



NSW Education Standards Authority

**2022** HIGHER SCHOOL CERTIFICATE EXAMINATION

# Software Design and Development

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**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 39, 43 and 47

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**Total marks: 100****Section I – 20 marks** (pages 2–11)

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

**Section II – 60 marks** (pages 13–32)

- Attempt Questions 21–31
- Allow about 1 hour and 50 minutes for this section

**Section III – 20 marks** (pages 33–49)

- Attempt either Question 32 or Question 33
- 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** Which of the following pseudocode keywords is associated with multiway selection?

- A. CASEWHERE
- B. IF
- C. REPEAT
- D. WHILE

**2** A user is asked to enter the state in which they live, for example NSW, VIC, QLD.

Which screen element ensures that the entered value is valid?

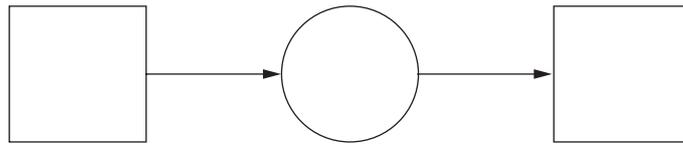
- A. Text box
- B. Scroll bar
- C. Check box
- D. Drop down list

**3** The day before a school's swimming carnival, the sports teacher used spreadsheet software to develop an application enabling her to store and process the results during the carnival.

Which development approach did she use?

- A. Agile
- B. End User
- C. Prototype
- D. Structured

4 What type of system modelling tool is this?



- A. IPO chart
  - B. Storyboard
  - C. Context diagram
  - D. System flowchart
- 5 Which of the following requires inclusivity to be considered when designing interfaces for a proposed system?
- A. Incomplete testing
  - B. A culturally diverse user base
  - C. The use of images created by others
  - D. The storage of sensitive customer data
- 6 What is the main benefit of collaboration between developers?
- A. Removal of copyright issues
  - B. Training of more developers
  - C. Simplification of code maintenance
  - D. Production of a better-quality product
- 7 A large amount of data is to be accessed by different systems. The data is to be accessed randomly.

What is the most effective way to store this data?

- A. A relative file
- B. A sequential file
- C. An array of records
- D. A two-dimensional array

8 Consider the following algorithm.

```
BEGIN
  A = 3
  B = 4
  C = 5
  A = B + C
  B = A
  C = B
  D = A + B + C
  Display D
END
```

What output is produced?

- A. 12
- B. 16
- C. 26
- D. 27

9 A programmer needs to find out how to code a particular function in a specific programming language.

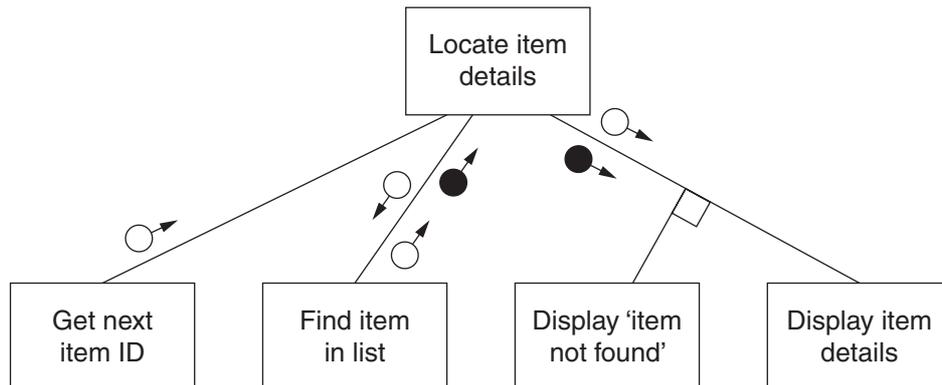
Which type of documentation should they refer to?

- A. Logbook
- B. User manual
- C. Data dictionary
- D. Railroad diagram

10 Why would a developer choose to define a variable as *global*?

- A. It results in code that executes more quickly.
- B. It can be accessed and changed by all modules.
- C. It allows the code to run on multiple platforms.
- D. It can have different values in different modules.

