BOARD OF STUDIES
NEW SOUTH WALES

2011

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 pages 13, 17, 21, 25, 27, 31, and either pages 33 and 35, or pages 39 and 43

Total marks – 100

(Section I) Pages 2–10

20 marks

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

(Section II) Pages 13–32

60 marks

- Attempt Questions 21–32
- Allow about 1 hour and 50 minutes for this section

(Section III) Pages 33–45

20 marks

- Attempt either Question 33 or Question 34
- 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 Software developers have a responsibility to ensure that software products

(A) are free from viruses.

(B) use a copyright symbol.

(C) use appropriate packaging.

(D) are compatible on most game consoles.

2 The following symbol is used in a structure chart.

What does this symbol represent?

(A) A flag

(B) Repetition

(C) A decision

(D) Data movement

3 Which of the following is an example of a metalanguage?

(A) ASCII

(B) Data dictionary

(C) EBNF

(D) Pseudocode

4 What is the purpose of the program counter?

(A) To store the length of the object code

(B) To store the address of the next instruction

(C) To count how often a program has been installed

(D) To count the number of times a program loop is executed

5 A computer program is successfully compiled, but the object code produced is not yet executable.

Which of the following is the most likely reason for this?

(A) The object code still needs to be parsed.

(B) The syntax errors have not yet been fixed.

(C) The code elements have not yet been tokenised.

(D) The object code and library routines still need to be linked.

6 What does the maintenance of software solutions most commonly involve?

(A) Making frequent backups

(B) Testing the software regularly

(C) Modifying code to meet changing requirements

(D) Supporting the users of the software after its release

7 The following algorithm describes a subprogram that determines how often a particular character occurs in a target string.

```
BEGIN SUBPROGRAM CountHowOften(character, target, count)
    count = 0
    FOR loop = 1 TO length of target
        IF characterAtPosition(target, loop) = character THEN
            count = count + 1
        ENDIF
    NEXT loop
END SUBPROGRAM CountHowOften
```

The following main program calls the subprogram but a line is missing.

```
BEGIN MAINPROGRAM
    INPUT string
    INPUT letter
    ……
    DISPLAY number
END MAINPROGRAM
```

Which line is needed to complete the main program?

(A) CountHowOften(string, letter, number)

(B) CountHowOften(character, target, count)

(C) CountHowOften(string, letter, count)

(D) CountHowOften(letter, string, number)

8 What should a software developer use to document each variable in a software solution?

(A) Data dictionary

(B) Data file

(C) Data flow diagram

(D) Structured data types

9 Consider the following steps that occur during the execution of a computer program.

Step 1 Load the accumulator with the number currently stored in memory location X
Step 2 Add 4 to the accumulator
Step 3 Store the number currently in the accumulator into memory location Y

The memory location X originally contains the value 5.
The memory location Y originally contains the value 7.

Which of the following correctly shows the contents of the different locations after Step 3 has been executed?

	Accumulator	X	Y
(A)	4	0	4
(B)	4	5	11
(C)	9	0	16
(D)	9	5	9

10 A company has been contracted to develop a large software system. The project team leader has produced documentation ready to pass to the software design team.

What is most likely to be included in this documentation?

(A) A prototype

(B) A schedule

(C) A set of test data

(D) A storyboard

Use the following information to answer Questions 11–12.

A system has been designed to check the temperature in a machine. If the temperature is too low (below 50) or too high (above 100), a warning is displayed.

11   Which of the following algorithm fragments correctly performs this function?

(A)   IF temperature $<$ 50 THEN
      display warning
      IF temperature $\leq$ 100 THEN
      ELSE
         display warning
      ENDIF
  ELSE
  ENDIF

(B)   IF temperature $\leq$ 100 THEN
  ELSE
      IF temperature $<$ 50 THEN
         display warning
      ELSE
      ENDIF
      display warning
  ENDIF

(C)   IF temperature $>$ 100 THEN
      display warning
      IF temperature $<$ 50 THEN
         display warning
      ELSE
      ENDIF
  ELSE
  ENDIF

(D)   IF temperature $>$ 100 THEN
      display warning
  ELSE
      IF temperature $\geq$ 50 THEN
      ELSE
         display warning
      ENDIF
  ENDIF

12   The system described above is tested by running it for 24 hours under closely controlled conditions.

Which term best describes this process?

