



NSW Education Standards Authority

2021 HIGHER SCHOOL CERTIFICATE EXAMINATION

Software Design and Development

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Write your Centre Number and Student Number at the top of either pages 33 and 37 or pages 41 and 45

Total marks: 100

Section I – 20 marks (pages 2–10)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 60 marks (pages 13–32)

- Attempt Questions 21–33
- Allow about 1 hour and 50 minutes for this section

Section III – 20 marks (pages 33–48)

- Attempt either Question 34 or Question 35
- Allow about 35 minutes for this section

Section I

20 marks

Attempt Questions 1–20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

- 1** At which stage of the software development cycle are the needs of the client first identified?
- A. Implementation
 - B. Testing and evaluating
 - C. Planning and designing
 - D. Defining and understanding

- 2** A company wants to survey people to find out their top five sources of news. A person can choose up to five options from a list.

Which of the following should be used in the survey?

- A. Scroll bars
 - B. Check boxes
 - C. Radio buttons
 - D. Drop-down lists
- 3** A fragment of documentation is shown.

<i>Item</i>	<i>Type</i>	<i>Size</i>
surname	string	20
age	integer	2

What type of documentation is this?

- A. IPO chart
- B. Storyboard
- C. Data dictionary
- D. Context diagram

- 4 Which of the following describes a Creative Commons licence?
- A. It allows distribution of a limited version of the software product.
 - B. It makes software available for use with no intellectual property rights.
 - C. It specifies the maximum legal number of simultaneous users of the software.
 - D. It allows an author to specify how others can share, use and build upon their work.
- 5 Which of the following is an essential feature of event-driven software?
- A. It is coded using a low-level language.
 - B. It has a graphic user interface with buttons.
 - C. The programmer determines the order of execution.
 - D. Inputs are processed to determine what happens next.
- 6 What is the purpose of a sentinel value in a sequential file?
- A. It marks the end of data in the file.
 - B. It identifies a specific item in the file.
 - C. It prevents unauthorised access to the file.
 - D. It indicates the number of items in the file.
- 7 In a program, a sequence of statements must be executed at least once.
- Which control structure will ensure that this occurs?
- A. Binary selection
 - B. Pre-test repetition
 - C. Post-test repetition
 - D. Multiway selection

8 Consider the following code fragment.

1. IF Age > 12 THEN
2. Let charge = 8
3. ELSE
4. Let charge = 4
5. ENDIF
6. Cost = CalcCost (charge)
7. Display "The charge is", Cost

Which of the following involves parameter passing?

- A. Line 6 only
- B. Line 7 only
- C. Lines 2 and 4
- D. Lines 6 and 7

Use the following information to answer Questions 9 and 10.

In a complex modular system, module A calls module B. During the testing process, an error message was produced indicating that module A had provided too few parameters for module B to proceed.

9 Which type of error had occurred?

- A. Syntax
- B. Runtime
- C. Overflow
- D. Type mismatch

10 Which system modelling tool would best help a developer understand the cause of the error?

- A. Context diagram
- B. Storyboard
- C. Structure chart
- D. System flowchart

- 11** In a project meeting, team members presented their code for others to review and identify errors.

Which error detection method was being applied?

