NSW Education Standards Authority

2020 **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 29 and 33 or pages 37 and 41

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 13–28)

- Attempt Questions 21–28
- Allow about 1 hour and 50 minutes for this section

Section III – 20 marks (pages 29–42)

- Attempt either Question 29 or Question 30
- 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.

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1 Consider the following pseudocode.

```
IF final THEN
        display winner
ENDIF
```

Which data type is final most likely to be?

A. Boolean

B. Integer

C. Real

D. String

2 Various forms of documentation are produced when software is developed.

Which row of the table correctly identifies ONE type of user documentation and ONE type of developer documentation?

	User	*Developer*
A.	Source code	Reference manual
B.	Online help	Installation guide
C.	Tutorial	Structure chart
D.	System flowchart	IPO chart

3 An engineer created a spreadsheet to estimate the cost of her next project.

Which software development approach was used to create the spreadsheet?

A. Agile

B. End user

C. Prototyping

D. Structured

4 A piece of software is to be developed for people to learn to play the piano.

During which stage of the software development cycle should the boundaries of the software first be considered?

A. Defining and understanding

B. Planning and designing

C. Implementing

D. Testing and evaluating

5 An array contains the names of 7 countries.

Albania	Canada	France	Kenya	Laos	Qatar	Zambia

Using a binary search, how many comparisons are required to determine that Australia is not in the array?

A. 1

B. 2

C. 3

D. 7

6 Which row of the table shows features of both bubble sort and selection sort that are always true?

	Bubble Sort	*Selection Sort*
A.	A sort of 6 elements requires 6 passes to ensure completion	Each pass through the unsorted part finds the next largest value
B.	The sort is complete when all adjacent pairs of elements have been compared once	A sort of 6 elements requires 5 passes to ensure completion
C.	The sort can be exited as soon as a pass has been completed with no swaps required	Elements in the sorted part are shuffled to allow the next element to be placed correctly
D.	Pairs of adjacent elements are compared and swapped if necessary	The sorted part of the array increases by one element in each pass

7 Consider this algorithm.

```
BEGIN
    input x
    FOR index = 0 TO 10 STEP 4
            x = x + index
    NEXT index
    input y
    x = x – y
    display x
END
```

What is the output of this algorithm if it is tested with data values of 3 and 14?

A. –7

B. 1

C. 15

D. 25

8 In which row of the table are the statements correct for both syntax error and logic error?

	Syntax error	*Logic error*
A.	Code statement does not follow the grammar rules of the language	Machine code cannot be generated
B.	Program stops execution unexpectedly	The source code can still be translated
C.	End user receives an error message	The statement containing the error is displayed
D.	Code statement cannot be translated	The program does not function as intended

9 At which level of testing would a software developer use a driver?

A. Acceptance

B. Module

C. Program

D. System

10 During which process would a software developer be most likely to use a metalanguage?

A. Creating source code

B. Developing a token stream

C. Conducting lexical analysis

D. Generating random test data

11 Which of the following best describes *quality assurance*?

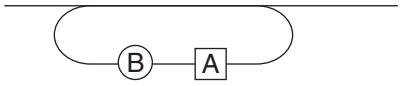
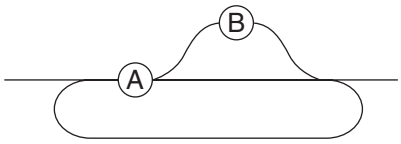
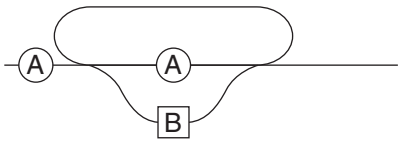
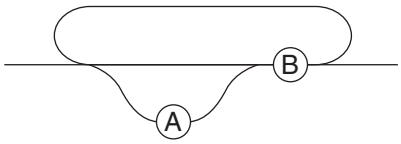
A. Comparing the performance of similar technologies

B. Responding to user feedback to improve a software package

C. Implementing a documented process to ensure defined criteria are met

D. Evaluating a software product to ensure that the client's needs are satisfied

12 Which of the following correctly matches an EBNF statement with its corresponding railroad diagram?

	EBNF statement	Railroad diagram
A.	{<A>B}	
B.	A{A[B]}	
C.	<A>{<A>|B}	
D.	[A]B[A]B	

13 Consider this code fragment.

```
Let NumInFinal = 10
LoadScores(Scores)
NumCompetitors = CountScores(Scores)
SortDescending (Scores)
PrintTopCompetitors(Scores, NumInFinal)
```

What is a benefit of writing the code in this manner?

