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COMPUTER SCIENCE **9618/23**

Paper 2 Fundamental Problem-solving and Programming Skills **October/November 2023**

2 hours

You must answer on the question paper.

You will need: Insert (enclosed)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use an HB pencil for any diagrams, graphs or rough working.
- Calculators must **not** be used in this paper.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].
- No marks will be awarded for using brand names of software packages or hardware.
- The insert contains all the resources referred to in the questions.

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Refer to the **insert** for the list of pseudocode functions and operators.

1 A program is being developed in pseudocode before being converted into a programming language.

(a) The following table shows four valid pseudocode assignment statements.

Complete the table by giving the data type that should be used to declare the variable underlined in each assignment statement.

Assignment statement	Data type
MyVar1 ← Total1 / Total2	REAL
MyVar2 ← 27/10/2023	DATE
MyVar3 ← "Sum1 / Sum2"	STRING
MyVar4 ← Result1 AND Result2	BOOLEAN

[4]

(b) Other variables in the program have example values as shown:

Variable	Value
Active	TRUE
Fraction	0.2
Code	"Ab12345"

Complete the table by evaluating each expression using the example values.

Expression	Evaluates to
Fraction >= 0.2 AND NOT Active	FALSE
INT((Fraction * 100) + 13.3)	33
STR_TO_NUM(MID(Code, 4, 2)) + 5	28
LENGTH("TRUE" & Code)	11

[4]

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(c) The program makes use of complex statistical functions. The required functions are not built-in to the programming language and are too complicated for the programmer to write.

One solution would be to employ another programmer who has experience of writing these functions, as there is no time to train the existing programmer.

State **one other** way that these functions may be provided for inclusion in the program.

Use of library routine.

[1]

(CH-12)

(d) The hardware that runs the program is changed and the program needs to be modified so that it works with the new hardware.

Identify the type of maintenance that this represents **and** give **one other** reason why this type of maintenance may be needed.

Type Adaptive

Reason The users requirment changes.

[2]

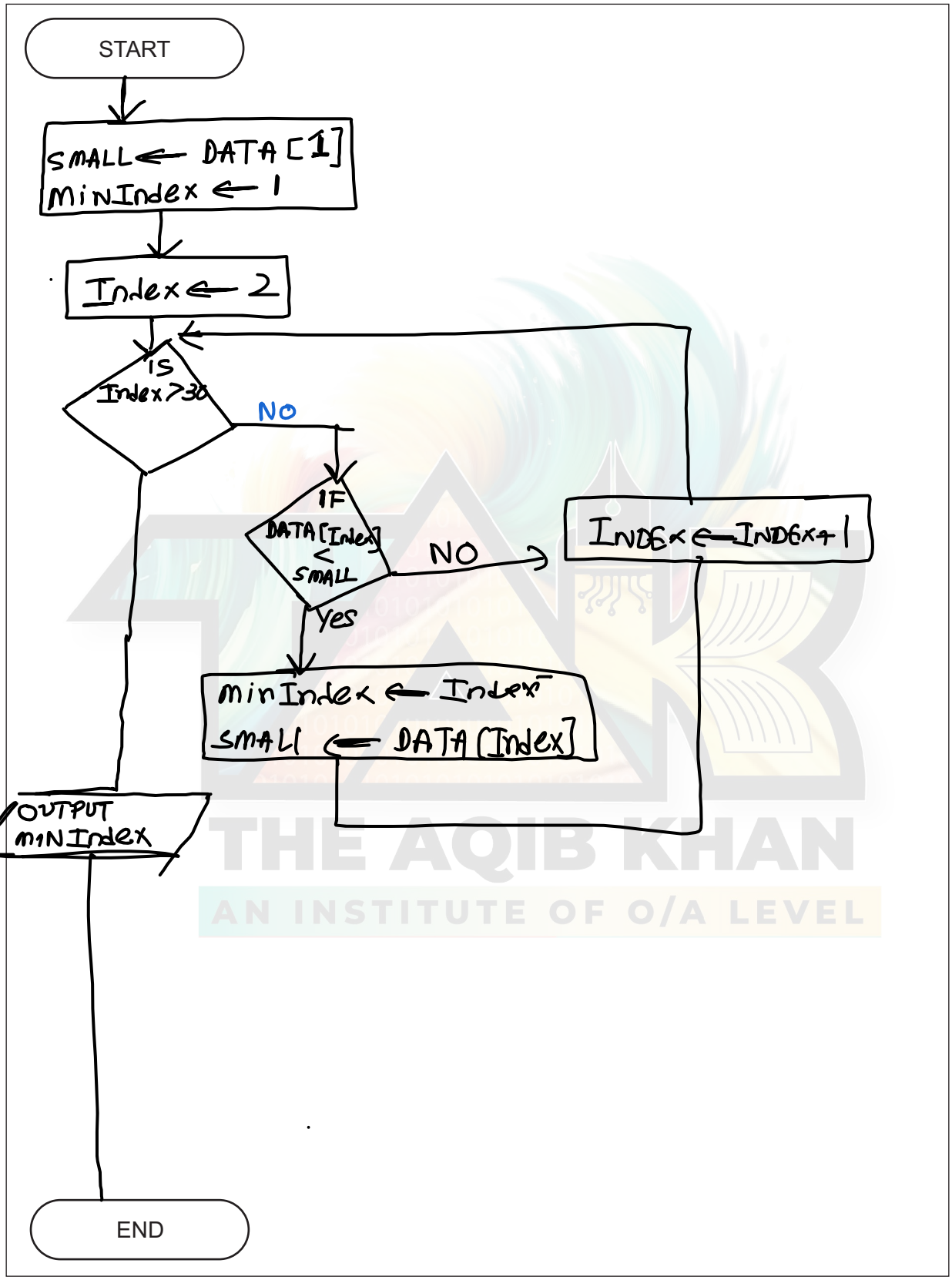
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Total ← TOTAL + N (COUNT ← COUNT + 1