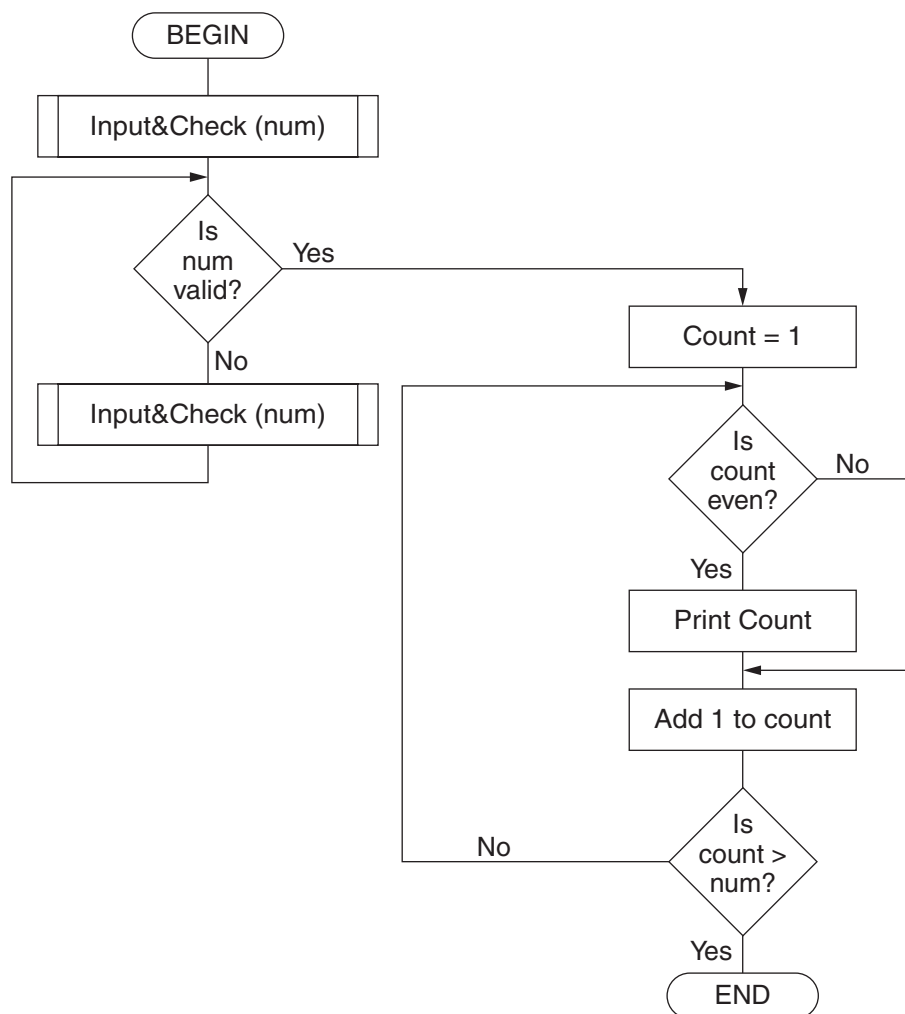
- A. Deskchecking
- B. Program trace
- C. Single line stepping
- D. Structured walkthrough

- 12** In an array of records, `Members(X).FeesPaid` stores whether or not a member has paid their fees.

Which row of the table correctly shows the data type for `X` and the data structure for `FeesPaid`?

	<i>Data type for X</i>	<i>Data structure for FeesPaid</i>
A.	Boolean	Record
B.	Integer	Field
C.	Integer	Record
D.	Boolean	Field

Use the following flowchart to answer Questions 13 and 14.



13 A number is valid if it is positive and less than 100.

If the value 8 is input, what is the output produced?

- A. 8
- B. 2, 4, 6
- C. 2, 4, 6, 8
- D. 1, 2, 3, 4, 5, 6, 7

14 Which pseudocode fragment matches the logic in the flowchart?

- A. BEGIN
 Input&Check (num)
 WHILE num NOT Valid
 Input&Check (num)
 ENDWHILE
 count = 1
 REPEAT
 IF count is Even THEN
 Print count
 END IF
 count = count + 1
 UNTIL count > num
END
- B. BEGIN
 Input&Check (num)
 REPEAT Until Valid
 Input&Check (num)
 END REPEAT
 count = 1
 WHILE count < num
 IF count is Even THEN
 Print count
 END IF
 count = count + 1
 ENDWHILE
END
- C. BEGIN
 Input&Check (num)
 WHILE num NOT Valid
 Input&Check (num)
 ENDWHILE
 count = 1
 REPEAT
 IF count is Even THEN
 Print count
 END IF
 UNTIL count = num
END
- D. BEGIN
 REPEAT
 Input&Check (num)
 UNTIL num is Valid
 count = 1
 WHILE count < num
 IF count is Even THEN
 Print count
 END IF
 count = count + 1
 ENDWHILE
END

15 The function rand(low, high) produces a random integer from low to high inclusive.

What is the full range of possible values produced by the statement:
rand(20, 30) – rand(5, 10)?

- A. 10 to 25
B. 15 to 20
C. 25 to 40
D. 30 to 35

- 16 Using EBNF, a valid product code is defined as $Pcode = Y[X]({Y})[X]$.

Which row of the table correctly shows the minimum and maximum number of times that X and Y can occur in a valid product code?

	<i>Occurrences of X</i>		<i>Occurrences of Y</i>	
	<i>Minimum</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Maximum</i>
A.	1	unlimited	2	unlimited
B.	1	unlimited	0	2
C.	0	2	1	2
D.	0	2	1	unlimited

- 17 Consider the following code fragment.

```
X = 5
Y = 5
WHILE X < 10
    X = Y
    REPEAT
        add 1 to Y
    UNTIL Y >= 10
ENDWHILE
print X, Y
```

What is the output produced?

