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COMPUTER SCIENCE **9618/21**

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.

This document has **20** pages. Any blank pages are indicated.

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

1 The following pseudocode represents part of the algorithm for a program:

```
CASE OF ThisValue
   < 30        : Level ← "Low"            // less than 30

                 Check ← 1
   < 20        : Level ← "Very Low"       // less than 20
                 Check ← ThisValue / 2
   30 TO 40    : Level ← "Medium"         // between 30 and 40
                 Check ← ThisValue / 3
                 Data[ThisValue] ← Data[ThisValue] + 1
   > 40        : Level ← "High"
ENDCASE
```

(a) Complete the table by writing the answer for each row:

	Answer
The value assigned to `Level` when `ThisValue` is 40	"Medium"
The value assigned to `Check` when `ThisValue` is 36	12
The value assigned to `Level` when `ThisValue` is 18	"Low"
The number of elements in array `Data` that may be incremented	11

[4]

(b) The pseudocode contains four assignments to variable `Level`. One of these assignments will never be performed.

Identify this assignment **and** explain why this is the case.

MP1 Level ← "Very Low" // the level is assigned value "very low"

Explanation points:

MP2 because CASE clauses are checked in sequence // because of the order of the clauses
MP3 a value < 30 satisfies the first clause // Clause '< 20' will never be tested

..... [3]

(c) The following line is added immediately before the `ENDCASE` statement:

```
OTHERWISE : Level ← "Undefined"
```

State why this assignment is never performed.

MP1 all of the possible values are addressed via all / four / three / the other clauses // there are no other possible values to map to OTHERWISE

..... [1]

(d) Give the appropriate data types for the variables `ThisValue`, `Check` and `Level`.

`ThisValue` .....

`Check` .....

`Level` .....

INTEGER
REAL
STRING

[3]

2 **(a)** An algorithm is expressed as follows:

- input 100 numbers, one at a time
- keep a total of all numbers input that have a value between 30 and 70 inclusive and output this total after the last number has been input.

Outline, using stepwise refinement, the five steps for this algorithm which could be used to produce pseudocode.

Do **not** use pseudocode statements in your answer.

Step 1 .....

.....

Step 2 .....

.....

Step 3 .....

.....

Step 4 .....

.....

Step 5 .....

.....

MP1 Set total to zero
MP2 Input a number
MP3 Check if number greater than 29 and less than 71
MP4 … if check is true - add number to total
MP5 Repeat from step 2 99 times // for a total of 100 iterations
MP6 Output the total

[5]

(b) Sequence is one programming construct.

Identify **two other** programming constructs that will be required when the algorithm is converted into pseudocode.

Construct 1 .....

.....

Construct 2 .....

.....

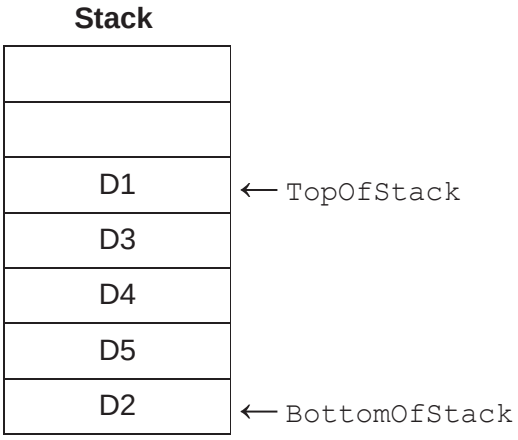
MP1 An iterative construct // a (count-controlled) loop
MP2 A selection construct // an IF statement

[2]

3 The diagram represents an Abstract Data Type (ADT).

The operation of this stack may be summarised as follows:

- The `TopOfStack` pointer points to the last item added to the stack.
- The `BottomOfStack` pointer points to the first item on the stack.