(A)   Benchmarking

(B)   Desk checking

(C)   Logic testing

(D)   Syntax checking

13 A part of a system for managing customer files involves sorting each file and then merging the sorted files into one direct access file.

Which of the following system flowcharts best represents this?

(A)

(B)

(C)

(D)
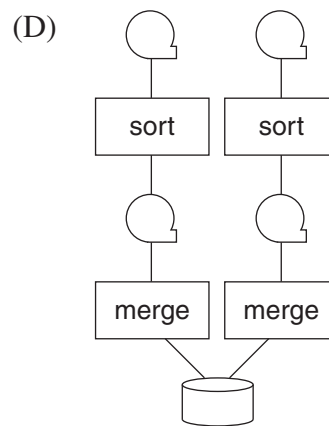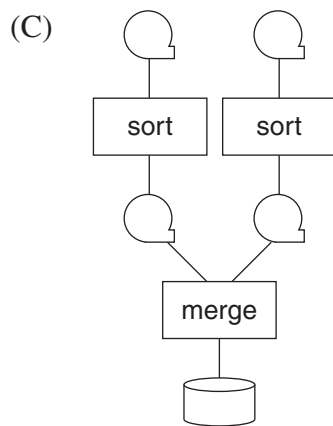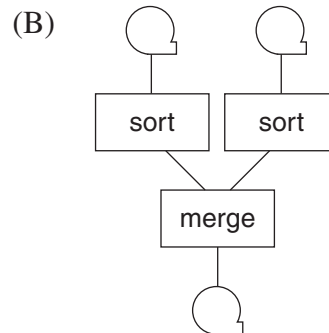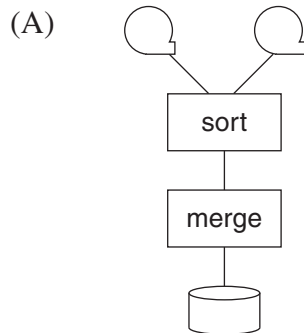
14 Which two types of documentation are most useful in understanding the logic of programming code?

(A) Storyboard and CASE tools

(B) CASE tools and pseudocode

(C) Internal documentation and storyboard

(D) Pseudocode and internal documentation

15   Consider the following algorithm:

```
BEGIN
      READ X
      WHILE X > 5
            OUTPUT X + 3
            X = X − 1
      ENDWHILE
END
```

Using the test data X = 7, what is the output from this algorithm?

(A)   8

(B)   9, 8

(C)   10, 9

(D)   10, 9, 8

16   An array contains the following elements.

4	6	2	5	3

After the first pass of a sort the elements are in the following order.

6	4	2	5	3

Which of the following shows the sort used and the order of the elements after the second pass of that sort?

(A)   Bubble

6	4	5	2	3

(B)   Bubble

6	5	4	2	3

(C)   Insertion

6	4	2	5	3

(D)   Selection

6	5	4	2	3

Use the following information to answer Questions 17–18.

The diagram shows a two-dimensional array called matrix.

7	2	1	9
3	4	5	0
1	2	3	4
5	6	7	8
1	2	3	5

In this array, matrix[2,4] is 0.

17 What is the value of matrix[4,1] + matrix[2,3]?

(A) 7

(B) 10

(C) 11

(D) 14

18   Which of the following correctly calculates the total of all the numbers stored in the array matrix?

(A)   BEGIN SUBPROGRAM Adding
            total = 0
            FOR p = 1 TO 4
                FOR t = 1 TO 5
                    total = total + matrix[p,t]
                NEXT
            NEXT
        END SUBPROGRAM Adding

(B)   BEGIN SUBPROGRAM Adding
            total = 0
            FOR p = 1 TO 5
                FOR t = 1 TO 4
                    total = total + matrix[p,t]
                NEXT
            NEXT
         END SUBPROGRAM Adding

(C)   BEGIN SUBPROGRAM Adding
            total = 0
            FOR t = 1 TO 4
                FOR p = 1 TO 5
                    total = total + matrix[t,p]
                NEXT
            NEXT
         END SUBPROGRAM Adding

(D)   BEGIN SUBPROGRAM Adding
            total = 0
            FOR t = 1 TO 5
                FOR p = 1 TO 4
                    total = total + matrix[p,t]
                NEXT
            NEXT
         END SUBPROGRAM Adding

19 A binary search is performed on the following list of 15 values.

31	32	33	35	37	39	45	48	49	52	57	59	62	64	65

How many values need to be tested to determine that the number 42 is not in the list?