- A. 10, 10
B. 10, 11
C. 11, 10
D. 11, 11
- 18 The purpose of lexical analysis is to
- A. parse a set of code elements.
B. convert a sequence of characters into a sequence of tokens.
C. confirm that the code conforms to the rules of the language.
D. determine the correct order of tokens prior to code generation.

19 Consider the following code fragment.

```
BEGIN Program
    Num = the number of elements in List
    X = 1
    Y = Num
    REPEAT
        List(X) = List(Y)
        List(Y) = List(X)
        X = X + 1
        Y = Y - 1
    UNTIL X > Num
END Program
```

The original content of List is shown in the following table.

Index	1	2	3	4	5
List	3	6	5	8	6

What is the content of List after the code is executed?

- A.

3	6	5	8	6
---	---	---	---	---
- B.

6	8	5	6	3
---	---	---	---	---
- C.

6	8	5	8	6
---	---	---	---	---
- D.

3	6	5	6	3
---	---	---	---	---

- 20** The original contents of an unsorted array are shown.

1	4	2	7	6	3	5
---	---	---	---	---	---	---

At a certain point during the process of sorting, the contents of the array were as follows.

1	2	4	7	6	3	5
---	---	---	---	---	---	---

At a later point the contents of the array were as follows.

1	2	4	6	3	7	5
---	---	---	---	---	---	---

Which sort method was being used?

- A. Insertion sort (from the right)
- B. Insertion sort (from the left)
- C. Bubble sort (from the right)
- D. Bubble sort (from the left)

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Centre Number

Software Design and Development

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Student Number

Section II Answer Booklet

60 marks

Attempt Questions 21–33

Allow about 1 hour and 50 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- If you include diagrams in your answer, ensure that they are clearly labelled.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (3 marks)

Outline TWO techniques that are used to prevent software piracy.

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Question 22 (3 marks)

A large company is developing a system to automatically generate appropriate responses to common customer queries.

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Explain why live test data is useful in testing this system.

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Question 23 (9 marks)

A large team is developing software to manage athletics carnivals.

- (a) Outline TWO responsibilities of the software developers in relation to the development of this software. **2**

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- (b) Describe TWO ways in which CASE tools can help in the development of this software. **3**

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Question 23 continues on page 16

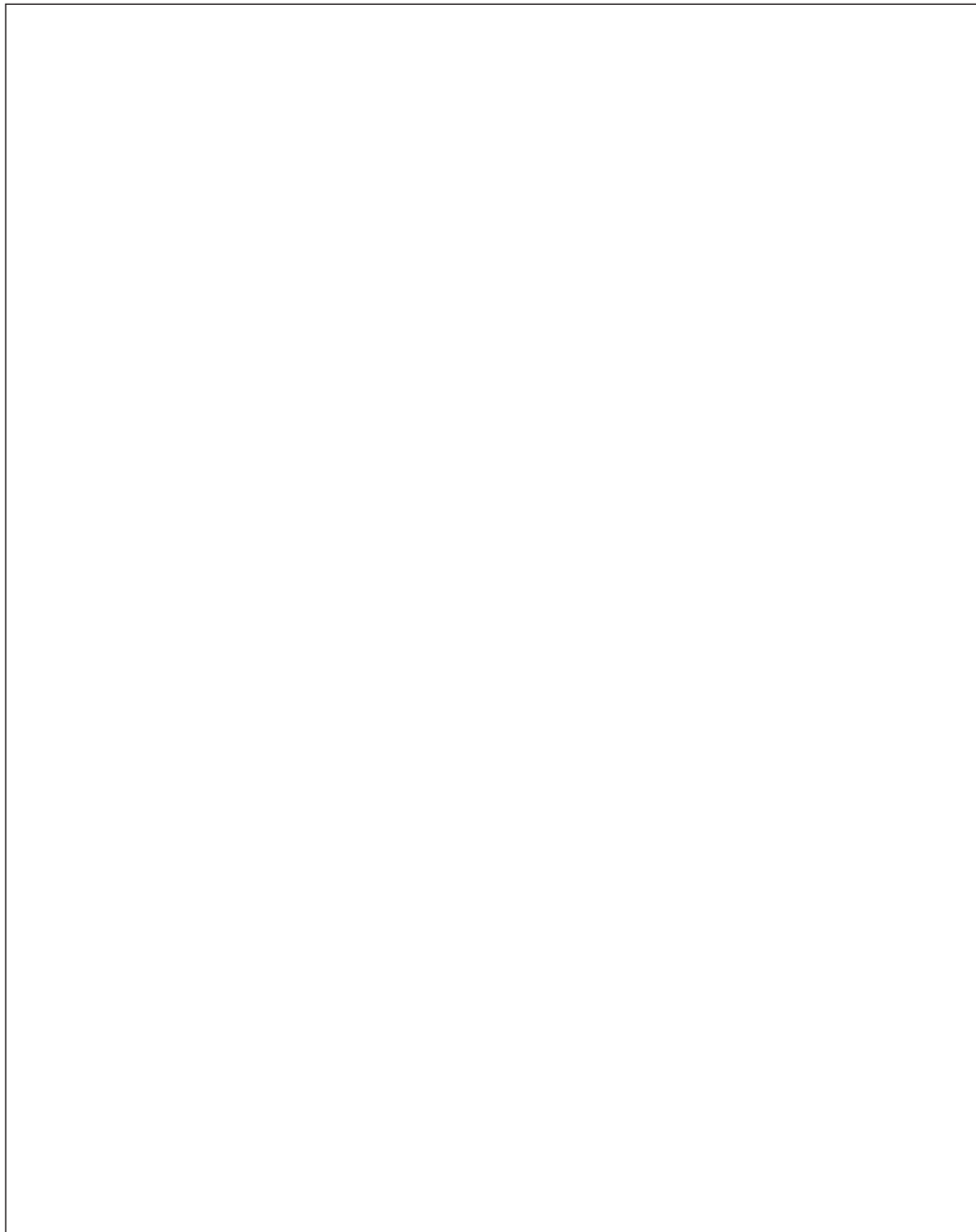
Question 23 (continued)

