COMPANY SCIENCE
(ITC315118)

SECTION A
Time allocated: 36 minutes

Candidate Instructions

1. You MUST make sure that your responses to the questions in this examination paper will show your achievement in the criterion being assessed.

2. Answer ALL questions. Answers must be written in the spaces provided on the examination paper.

3. You should make sure you answer all parts within each question so that the criterion can be assessed.

4. This examination is 3 hours in length. It is recommended that you spend approximately 36 minutes in total answering the questions in this booklet.

5. The 2019 External Examination Information Booklet for Computer Science can be used throughout the examination.

6. All written responses must be in English.

On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course document:

Criterion 1  Design, extend and improve algorithmic solutions to a range of problems.
Additional Instructions for Candidates

To be considered for a ‘C’ rating on a criterion, you must provide a satisfactory answer to at least the first question of the relevant section.

To be considered for a ‘B’ rating on a criterion, you must provide a satisfactory answer to at least the first TWO questions of the relevant section.

To be considered for an ‘A’ rating on a criterion, you must provide a satisfactory answer to all THREE questions of the relevant section.

Show the methods used in deriving answers.

Take care with the presentation of your answers, which should be complete and to the point.

Diagrams should be used where appropriate.

Complete sentences should be used in questions involving explanations.

You are reminded that poor handwriting, spelling and expression that make it difficult for the examiners to understand what you mean may lead to lower marks.

A spare answer page has been provided in the back of the answer booklet for you to use if required.

If you DO use the spare answer page, you MUST indicate you have done so in your answer to that question.
Question 1

Consider the following algorithm for calculating a salary increase.

Line numbers are for reference only.

**Initially**
1. Set salary=0
2. Set increase=0
3. Set extra=0
4. Set newSalary=0

5. **When user enters a value in the salaryCurrent TextField**
6. Set salary to value in salaryCurrent TextField

7. **When user enters a value in the positionType TextField**
8. Set position to value in positionType TextField
9. if (position==1) increase = 12
10. if (position==2) increase = 10
11. if (position==3) increase = 20

12. **When the calculateNewSalary Button is pressed**
13. set extra= salary * increase/100
14. set newSalary to salary + extra
15. print newSalary
16.

(a) Circle the correct answer for each question.

i. If the user enters a salary of $25000 and a position type of 2, what will the newSalary be?

25000 25500 27500 28050

ii. At what point of the program would you add a line to set the increase back to 0 if the user enters a position type other than 1,2,3? (Give the line number before which you will place this line.)

6 9 12 13

iii. Which of the following is not a valid value for position?

1 2 3 4

Question 1 continues
Question 1 (continued)

(b) The user also gets an additional two (2) percent salary increase no matter what position they occupy, if they have worked for the company for more than 5 years. What statements would you add to the template below to achieve this?

**When user enters a value in the lengthOfService TextField**

Set serviceLength to value in lengthOfService TextField.

(c) Modify the algorithm so that the value entered from the textfield for variable `position` is validated. If the value entered for `position` is not valid, `position` is to be set to 0.

(d) Add a reset button to the algorithm to allow the user to start over.
Question 2

The following is a partially completed applet to trial a dice game. Two players each take turns in rolling a pair of dice and recording a score for each throw. A score for each throw is calculated and added to a player total until one player makes a score of 60 or more.

The rules for scoring are as follows:

- If the dice are a pair the score is the sum of the dice plus 6
- If the dice are both even, the score is the sum plus 2
- If the dice are both odd, the score is the sum less 2
- Otherwise the score is the sum of the dice.

Line numbers are for reference only.

1. Initially
2. dice1 = 0
3. dice2 = 0
4. player1Score = 0
5. player2Score = 0
6. set textField1 to "0"
7. set textField2 to "0"
8. score = 0
9. player1Turn = true

10. When the "Roll" button is pressed
11. dice1 = random(6) // random(6) returns a random value between 1 & 6
12. dice2 = random(6)
13. set textField1 to dice1
14. set textField2 to dice2
15. if (dice1 == dice2)
16. score = dice1 + dice2 + 6
17. // code to be inserted below in part (a)
18. display "you scored", score, " for this throw"

20. When the "Total" button is pressed

(a) Complete the algorithm for the "Roll" button after line 17.

18. .................................................................
Question 2 (continued)

(b) Complete the algorithm for the "Total" button. When pressed, it should display the running totals and whether either player has won the game. If the game continues, display who should take the next throw.

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Question 3

The cost for parking a car in a car park complex depends on the duration and type of parking chosen. Vouchers have to be purchased from a voucher machine as explained below. Rate A relates to “under-cover” parking and Rate B relates to “outside” parking.

