BOARD OF STUDIES
NEW SOUTH WALES

2013

HIGHER SCHOOL CERTIFICATE EXAMINATION

Software Design and Development

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- Draw diagrams using pencil
- Write your Centre Number and Student Number at the top of either pages 37 and 41, or pages 45 and 49

Total marks – 100

Section I Pages 2–10

20 marks

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

Section II Pages 13–35

60 marks

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

Section III Pages 37–51

20 marks

- 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.

---

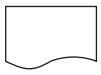
1 Consider this fragment of code.

```
length = 0
breadth = 0
area = length * breadth
length = 5
breadth = 4
```

What are the values of length, breadth and area after the fragment of code has been executed?

	length	breadth	area
(A)	0	0	0
(B)	0	0	20
(C)	5	4	0
(D)	5	4	20

2 Which of the following is NOT a system flowchart symbol?

(A) 

(B) 

(C) 

(D) 

3 Which of the following would be best to use to show the planned sequence of events for a development process?

(A) Logbook

(B) Gantt chart

(C) Context diagram

(D) Program flowchart

4 Which of the following is most effective in preventing software piracy?

(A) Using a site licence

(B) Using an encryption key

(C) Making a file 'Read-only'

(D) Providing source code instead of compiled code

5 The Millennium Bug (also known as the year 2000 problem) resulted from the common practice of only storing the last two digits of a calendar year (eg 63 instead of 1963) in order to save memory.

Which of the following is TRUE of the Millennium Bug?

(A) It was a virus, as it affected software worldwide.

(B) It was a logic error, resulting in inappropriate calculations.

(C) It was caused by an inappropriate data structure, requiring a lot of software to be updated.

(D) It was malware, introduced by programmers who were later employed to fix the problem they had created.

6 The quality of a piece of software is determined by a number of criteria.

At which stage of the software development cycle should these criteria be identified?

(A) Defining and understanding the problem

(B) Planning and designing the software solution

(C) Implementing the software solution

(D) Testing and evaluating the software solution

7 Which of the following is the most appropriate data type for storing telephone numbers?

(A) String

(B) Record

(C) Integer

(D) Floating point

8 Which of the following is NOT a valid reason for maintaining software?

(A) Existing software also has to work on hand-held devices, such as tablets.

(B) Equal opportunity legislation demands greater inclusivity in user interfaces.

(C) There are legislative changes, such as the introduction of the GST, requiring added functionality.

(D) The increased speed of the national broadband network (NBN) allows users to download software more efficiently.

9 Which type of documentation provides the most detailed information about calculations used in programs?

(A) IPO diagram

(B) Structure chart

(C) Data dictionary

(D) Data flow diagram

10 Which type of coding error is test data used to detect?

(A) Compiler

(B) Lexical

(C) Logic

(D) Syntax

11 A user pays for and installs a software package with a single user licence. Later, the user pays for and installs an upgrade to the package.

What is the user allowed to do with the original version?

(A) Sell it

(B) Archive it onto a DVD

(C) Give it away but not sell it

(D) Use it on a different computer

12 Consider the following code, where variables `a`, `b` and `c` each store different integer values.

```
IF a > b THEN
    IF b > c THEN
        PRINT c
    ELSE
        PRINT b
    ENDIF
ELSE
    IF a > c THEN
        PRINT c
    ELSE
        PRINT a
    ENDIF
ENDIF
```

What will this code print?

(A) The numbers in ascending order

(B) The numbers in descending order

(C) Only the largest of the three values

(D) Only the smallest of the three values

Use the following information to answer Questions 13–14.

Consider the fragment of code.

```
BEGIN Library-fine
    input days
    calculate
    print owing
END Library-fine

BEGIN calculate
    IF days > 5 THEN
        owing = days * 2
    ELSE
        owing = 0
    ENDIF
END calculate
```

13 The fragment of code works correctly, producing the correct output. Which row in the table correctly identifies the category of each variable?

	days	owing
(A)	local	local
(B)	global	global
(C)	local	global
(D)	global	local

14 The above fragment of code has been modified as shown.

```
BEGIN Library-fine
    fine = 2
    freedays = 5
    input days
    calculate
    print owing
END Library-fine

BEGIN calculate
    IF days > freedays THEN
        owing = days * fine
    ELSE
        owing = 0
    ENDIF
END calculate
```

What is the most likely reason for making the modifications?

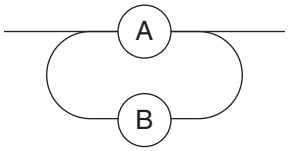
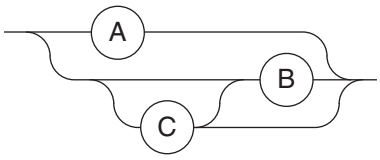
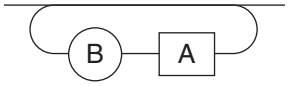
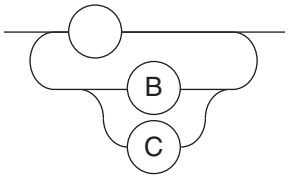
(A) It makes the code easier to maintain.

(B) The number of fine-free days has changed.

(C) The penalty for overdue items has changed.

(D) The functionality of the program needs to be increased.