A. It uses global variables.

B. It simplifies maintenance.

C. It minimises syntax errors.

D. It improves execution speed.

14 Consider this statement.

```
Students(3).Age = 17
```

Which of the following best describes Students(3)?

A. Field

B. Index

C. Integer

D. Record

15 Consider this code fragment.

```
BEGIN FileHandling
    open ItemList for append
    input number
    WHILE number >= 0
      write number to ItemList
      input number
    ENDWHILE
    close ItemList
END FileHandling
```

The file ItemList initially contains 4 and 2. The values 9 and –1 are used as input.

What are the contents of ItemList after the code is run?

A. 9

B. 9, –1

C. 4, 2, 9

D. 4, 2, 9, –1

16 What is the purpose of dynamic link libraries (DLLs)?

A. To enable faster compilation of source code

B. To allow developers to re-use their programs

C. To allow appropriate system modules to be accessed at run time

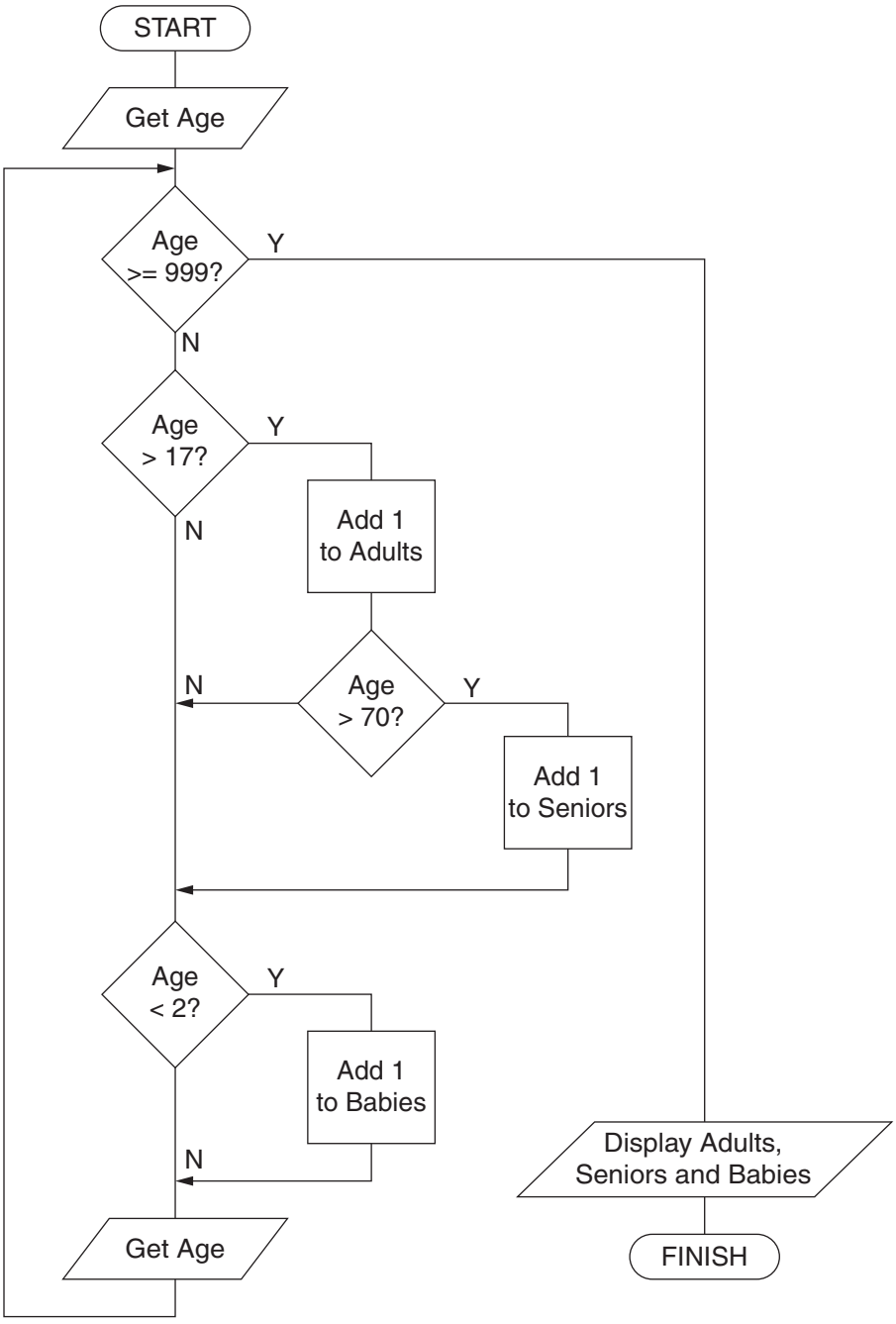
D. To enable modules written in different higher-level languages to be incorporated