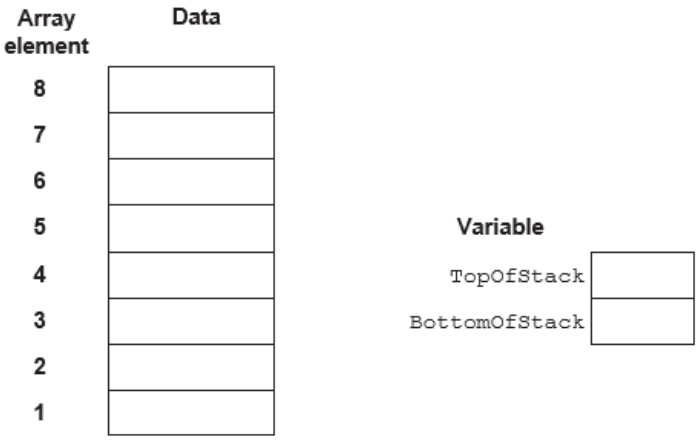


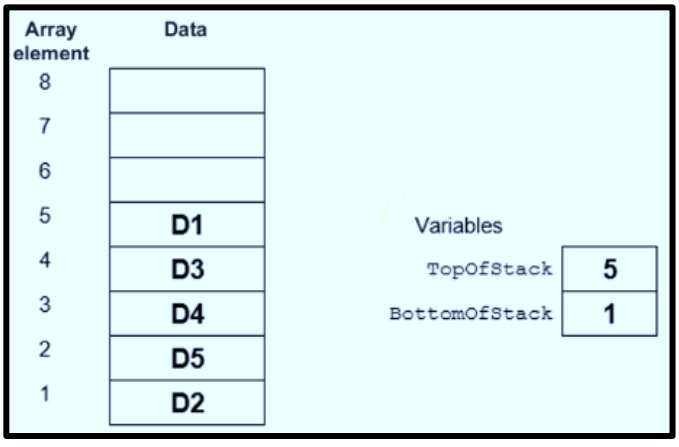
(a) The stack is implemented using two variables and a 1D array of 8 elements as shown.

The variables are used to reference individual elements of the array, in such a way that:

- the array is filled from the lowest indexed element towards the highest
- all the elements of the array are available for the stack.

Complete the diagram to represent the state of the stack as shown above.





(b) A function `Push()` will add a value onto the stack by manipulating the array and variables in **part (a)**.

Before adding a value onto the stack, the algorithm will check that space is available.

If the value is added to the stack, the function will return `TRUE`, otherwise it will return `FALSE`.

The algorithm is expressed in five steps.

Complete the steps.

1. If ..... then return `FALSE`
2. Otherwise ..... `TopOfStack`
3. Use `TopOfStack` as an .....to the array.
4. Set the element at this ..... to the .....being added.
5. Return ..... .

[5]

MP1 If **`TopOfStack = 8`** // **(stack) full** then return `FALSE`

MP2 Otherwise, **increment** `TopOfStack`

MP3 Use `TopOfStack` as an **index** to the Array

MP4 Set the element at this **index / location / position** to the **value / data / item** being added

MP5 Return **`TRUE`**

4 A global array is declared in pseudocode as follows:

```
DECLARE Data : ARRAY[1:150] OF STRING
```

A function `TooMany()` will:

1. take two parameters:
   - a string (the search string)
   - an integer (the maximum value)
2. count the number of strings in the array that exactly match the search string
3. return `TRUE` if the count is greater than the maximum value, otherwise will return `FALSE`

(a) Write pseudocode for the function `TooMany()`.

```
FUNCTION TooMany(Search : STRING, Max : INTEGER) RETURNS
                                                  BOOLEAN
   DECLARE Count, Index : INTEGER

   Count ← 0

   FOR Index ← 1 TO 150
      IF Data[Index] = Search THEN
         Count ← Count + 1
      ENDIF
   NEXT Index

   IF Count > Max THEN
      RETURN TRUE
   ELSE
      RETURN FALSE
   ENDIF

ENDFUNCTION
```

..... [6]

(b) The global array is changed to a 2D array, organised as 150 rows by 2 columns. It is declared in pseudocode as follows:

```
DECLARE Data : ARRAY[1:150, 1:2] OF STRING
```

The algorithm for the function in **part (a)** is changed. Strings will only be counted if **both** of the following conditions are true:

- The current row is an even number.
- The search string exactly matches the value in **either** column.