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

(A)	A {A B}	
(B)	A | B | C [B]	
(C)	{A < B >}	
(D)	A [{B} | {C}]	

16 Which of the following best describes *acceptance testing*?

(A) Testing that the system can accept large volumes of data

(B) Testing the user-friendliness of the interface by the end users

(C) Testing whether the response times are acceptable to the end users

(D) Testing whether the system is ready to become available to the end users

17 An array of 15 integers has been sorted in ascending order. A standard binary search algorithm is used to find out if a particular integer is in the array.

What is the maximum number of elements that need to be checked?

(A) 2

(B) 4

(C) 8

(D) 15

Use the following code to answer Questions 18–19.

The subroutine getValue is designed to return a number within a given range.

```
BEGIN getValue(low, high, number)
    print "Enter a value between" low " and " high
    input number
    WHILE (number < low) AND (number > high)  'REM this statement is checking the range
        input number
    ENDWHILE
END getValue
```

18 Which of the following is the most suitable for testing that the subroutine getValue returns a number between 15 and 20 inclusive?

(A)
```
getValue(14, 21, number)
output number
```

(B)
```
low = 14
high = 21
getValue(number, low, high)
output number
```

(C)
```
FOR number = 14 TO 21
    getValue(14, 21, number)
NEXT number
output number
```

(D)
```
REPEAT
    getValue(14, 21, number)
UNTIL (number < 14) AND (number > 21)
output number
```

19 The subroutine getValue has been modified as shown.

```
BEGIN getValue(low, high, number)
    'REM print "Enter a value between" low " and " high
    'REM input number
    'REM WHILE (number < low) AND (number > high) 'REM this statement is checking the range
    'REM input number
    'REM ENDWHILE
    number = (low + high) /2
END getValue
```

What is the most likely reason for modifying the code?

(A) To test what would happen if a number outside the range was generated

(B) To test whether the lines marked 'REM can be removed for greater efficiency

(C) To determine whether the original subroutine was the cause of incorrect output

(D) To add comments to help explain the logic of the code for maintenance purposes

Please turn over

20 A CPU with a single accumulator is able to carry out these assembly language instructions.

Note: x represents a memory location.

Instruction		*Meaning*
LOAD	x	Load the contents of x into the accumulator
STORE	x	Store the contents of the accumulator into x
SUBTR	x	Subtract the contents of x from the accumulator
JUMP	label	Jump to the instruction labelled "label"
JMPN	label	Jump to the instruction labelled "label" if the value in the accumulator is negative

Consider this higher-level language statement.

```
IF a > b THEN
    c = a
ELSE
    c = b
ENDIF
```

Which of the following represents a correct assembly language implementation of the statement for this CPU?

(A)
```
        LOAD    b
        SUBTR   a
        JMPN    else
        LOAD    a
        STORE   c
        JUMP    endif
else    LOAD    b
        STORE   c
endif
```

(B)
```
        LOAD    a
        SUBTR   b
        JMPN    else
        LOAD    c
        STORE   a
        JUMP    endif
else    LOAD    c
        STORE   b
endif
```

(C)
```
        LOAD    b
        SUBTR   a
        JMPN    else
        LOAD    b
        STORE   c
        JUMP    endif
else    LOAD    a
        STORE   c
endif
```

(D)
```
        LOAD    a
        SUBTR   b
        JMPN    else
        LOAD    c
        STORE   b
        JUMP    endif
else    LOAD    c
        STORE   a
endif
```

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2013 HIGHER SCHOOL CERTIFICATE EXAMINATION

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Section II

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

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 on pages 34 and 35. If you use this space, clearly indicate which question you are answering.

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Question 21 (3 marks)

A well-designed data input interface allows for: **3**

- minimal keystrokes
- minimal mouse movements
- data validation.

Describe how these features can be achieved.

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Question 22 (8 marks)

Pike Pathology provides patients with medical strips to conduct blood tests at home. These medical strips can be inserted into smart phones using special attachments.

The smart phone has an app that:

- processes data captured from the medical strips
- records the blood test data on the patient's phone
- transmits this data to Pike Pathology.

Software on Pike Pathology's computer system will:

- analyse the data and store the result in the database
- alert the patient if a blood test has not been done
- alert the patient's doctor if the results of a test are abnormal
- allow the patient's doctor to access Pike's database to retrieve results.

The doctor then communicates with the patient, if necessary.

(a) Issues relevant to the use of such a system include access to data, privacy, the need for accuracy, and technical issues. **4**

Discuss TWO of these issues with reference to the scenario.