(A) 4

(B) 7

(C) 10

(D) 15

20 While compiling a program the following error message occurred.

```
unexpected '=' in code line 57
```

What is the most likely cause of this message?

(A) Line 57 causes an incorrect output.

(B) A global variable has not been initialised.

(C) The syntax rules of the programming language have not been followed.

(D) The incorrect logical or arithmetic operator has been used in a calculation.

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Section II

60 marks
Attempt Questions 21–32
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.

Question 21 (4 marks)

Describe how CASE tools can be used at various stages of the software development   **4**
cycle.

You may refer to your own project work in your response.

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Question 22 (8 marks)

Your software company has been contracted to create a web-based system which will allow job seekers to make themselves known to potential employers.

The following features are needed for this system:

- a registration process for new employers
- a registration process for new job seekers
- a single data store for registration details of all existing users
- a secure login for existing job seekers
- a secure login for existing employers
- a search engine that allows employers to find potential new employees
- once registered, job seekers can submit or update their resumes.

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

Question 22 (continued)

(b)   Construct a partial data dictionary for the registration details file, showing TWO   **2**
      different data types.

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(c)   To avoid duplication in the registration details file, the name of a new user needs   **2**
      to be checked against existing registration details.

      Compare the use of a sequential file with the use of a random file for checking
      whether a user's name already exists in the file.

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End of Question 22

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Section II (continued)

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Question 23 (3 marks)

A large and complex program contains many modules that manipulate data. The **3** program produces incorrect output, possibly as a result of calculation errors in one or more modules.

Desk checking the source code and peer checking are two techniques that could be used to debug this program.

Describe how OTHER techniques could be used to help locate the errors in THIS program.

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Question 24 (8 marks)

Bobby owns a cat boarding business with three locations in Sydney. To streamline the operation, Bobby wants a new computer system networking the three locations. Bobby can either buy off-the-shelf software or outsource the development of the software to Salmon Software Enterprises.

(a) Compare the benefits of these two development approaches.   **3**

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(b) What are the ownership issues that could arise if Bobby decides to buy off-the-shelf software and have it customised by Salmon Software Enterprises?   **2**

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Question 24 (continued)

(c) What are the issues that the developer needs to consider when developing software for network use rather than for stand-alone computers? **3**

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End of Question 24

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Student Number

Section II (continued)

Question 25 (3 marks)

A program has been developed to accept five numbers as input. Its output is the largest **3**
of those five numbers. The program needs to be tested.

Frances suggests testing the program with the five numbers –4, –3, –2, –2, –1

Morgan suggests using the six numbers 3.1, 4, 0, 8, 6, 9.5

Discuss the effectiveness of each suggested set of test data.

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Question 26 (5 marks)

A valid password consists of a letter followed by four digits. F1837 is an example of a valid password.

The following algorithm was designed for checking the validity of a password. The algorithm has logic errors.

```
1   BEGIN password_check
2       INPUT password
3       IF the length of password = 5 THEN
4           valid = true
5       ENDIF
6       IF character 1 of password is a letter THEN
7           valid = true
8           FOR n = 2 TO 5
9               IF character n of password is a digit THEN
10                  valid = true
11              ELSE
12                  valid = false
13              ENDIF
14          NEXT
15      ENDIF
16      PRINT 'PASSWORD IS VALID?', valid
17  END
```

(a)   Use the password H43k21 to desk check the algorithm.   **2**

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Question 26 (continued)

(b)   Explain the errors in the logic of the algorithm.   **3**

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End of Question 26

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Software Design and Development

Section II (continued)

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Question 27 (6 marks)

Kim has developed a routine which she has compiled and distributed to other software developers for use in their own software.

(a)   Outline the rights and responsibilities of a developer who uses Kim's routine in their own software solutions.