(c) The software will use the files EVENTS and ATHLETES to allow:

4

- administrators to enter or update information for athletes and enter their performances
- athletes to search for a particular event to see the details of the current record-holder
- updating of the current record-holder when a record is broken.

Design a data flow diagram that models the proposed software.



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End of Question 23

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Question 24 (3 marks)

Outline TWO ways in which a log book may be used to assist in the development of a software solution.

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Question 25 (11 marks)

A mobile phone app is to be developed to allow two people speaking different languages to have a conversation. The app translates the speaker's language into the language of the listener.

- (a) Describe ONE social or ethical issue associated with this app. 2

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- (b) Outline an appropriate method of installation for this app. 2

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- (c) Justify an appropriate software development approach for this app. 3

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Question 25 continues on page 19

Question 25 (continued)

- (d) Describe ONE compatibility issue and ONE performance issue relevant to this app.

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End of Question 25

Question 26 (4 marks)

In a game called *Guess My Number*, a player plays against the computer.

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- The computer generates a random integer, between 1 and 100 inclusive.
- The player enters guesses until they are correct or have made 10 guesses.
- The output for each guess will be 'Too high', 'Too low' or 'Correct'.
- After 10 unsuccessful guesses the number is displayed with the message 'Sorry, too many guesses'.

Design an algorithm for this game, using the function RandomNumber to generate a random integer between 1 and 100.