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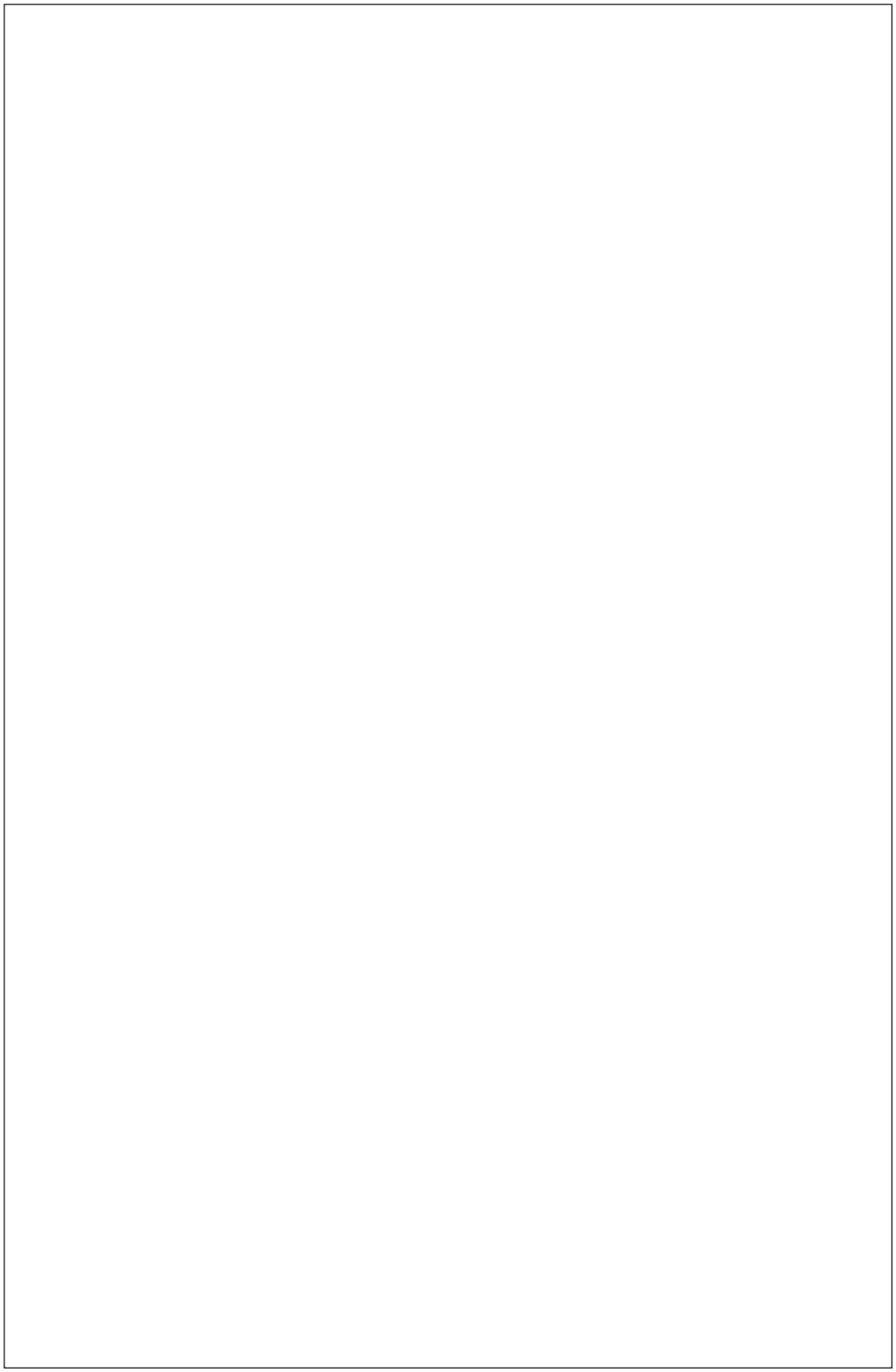
Question 22 continues on page 17

Question 22 (continued)

(b) Draw a data flow diagram of this system. **4**



End of Question 22

Question 23 (3 marks)

Describe TWO ways in which a team of developers can make use of computer networks to support the development of software. **3**

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Question 24 (7 marks)

An app is being developed for a mobile device to display train timetable information.

The app should be able to:

- allow the user to choose a start station and a destination station
- display information about the next suitable train to arrive at the start station
- provide an option to view a list of the stations on the chosen trip.

(a) Draw an IPO diagram for this app. **3**

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Question 24 continues on page 21

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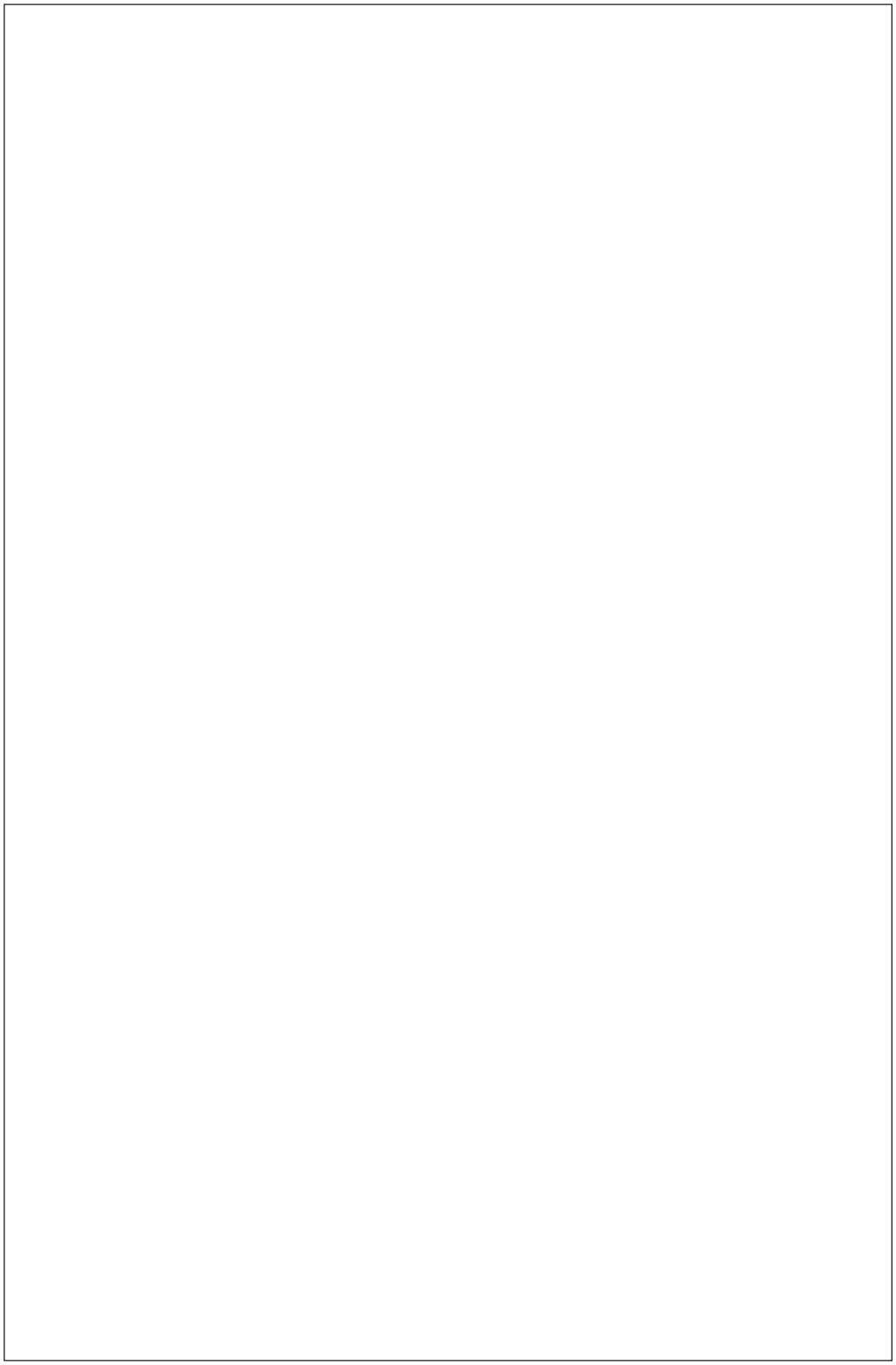
Question 24 (continued)