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(b)   Kim can distribute the routine either in compiled form or as source code.

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What are the advantages and disadvantages of distributing the routine in compiled form?

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Question 28 (6 marks)

Redtown Junior High School and Yellowtown Senior High School are merging into a new high school named Orangeville College in 2012. Presently, each school uses its own attendance system. As a result of the merger, the two existing school leadership teams are planning to combine the best processes from each existing attendance system into a new Orangeville College Attendance System (OCAS). The new attendance system will be developed by an in-house software development team.

(a) Describe technical and operational feasibility issues that these two schools should consider before developing the merged attendance system.   **3**

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(b) Recommend an appropriate implementation method for the new attendance system.   **3**

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Section II (continued)

Student Number

Question 29 (8 marks)

Please turn over

Question 29 (8 marks)

In a computer game, each player has 10 rounds and the maximum score for each round is 5. Every time a player scores 5, they also add the score from the next round as a bonus. If a player scores 5 in the last round, they get 10 points.

A player's scores and corresponding points for a full game are shown below.

Player's score	3	5	5	2	1	4	0	1	4	5
Player's points	3	10	7	2	1	4	0	1	4	10

The 10 scores for a player are stored in a one-dimensional array called SCORES.

(a)　Design an algorithm to calculate the total points for a player, taking into account the bonuses.　　**4**

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Question 29 continues on page 29

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Question 29 (continued)

(b) The array TOPPLAYERS contains the ten best total points and the names of the players that achieved them. The array is sorted by total points, in descending order, and is defined to contain up to 10 records.   **4**

The game displays the top ten total points as shown.


```
        TOP PLAYERS

   Berty        75
   Pisces       38
   PHYSH        25
```

A player has achieved a large total.

Write an algorithm that:

• checks whether the player's total is large enough to be included on the TOPPLAYERS list, and

• if it is, inserts the player's name and total in the correct place in the TOPPLAYERS array.

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End of Question 29

Question 30 (3 marks)

Consider the following railroad diagram. **3**
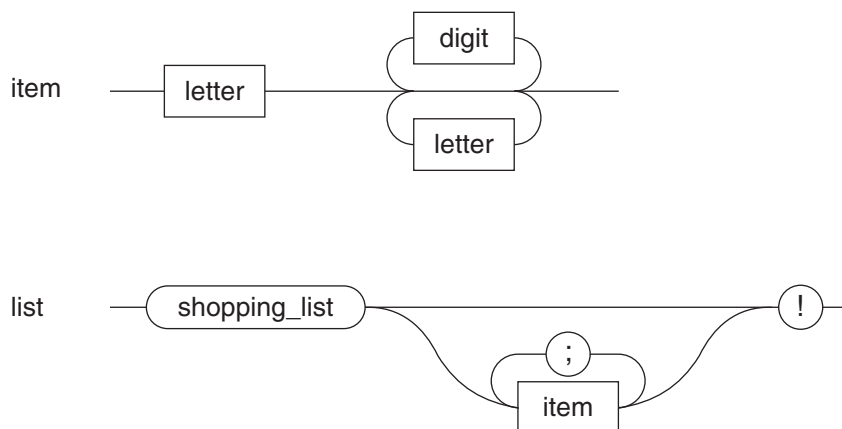
Express the syntax described in the railroad diagram in Extended Backus–Naur Form (EBNF).

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Software Design and
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Section II (continued)

Question 31 (3 marks)

The following algorithm, when coded and run on an interpreter, runs more slowly than
the programmer expected.

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```
READ X
WHILE X < 6
        A = 5
        Z = A + X
        IF X < 7 THEN
            PRINT Z
        ELSE
        ENDIF
        READ X
ENDWHILE
```

Explain how some features in the pseudocode might contribute to the program running
more slowly than expected.

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Question 32 (3 marks)

A computer program written in a high-level language is compiled. The object code is then decompiled.

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How are the object code and the decompiled code similar and how are they different?

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Section III

20 marks
Attempt either Question 33 or Question 34
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 33 — Evolution of Programming Languages (20 marks)

(a)   *Different programming paradigms enable software developers to solve different*   **3**
    types of problems and achieve greater productivity.

    Do you agree with this statement? Provide reasons for your answer.

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Question 33 continues on page 34

Question 33 (continued)

(b) The following fragment of code is based on the logic paradigm.

