This examination paper consists of THREE sections: Computer Architecture and Organisation, Problem Solving with Computers and Programming.

Each section consists of 2 questions
The maximum mark for each section is 50.
The maximum mark for this examination is 150.
This examination consists of 6 printed pages.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. Do NOT open this examination paper until instructed to do so.
2. Answer ALL questions from the THREE sections.
SECTION A

COMPUTER ARCHITECTURE AND ORGANIZATION

Answer BOTH questions.

1. (a) A certain circuit has two inputs, x and y. Its output is given by the boolean function, F, where

\[ F = xy' + x'y \]

(i) Give the truth table of the circuit. \[4 \text{ marks}\]

(ii) Using only the primary logic gates, design and draw the circuit. \[6 \text{ marks}\]

(b) (i) Draw a clearly labelled block diagram of a 4-to-1 line multiplexer. \[4 \text{ marks}\]

(ii) In a security system, four sensors must transmit data to a single line for alarm notification. Each sensor transmits data for 1 second.

Explain how a multiplexer can be used for the purpose described above and discuss how data from each sensor is transmitted through the alarm notification line. \[6 \text{ marks}\]

(c) (i) Showing all working, find the largest and smallest integers that can be stored in four bits when signed magnitude representation is used. \[2 \text{ marks}\]

(ii) Consider the following floating point representation:

1-bit sign, 3-bit exponent, 5-bit mantissa

Calculate the decimal equivalent of 101100011. \[3 \text{ marks}\]

Total 25 marks

2. (a) (i) Explain what is meant by the ‘instruction set’ of a central processing unit (CPU). \[2 \text{ marks}\]

(ii) Briefly describe THREE types of instructions that are typically included in an instruction set. \[6 \text{ marks}\]

(iii) Explain how cache memory can increase the efficiency of data retrieval. \[3 \text{ marks}\]
(b) (i) Distinguish between the opcode and the operands of an instruction. [2 marks]

(ii) Two typical instruction formats are one-address and two-address. Describe how the operands are obtained in EACH case and specify where the results are stored. [6 marks]

(c) (i) Explain how a hard disk differs from RAM in terms of access method and access speed. [3 marks]

(ii) Explain how RAM differs from a CD-R device in terms of volatility and storage capacity. [3 marks]

Total 25 marks

SECTION B

PROBLEM SOLVING WITH COMPUTERS

Answer BOTH questions.

3. (a) Explain the role of an algorithm in the problem-solving process. [2 marks]

(b) Examine the TWO algorithms below (labelled Algorithm 1 and Algorithm 2) and answer the questions that follow.

Algorithm 1

FOR X = 0 TO 15 DO
PRINT X
END FOR

Algorithm 2

READ X
WHILE X ! = 999 DO {Note that ! = means “not equal to”}
    SUM = SUM + X
    READ X
END WHILE

(i) Which of the algorithms above illustrates bounded iteration? Justify your answer. [3 marks]

(ii) Which of the algorithms above illustrates unbounded iteration? Justify your answer. [3 marks]
(c) A primary school is conducting a survey on the popularity of certain colours. Students are asked to vote for any of four choices: red, blue, green, none. If red, blue or green is not the favourite, students vote for ‘none’.

Write an algorithm to find and print the

(i) number of students that voted for EACH of the colours: red, blue, green.
(ii) TOTAL number of students that voted for red, blue or green.

Assume that on the day of the survey, 150 students are present. Also assume that all votes are valid. 

[10 marks]

(d) Write an algorithm that uses iteration to find the sum of all multiples of 4 and all multiples of 7 between \( m \) (inclusive) and \( n \) (inclusive) where \( m \) and \( n \) are two positive integers entered via the keyboard. Assume that \( n > m \).

[7 marks]

Total 25 marks

4. (a) Construct a flow chart to represent the following algorithm.

```
begin
  Prompt for numDays
  Read numDays
  Set day to 1
  Set totalComm to 0
  While day <= numDays do
    read numItemsSold
    if numItemsSold < 500 then
      comm = numItemsSold * 4
    else comm = numItemsSold * 5
    endif
    totalComm = totalComm + comm
  Print comm
  Add 1 to day
  Endwhile
  Print numDays, totalComm
stop
```

[12 marks]

(b) An algorithm is shown below.

```
read j
sum = 0
while j < 5 do
  sum = sum + j
  print j
  read j
endwhile
print 'sum =', sum
```

What would the algorithm print given the line of input data below? Show your working.

3 2 1 5 7 4

[3 marks]
(c) Trace through the execution of the following algorithm and draw the output in your answer booklet, exactly as it would be generated by the algorithm. You should carefully note the following:

- \textit{printSpaces} \text{(n)} prints \textit{n} spaces from the current cursor position
- \textit{print} continues output on the current line from the current cursor position
- \textit{println} terminates output on the current line at the current cursor position.

Any subsequent output begins on a new line (e.g., line 18)

- \textit{println} \text{(output-list)} outputs ‘output-list’ on the current line and then places the cursor at the beginning of the following line (e.g., line 4).

1. \texttt{begin}
2. \texttt{SIZE = 10}
3. \texttt{printSpaces ( SIZE + 1 )}
4. \texttt{println ( '*' )}
5. \texttt{j = SIZE \ - \ 2}
6. \texttt{while j >= 0}
7. \texttt{begin}
8. \texttt{printSpaces ( j + 1 )}
9. \texttt{print ( '*' )}
10. \texttt{printSpaces ( SIZE \ - \ j )}
11. \texttt{println ( '&' )}
12. \texttt{j = j \ - \ 2}
13. \texttt{endwhile}
14. \texttt{printSpaces (1)}
15. \texttt{for j = 1 to (SIZE + 1) do}
16. \texttt{print ( '+' )}
17. \texttt{endfor}
18. \texttt{println}
19. \texttt{end}

[10 marks]

Total 25 marks

SECTION C

PROGRAMMING

Answer BOTH questions

5. (a) Briefly describe THREE stages of the program translation process. [6 marks]

(b) Write a C function which accepts a positive integer, \( n \), and returns \( 2^n \). State any assumptions made. [7 marks]

(c) (i) Write C code to store the even numbers from 2 (inclusive) to 40 (inclusive) in a file called “num.dat”. [7 marks]

(ii) Write C code to read the integers from the file “num.dat” created in c (i), add 5 to each integer and then print the result on the screen. [5 marks]

Total 25 marks

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6. (a) Explain THREE ways in which good programming style can be maintained. [6 marks]

(b) A grocer needs to store data about some products using a C application. Each product has an ID (integer), a quantity in stock (integer) and a price (floating point).

(i) Write a declaration for a C struct `productRec` that can store the record for each product. [2 marks]

(ii) Declare TWO variables, `item1` and `item2`, that have the record structure declared in b (i) above. [1 mark]

(iii) Write C code to put data in the `item1` struct from b (ii) above. You can use any values you like. [2 marks]

(iv) Assume that two `productRec` structs, `item3` and `item4`, are already loaded with data. Write C code to exchange the values in `item3` and `item4`. [3 marks]

(c) Write C code to read a string entered by the user at the keyboard, store it in a character array and print the vowels that are present in the string. If no vowels are present, print "NO VOWELS". Assume that the string is entered in upper case letters and that the string is exactly 7 characters in length. Also, count and print the number of occurrences of the letter 'A' in the string.

Example:

Please enter name: MICHAEL

Vowel I present. Vowel A present. Vowel E present. Number of As = 1 [11 marks]

Total 25 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.