- 11 What is the purpose of a benchmark report when developing software?
- To ensure that the technology works under different conditions
  - To inform the choice of technology to be used in the proposed system
  - To document the standard that the developers must meet in the new system
  - To guarantee that the quality of the developed system meets defined criteria
- 12 Consider the following structure chart.



What is the purpose of the symbols shaped  and ?

- They indicate whether the item is found.
- They indicate that a search was carried out.
- They pass on the error message 'Item not found'.
- They pass on the item details that were found in the list.

**13** The following algorithm is designed to calculate an average mark.

999 is used as a sentinel value.

```
BEGIN
  Count = 0
  Total = 0
  Get Mark
  WHILE Mark <> 999
    Count = Count +1
    Total = Total + Mark
    Get Mark
  ENDWHILE
  Average = Total / Count
  Display Average
END
```

When the algorithm is coded, compiled and executed, which type of error is possible?

- A. Logic
- B. Runtime
- C. Syntax
- D. System

**14** The prototyping process in the early stages of developing a solution was more time-consuming and expensive than anticipated.

Why could this have occurred?

- A. There were logic errors in the initial algorithms.
- B. The communication between the developer and the client was poor.
- C. The modules to be incorporated in the solution were not readily available.
- D. The developer selected an inappropriate programming language to implement the solution.

15 Programs can be sequential or event-driven.

Which of the following statements is true?

- A. Event-driven programs must include a loop to detect inputs.
- B. Sequential programming is required for automated processes.
- C. In an event-driven program, inputs do not affect the order in which modules are executed.
- D. In a sequential program, the user has no control over the order in which modules are executed.

16 The list 7 9 2 4 1 is being sorted.

After the first pass the list becomes 7 2 4 1 9.

Which of the following shows the result of the next pass?

- A. 1 2 4 7 9
- B. 2 4 1 7 9
- C. 2 7 4 1 9
- D. 7 2 1 4 9

17 Which row of the table contains a correct statement about each search method when used with an array?

	<i>Binary search</i>	<i>Linear search</i>
A.	Continually discards half of the remaining elements	Will not search very large arrays
B.	Only works on an even number of elements	Only applicable where each element in the array is unique
C.	Can only be used with a sorted array	Looks at each element in order
D.	Can only search an array with numerical data	Takes twice as long as a binary search

- 18 A program requires the user to enter the number of tickets to be purchased. This must be an integer from 1 to 10 inclusive.

Which algorithm should be used to validate the entered data?

- A. Get NumTick  
WHILE NumTick <1 AND NumTick >10  
    Display "Please enter a valid number of tickets"  
    Get NumTick  
ENDWHILE  
ProcessPurchase
- B. Get NumTick  
REPEAT  
    Display "Please enter a valid number of tickets"  
UNTIL NumTick > 0 AND NumTick < 10  
ProcessPurchase
- C. Get NumTick  
IF NumTick <1 OR NumTick > 10  
    Display "Please enter a valid number of tickets"  
ENDIF  
ProcessPurchase
- D. Get NumTick  
WHILE NumTick <1 OR NumTick >10  
    Display "Please enter a valid number of tickets"  
    Get NumTick  
ENDWHILE  
ProcessPurchase

19 The array List( ) contains the following data.

index	1	2	3	4	5	6
List( )	7	3	6	8	7	1

The following code fragment is run.

```
BEGIN change
  index = 1
  REPEAT
    IF List(index) < List(index+1) THEN
      List(index) = List(index + 1)
      List(index + 1) = List(index)
    ENDIF
    add 1 to index
  UNTIL index = 6
END change
```

Which of the following shows the contents of List( ) after execution?

A. 

7	6	8	8	7	1
---	---	---	---	---	---

B. 

3	6	7	7	1	8
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C. 

1	3	6	7	7	8
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D. 