17 Executable code has been decompiled.

Which row of the table correctly shows features of the code produced by the decompilation process?

	Contains internal comments	*Produces the same output as the executable code when run*
A.	No	Yes
B.	Yes	No
C.	No	No
D.	Yes	Yes

18 Consider this flowchart.



Question 18 continues on page 9

Question 18 (continued)

Which pseudocode fragment has the same output as the flowchart?

A.
```
BEGIN Count_People
    Get Age
    WHILE Age < 999
        IF Age > 17 THEN
            Add 1 to Adults
            IF Age > 70 THEN
                Add 1 to Seniors
            END IF
        END IF
        IF Age < 2 THEN
            Add 1 to Babies
        ENDIF
        Get Age
    ENDWHILE
    Display Adults, Seniors, Babies
END Count_People
```

B.
```
BEGIN Count_People
    Get Age
    REPEAT
        IF Age > 17 THEN
            Add 1 to Adults
            IF Age > 70 THEN
                Add 1 to Seniors
            END IF
        END IF
        IF Age < 2 THEN
            Add 1 to Babies
        ENDIF
        Get Age
    UNTIL Age > 999
    Display Adults, Seniors, Babies
END Count_People
```

C.
```
BEGIN Count_People
    Get Age
    REPEAT
        CASEWHERE Age is
            > 17 : Add 1 to Adults
            > 70 : Add 1 to Seniors
            < 2 : Add 1 to Babies
        ENDCASE
        Get Age
    UNTIL Age > 999
    Display Adults, Seniors, Babies
END Count_People
```

D.
```
BEGIN Count_People
    Get Age
    WHILE Age < 999
        CASEWHERE Age is
            > 17 : Add 1 to Adults
            > 70 : Add 1 to Seniors
            < 2 : Add 1 to Babies
        ENDCASE
        Get Age
    ENDWHILE
    Display Adults, Seniors, Babies
END Count_People
```

End of Question 18

Use the following code to answer Questions 19 and 20.

```
        LDR Reg1, Mem1      Load the contents of memory location Mem1 into register Reg1
        LDR Reg2, Mem1
        LDR Reg3, Mem2
        LDR Reg4, Mem2
Loop:   ADD Reg1, Reg2      Add the contents of Reg2 to the contents of Reg1, and put the result
                            in Reg1
        ADD Reg3, Reg4
        STR Reg1, Mem1      Store the contents of Reg1 in Mem1
        STR Reg3, Mem2
        CMP Mem2, Mem3      Compare the contents of Mem2 and Mem3
        BNE Loop            Branch if not equal
        END
```

19 The following values are already in memory.

Mem1 = 10
Mem2 = 1
Mem3 = 3

What is in Mem1 as a result of running this code?

A. 10

B. 20

C. 30

D. 40

20 Which statement can alter the value in the program counter?

A. LDR Reg1, Mem1

B. Loop: ADD Reg1, Reg2

C. CMP Mem2, Mem3

D. BNE Loop

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Centre Number

Student Number

Software Design and Development

Section II Answer Booklet

60 marks
Attempt Questions 21–28
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.

Please turn over

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Question 21 (11 marks)

A development team is to create a software application that allows ordering and delivery of food.

- Registered customers can select items from participating restaurants.
- The order is sent to the selected restaurant.
- A driver is sent the order details with a map showing the fastest route from their current position to the restaurant and then to the customer.
- Payment for the order is made using the customer's stored credit card details.