```
animal (crocodile)
pet (dog)
pet (cat)
pet (bird)
pet (fish)
likes (cat,sleep)
likes (dog,walk)
likes (bird,fly)
happy_pet (X):- pet (X), likes (X,Y)
```

(i) Using the fragment of code, describe how backward chaining can be used to determine whether a crocodile is a happy pet.

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(ii) Show how the code could be expanded to include the following in the most efficient way:

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- a pet is an animal
- dogs, cats and crocodiles have teeth
- animals or pets that have teeth can bite.

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Question 33 continues on page 36

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Software Design and Development

Section III (continued)

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Question 33 continues on page 36

Question 33 (continued)

(c)   The following fragment of code is based on the object oriented programming (OOP) paradigm.

```
class VEHICLE {
        private –
                empty_seats: integer
                colour: string
                wheels: integer
                seats: integer
                manufacturer: string
        public –
                getemptyseats()
                        empty_seats = seats – 1
                        return empty_seats
                end getemptyseats
}

sub-class CAR {
        is a VEHICLE
        private –
                empty_seats: integer
                passengers: integer
                gears: integer
                doors: integer
                body: string
        public –
                getemptyseats()
                        empty_seats = seats – passengers – 1
                        return empty_seats
                end getemptyseats
}
```

(i)   Explain how polymorphism is applied in this fragment of code.   **3**

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Question 33 (continued)

    (ii)   Show how the code could be expanded to include the following in the most efficient way: **3**

- definition of a sub-class PLANE with attributes staff (integer), passengers (integer) and empty_seats (integer)

- a method to calculate the empty seats based on the number of passengers and staff already on board.

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    (iii) Currently it is not possible to use the code to determine the colour of a car.   **2**

Suggest TWO different ways in which the code can be modified to make it possible to determine the colour of the car.

