Tutorial 2c
Flowchart Structures

Introduction

There are three basic structures in flowcharting – sequential, selection and repetition, and some other addition including function and combination of them. Computer programming also has the same structures. The purpose of this exercise is to train you to think in a structured way. Doing computer programming is easier if you could think in that way. In this exercise, you are going to explore when and how to use those structures in designing algorithms. You will be given a flowchart of certain structure and needed to convert it to other structure. For each question you will be given an example as a guideline. Study the examples before doing the questions.

## Objective

After completing this exercise, you should
- know when and how to use each structure espiacally repetition and function
- be able to convert a flowchart from a complex structure to a simpler one
- be able to identify the structure of a problem

Part 1: Using Repetition Structure

Repetition structure is usually used for repeated actions. In this part you will convert some flowcharts which are given in a sequential structure to a repetition structure.

Example

The following flowchart will print numbers 1, 2, 3, and 4. Create a new flowchart using a repetition structure to print the same output.
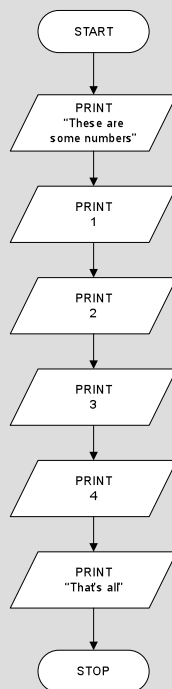

Solution

Do these two steps first:
- Fistly, identify which **actions are about the same** – i.e. they look like repeated. You can see the actions "PRINT 1", "PRINT 2", PRINT 3", and "PRINT 4" are about the same; they all do "PRINT". The only difference is the number they print.

- Secondly, identify the **general form** of the repeated actions. The general form of the four PRINTs is "**PRINT n**" where **n** represents a number of 1, 2, 3 and 4.

The flowchart in a repetition structure should look like this
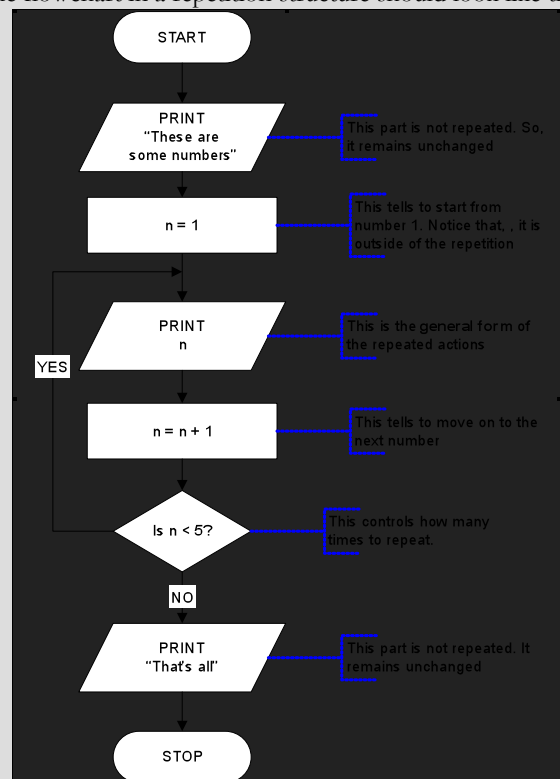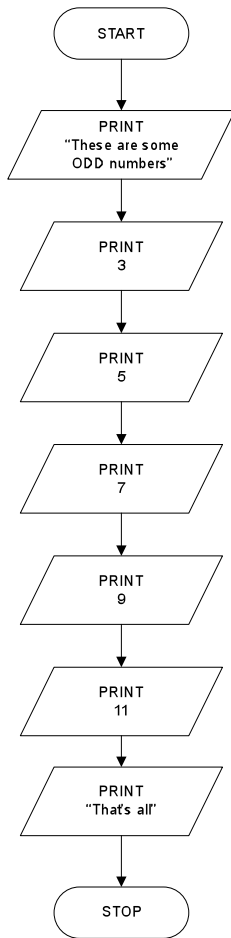

Question

What changes should be made to the flowchart so that it will print numbers 3 to 10?