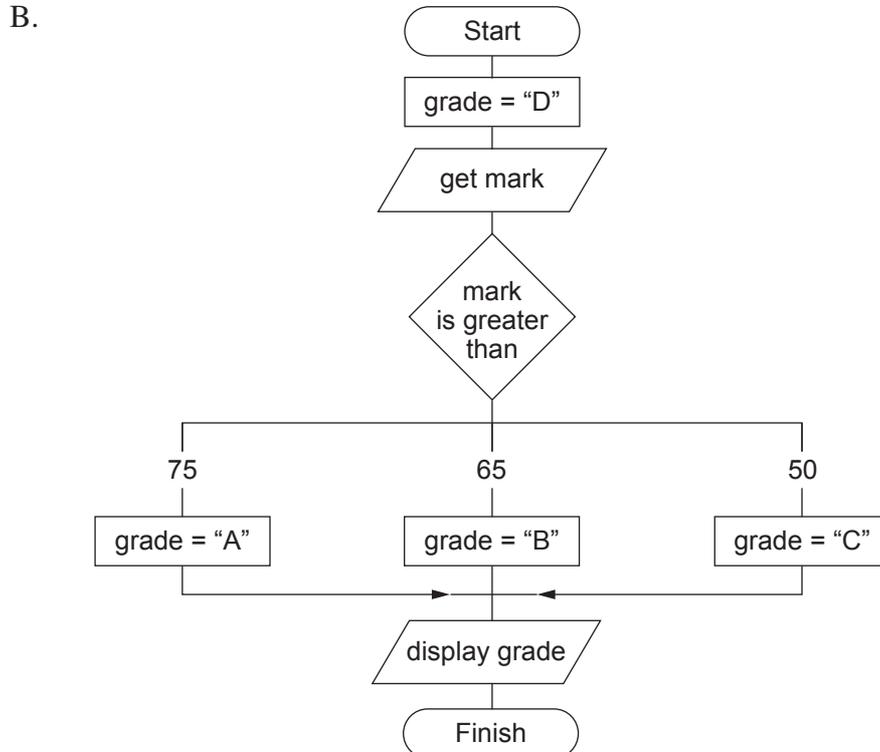
3	3	6	7	1	1
---	---	---	---	---	---

20 Grades are allocated based on a mark as follows:

MARK	Grade
0 to 49	D
50 to 64	C
65 to 74	B
75 to 100	A

Which of the following algorithms allocates the correct grade for an entered mark?

A. BEGIN  
    get mark  
    CASEWHERE mark is  
        greater than 49 : grade = "C"  
        greater than 64 : grade = "B"  
        greater than 74 : grade = "A"  
        OTHERWISE : grade = "D"  
    ENDCASE  
    display grade  
END



Question 20 continues on page 11

Question 20 (continued)

C. BEGIN

grade = "D"

get mark

IF mark > 49 THEN

grade = "C"

ENDIF

IF mark > 64 THEN

grade = "B"