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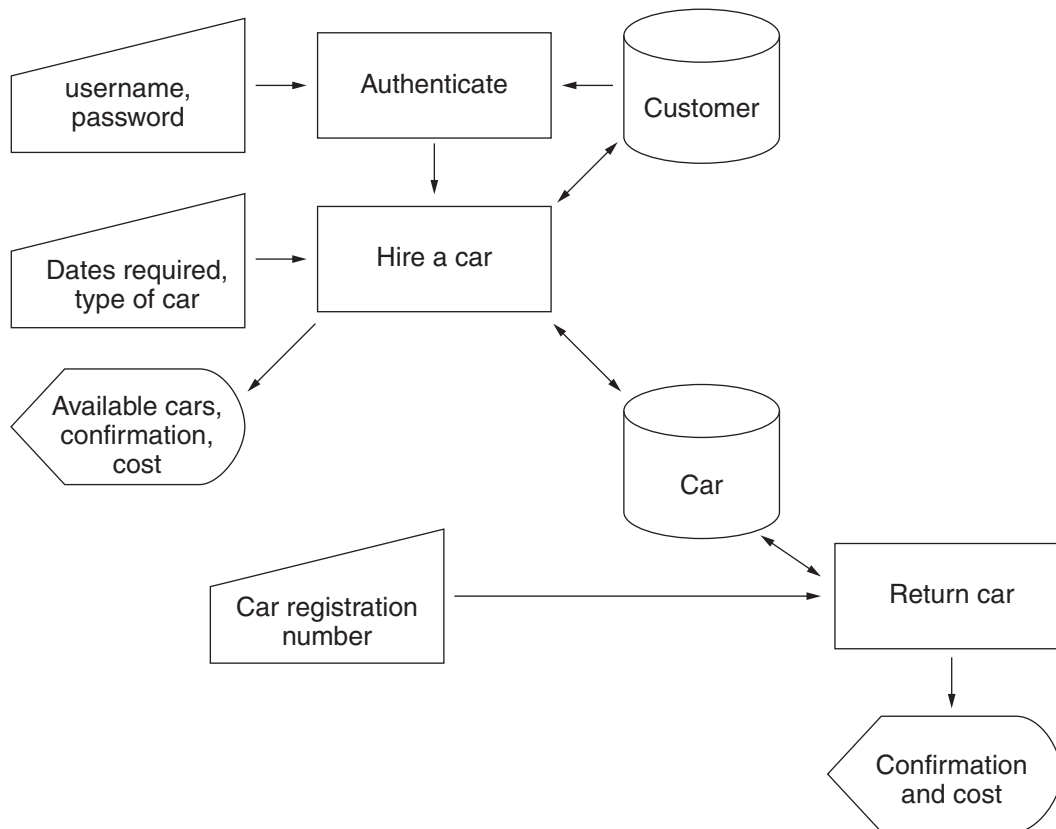
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Question 27 (3 marks)

A company allows registered customers to hire a car from their fleet of available cars. The company's system is represented by the following system flowchart.

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Describe how the data in the files are used in this system.

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Question 28 (5 marks)

A student, attempting to perform a binary search on an array called List with 7 elements, wrote the following algorithm.

The algorithm contains errors.

```
1      BEGIN Search
2          low = 1
3          high = 7
4          found = FALSE
5          input SearchItem
6          WHILE found = FALSE AND high > low
7              index = integer part of (low + high)/2
8              IF SearchItem = List(index) THEN
9                  found = TRUE
10             ELSE
11                 IF SearchItem < List(index) THEN
12                     high = index
13                 ELSE
14                     low = index
15                 ENDIF
16             ENDIF
17         ENDWHILE
18         IF found = TRUE THEN
19             print "Found at ", index
20         ELSE
21             print "Not found"
22         ENDIF
23     END Search
```

Question 28 continues on page 23

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Question 28 (continued)

- (a) The contents of List are shown.

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index	1	2	3	4	5	6	7
List	33	38	40	44	50	60	75

Perform a desk check of the algorithm using the value 42 for SearchItem.

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- (b) The logic is not correct in lines 12 and 14 of the algorithm.

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Modify these lines so that the logic is correct.

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End of Question 28

Question 29 (3 marks)

Consider the following linear search algorithm.

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```
BEGIN
    'REM N = number of elements in the array Items
    Get String
    Found = FALSE
    Count = 1
    WHILE Count <= N AND Found = FALSE
        IF Items(Count) = String THEN
            Display String, " is in the array"
            Found = TRUE
        ENDIF
        Count = Count + 1
    ENDWHILE
    IF Found = FALSE THEN
        Display String, " is not in the array"
    ENDIF
END
```

Identify the variable that is used as a flag and explain how using a flag helps the efficiency of this algorithm.

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Question 31 (3 marks)

The following are all valid multiway selection statements in a particular programming language.

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```
SELECT case
    x > 10      : print x ; print "Done!"
END SELECT
```

```
SELECT case
    x < 0      : print "-"
    x = 0      : print "0"
    OTHERWISE  : print "+" ; sub0
END SELECT
```

```
SELECT case
    y = 1      : sub1
    y = 2      : sub2
    y = 3      : sub3 ; sub4 ; sub5
    OTHERWISE  :
END SELECT
```

Using EBNF, provide a definition for the multiway selection statement.

You may assume <condition> (such as $x > 10$ or $y = 1$) and <statement> (such as print "0" or sub4) have already been defined.

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Question 32 (4 marks)

SUB and STORE are two assembly instructions available for a central processing unit.

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SUB A, B, C subtracts the contents of Register B from the contents of Register A and places the result in Register C.

STORE X, Y stores a copy of the contents of Register X in memory location Y.