Questions

Below are some flowcharts that use a sequential structure. Convert each flowchart to a repetition structure. The converted flowchart must do the same thing as its original. Draw the flowcharts in the specified areas. Finally, check your answer by tracing the flowchart.

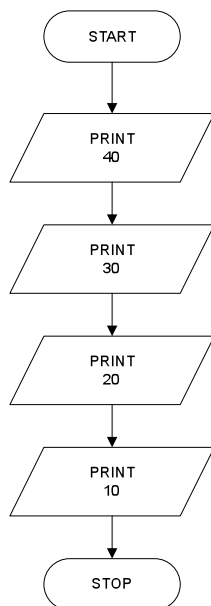1. This flowchart prints odd numbers 3, 5, 7, 9 and 11.

Answer:
For this question, you are given the template of the flowchart as follows. You only need to fill in the symbols.
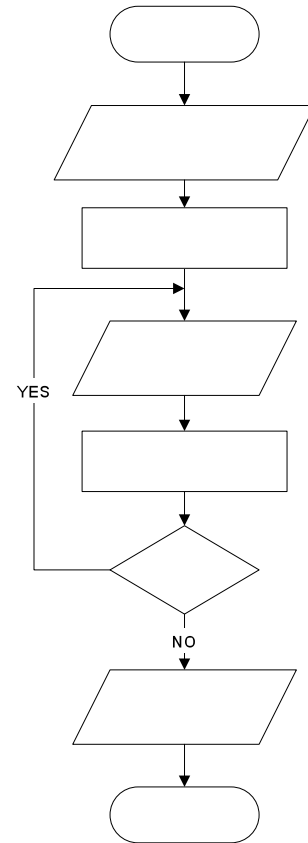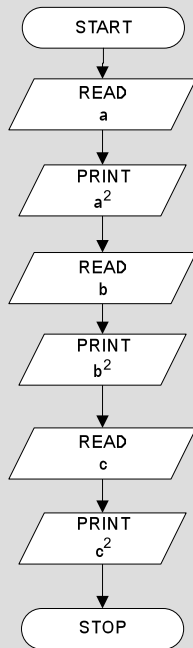

2. This flowchart prints numbers 40, 30, 20 down to 10
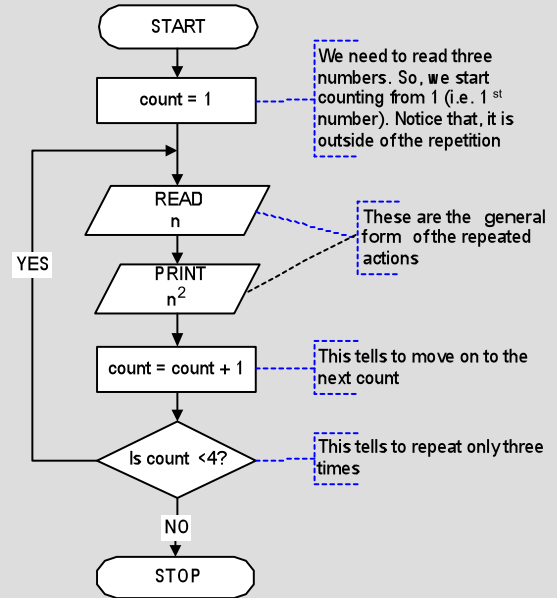

Answer:

Example

The following flowchart asks the user to enter three numbers (i.e. represented by a, b and c respectively), and then prints the square of each number. Create a new flowchart using a repetition structure that does the same thing.
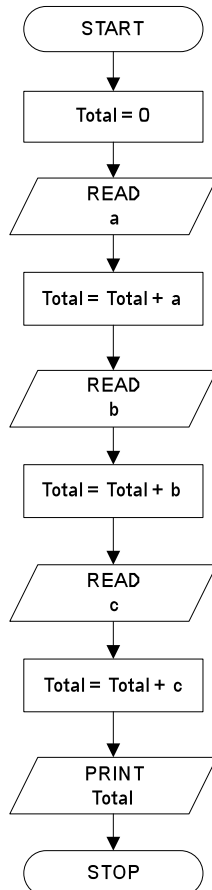
```
START
  │
  ▼
READ
 a
  │
  ▼
PRINT
 a²
  │
  ▼
READ
 b
  │
  ▼
PRINT
 b²
  │
  ▼
READ
 c
  │
  ▼
PRINT
 c²
  │
  ▼
STOP
```

Solution

- *Repeated actions:*
  "READ a , PRINT a^2",
  "READ b , PRINT b^2",
  "READ c , PRINT c^2",
- *General form of the repeated actions:*
  "READ **n** , PRINT n^2 "

```
           START
             │
             ▼
        count = 1
             │
             ▼
   ┌──────► READ
   │         n
   │         │
   │         ▼
  YES      PRINT
   │        n²
   │         │
   │         ▼
   │   count = count + 1
   │         │
   │         ▼
   └─── Is count <4?
             │
             NO
             │
             ▼
           STOP
```

We need to read three numbers. So, we start counting from 1 (i.e. 1 st number). Notice that, it is outside of the repetition