Write pseudocode to check these conditions.

Assume that the row index is contained in variable `Row` and the search string in variable `Search`.

```
IF Row MOD 2 = 0 AND __
   (Data[Row, 1] = Search OR Data[Row, 2] = Search) THEN
```

..... [3]

5 An algorithm is designed to find the smallest numeric value from an input sequence and count how many numeric values have been input.
An example of an input sequence is:

23, AB56, 17, 23ZW, 4, 10, END

Numeric input values are all integers and non-numeric input is ignored, except for the string "END" which is used to terminate the sequence.

The algorithm is expressed in pseudocode as shown:

```
DECLARE NextInput : STRING
DECLARE Min, Count, Num : INTEGER

Min ← 999
Count ← 0

REPEAT
   INPUT NextInput
   IF IS_NUM(NextInput) = TRUE THEN
      Num ← STR_TO_NUM(NextInput)
      IF Num > Min THEN
         Min ← Num
      ENDIF
      Count ← Count & 1
   ENDIF
UNTIL NextInput ← "END"

OUTPUT "The minimum value is ", Min, " and the count was ", Count
```

(a) The pseudocode contains three errors due to the incorrect use of **operators**.

Identify each error **and** state the correction required.

1 .....

.....

2 .....

.....

3 .....

.....

MP1 `Num > Min` should be `Num < Min`
MP2 `Count & 1` should be `Count + 1`
MP3 `NextInput ← "END"` should be `NextInput = "END"`

[3]

(b) The operator errors are corrected and the algorithm is tested as follows:

The input sequence:

```
18, 4, ONE, 27, 189, ERIC, 3, 65, END
```

produces the output:

```
The minimum value is 3 and the count was 6
```

The algorithm is tested with a different test data sequence. The sequence contains a mix of integer and non-numeric values. It is terminated correctly but the algorithm produces unexpected results.

(i) Explain the problem with the algorithm.

MP1 If all the numeric input values are greater than 999 // If there are no numeric values in the sequence
MP2 then the minimum will be given as **999** (and not one of the input values)

[2]

(ii) Give a sequence of **four** test data values that could be input to demonstrate the problem.

Value 1 ....
Value 2 ....
Value 3 ....
Value 4 ....

MP1
Mixture non-numeric and numeric with 3 or 4 values - with all numerics greater than 999
Examples:
1325, DOG, 7868, 7615
// SNAKE, 3478, SPIDER

MP2 Final value: END

[2]

6 The pseudocode `OUTPUT` command starts each output on a new line.

(a) A new procedure `MyOutput()` will take a string and a Boolean parameter. `MyOutput()` may be called repeatedly and will use concatenation to build a string using a global variable `MyString`, up to a maximum length of 255 characters.

`MyString` will be output in either of these two cases:

1. The Boolean parameter value is `TRUE`
2. The resulting string (after concatenation) would be longer than 255 characters.

If `MyString` is not output, the string is concatenated with `MyString`.

For example, the calls to `MyOutput()` given below would result in the output as shown:

```
MyOutput("Hello ", FALSE)
MyOutput("ginger ", FALSE)
MyOutput("cat", TRUE)
MyOutput("How are you?", TRUE)
```

Resulting output:

```
Hello ginger cat
How are you?
```

Notes:

- `MyString` is initialised to an empty string before `MyOutput()` is called for the first time.
- No string passed to `MyOutput()` will be longer than 255 characters.

Write pseudocode for `MyOutput()`.

```
PROCEDURE MyOutput(NewString : STRING, EOL : BOOLEAN)

   IF LENGTH(MyString) + LENGTH(NewString) > 255 THEN
      OUTPUT MyString  // Resulting string would be too
                                                    long
      MyString ← NewString
   ELSE
      MyString ← MyString & NewString // Concat with
                                                  MyString

      IF EOL = TRUE THEN
         OUTPUT MyString
         MyString ← ""
      ENDIF
   ENDIF

ENDPROCEDURE
```

[7]

(b) The design of the procedure given in **part (a)** is modified and `MyString` is changed from a global to a local variable declared in `MyOutput()`.