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Question 33 continues on page 38

Question 33 (continued)

(d)   A company that manufactures televisions is considering automating the **4**
       following operations:

       1. assembling components such as the motherboard and other circuit boards
       2. testing of the completed television before it is packed
       3. controlling the warehousing of television packages before they are shipped out.

       The automated processes are shown diagrammatically.
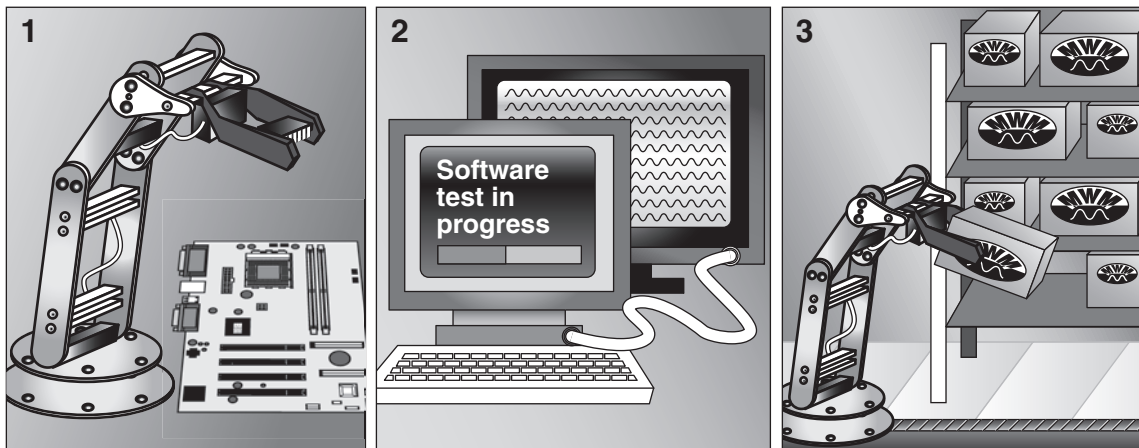
       A software system is being developed to perform these three operations. Suggest
       an appropriate programming paradigm for developing each software component
       of this system. Justify your choices.

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End of Question 33

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Section III (continued)

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Do NOT attempt Question 34 if you have already attempted Question 33.

Question 34 — The Software Developer's View of the Hardware (20 marks)

(a) A simple computer system uses 8-bit two's complement to represent integers.   **2**

Show how −128 is represented as 10000000 in this system.

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(b) Why is the shifting of bits necessary in the CPU?   **2**

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Question 34 (continued)

(c) In a food processing plant, a sensor monitors the temperature in a pressure cooker. If the temperature goes above 300 degrees, power to the cooker is switched off.

- The sensor produces a **1** if the temperature is above 300 degrees, otherwise it produces a **0**.

- A master switch will turn the monitoring system on or off. A **1** means the system is on.

- If the cooker power supply receives a **1**, the cooker is on, otherwise it is off.

The logic circuit in Figure 1 has been designed to implement this system.
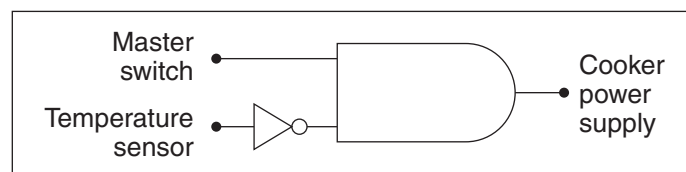
Figure 1

(i) What would be the effect on the system if the AND gate in the circuit shown in Figure 1 is replaced with an OR gate?
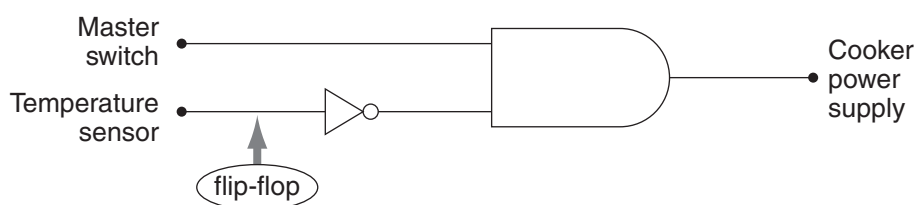
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Question 34 (continued)

(ii) The power to the cooker should also be turned off if the pressure in the cooker goes above 20 kilopascals.   **2**

Show how the circuit in Figure 1 would need to be modified to achieve this.

(iii) A flip-flop is inserted into the circuit in Figure 1 in the position shown by the arrow in the diagram.   **3**