These are the general form of the repeated actions

This tells to move on to the next count

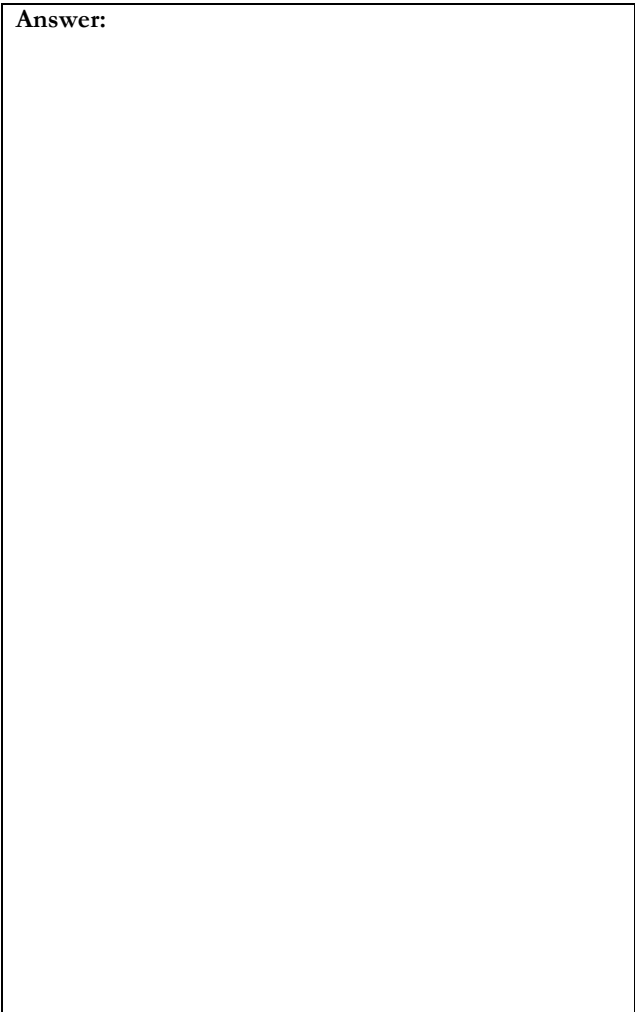This tells to repeat only three times

Question

3. This flowchart asks the user to enter three numbers (i.e. represented by a, b and c respectively), finds the total of the numbers and finally prints the total. Convert the flowchart to a repetition structure.
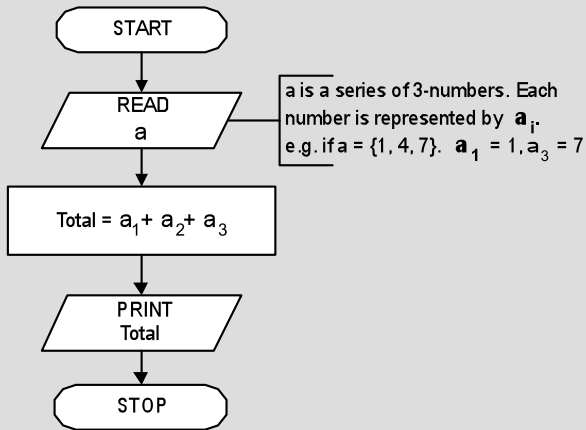
```
START
  │
  ▼
Total = 0
  │
  ▼
READ
 a
  │
  ▼
Total = Total + a
  │
  ▼
READ
 b
  │
  ▼
Total = Total + b
  │
  ▼
READ
 c
  │
  ▼
Total = Total + c
  │
  ▼
PRINT
Total
  │
  ▼
STOP
```
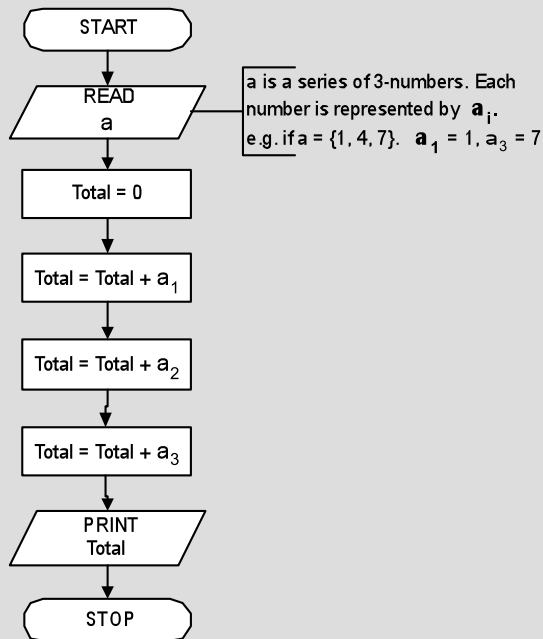
Answer:

Example

Both flowcharts below are equivalent. They firstly ask the user to enter a series of number, which contains three numbers, then calculate the total of the series and finally print the total. Create a new flowchart using a repetition structure that does the same thing.
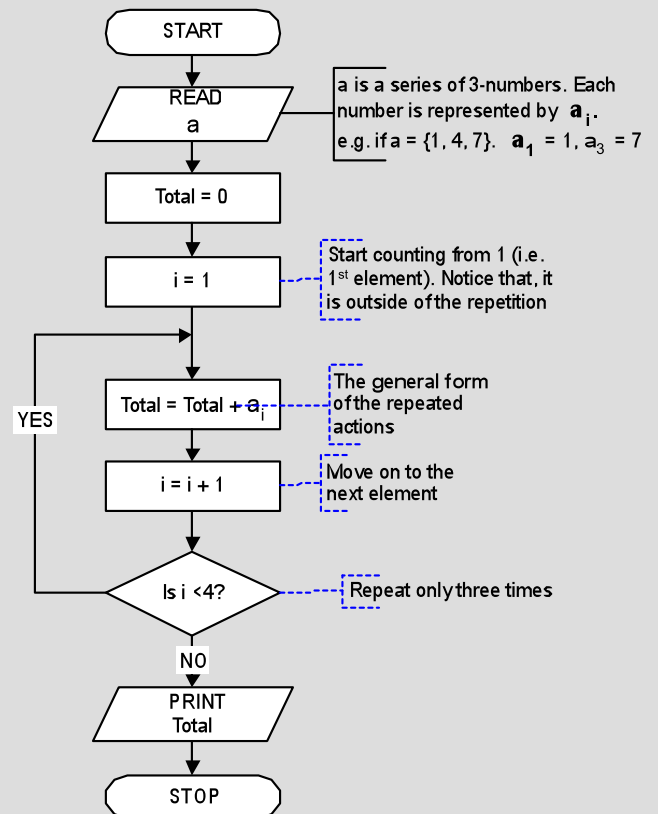
```
        ( START )
           |
         / READ /
        /   a   /
           |
   [ Total = a_1 + a_2 + a_3 ]
           |
        / PRINT  /
       /  Total  /
           |
        ( STOP )
```