2 `Data` is a 1D array of integers, containing 30 elements. All element values are unique.

(a) An algorithm will output the index of the element with the smallest value.

Draw a program flowchart to represent the algorithm.



[5]

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(b) The 30 data values could have been stored in separate variables rather than in an array.

Explain the benefits of using an array when designing a solution to part **(a)**.

Simplifies the code, it is possible to iterate through the values [2]

(c) The requirement changes. Array `Data` needs to hold 120 elements and each value may include a decimal place.

Write a pseudocode statement to declare the modified array.

DECLARE Data[1:20] : ARRAY OF REAL

[2]

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3 The diagram represents a queue Abstract Data Type (ADT).

The organisation of this queue may be summarised as follows:

- The `FrontOfQueue` pointer points to the next data item to be removed.
- The `EndOfQueue` pointer points to the last data item added.

Queue

D3	← `FrontOfQueue`
D4	
D1	
D2	
D5	← `EndOfQueue`

The queue is implemented using three variables and a 1D array of eight elements as shown. The variable `NumItems` stores the number of items in the queue.

The pointer variables store indices (index numbers) of the array.

(a) Complete the diagram to represent the state of the queue as shown above.

Index	Array
1	
2	D3
3	D4
4	D1
5	D2
6	D5
7	
8	

Front of Queue → 2

End of Queue → 6

Variable	
`FrontOfQueue`	2
`EndOfQueue`	6
`NumItems`	5

[3]

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(b) A module `AddTo()` will add a value to the queue by manipulating the array and variables in part **(a)**.

The queue implementation is circular. When pointers reach the end of the queue, they will 'wrap around' to the beginning.

Before a value can be added to the queue, it is necessary to check the queue is not full.

The algorithm to add a value to the queue is expressed in six steps.

Complete the steps.

1. If `NumItems` ..... = 8 ..... then jump to step 6.
2. Increment ..... End of Queue + 1 ..... .
3. If ..... End of Queue = 9 ..... then set `EndOfQueue` to ..... 1 ..... .
4. Increment ..... Num Items ..... .
5. Set the ..... Element ..... at the index stored in ..... End of Queue ..... to the ..... data item ..... being added.
6. Stop.

[6]

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4 A procedure `RandList()` will output a sequence of 25 random integers, where each integer is larger than the previous one.

(a) Write pseudocode for procedure `RandList()`.

```
PROCEDURE RandList()
  DECLARE Count, Perv, Num : INTEGER
COUNT ← 1
perv ← Random(1,10) // generate first random integer
OUTPUT Perv
    WHILE COUNT < 25 DO
      Num ← Random(perv+1, perv+10)
      Output Num
      perv ← Num
      Count ← Count + 1
ENDWHILE
ENDPROCEDURE
```

[6]

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(b) Procedure `RandList()` is modified so that the random numbers are also written into a 1D array `Result`.

A new module is written to confirm that the numbers in the array are in ascending order.

This module contains an `IF` statement that performs a comparison between elements:

```
IF (Result[x + 1] = Result[x]) OR (Result[x] > Result[x + 1]) THEN
   Sequence ← FALSE
ENDIF
```

Write a simplified version of the conditional clause.

Result[x] = Result[x+1]

.....

.....

..... [1]

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5 A global 1D array of integers contains four elements, which are assigned values as shown:

```
Mix[1] ← 4
Mix[2] ← 2
Mix[3] ← 3
Mix[4] ← 5
```

A procedure `Process()` manipulates the values in the array.