(b) Draw a storyboard for this app. **4**



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End of Question 24

Question 25 (8 marks)

A database for a courthouse contains data about the various trials and hearings that will take place. The data includes:

- dates, times and locations
- the names of the presiding judges
- the names of jurors
- details of the accused.

A system is being developed to give stakeholders (eg witnesses, court staff and police) access to appropriate data, using touch screens in kiosks at the entrance to the courthouse as well as web-based access.

(a) Compare the agile approach and an alternative approach, with regard to their suitability for developing this system. **4**

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Question 25 continues on page 23

Question 25 (continued)

(b) Describe the criteria by which the quality of this system can be determined. **4**

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End of Question 25

Please turn over

Question 26 (3 marks)

An existing computer-based system is to be replaced. Management wants the new system to be operational quickly. Users need time to be trained in the new system. Many of the users will need to be convinced of the value of the new system. The data generated by the system is very important and must be correct. **3**

Recommend an installation method for this system, and justify your choice.

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Question 27 (5 marks)

Consider the following array called num which contains 52 elements.

num	1	2	3	4	5	6	7	8	9	10	11	...	51	52

(a) Write an algorithm which populates the array num as shown above. **2**

(b) The following algorithm is applied to the array num. **3**

```
FOR k = 1 TO 52
    REPEAT
        index = RANDBETWEEN(1,52)
    UNTIL num(index) is not equal to –1
    newnum(k) = num(index)
    num(index) = –1
NEXT k
```

Note:

- the function RANDBETWEEN(a,b) returns an integer between a and b inclusive
- there is a second array, newnum

Explain how the algorithm fulfils its purpose.

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Question 28 (6 marks)

The following algorithm sorts an array into ascending order.

```
1   BEGIN BubbleSort
2       Last = number of elements in the array
3       Swapped = true
4       WHILE Swapped = true
5           Swapped = false
6           k = 1
7           WHILE k < Last
8               IF Num (k) > Num (k+1) THEN
9                   Temp = Num (k)
10                  Num (k) = Num (k+1)
11                  Num (k+1) = Temp
12                  Swapped = true
13              ENDIF
14              k = k+1
15          ENDWHILE
16          Last = Last – 1
17      ENDWHILE
18  END BubbleSort
```

(a) The array Num contains 33, 44, 22 and 11. **3**

Perform a desk check of the above algorithm until the first time you reach line 16.

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Question 28 continues on page 27

Question 28 (continued)

(b) An array of five numbers is NOT sorted. Determine both the minimum and maximum number of passes needed to sort the array using BubbleSort. Justify your answer. **3**

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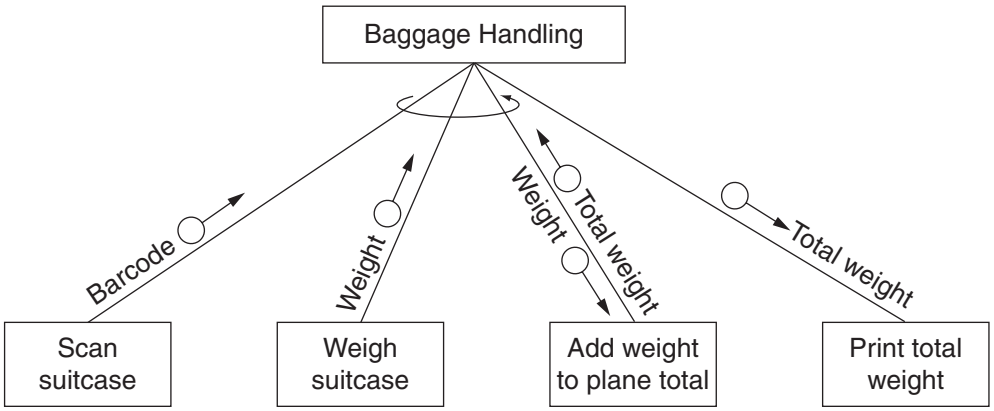
End of Question 28

Please turn over

Question 29 (6 marks)

At an airport the maximum baggage limit per item is 20 kg. The following structure chart represents part of the baggage handling system.



