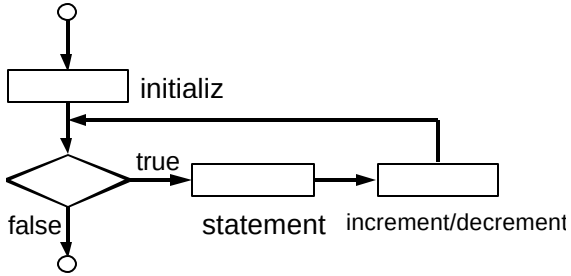
while structure



do-while



for structure



PSEUDOCODE AND ALGORITHM DEVELOPMENT

Description of problem:

The U.S. post office has rules about mailing packages. A package cannot be mailed first class if the sum of its length and girth is greater than 100 inches, or if the package weighs more than 70 pounds. The girth is the perimeter around the height and width, where the length is defined as the longest of the three dimensions.

Write a program that takes in the weight of the package and the three dimensions of the package in any order. The program should determine the longest dimension of the package, calculate the girth, and compute the size of the box. The program should then print out one of the following messages about this package:

1. Package is too large and too heavy.
2. Package is too large.
3. Package is too heavy.
4. Package is acceptable.

Development of pseudocode:

Stepwise refinement 1 - Overall sections of this problem:

Get data from user
Solve math
Print answer

Stepwise refinement 2 - More detailed pseudocode version:

Prompt user for three dimensions
Prompt user for weight

Determine longest of three dimensions
Calculate the girth using the other two dimensions

If package is too big and too heavy, print appropriate message
else if package is too big, print appropriate message
else if package is too heavy, print appropriate message
else print package is acceptable

Stepwise refinement 3 - Determining longest of three dimensions:

My strategy is to end up with dim1 holding the largest value
Compare dim2 and dim1, if dim2 is greater, swap dim1 and dim2, dim1 will be holding largest value
Compare dim3 and dim1, if dim3 is greater, swap dim1 and dim3, dim1 is still holding largest value

Dim1 has largest value, compute math for package

Source code answer for mail problem:

```
import chn.util.*;

class CheckMail
{
   private int myWeight, myLength, myWidth, myHeight;

   // Here are the constructor methods...
   public CheckMail ()
   {
      myWeight = myLength = myWidth = myHeight = 1;
   }

   public CheckMail(int weight, int length, int width, int height)
   {
      myWeight = weight;
      myLength = length;
      myWidth = width;
      myHeight = height;
   }

   public void dataInput()
   {
      ConsoleIO keyboard = new ConsoleIO();
      int temp = 0;

      System.out.print("Enter the weight --> ");
      myWeight = keyboard.readInt();

      System.out.print("Enter 3 dimensions separated by spaces --> ");
      myLength = keyboard.readInt();
      myWidth = keyboard.readInt();
      myHeight = keyboard.readInt();

      if (myWidth > myLength)
      {
          // swapping values of myWidth and myLength, using third variable temp
         temp = myWidth;  myWidth = myLength;   myLength = temp;
      }
      if (myHeight > myLength)
      {
          // swapping values of myHeight and myLength, using third variable temp
         temp = myHeight;  myHeight = myLength;   myLength = temp;
      }
      System.out.println();
      System.out.println();
   }

   //  prints out answers
   public void printAnswer()
   {
      int total = myLength + (myWidth*2) + (myHeight*2);
      boolean tooLarge = (total > 100);
```

```
      boolean tooHeavy = (myWeight > 70);

      System.out.println("Weight = " + myWeight + " lbs");
      System.out.println("Length = " + myLength);
      System.out.print("Other two dimensions = ");
      System.out.println(myWidth + "   " + myHeight);
      System.out.println();









      System.out.print("  Package is - ");

      if (tooLarge && tooHeavy)
         System.out.println("too large and too heavy");
      else if (tooLarge && !tooHeavy)
         System.out.println("too large");
      else if (!tooLarge && tooHeavy)
         System.out.println("too heavy");
      else if (!tooLarge && !tooHeavy)
         System.out.println("acceptable");

      System.out.println();
   }

   public static void main(String[] args)
   {
      CheckMail aPackage = new CheckMail ();

      aPackage.dataInput();
      aPackage.printAnswer();
   }

}
```