a is a series of 3-numbers. Each number is represented by a_i.
e.g. if a = {1, 4, 7}. $a_1 = 1$, $a_3 = 7$

The following flowchart is more detail. Use it as the base for the conversion.

```
        ( START )
           |
        / READ /
       /   a   /
           |
    [ Total = 0 ]
           |
    [ Total = Total + a_1 ]
           |
    [ Total = Total + a_2 ]
           |
    [ Total = Total + a_3 ]
           |
       / PRINT  /
      /  Total  /
           |
        ( STOP )
```

a is a series of 3-numbers. Each number is represented by a_i.
e.g. if a = {1, 4, 7}. $a_1 = 1$, $a_3 = 7$
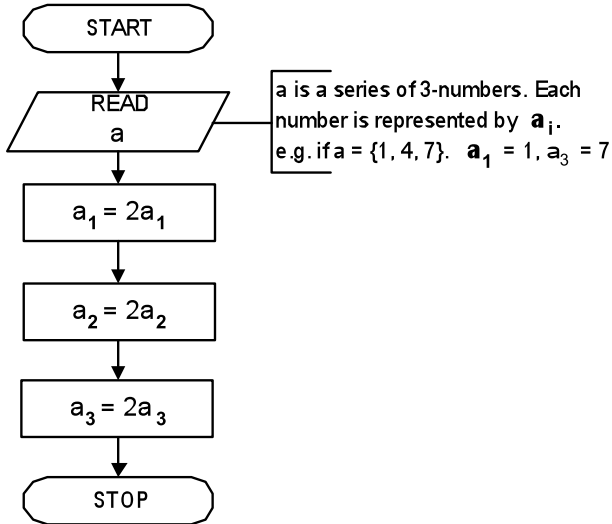
Solution

The solution is derived from the second flowchart.

- *Repeated actions:*
  "Total = Total + a_1",
  "Total = Total + a_2",
  "Total = Total + a_3"

- *General form of the repeated actions:*
  "Total = Total + a_i",

```
        ( START )
           |
        / READ /
       /   a   /
           |
    [ Total = 0 ]
           |
    [ i = 1 ]
           |
    [ Total = Total + a_i ] <---- YES
           |                        |
    [ i = i + 1 ]                   |
           |                        |
      < Is i <4? > -----------------
           | NO
       / PRINT  /
      /  Total  /
           |
        ( STOP )
```

a is a series of 3-numbers. Each number is represented by a_i.
e.g. if a = {1, 4, 7}. $a_1 = 1$, $a_3 = 7$

Start counting from 1 (i.e. 1st element). Notice that, it is outside of the repetition