ENDIF

IF mark > 74 THEN

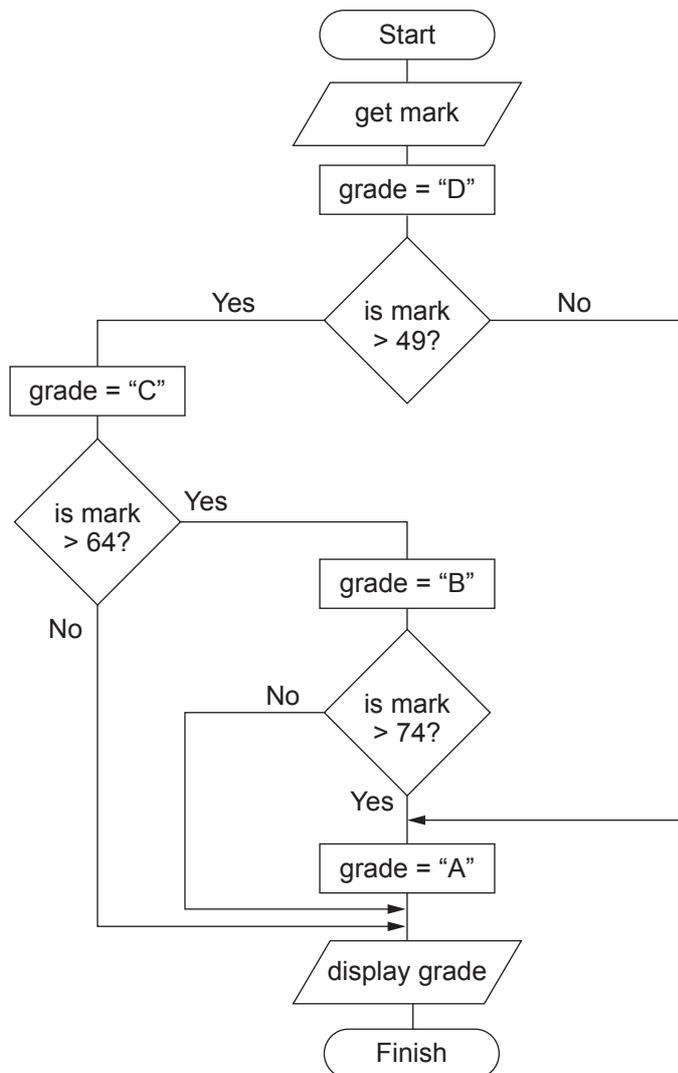
grade = "A"

ENDIF

display grade

END

D.



End of Question 20

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## Section II Answer Booklet

60 marks

Attempt Questions 21–31

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.

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**Please turn over**

**Question 21** (3 marks)

Describe TWO responsibilities of software developers when developing new systems.

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Do NOT write in this area.

**Question 22** (6 marks)

(a) Explain the need for maintenance in the software development cycle. **3**

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(b) One way of making future maintenance easier is by using explanatory comments in the code. **3**

Explain TWO other ways in which programmers can write code that makes maintenance of a software system easier.

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**Question 23** (4 marks)

Compare the use of an *interpreter* with the use of a *compiler*.

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Consider the perspectives of both the programmer and the client.

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**Question 24** (3 marks)

The following EBNF definitions specify syntax for a particular language.

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Assignment = Make This <variable> , (That <variable>) | <value>

Iteration = WHILEEVER <condition> DO  
<statement> [<statement>]  
ENDWHILEEVER

Selection = WHEN <condition> DO  
<statement> , {and <statement>}  
ENDWHEN

Print = Display “ <value> ” | <variable>

Assume that variable, value, condition and statement are all defined elsewhere.

Consider the following code fragment using this language.

Line numbers are provided for reference only.

```
1 Make This score , That age 18
2 WHILEEVER Score < 18
3     Display Score
4     Display “Underage”
5     Display “No entry”
6 ENDWHILEEVER
7 WHEN Score > 70 DO
8     Display “Retired” ,
9     Make Work = F
10 ENDWHEN
```

With reference to line numbers, describe THREE syntax errors in this code fragment.

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Do NOT write in this area.

**Question 25** (11 marks)

A developer has been employed by a local high school to design and develop a study app to track students' HSC revision routines. The app must be ready as soon as possible.

The app will:

- provide links to resources for all subjects that the school offers
- track the number of hours students are logged in to the site
- track the number of past examination papers accessed
- allow students to input questions for teachers
- send reminders to students who have not used the app.

(a) Recommend and justify a suitable development approach for this HSC revision app. **3**

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(b) Describe ONE benefit of the use of a pilot installation for this HSC revision app. **2**

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**Question 25 continues on page 19**

Question 25 (continued)

- (c) Outline TWO reasons why system testing is necessary in the development of this HSC revision app. 3

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- (d) Explain TWO factors outside the developer’s control which can affect the quality of a user’s experience with this HSC revision app. 3

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**End of Question 25**

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**Question 26** (4 marks)

Explain TWO ways in which CASE tools can improve the productivity of a development team during the development of a large software project.