(a) There are a number of significant social and ethical issues relevant to the development of this application. **3**

Describe how TWO of these issues can be addressed.

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(b) Describe TWO ways in which CASE tools can assist the team developing this application. **3**

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Question 21 continues on page 15

Question 21 (continued)

(c) A Gantt chart is used to manage the development process of the application. Some of the tasks and the allocated team members are shown in the partial Gantt chart. **2**

	Task	***Team Member***	Week 1	Week 2	Week 3	Week 4
1	Display location of participating restaurants	Adam, Bill, Cara				
2	Select restaurant by location or food type	Bill				
3	Customer selection of items	Adam				
4	Send generated order details to restaurant	Dave, Emily				
5	Select potential close drivers	Adam, Cara				

Some team members have been allocated to work on a number of modules, but they can only work on one module at a time.

Outline the impact on the development process if Task 1 is not completed on time.

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(d) How could benchmarking be used to assess the performance of this application? **3**

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End of Question 21

Question 22 (3 marks)

Explain why the software development cycle is called a *cycle*. Refer to its stages in your answer. **3**

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Question 23 (4 marks)

Should a developer use an interpreter or a compiler for developing and distributing a software package? Justify your answer. **4**

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Question 24 (10 marks)

A games package is being developed to include four games.

(a) Explain TWO benefits of consistency in interface design for this games package. **3**

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Question 24 continues on page 18

Question 24 (continued)

Players who log into the package will be presented with a menu that offers a choice of games to play, as well as their best scores for each game.

After each game, players can choose to replay that game or return to the menu where they can select a different game or quit.

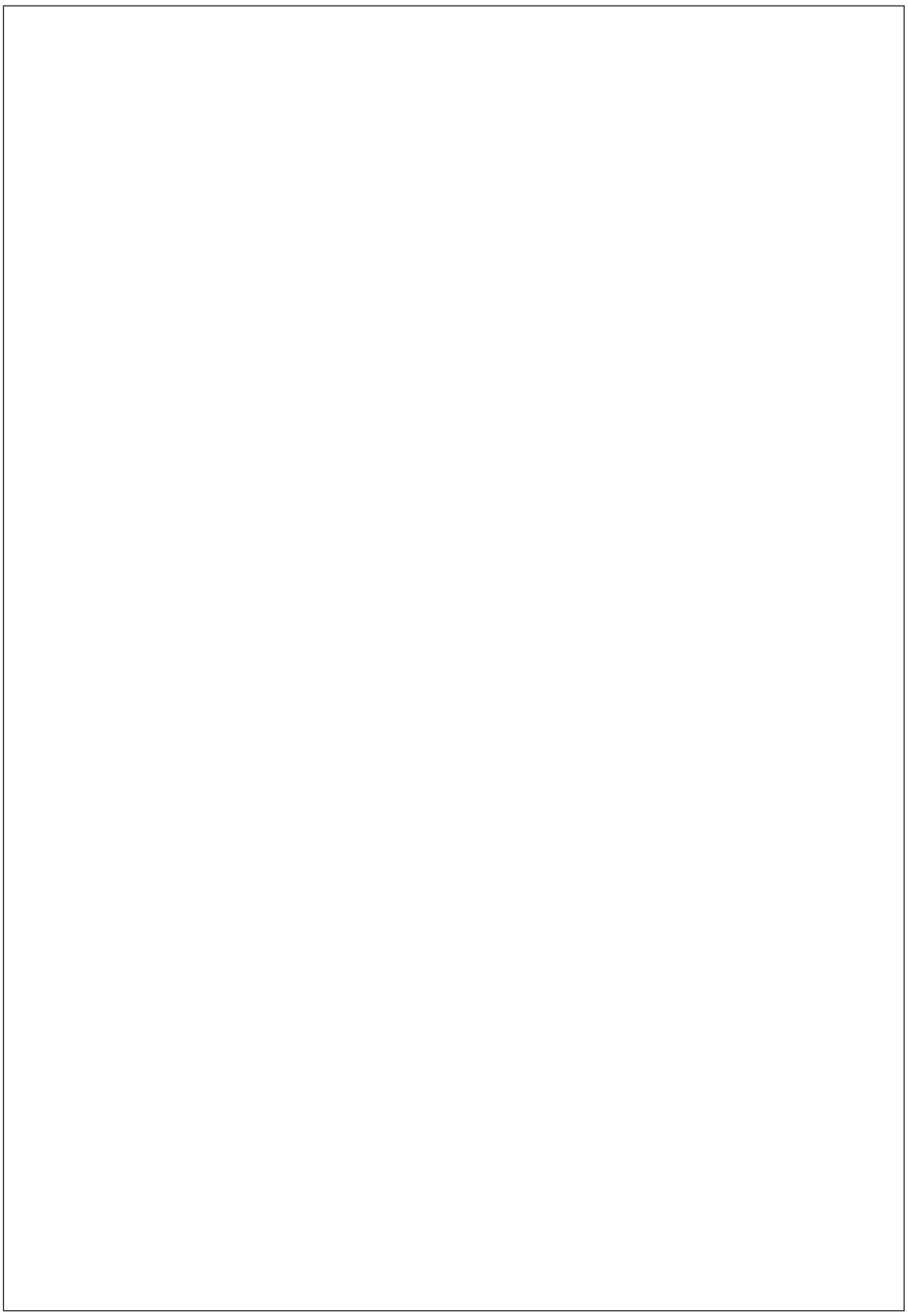
(b) Produce a partial storyboard for the package, showing consistent interface design and navigation for the login screen, the main menu and the welcome screens for two of the games. **3**