Consider the following fragment of code which is currently stored in RAM.

```
SUB R3, R1, R2
STORE R2, N3
```

Describe how the instruction SUB R3, R1, R2 is executed in the CPU. In your answer, refer to the fetch–execute cycle and the use of the program counter.

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Question 33 (5 marks)

An employer requires a program to manage overtime hours worked.

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A file called `Employees` is used to store the details of each employee. Each record has the following structure.

<code>EmpID</code>	Integer
<code>Name</code>	String
<code>OvertimeHours</code>	Real
...	...

This file is a relative file, which uses the `EmpID` to locate the required employee record.

Details of employee overtime hours for each week are stored in a sequential file called `Overtime`. An example of the data is shown.

EmpID	Hours
21742	1.5
35217	2.0
56728	2.75
...	...

A valid `EmpID` is any 5 digit number.

Design an algorithm that does the following:

- reads the `Overtime` file
- validates the `EmpID`
- if the `EmpID` is valid
 - retrieves the correct record from the `Employees` file
 - updates their `OvertimeHours`
- if the `EmpID` is not valid prints an appropriate message.

Question 33 continues on page 29

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Section II extra writing space

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Section III

20 marks**Attempt either Question 34 or Question 35****Allow about 35 minutes for this section**

Answer the question in the spaces provided. These spaces provide guidance for the expected length of response.

If you include diagrams in your answer, ensure that they are clearly labelled.

Question 34 — Programming Paradigms (20 marks)

Please turn over

Question 34 — Programming Paradigms (20 marks)

- (a) A school library requires a system that allows books to be borrowed and returned. Books can belong to different categories such as fiction, reference and non-fiction. Borrowers can be students, staff and parents. Books can be on loan, available or overdue.

The system will be developed using the object oriented paradigm (OOP).

- (i) Complete the table to identify an example of a class for this system, and provide a subclass and an attribute for this class. **3**

	<i>Example</i>
Class	
Subclass	
Attribute	

- (ii) The system is to be modified so it can notify borrowers of overdue books and calculate fines. **3**

Describe how OOP methods can be used to add the necessary changes.

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Question 34 continues on page 35



Question 34 (continued)

- (iii) The system is to be expanded to suggest to borrowers books that they might like. **3**

Explain how artificial intelligence (AI) can assist in providing this additional functionality.

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Question 34 continues on page 37



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Student Number

Section III (continued)

Question 34 (continued)

Question 34 continues on page 38

Question 34 (continued)

- (b) The following fragment of code is written using the logic paradigm.

```
eats(cow, plants)
eats(sheep, plants)
eats(human, sheep)
eats(human, cow)
eats(human, plants)
herbivore(H):- eats(H, plants)
carnivore(C):- eats(C, sheep)
carnivore(C):- eats(C, cow)
omnivore(M):- carnivore(M), herbivore(M)
```

- (i) The query ?eats(A, plants) produces the result

2

cow
sheep
human

Write a query that will produce the result

sheep
cow
plants

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- (ii) A self_eater is any animal that eats other animals of its own kind.

2

Provide a new rule that defines self_eater.

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Question 34 continues on page 39



Question 34 (continued)

- (iii) Contrast the use of forward chaining and backward chaining when evaluating the query ?omnivore(human). **3**

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- (c) Explain a range of factors that influence the choice of paradigm for developing a software solution. **4**

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End of Question 34



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Section III (continued)

Student Number

Do NOT attempt Question 35 if you have already attempted Question 34.

Question 35 — The Interrelationship between Software and Hardware (20 marks)

- (a) The binary representation of the ASCII code for the uppercase letter L is 0100 1100. **2**

What is the hexadecimal representation of the ASCII code for the uppercase letter M?

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- (b) Explain why the result of multiplying the 8-bit 2's complement binary numbers 00100000 (32_{10}) and 00000101 (5_{10}) is displayed as a negative number. **3**

Show your working for the binary multiplication.

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Question 35 continues on page 42

Question 35 (continued)

- (c) The Boolean expression for a logic circuit is shown.

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$$\bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + A\bar{B}C$$

Design a circuit with the same logic that uses no more than four gates. Use Boolean algebra or a truth table to support your answer.