The procedure is written in pseudocode as follows:

```
PROCEDURE Process(Start : INTEGER)
   DECLARE Value, Index, Total : INTEGER

   Index ← Start
   Total ← 0

   WHILE Total < 20
      Value ← Mix[Index]
      Total ← Total + Value

      IF Index < 4 THEN
         Mix[Index] ← Mix[Index] + Mix[Index+1]
      ELSE
         Mix[Index] ← Mix[Index] + Mix[1]
      ENDIF
      Index ← (Value MOD 4) + 1

   ENDWHILE

   Mix[1] ← Total * Index

ENDPROCEDURE
```

Complete the trace table on the opposite page by dry running the procedure when it is called as follows:

```
CALL Process(2)
```

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Index	Value	Total	Mix[1]	Mix[2]	Mix[3]	Mix[4]

[6]

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6 A function `TestNum()` will take a six-digit string as a parameter.

The function will test whether the string meets certain conditions and will return an integer value as follows:

Return value	Condition	Example
1	The last three digits are the same but non-zero.	"253444"
2	The last three digits are zero	"253000"
3	The first three and last three digits are the same.	"410410"

The function will return the highest possible value for the given string.

If the string does not meet any of the conditions, zero is returned.

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Write pseudocode for function `TestNum()`.

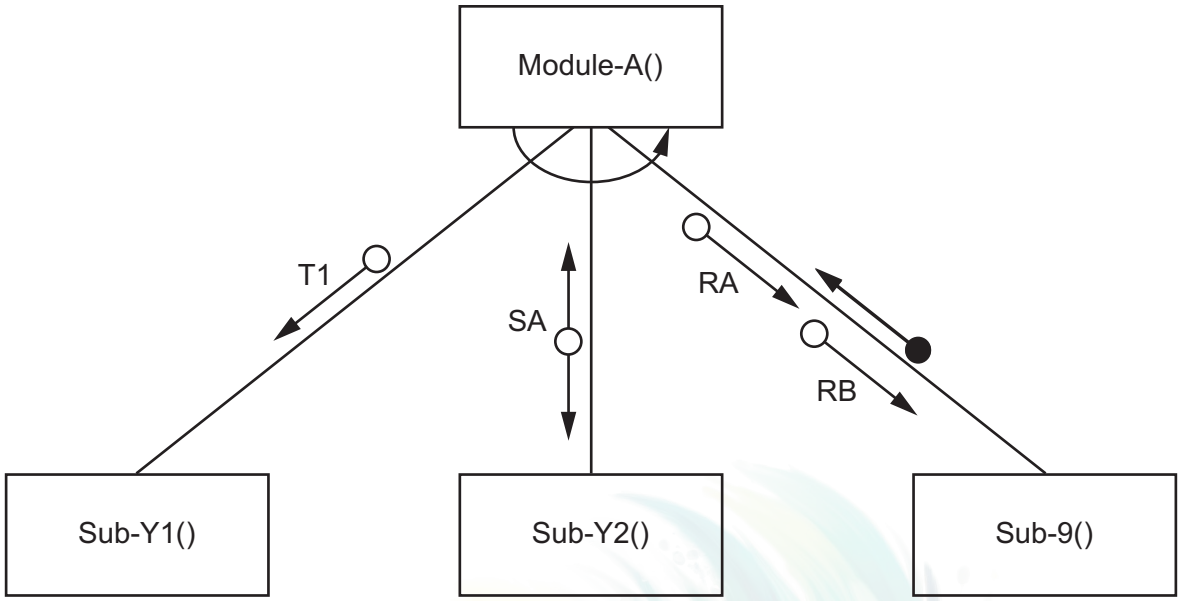
Assume that the parameter is valid.

```
FUNCTION TestNum (ThisNum: STRING) RETURNS INTEGER
    IF LEFT (ThisNum,3) = RIGHT (ThisNum,3) THEN
        RETURN 3
    ENDIF
    IF RIGHT (ThisNum,3) = 000 THEN
        RETURN 2
    ENDIF
    IF MID (ThisNum,4,1) = MID (ThisNum,5,1)
        AND MID (ThisNum 5,1) = MID(This Num 6,1) THEN
        RETURN 1
    ENDIF
    RETURN 0
ENDFUNCTION
```

[6]

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7 A structure chart shows the modular structure of a program:



(a) Explain the meaning of the curved arrow symbol which begins and ends at Module-A().

It is a looping which is running all four modules correctly sequentially.

[2]

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(b) The structure chart shows that Sub-9() is a function.

A Boolean value is returned by Sub-9() for processing by Module-A().

The original parameter RA is of type integer and RB is of type string.

A record type `MyType` will be defined with three fields to store the values passed between the two modules.

(i) Write pseudocode to define `MyType`.

```
TYPE MyType
    DECLARE RA : INTEGER
    DECLARE RB : STRING
    DECLARE RC : BOOLEAN
ENDTYPE
```

[3]

(ii) The design is modified and Sub-9() is changed to a procedure.