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Question 27 (continued)

- (b) Design an appropriate data structure to store customer details for this fast-food ordering system. Do NOT include food choices in this data structure. 3

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- (c) Before the start of the development of this fast-food ordering system, the project manager was provided with information about the project team, including how many members are available and their skills. 3

Describe how the project manager can use Gantt charts effectively throughout the development of this system.

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**End of Question 27**

**Question 28** (6 marks)

An algorithm was designed to remove repeating consecutive characters in a phrase, replacing them with a single character.

The algorithm:

- allows input of a phrase
- removes repeated characters
- displays the shortened phrase.

For example, if the input is 'aaaabbbbaa' the output will be 'aba'.

Note: The function `right (m, n)` gets the last `n` characters of `m`.

There are errors in the algorithm.

```
1  BEGIN Shorten
2      input phrase
3      phrase = phrase + "X"           'Adds an X to the end of phrase
4      Len = number of characters in phrase
5      NewPhrase = ""
6      REPEAT
7          done = FALSE
8          NewPhrase = NewPhrase + 1st character of phrase
9          REPEAT
10             IF 1st character of phrase does not equal 2nd character of phrase THEN
11                 done = TRUE
12             ENDIF
13             Len = Len - 1
14             phrase = right (phrase, Len)
15         UNTIL done = TRUE
16     UNTIL Len < 1
17     output phrase
18     phrase = NewPhrase
19 END Shorten
```

**Question 28 continues on page 25**



**Question 29** (3 marks)

Using an example, explain why programmers need to use different data types in their code.

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Question 30 (continued)

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**End of Question 30**

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**Question 31** (5 marks)

- (a) Contrast the purpose of the *program counter* with that of the *accumulator*. **2**

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- (b) A CPU can carry out the following assembly language instructions. **3**

<b>Instruction and operand</b>	<b>Meaning</b>
LOAD y	Load the contents of y into the accumulator
STORE y	Store the contents of the accumulator in y
ADD y	Add the contents of y to the accumulator
SUBTR y	Subtract the contents of y from the accumulator
JUMP address	Jump to the instruction at 'address'
JMPN address	Jump to the instruction at 'address' ONLY if the value in the accumulator is negative
OUTP	Display the value in the accumulator
END	Stop execution

Consider the following assembler code fragment.

Address	Instruction	Operand
Label 1	LOAD	a
	SUBTR	b
	JMPN	Label 2
	STORE	a
	LOAD	d
	ADD	c
	STORE	d
	JUMP	Label 1
Label 2	LOAD	d
	SUBTR	c
	OUTP	
	END	

**Question 31 continues on page 31**





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## Section III

**20 marks**

**Attempt either Question 32 or Question 33**

**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 32 — Programming Paradigms (20 marks)

- (a) Describe *abstraction* in the context of object oriented programming. **2**

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**Question 32 continues on page 34**



Question 32 (continued)

- (b) Consider the following fragment of code which has been written using the object oriented programming (OOP) paradigm.

```
class BIRD {
    public -
        IDNo: Integer
        BiologicalName: String
        CommonName: String
        CountryOfOrigin: String

        GetWholeName(IDNo)
            WholeName = BiologicalName & CommonName
            Return Wholename
        end GetWholename
}

subclass WATERBIRD is a BIRD {
    public -
        Wader: Boolean
        Diver: Boolean
        WaterHabitat: String
}
```

- (i) With reference to the fragment of code above, explain the importance of *inheritance* in the OOP paradigm. **3**

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**Question 32 continues on page 35**





Question 32 (continued)

- (ii) Write the code to define a subclass of WATERBIRD called SEABIRD which has the following attributes and method. 3

Ocean	the ocean where the bird is most commonly found eg Pacific
MaxDistance	the maximum distance the bird can fly, in whole kilometres
MaxAltitude	the maximum height at which the bird can fly, in whole metres
HowHigh	a method that returns the MaxAltitude flown by a seabird with the common name entered by the user

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- (c) A system uses cameras to detect whether drivers have used their mobile phone while driving. 3

Describe how software in this system can determine whether or not a driver has used their phone.