Login	Menu
Image of Game 1	Image of Game 2
Game 1	Game 2

Question 24 continues on page 19

Question 24 (continued)

(c) Draw a data flow diagram for the games package. **4**



End of Question 24

Question 25 (8 marks)

The following code fragment is designed to calculate the cost of purchases for a customer. Customers are identified by a customer ID. Individual customers may get a discount. The percentage discount, if applicable, is retrieved from a file.

```
BEGIN CalculateCost
        more = "Yes"
        total = 0
        WHILE more = "Yes"
                input cost_of_item
                total = total + cost_of_item
                input "Any more items?", more
        ENDWHILE
        input "Enter your customer ID" , CustID
        discount = FindDiscount(CustID)
        print "Your discount is ", discount
END CalculateCost

BEGIN FindDiscount(CustID)     'REM This is a stub
        print CustID
        discount = 15
        return discount
END FindDiscount(CustID)
```

(a) The subroutine FindDiscount() is currently written as a stub. **2**

Describe ONE benefit of writing this subroutine as a stub.

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Question 25 continues on page 21

Question 25 (continued)

(b) Complete the following data dictionary for the code fragment. **3**

Data item	*Data type*	*Number of bytes required for storage*

(c) Each customer's ID and its discount can be stored in a sequential file or a relative file. **3**

Discuss the suitability of these two file types for this scenario.

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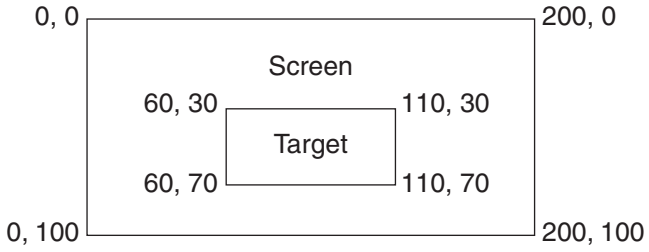
End of Question 25

Question 26 (9 marks)

As part of a game, players attempt to hit a rectangular target (50 × 40) which is placed inside a screen (200 × 100).



The following algorithm accepts as input two coordinates which must be multiples of 10. It checks whether the coordinates are within the target, outside the target or on the boundary of the target, and displays an appropriate message. There may be errors in the algorithm.

```
BEGIN
    message = ""
    display "enter 2 multiples of 10"
    input x, y
    IF x >= 60 AND x <= 110 THEN
        IF y > 30 AND y < 70 THEN
            message = "Inside"
        ELSE
            IF (x = 60 OR x = 110) AND (y = 70 OR y = 30) THEN
                message = "Boundary"
            ELSE
                message = "Outside"
            ENDIF
        ENDIF
    ENDIF
    display message
END
```

(a) Desk check the algorithm using the coordinates (60, 70) and (150, 30). **2**

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Question 26 continues on page 23

Question 26 (continued)

(b) To thoroughly test the algorithm, additional test data is needed. **3**

Provide TWO additional sets of coordinates to include in the test data and justify your choice.