The procedure will be called with a single parameter of type `MyType`.

Write the pseudocode header for procedure `Sub-9()`.

```
PROCEDURE Sub-9(BYREF Param : MyType)
```

[2]

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8 A class of students are developing a program to send data between computers. Many computers are connected together to form a wired network. Serial ports are used to connect one computer to another.

Each computer:
- is assigned a unique three-digit ID
- has three ports, each identified by an integer value
- is connected to between one and three other computers.

Messages are sent between computers as a string of characters organised into fields as shown:

```
<STX><DestinationID><SourceID><Data><ETX>
```

Field name	Description
`STX`	a single character marking the start of the message (ASCII value 02)
`DestinationID`	three numeric characters identifying the destination computer
`SourceID`	three numeric characters identifying the source computer
`Data`	a variable length string containing the data being sent (Minimum length is 1 character)
`ETX`	a single character marking the end of the message (ASCII value 03)

For example, the following message contains the data "Hello Jack" being sent from computer "202" to computer "454":

```
<STX>"454202Hello Jack"<ETX>
```

Each computer will run a copy of the same program. Each program will contain a global variable `MyID` of type string which contains the unique ID of the computer in which the program is running.

The first two program modules are defined as follows:

Module	Description
`GetData()` (already written)	• returns the data field from a message that has been received • If no message is available, the module waits until one has been received.
`ReceiveFile()` PROCEDURE	• takes a file name as a parameter of type string • creates a text file with the given file name (no checking required) • writes the data field returned by `GetData()` to the file • repeats until the data field is `"EOF"`, which is not written to the file • outputs a final message giving the total number of characters written to the file, for example: `132456 characters were written to newfile.txt`

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(a) Write pseudocode for module `ReceiveFile()`.

Module `GetData()` has already been written and must be used.

```
PROCEDURE ReceiveFile(FileName: STRING)
    DECLARE Data : STRING
    DECLARE CharCount : INTEGER
    CONSTANT Terminator = "*****"
    OPENFILE FileName FOR WRITE
    Data ← GetData()
    CharCount ← 0
    WHILE Data <> Terminator
        WRITEFILE FileName, Data
        CharCount ← CharCount + LENGTH(Data)
        Data ← GetData()
    ENDWHILE
    CLOSEFILE FileName
    OUTPUT CharCount, " = characters were written to", FileName
ENDPROCEDURE
```

[7]

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(b) The use of the string "*****" as explained in the module description for `ReceiveFile()` may cause a problem.

Explain the problem and suggest a solution.

Problem If the file being sent contains a line of string "*****" then the file being written by Receiver file will end at this point.

Solution Read the file at the sending end to find the number of lines it contains.

[3]

(c) Two new modules are defined, which will allow two users to exchange messages.

Module	Description
`Transmit()` (already written)	• takes two parameters: ○ a string representing a message ○ an integer representing a port number • transmits the message using the given port
`Chat()` Procedure	• takes two parameters: ○ a string representing a Destination ID ○ an integer representing a port number • extracts data from a received message using `GetData()` and outputs it • forms a message using data input by the user and sends it using `Transmit()` • repeats until either the output string or the sent string is `"Bye"`

Reminders:

- Each program contains a global variable `MyID` of type string which contains the unique ID of the computer in which the program is running.
- Messages are sent between computers as a string of characters organised into fields as shown:

```
<STX><DestinationID><SourceID><Data><ETX>
```

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Write pseudocode for module `Chat()`.

Modules `GetData()` and `Transmit()` must be used.

```
PROCEDURE Chat(Destination: STRING, Port: INTEGER
    DECLARE Data: STRING
    DECLARE Finished: BOOLEAN
    CONSTANT Terminator = "Bye"
    CONSTANT STX = CHR(2)
    CONSTANT ETX = CHR(3)
    Finished ← FALSE
  REPEAT
    Data ← GetData()
    OUTPUT Data
    IF Data = Terminator THEN
      Finished ← TRUE
    ENDIF
      IF Not Finshed THEN  // about to reply
        INPUT Data
        Transmit(STX and Destination and MyID and Data and ETX for
        IF Data = Terminator THEN
          Finshed ← TRUE
        ENDIF
      ENDIF
  UNTIL Finshed = TRUE
ENDPROCEDURE
```

[7]

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(d) Module `GetData()` returns the data field from a message that has been received. If no message is available, the module waits until one has been received.

Explain the limitation of this on module `Chat()` from part **(c)**.

Describe a modification to `GetData()` to address this limitation.

Limitation Get Data does not return the value until the message has been received. So the chat is of half duplex.

Modification If no response it allow the receiver to exit chat at any time. Get Data should immediately return a suitable message.

[3]

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