(a) It is found that the Print total weight subroutine is always outputting a value between 0 and 20 kg. Describe strategies for locating the error in the system. **3**

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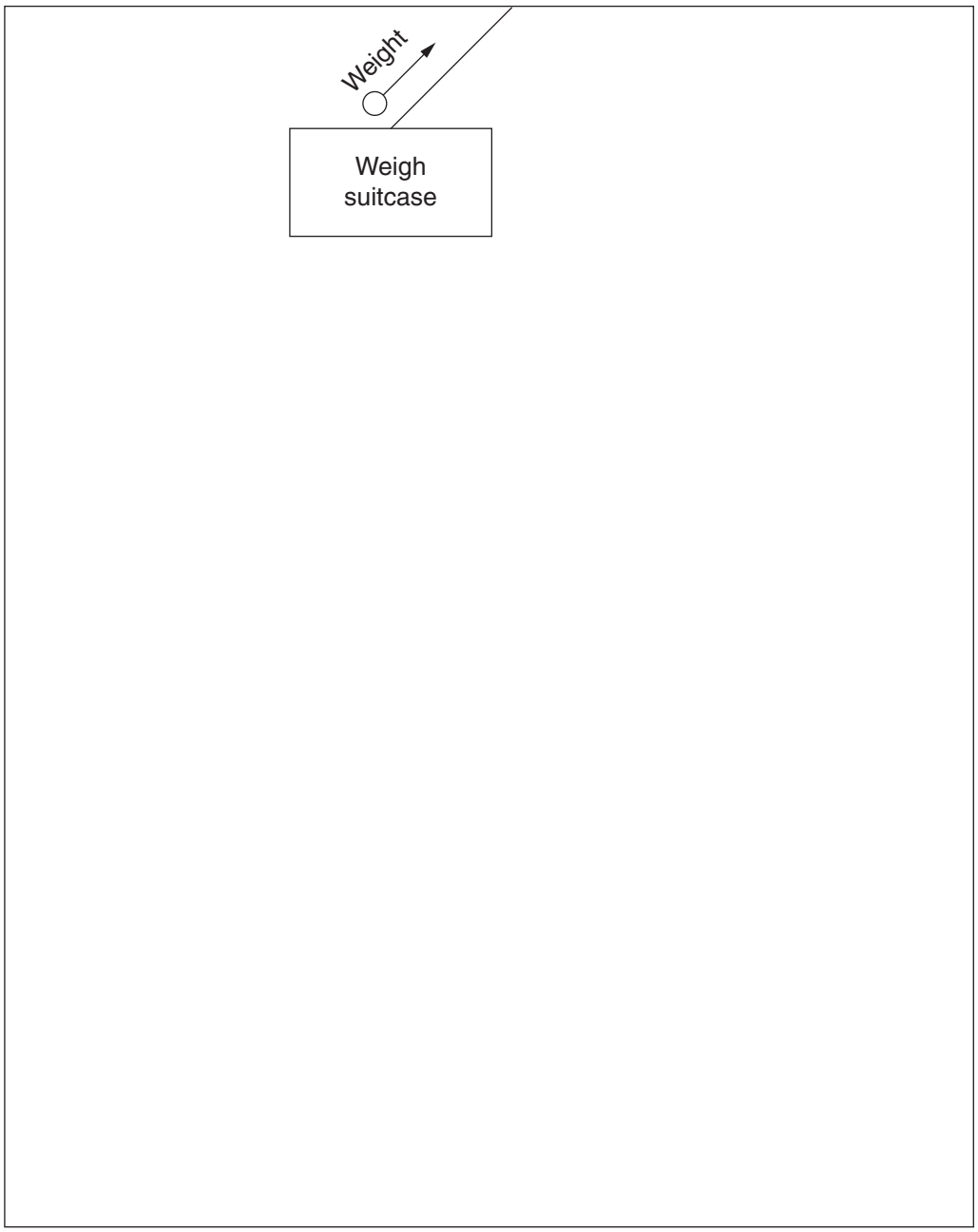
Question 29 continues on page 29

Question 29 (continued)

(b) The system is to be extended so that: **3**

- as each suitcase is weighed, the system reports on whether it is within the allowed limit or is overweight
- if the suitcase is overweight, the system will calculate a fee to be paid based on the weight.

Complete this section of the structure chart to represent this extension of the system.