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**Question 32 continues on page 37**





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## Section III (continued)

Question 32 (continued)

(d) The following facts have been defined using the logic paradigm.

```

larger(elephant, horse)      means that an elephant is larger than a horse
larger(horse, donkey)
larger(donkey, dog)
larger(donkey, cat)

```

(i) Explain the result of the following query. 2

?- larger(elephant, cat)

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(ii) The following rules are defined. 3

```

is_bigger(X, Y) :- larger(X, Y)
is_bigger(X, Y) :- larger(X, Z), larger(Z, Y)

```

Write a query to find animals that are both smaller than a donkey and bigger than a cat.

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**Question 32 continues on page 38**

Question 32 (continued)

- (e) Using examples, explain how the use of appropriate paradigms can improve the productivity of a programmer. **4**

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**End of Question 32**

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## Section III (continued)

**Do NOT attempt Question 33 if you have already attempted Question 32.**

### Question 33 — The Interrelationship between Software and Hardware (20 marks)

- (a) Show how TWO different integers can be represented by the binary number 10000011. **2**

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- (b) Show how to calculate the 32-bit IEEE754 single precision floating point number that represents the decimal fraction  $-\frac{1}{32}$ . **3**

The first step is done for you.

Convert to binary:  $-\frac{1}{32} = -0.00001$

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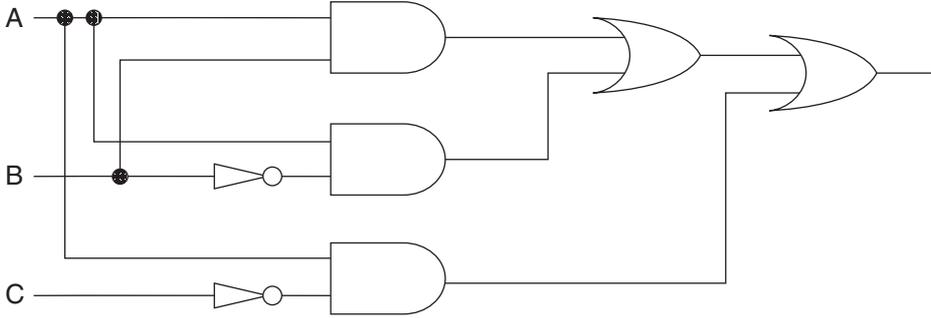
**Question 33 continues on page 40**



Question 33 (continued)

(c) Write a Boolean representation for the following logic circuit.

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**Question 33 continues on page 41**







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Section III (continued)

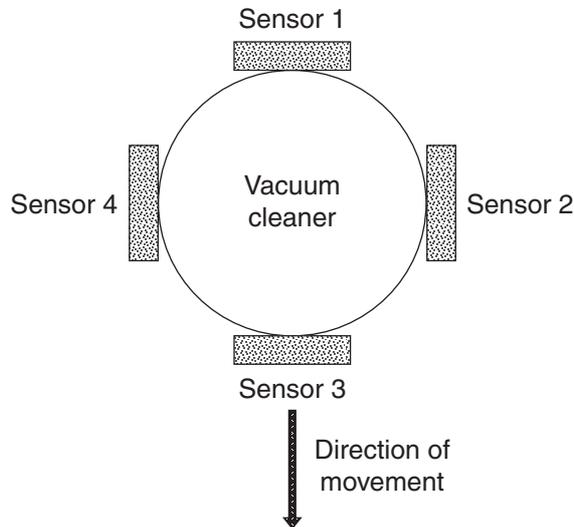
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Question 33 (continued)