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(c) The algorithm needs to make sure that the coordinates x and y represent points on the screen. To achieve this data validation, a subroutine GetValid(x, y) is to replace the statement 'input x, y'. **4**

Write an algorithm for the GetValid(x, y) subroutine. Include appropriate error messages.

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End of Question 26

Question 27 (12 marks)

A school is to redevelop its seat-booking system for school concerts held in the school hall.

(a) The next concert is to be held in 12 months time. School executive staff would like the opportunity to be involved in the development of the redesigned system. **3**

Propose an appropriate software development approach for the redesigned system and justify your choice.

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Question 27 continues on page 25

Question 27 (continued)

(b) The current seat-booking system consists of a number of modules, including: **4**

- booking and seat allocation
- online payment
- ticket production
- printing of seating plan
- cost/profit statement.

The current system sometimes produces unexpected outputs. Tickets do not print correctly and the amount charged is not always correct.

Describe methods that can be used to isolate these problems to specific modules and specific lines of code within the modules.

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Question 27 continues on page 26

Question 27 (continued)

(c) The redesigned booking and seat allocation module needs to fulfil these requirements. **5**

- Ask the user for the number of tickets required.
- If only one ticket is required, allocate any unallocated seat.
- If more than one ticket is required, allocate seats next to each other in the same row. However, if the required seats cannot be found together, an appropriate message should be displayed and the booking process restarted.
- Output the allocated seat number(s).

The audience is to be seated in 14 rows of 10 seats.

The diagram shows the seating plan represented as a 2-dimensional array. Column `0` contains the letters `A` to `N`. Row `0` contains the numbers `1` to `10`. An '`X`' indicates that the seat has already been allocated.

For example, if four tickets are ordered, the seats `B6`, `B7`, `B8` and `B9` will be allocated.

	1	2	3	4	5	6	7	8	9	10
A	X	X	X	X				X	X	
B	X	X	X	X	X					
C	X	X	X	X	X	X				
. . .										
N										

Question 27 continues on page 27

Question 27 (continued)

Write an algorithm for the booking and seat allocation module.

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End of Question 27

Question 28 (3 marks)

The following are all valid examples of the FOR/NEXT loop in a particular programming language. **3**

Structure	*Example*
FOR variable = value TO value statement; statement; statement NEXT variable	FOR X = 1 TO 10 Input Y; Add Y to X; Display X NEXT X
FOR variable = value TO value STEP value statement NEXT	FOR Count = 1 TO 10 STEP 3 Print Count NEXT
FOR variable = value TO value STEP value NEXT variable	FOR Count1 = 7 TO −5 STEP −2 NEXT Count1

Using a railroad diagram, write a syntax definition of the FOR/NEXT loop for this language. You are NOT required to define statement, value or variable.

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Section III

20 marks
Attempt either Question 29 or Question 30
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 29 — Programming Paradigms (20 marks)

(a) A computer game consists of players controlling characters that move through a fantasy world, collecting items, performing tasks and interacting with other characters. **3**

Explain why object-oriented programming languages are particularly suited to the development of such a computer game.

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Question 29 continues on page 30

Question 29 (continued)

(b) The following is a fragment of code, written using the logic paradigm, to show facts and rules relating to a software development company.

leader(validation, george)	means that George leads the validation team
leader(prototyping, tracey)	
leader(data_entry, tracey)	
leader(testing, sam)	
member(testing, ira)	means that Ira is a member of the testing team
member(prototyping, annette)	
member(data_entry, hayley)	
member(prototyping, adam)	
member(validation, chris)	
member(testing, adam)	
member(benchmarking, chris)	
team_mates(A, X, Y) :– member(A, X), member (A, Y), X ≠ Y	determines whether X and Y are different people on the same team
manager(X, Y) :– leader(Z, X), member(Z, Y)	determines whether Y is in a team led by X

(i) Extend the code to include the following logic: **3**

- lina is the team leader of the benchmarking team
- two_managers(A, B, C) determines whether A and B are both managers for C.

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Question 29 continues on page 31

Question 29 (continued)

(ii) Describe how the query manager(X, adam) is evaluated. In your response, make reference to the relevant facts and rules. **3**

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(c) An expert system is a software package that emulates the decision-making processes used by humans to solve complex problems, for example to provide a medical diagnosis using a set of symptoms. **3**

Contrast the use of the imperative paradigm with the use of the logic paradigm for developing an expert system.