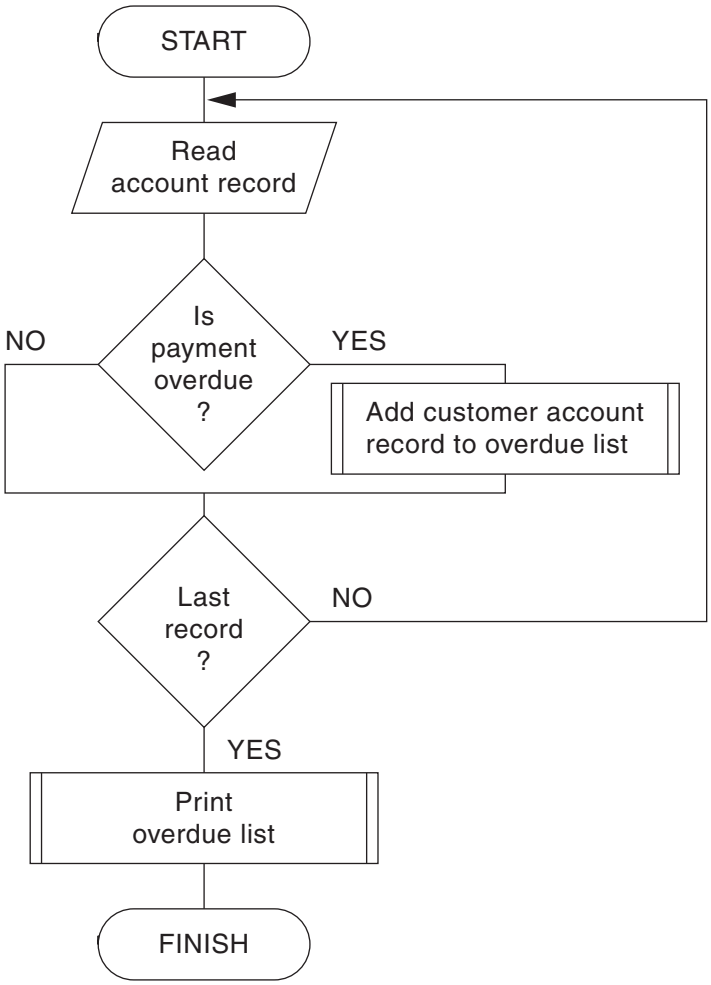
End of Question 29

Question 30 (6 marks)

The flowchart below is part of the design of a larger system. The algorithm is designed to read customer account records and record all overdue payments.

The structure of a customer account record is | custID | payment due | date due |.

The last record is indicated by a custID of 0 and contains no valid data.



Question 30 continues on page 31

Question 30 (continued)

(a) You have been asked to rewrite the algorithm in pseudocode, but you realise there is a logic error in the flowchart. **3**

Identify the logic error in the flowchart and write the correct algorithm in pseudocode.

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(b) List the specifications and assumptions necessary for a programmer to code the module Add customer account record to overdue list. **3**

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End of Question 30

Question 31 (5 marks)

The following subroutine returns the maximum value in the array Element.

```
1   BEGIN subroutine get_Max_Value (Element, NumElementsInArray, MaxValue)
2       Let MaxValue = Element(1)
3       Let position = 2
4       REPEAT
5           IF Element(position) > MaxValue THEN
6               Let MaxValue = Element(position)
7           ENDIF
8           Let position = position + 1
9       UNTIL position > NumElementsInArray
10  END get_Max_Value
```

(a) The subroutine get_Max_Position is obtained by modifying the subroutine get_Max_Value. It should return the position of the maximum value the first time it occurs in the array. **2**

Complete the code below so that subroutine get_Max_Position works correctly.

```
1   BEGIN subroutine get_Max_Position (Element, NumElementsInArray, MaxPos)
2       Let MaxPos = .....
3           Let position = 2
4               REPEAT
5               IF ..... THEN
6                   Let .....
7               ENDIF
8           Let position = position + 1
9       UNTIL position > NumElementsInArray
10  END get_Max_Position
```

Question 31 continues on page 33

(b) An array Element contains 20 numbers. Write an algorithm that outputs ALL positions where the maximum value occurs in the array. You may use the subroutine get_Max_Value in your algorithm. **3**

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End of Question 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)

Please turn over

Question 32 — Programming Paradigms (20 marks)

(a) The following fragment of code from a library loan system is based on the object oriented programming (OOP) paradigm.

```
class BOOK {
        private –
                status: string
        public –
                dueDate: string
                title: string
                author: string

                borrow ()
                        IF status = "on loan" THEN
                                display "book is currently on loan"
                        ELSE
                                'REM The book is available for loan
                                status = "on loan"
                        ENDIF
                end borrow

                return ()
                        status = "available"
                end return
                        …
                        …
}

sub-class FICTION is a BOOK {
        public –
                copyNumber: integer
                largePrint: Boolean
}
```

Question 32 continues on page 39

Question 32 (continued)

(i) Identify an attribute AND a method for the FICTION sub-class. **2**

Attribute: .....

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Method: .....

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(ii) Extend the code to include a non-fiction book with an attribute for subject area. **2**

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(iii) Justify the use of encapsulation in the code for the BOOK class. **3**

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Question 32 continues on page 41

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Section III (continued)

Question 32 (continued)

Please turn over

Question 32 (continued)

(b) A museum has a database which identifies dinosaurs based on their features. The software associated with the database was developed using the imperative paradigm.

The following is part of the information in the database.

Name of dinosaur	*Period lived*	*Number of legs*	*Diet type*
Allosaurus	Jurassic	Two	Carnivore
Diplodocus	Jurassic	Four	Herbivore
Triceratops	Cretaceous	Four	Herbivore
Tyrannosaurus	Cretaceous	Two	Carnivore

The following fragment of code was part of the software.

```
IF X had two legs THEN
    X could run
ENDIF

IF X was a dinosaur AND X was a carnivore THEN
    IF X and Y lived in the same period THEN
        X could eat Y
    ENDIF
ENDIF
```

Question 32 continues on page 43

Question 32 (continued)

(i) What are the limitations of using the imperative approach for developing this database software? **3**

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The database software will be rewritten using the logic paradigm.