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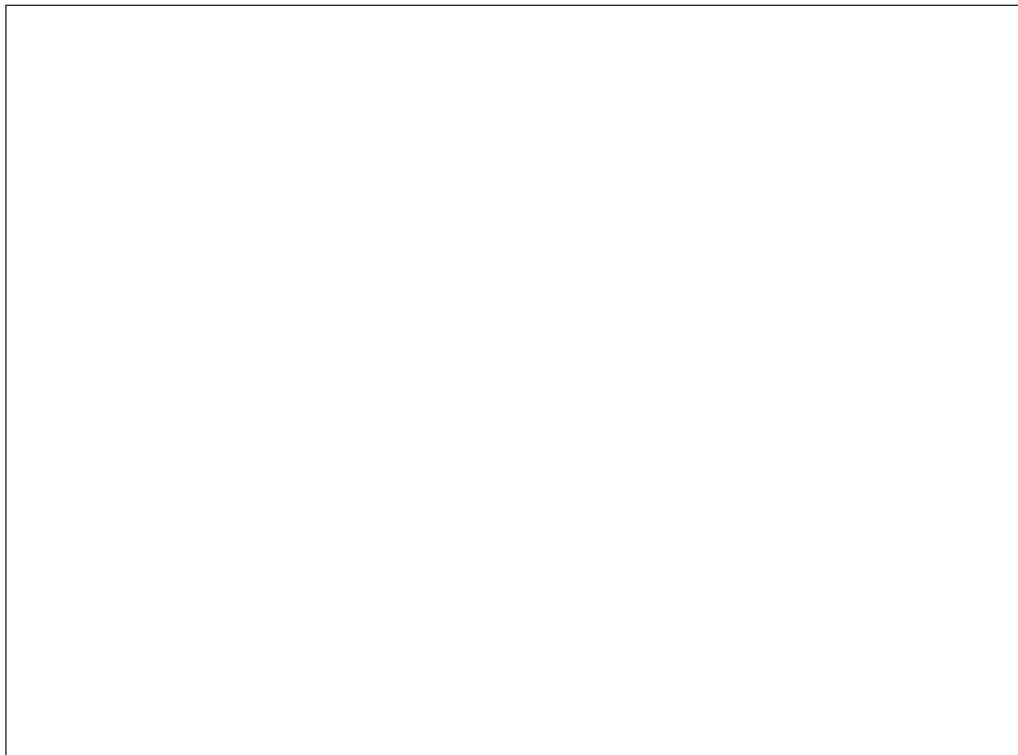
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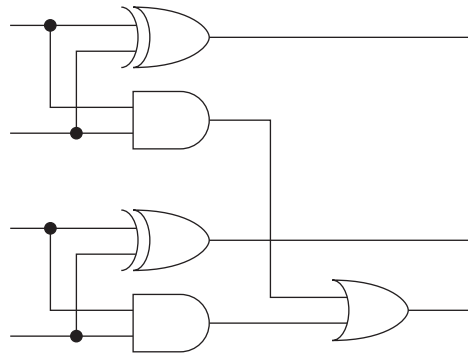


Question 35 continues on page 43

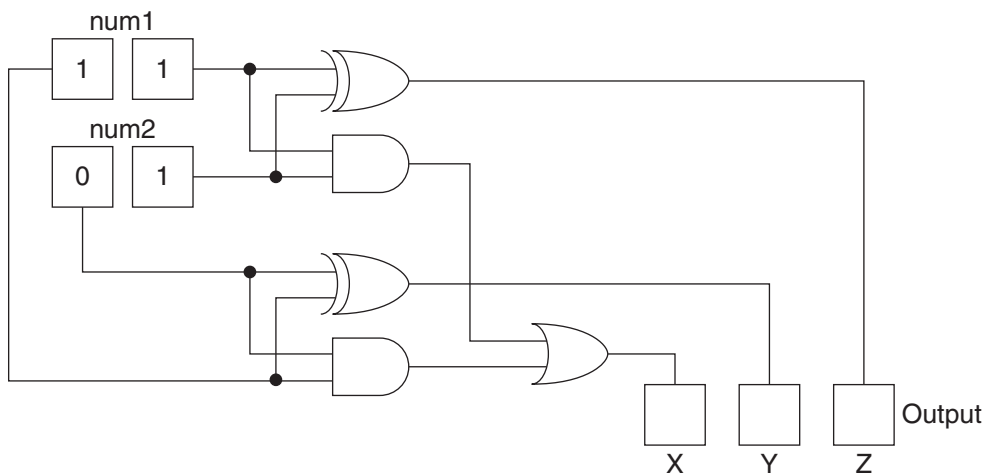
Question 35 (continued)

- (d) A student designed the following logic circuit for the addition of any two 2-bit numbers.