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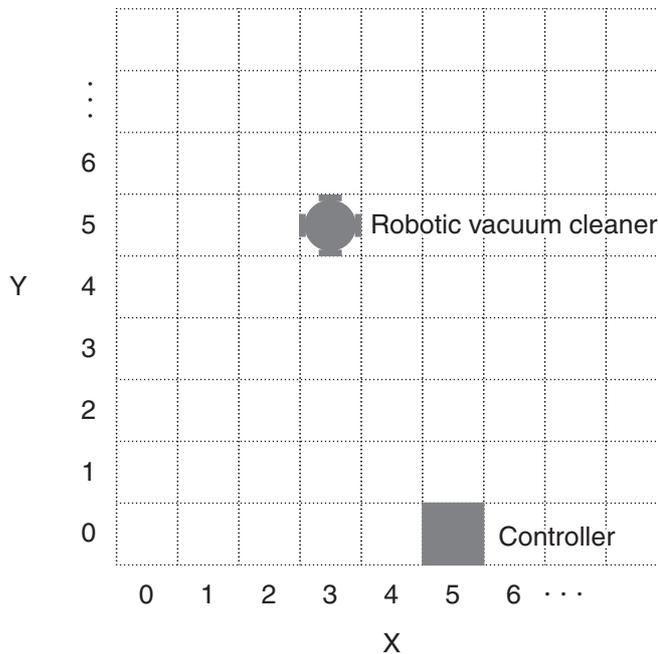
Question 33 (continued)

- (e) A basic robotic vacuum cleaner can move across the floor of a rectangular-shaped room, vacuuming as it goes. The cleaner is circular, with four sensors as shown below. Each sensor detects objects that the cleaner is about to bump into.



A controller sends and receives data streams to and from the cleaner.

Looking down at a part of the room, it could appear as shown.



The cleaner is currently at (3, 5).

**Question 33 continues on page 45**

Question 33 (continued)

(i) **Data stream from the controller to the cleaner**

**3**

This data stream instructs the cleaner to either

- move to the specified coordinates

OR

- change direction and move one square.

The format of the 16-bit data stream depends on the type of move, as specified in the first bit.

1																0
Type of move	X coordinate (7 bits)							Y coordinate (7 bits)							Not used (1 bit)	

OR

0			0	0	0	0	0	0	0	0	0	0	0	0	0
Type of move	Direction (2 bits)		Not used (13 bits)												

The two direction bits are as follows:

- 00 – continue in the same direction and move one square
- 01 – change direction 90° anticlockwise and move one square
- 10 – change direction 90° clockwise and move one square
- 11 – change direction 180° and move one square.

What does the following data stream achieve?

```
1 1 1 0 0 1 0 0 0 1 0 1 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

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**Question 33 continues on page 46**



Question 33 (continued)

(ii) **Data stream from the cleaner to the controller**

**3**

As the cleaner moves around the room, it regularly sends a data stream back to the controller.

The cleaner also indicates when the battery needs to be recharged.

The data stream has the following format:

X coordinate (7 bits)							Y coordinate (7 bits)							Sensor	Battery		

The sensor bit can be:

- 0 – no object sensed in the direction of movement OR
- 1 – object sensed in the direction of movement.

The battery bit can be:

- 0 – sufficient charge OR
- 1 – needs recharging.

The cleaner is currently at (42, 18). The battery needs recharging and the sensors have not detected an object.

Create the data stream sent from the cleaner to the controller.

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**Question 33 continues on page 47**





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Section III (continued)

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Question 33 (continued)

**Please turn over**





Question 33 (continued)

- (iii) The controller is located at (5, 0) and contains a battery charger.

4

A module called Check\_Battery is required to enable the following:

- The controller determines if the cleaner has a low battery by checking the data stream sent by the cleaner.
- If so, the controller needs to send a data stream to recall the cleaner back to the controller.
- As the cleaner moves back to the controller, it continues to send data streams. If the cleaner's sensor indicates an object in its path, it is sent an instruction to change direction 90 degrees clockwise and move one square if the path is clear.
- This process continues until the cleaner has arrived back at the controller.

Design the required algorithm for Check\_Battery.

Note: You can use the routine Extract (variable, start\_bit, no\_of\_bits) in your algorithm.

For example,

String = "110111"

Extract (String, 4, 2) takes the 4th and 5th bits (11) and converts them to their decimal value (3).

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Question 33 continues on page 49





Question 33 (continued)

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