(ii) Describe the role of the inference engine in this new software. **3**

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(iii) Write code for TWO facts and TWO rules for the new software based on the information provided on the previous page. **4**

Facts: .....

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Rules: .....

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Question 32 continues on page 44

Question 32 (continued)

(c) A computer store is developing a software program to assist its customers in choosing a computer. Customers will be able to choose computers by specifying preferences, such as computer type, price range, screen size and memory capacity. The software then displays a list of products that best match the customer's preferences. **3**

How could the logic paradigm and the object oriented paradigm be applied to different parts of this system?

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End of Question 32

2013 HIGHER SCHOOL CERTIFICATE EXAMINATION

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Student Number

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) How are ASCII and Unicode different? **3**

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Question 33 continues on page 46

Question 33 (continued)

(b) (i) Explain why bits are shifted in performing the binary multiplication 10110×101. **3**

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(ii) The following 32 bits represent a single precision floating point number using the IEEE754 standard: **3**

1	01111111	00000000000000000000000

A student claims that the number has a decimal value between –2 and –1 inclusive.

Is the student correct? Justify your answer.

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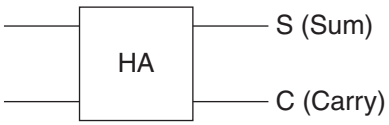
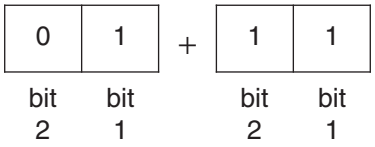
Question 33 continues on page 47

Question 33 (continued)

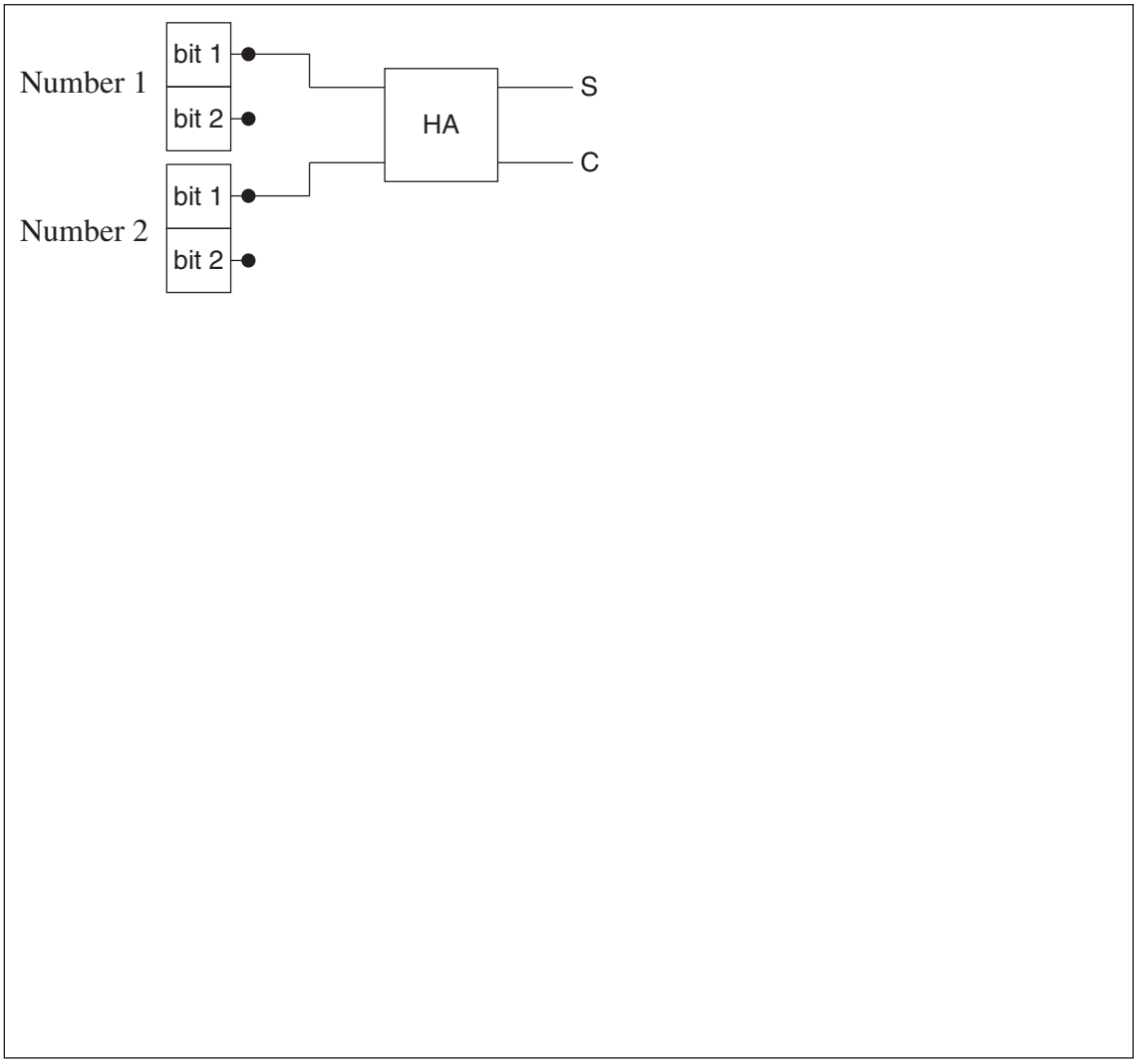
(c) (i) The symbol below represents a half adder. **3**



A circuit is required which will add two 2-bit numbers, for example



Using the symbol provided for a half adder and any other necessary logic gates, complete the following circuit so that it adds two 2-bit numbers.