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The student tested the circuit using the values num1 = 11 and num2 = 01.



On the diagram above, write the outputs from each of the five logic gates. Fill in the values for X, Y and Z. Using these output values, identify why this circuit does not always produce the correct result for the addition of any two 2-bit numbers.

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Question 35 continues on page 45



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Student Number

Section III (continued)

Question 35 (continued)

Question 35 continues on page 46

Question 35 (continued)

- (e) (i) Outline the structure of a typical data stream.

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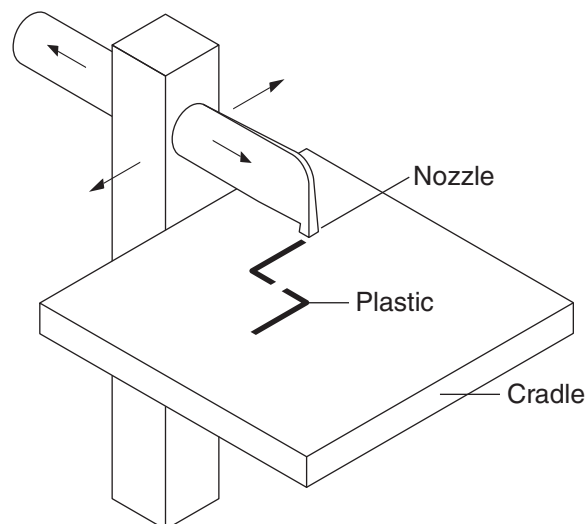
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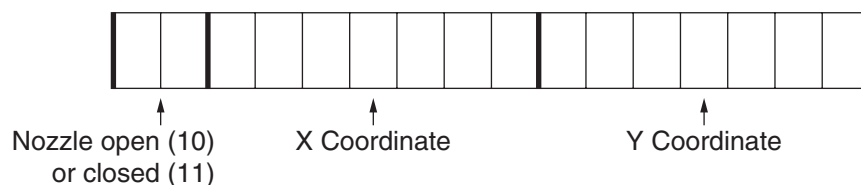
Use the following information to answer parts (ii) and (iii).

A simple 3-D printer is connected to a computer. The printer uses plastic that comes out of a nozzle and is cooled quickly. The nozzle can be directed to a specified position and can be set to be open or closed.

A 3-D product is produced by printing a series of separate lines on top of layers that are already printed.



A single printed layer is created by a series of 16-bit instructions in the data block, with the following format.



The printing nozzle moves to the position specified by the X, Y coordinates.

Question 35 continues on page 47



Question 35 (continued)

- (ii) The following data block (containing five instructions) is sent to the printer to produce a single layer. **3**

11 0010000 0010000

10 0110000 0110000

10 1010000 0010000

11 0110000 1110000

10 0110000 1000000

Draw the shape of the printed layer on the following grid.

	0	16	32	48	64	80	96	112
16								
32								
48								
64								
80								
96								
112								
128								

Question 35 continues on page 48



Question 35 (continued)

- (iii) The data block to the printer can contain the following control characters.

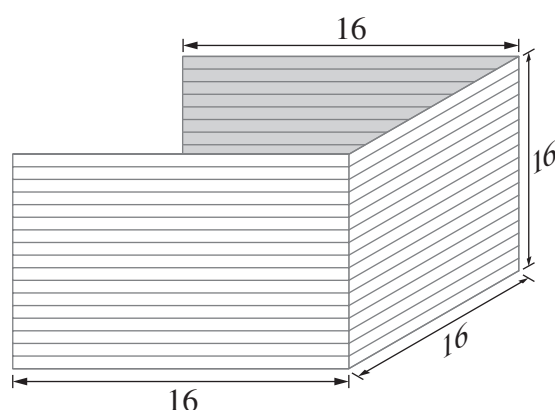
3

<i>Control characters</i>	<i>Meaning</i>
<ESC> FF	Directs the cradle to drop, allowing the next layer to be printed
<ESC> 0A nn	Specifies the start of a repeated set of instructions, to be repeated nn times, where nn is an 8-bit binary number
<ESC> 1A	Specifies the end of a repeated set of instructions

To drop the cradle, the following 16-bit instruction is sent to the printer.

ESC	F	F
0001 1011	1111	1111

Create the data block containing the required instructions to print a small 3-sided box without a top or bottom that is $16 \times 16 \times 16$ units, with one corner at (0, 0).



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