When the modified procedure is converted into program code, it does not work as expected.

Explain why it does not work as expected.

MP1 A new (instance of) variable `MyString` is created each time the procedure is called / executed
MP2 So the previous contents are lost

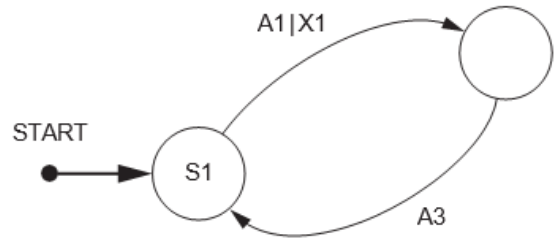
[2]

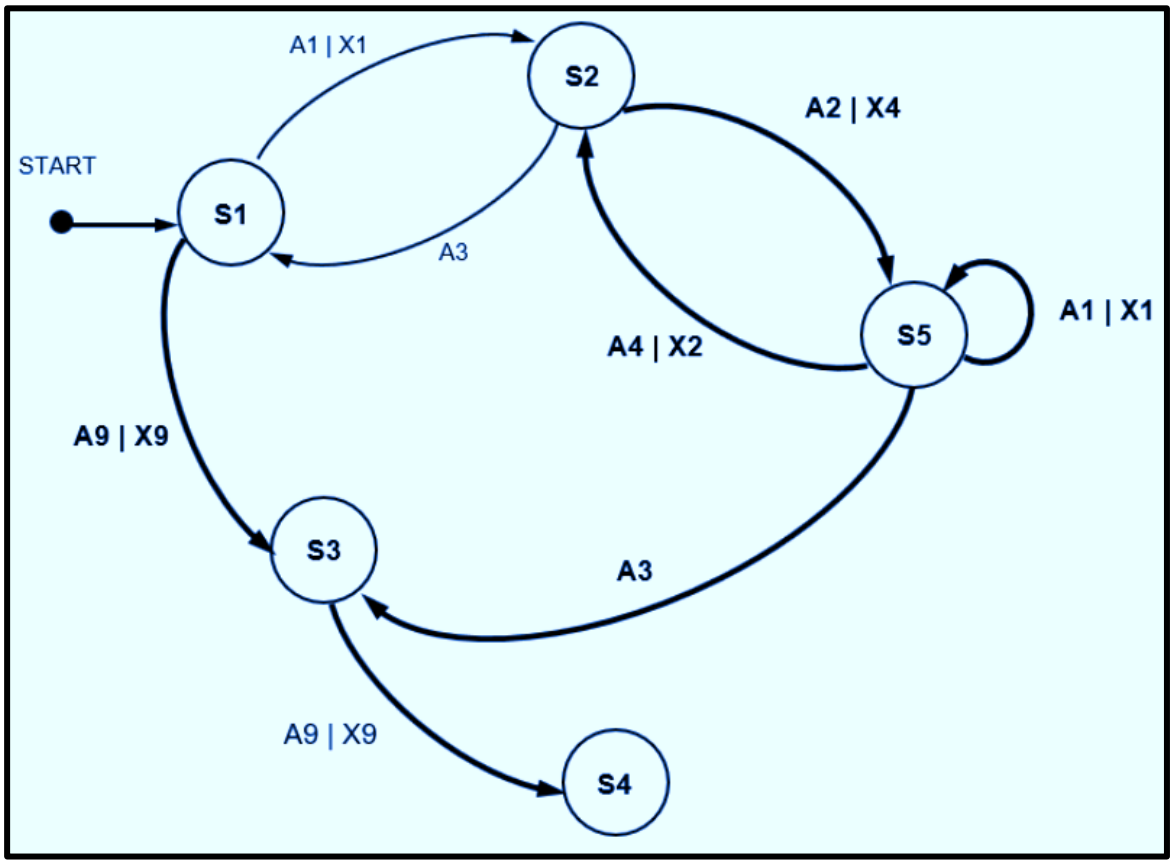
7 An algorithm is represented by a state-transition diagram.