Question 33 continues on page 48

Question 33 (continued)

(ii) The notations of Boolean algebra are: **2**

Notation	*Meaning*
$A \bullet B$	A AND B
$A + B$	A OR B
$A \oplus B$	A XOR B
$\overline{A}$	NOT A

Generate a truth table for the Boolean expression $(A \bullet B + \overline{A} \bullet B) \oplus \overline{A}$.

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(iii) Draw a circuit diagram to represent the logic of the Boolean expression given in part (ii) above. **2**

Question 33 continues on page 49

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Question 33 (continued)

Please turn over

Question 33 (continued)

(d) A remotely controlled robot is used to detect obstacles.

The robot can be instructed to:

- turn left in increments of 90°
- move forward.

A computer and the robot communicate using a data stream.

The structure of the data stream sent from the computer to the robot is:

Component	*Number of bits*	*Description*
Start bit	1	always 1
Turn	2	00 = no turn, 01 = turn 90° (turn left), 10 = turn 180°, 11 = turn 270° (turn right)
Distance	4	0000 = don't move … 1111 = move 15 steps
Stop bit	1	always 1

When the robot completes the instruction, or is stopped by an obstacle, it returns a data stream indicating how many steps it has moved and the positions of obstacles around it.

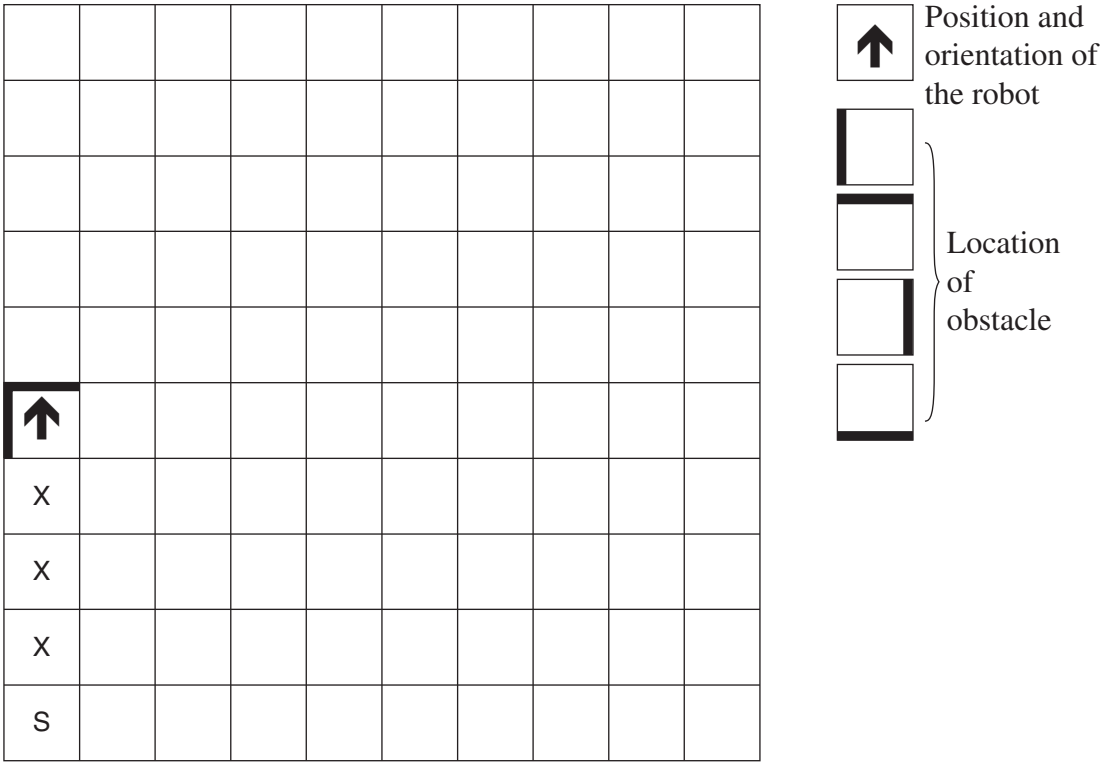
The structure of the data stream sent from the robot to the computer is:

Component	*Number of bits*	*Description*
Start bit	1	always 1
Obstacle in front	1	0 = no, 1 = yes
Obstacle on left	1	0 = no, 1 = yes
Obstacle on right	1	0 = no, 1 = yes
Distance actually moved	4	0000 = no movement, 1111 = 15 steps

Question 33 continues on page 51

Question 33 (continued)

After receiving the data stream 10001001, the robot moved from the starting position S to the position shown with  and discovered two obstacles, as indicated in the diagram below.



(i) What data stream should be sent from the robot back to the computer? **2**

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(ii) The following streams were then sent to and received from the robot. **2**

To the robot:	11101011
From the robot:	11000100
To the robot:	10100111
From the robot:	11110011

On the diagram above, show the path taken by the robot and all obstacles detected.

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