The general form of the repeated actions

Move on to the next element
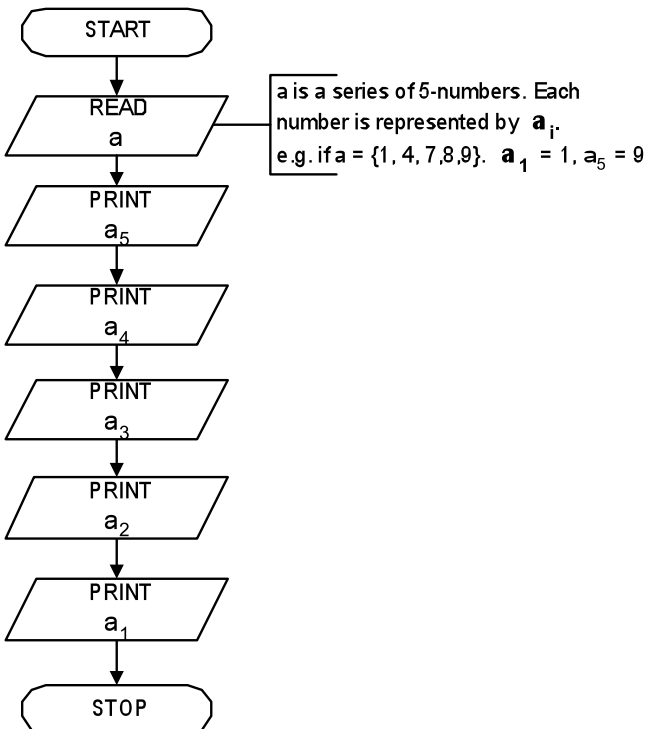
Repeat only three times

Question

4. The following flowchart firstly asks the user to enter a series of 3-numbers and then doubles the value of each element. Create a new flowchart using a repetition structure that does the same thing.

START

READ
a

$a_1 = 2a_1$

$a_2 = 2a_2$

$a_3 = 2a_3$

STOP

a is a series of 3-numbers. Each number is represented by a_i.
e.g. if a = {1, 4, 7}. a_1 = 1, a_3 = 7

Answer:

5. The following flowchart firstly asks the user to enter a series of 5-numbers and then prints the elements of the series in reverse order. Create a new flowchart using a repetition structure that does the same thing.

START

READ
a

PRINT
a_5

PRINT
a_4

PRINT
a_3

PRINT
a_2

PRINT
a_1

STOP

a is a series of 5-numbers. Each number is represented by a_i.
e.g. if a = {1, 4, 7,8,9}. a_1 = 1, a_5 = 9

Answer:

Name:……………………………………………………………. **IC NO:** ……………………………………………..

Post Tutorial:

The purpose of this section is to determine whether you have achieved the objective of the previous exercise – i.e. understanding on how and when to use repetition structures in designing algorithms. Answer the following question into specified box.

Question

6. Given the formula to calculate the average of a series of consecutive positive integers from 1 to a given number (n) as follows:

$$\overline{n} = \frac{\sum_{i=1}^{n} i}{n}$$

$$= \frac{1 + 2 + ... + (n-1) + n}{n}$$

Example: let say n=5

$$\overline{5} = \frac{\sum_{i=1}^{5} i}{5}$$

$$= \frac{1 + 2 + 3 + 4 + 5}{5}$$

$$= \frac{15}{5}$$

$$= 3$$

By using a repetition structure, create a flowchart that implements the formula above. Your flowchart should firstly ask the user to enter the value of **n**. It then does the calculations and finally prints the average.

When you have finished, check your answer by tracing your flowchart with some values of **n**. You may use these examples:

Input	Output
n: 3	average: 2
n: 5	average: 3
n: 1	average: 1

Answer:

Name:………………………………………………………………. **IC NO:** ……………………………………………..
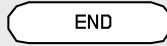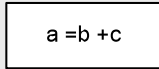
Pre-Tutorial:
The purpose of this section is to determine whether you are now able to think in a structured way. Answer the following question.

Question

Create a flowchart that prints numbers 1, 2, 3, and 4. Draw the flowchart into the following box. Use the appropriate symbols.

Answer:

Flowchart Symbols:

START   Start terminal

END   End terminal

a =b +c   A process. e.g. doing calculation

PRINT   Printing output to monitor

READ   Getting inpu from keyboard

condition   Making decision