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Question 29 continues on page 33

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Software Design and Development

Section III (continued)

Question 29 (continued)

(d) Explain how encapsulation can assist a team of programmers who are working on an object-oriented software project. **3**

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Question 29 continues on page 34

Question 29 (continued)

(e) Consider this code fragment.

```
1       class Operators {
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3               operator(string str1, string str2) {
4                       string s = str1 + str2
5                       Return s
6               }
7
8               operator(int a, int b) {
9                       int c = a + b
10                      Return c
11              }
12      }
13
14      class Main {
15              Operators obj = new Operators()
16              obj.operator(2, 3)
17              obj.operator("joe", "now")
18      }
```

(i) Describe how polymorphism is used in the code provided. Make reference to line numbers in your response. **3**

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Question 29 continues on page 35

Question 29 (continued)

(ii) A new method operator(int n, string str1) in the class Operators returns a single string with str1 repeated n times. **2**

For example, operator(3, “joe”) returns “joejoejoe”.

Write the code for this new method.

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End of Question 29

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Software Design and Development

Student Number

Section III (continued)

Do NOT attempt Question 30 if you have already attempted Question 29.

Question 30 — The Interrelationship between Software and Hardware
(20 marks)

(a) Explain why the use of Unicode is preferable to ASCII for representing characters in a wide range of languages. **2**

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Question 30 continues on page 38

Question 30 (continued)

(b) A home security system consists of a master switch and two sensors, with a light that can be turned on and a siren.

Component	*Description*	*Status*
A	A master switch for the system	1 for on
B	A sensor that detects if any window or external door is open	1 for open
C	A sensor that detects motion inside the house	1 for motion
X	A light	1 turns it on
Y	A siren	1 turns it on

This is the truth table for the security system.

A	*B*	*C*	*X*	*Y*
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	0
1	0	0	0	0
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

(i) Based on the information provided, describe how this security system operates. **3**

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Question 30 continues on page 39

Question 30 (continued)

(ii) Using the truth table, draw the required logic circuit for this security system. **3**

(c) In a research laboratory, samples are stored in one of four refrigerators. It is important that these samples are kept below a critical temperature.

A sensor inside each refrigerator measures the temperature (an integer between −20 to +20 degrees Celcius). Every hour a data stream is sent from each refrigerator to a central computer. The data streams include the hour of the day (from 0 to 23).

A light on each refrigerator will be turned on if the temperature has risen above the critical value, in which case all of the stored samples in that refrigerator will be thrown out.

(i) Construct a fully labelled data stream which would allow the measured data from the four refrigerators to be sent to the central computer. **3**

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Question 30 continues on page 40

Question 30 (continued)

(ii) When each data stream is received by the computer, the temperature is checked to ensure that it has not risen above the critical value. **3**

If the temperature is higher than the critical value, a signal is sent to the relevant refrigerator to turn the light on. The light is to stay on until a worker turns it off.

Explain how a flip-flop can be used in the circuitry of each refrigerator to operate the light.

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Question 30 continues on page 41

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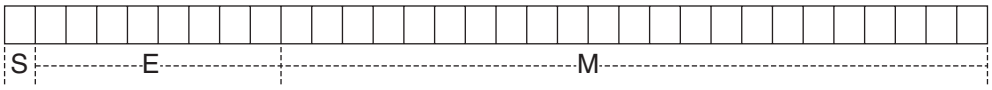
Section III (continued)

Question 30 (continued)

(d) Floating point numbers are represented in 32 bits using the format shown.



In this format:

- the first bit represents the sign (S) with 1 for negative and 0 for positive
- the next 8 bits represent the exponent (E)
- the remaining 23 bits represent the mantissa (M)

Note that 127 is added to the exponent before it is stored in the floating point representation and that the leading 1 of the mantissa is not stored.

(i) Convert the following floating point representation to its equivalent decimal fraction, showing working. **3**

1100 0001 0110 1000 0000 0000 0000 0000

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Question 30 continues on page 42

Question 30 (continued)

(ii) Design an algorithm that takes in a string of 32 characters representing a floating point number, and displays the exponent as its signed decimal value. **3**

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End of paper