Describe how the flip-flop affects the operation of the system. Include in your answer a description of how a flip-flop works.

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Question 34 continues on page 42

Question 34 (continued)

(d)   A single data item is stored in four consecutive bytes of memory in RAM. These   **3**
       four bytes, written in binary, are:

                 00000011   01001111   01100110   01100110

       There are three interpretations of these four bytes.

             Jo thinks they represent   55535206
             Ali thinks they represent 6.09494×10^{-37}
             Pat thinks they represent the word   Off

       How could each of these conclusions be reached? In your answer, refer to the
       binary representation of data. (There is no need to show calculations.)

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Software Design and Development

Section III (continued)

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Question 34 (continued)

(e)   A panel, designed to collect energy from the sun, can face in seven different directions. Direction 1 is West and direction 7 is East. The direction the panel is facing is controlled by a motor which receives instructions from a central computer.
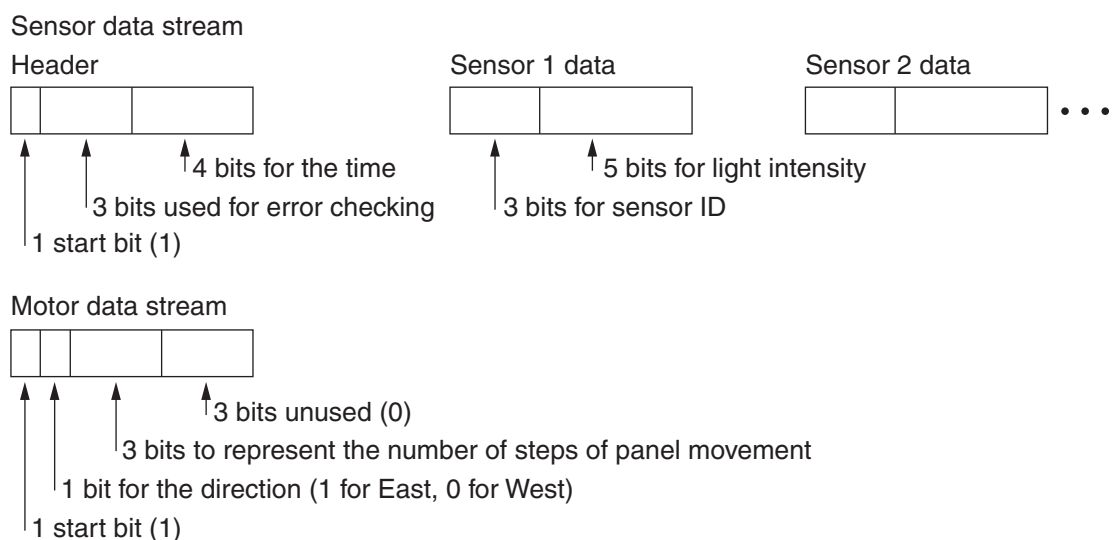
There are seven light sensors, each aimed at a different part of the sky. Each sensor detects the intensity of light coming from that part of the sky. Once every half hour the light intensity from each sensor is sent to the central computer.
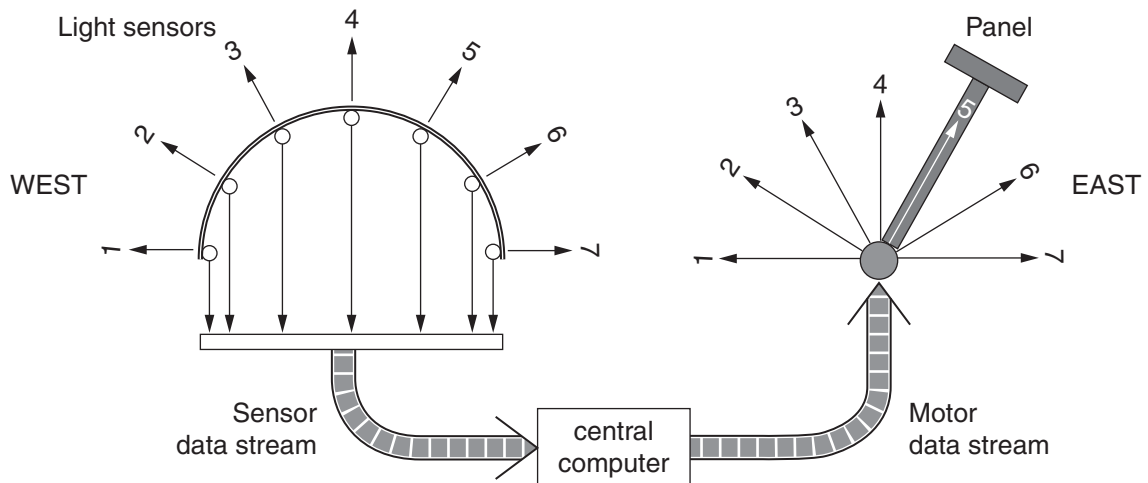
The central computer compares the direction of the strongest light and the direction which the panel is facing.

The central computer then calculates the number of steps and the direction to move the panel to face the strongest source of light.

The data streams are structured as follows:

Question 34 (continued)

(i) The panel is currently facing in direction 5. **4**

The following data stream is sent to the computer from the sensors.

$$1\ 1\ 1\ 1\ 1\ 1\ 0\ 0$$
$$0\ 0\ 1\ 0\ 0\ 0\ 1\ 0$$
$$0\ 1\ 0\ 0\ 0\ 1\ 1\ 0$$
$$0\ 1\ 1\ 0\ 0\ 1\ 0\ 1$$
$$1\ 0\ 0\ 1\ 1\ 1\ 0\ 0$$
$$1\ 0\ 1\ 1\ 0\ 0\ 0\ 1$$
$$1\ 1\ 0\ 1\ 0\ 0\ 1\ 0$$
$$1\ 1\ 1\ 0\ 1\ 1\ 0\ 0$$

What data stream will be sent from the computer to the motor? Show any relevant working.

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(ii) Compare the data stream sent to the computer with the data stream sent to the motor. **2**

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End of paper

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