The table shows the inputs, outputs and states for the algorithm:

Current state	Input	Output	Next state
S1	A1	X1	S2
S2	A3	none	S1
S2	A2	X4	S5
S5	A1	X1	S5
S5	A4	X2	S2
S5	A3	none	S3
S1	A9	X9	S3
S3	A9	X9	S4

Complete the state-transition diagram to represent the information given in the table.





[5]

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

For example, the following message contains the data "Hello Kevin" being sent from computer "101" to computer "232":

```
<STX>"232101Hello Kevin"<ETX>
```

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

The programmer has defined the first two program modules as follows:

Module	Description

`Transmit()` (already written)	• takes two parameters:
	  ○ a string containing a message
	  ○ an integer containing a port number
	• transmits the message using the given port

`SendFile()`	• takes three parameters:
	  ○ a string containing a text file name
	  ○ a string containing a Destination ID
	  ○ an integer containing a Port number
	• transmits the file one line at a time
	• transmits a final message with data string "`****`"

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

Assume:

- module `Transmit()` has already been written and is used to transmit a message
- the value of `MyID` may be used as `SourceID`
- the file specified contains no blank lines
- the file specified does not contain the line "`****`"

```
PROCEDURE SendFile(FileName, DestID : STRING, Port :
                                                INTEGER)
   DECLARE FileData : STRING

   CONSTANT STX = CHR(02)
   CONSTANT ETX = CHR(03)

   OPENFILE FileName FOR READ

   WHILE NOT EOF(FileName)
      READFILE FileName, FileData
      FileData ← STX & DestID & MyID & FileData & ETX
      CALL Transmit(FileData, Port)
   ENDWHILE

   CLOSEFILE FileName

   CALL Transmit(STX & DestID & MyID & "****" & ETX,
                                                Port)

ENDPROCEDURE
```

[7]

(b) Module `SendFile()` is used to copy a file from one computer to another.

A module within the program running on the destination computer will receive the data and write it to a new file.

Explain why module `SendFile()` transmits the message with data string `"****"` after the last line of the file.

.....

MP1 Indicates that all the lines of the file have been sent // it is the end of the transmission / file transfer
MP2 So that the receiving program can stop waiting for further data
MP3 The file can be closed / saved

..... [2]

(c) One of the text files to be sent contains several blank lines (lines that do not contain any text).

(i) Explain why this is a problem.

MP1 A message cannot contain a zero-length data field
MP2 … so a blank line cannot be sent // there is no way to send a blank line

..... [2]

(ii) Explain how the message format could be changed to allow a blank line to be sent.

MP1 Append a (special) character to the start of the message text
MP2 interpret the new field data as a blank line

ALTERNATIVE
MP1 Change the message protocol and use an additional field to act as an indicator
MP2 Interpret the new field data

..... [2]

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Question 8(d) starts on page 18.

(d) A new module has been defined:

Module	Description
`GetField()`	• takes two parameters: ○ a string containing a message ○ an integer containing a field number • If the field number is valid (in the range 1 to 3, inclusive), it returns a string containing the required field, otherwise it returns an empty string.

As a reminder, a message is defined as follows:

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

Field number	Field name	Description
Not applicable	`STX`	a single character marking the start of the message (ASCII value 02)
1	`DestinationID`	three numeric characters that identify the destination computer
2	`SourceID`	three numeric characters that identify the source computer
3	`Data`	a variable length string containing the data being sent (Minimum length is 1 character)
Not applicable	`ETX`	a single character marking the end of the message (ASCII value 03)

Write pseudocode for module `GetField()`.

```
FUNCTION GetField(Msg : STRING, FieldNo : INTEGER)
                                          RETURNS STRING
   DECLARE RetString : STRING

   CASE OF FieldNo
      1 : RetString ← MID(Msg, 2, 3)
      2 : RetString ← MID(Msg, 5, 3)
      3 : RetString ← MID(Msg, 8, LENGTH(Msg) - 8)
      OTHERWISE : RetString ← ""
   ENDCASE

   RETURN RetString

ENDFUNCTION
```

[6]

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