<table>
<thead>
<tr>
<th>Time Parked</th>
<th>Rate A</th>
<th>Rate B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hour – &lt; 1 hour</td>
<td>$1</td>
<td>$0.80</td>
</tr>
<tr>
<td>1 hour – &lt; 2 hours</td>
<td>$2.50</td>
<td>$2.00</td>
</tr>
<tr>
<td>2 hours – 3 hours</td>
<td>$6.00</td>
<td>$4.50</td>
</tr>
</tbody>
</table>

The voucher machine has an LCD screen initially with the message:

**Welcome to Sim City Central Parking.**
Please select “under-cover” or “outside parking”.

Coins or notes can be entered in the slots. The machine accepts 20c, 50c, $1 and $2 coins in the vertical slot as well as $5, $10 and $20 notes in the horizontal slot.

When money is entered in the slot(s), the LCD screen will display the duration, in hours of parking time purchased.

When the green button for the voucher is pressed, a voucher will be printed with the amount of parking time purchased, the time of purchase, the time of expiry and the amount paid.

Parking longer than 3 hours is not permitted. Change is not given by the voucher machine. For example, if someone put $20 in the machine, a 3 hour parking purchase voucher will be issued but NO change given. If the cancel button is pressed before the green button, your money will be returned.

Design the algorithm for 1, 2 and 3 hour parking vouchers.

(a) Design a possible screen for this applet, identifying all the textfields and/or buttons to be used.
Question 3 (continued)

(b) Using the Initially/When model write an algorithm for this applet.

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On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course document:

**Criterion 2**  Create programs in a high level programming language.
Additional Instructions for Candidates

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Question 4

(a)  
   i. What will be the value of e after the following code is executed?

   ```
   int e;
   e = 14 / 3;
   ```

   (Circle the correct answer)
   4  4.0  4.6666  11

   ii. What will be the value of t after the following code is executed?

   ```
   int m = 50;
   int t = 10;
   if ( m >= 5 )
   {   t = t + 50;
   }
   else
   {   t = t + 90;
   }
   ```

   (Circle the correct answer)
   50  60  100  140

   iii. What will be the value of d after the following code is executed?

   ```
   int d = 0;
   for (int p = 10; p>=1; p--)
   {   if (p = = 3 || p = = 5)
       {   d = d +5;
       }
   }
   ```

   (Circle the correct answer)
   3  5  10  15

Question 4 continues
Question 4 (continued)

(b) i. What will be the value of \( d \) after the following code is executed?

\[
\text{int } d; \\
\text{ } d = 3 + 5 \times 8 - 7; \\
\]

Value of \( d \): .................................................................

Explanation: ...........................................................................

ii. What will be the final value of \( e \) after the following code is executed?

\[
\text{int } e; \\
\text{ } e = 28 \% 3; \\
\]

Value of \( e \): .................................................................

Explanation: ...........................................................................

iii. Trace the following code and find the final value of the variable \( y \).

\[
\text{int } y = 3; \\
\text{while } (y < 16) \\
\text{ } \{} \\
\text{ } \{ y = y + 3; \} \\
\]

**Trace:**

<table>
<thead>
<tr>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

Final value of \( y \) is: .................................................................
Question 5

(a) What will be the value of \( d \) and \( e \) after the following code is executed?

```c
int i;
double d, e;
d = 6;
i = 4;
d = 6 / i;
e = 6 / (double)i;
```

Value of \( d \): ...........................................................

Value of \( e \): ...........................................................

Explanation: ...............................................................

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(b) Games is an int[8] array holding the following values:

<table>
<thead>
<tr>
<th>Index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Trace the following code and find the final value of the variable finish.

```c
int position = 5;
int finish = 0;
for (int i=1; i<=5; i++)
    if (games[i] == games[position])
        finish = finish + 1;
```

Use this trace table to show your answer. More rows have been provided in the table than you will need.

<table>
<thead>
<tr>
<th>position</th>
<th>finish</th>
<th>i</th>
<th>games[i]</th>
<th>games[position]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Question 5 continues
Question 5 (continued)

(c) Trace the following code to find the final contents of the array $x$.

```java
int[][] x = new int[4][5];
int cnt = 6;
for(int i = 0; i < 4; i++)
    for(int j = 0; j < 5; j++)
    {
        x[i][j] = cnt / 4 + 1;
        cnt = cnt + 1;
    }
```

X

<p>| | | | | |</p>
<table>
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</tbody>
</table>
Question 6

Refer to the code on pages 10 and 11. Line numbers have been added for reference.

(a) What will be displayed within the applet if the call to fillArrayWithRandom() fills the array elements with the following values: {4, 2, 7, 7, 8}?

Displayed: .................................................................

Explanation: .................................................................

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Question 6 continues
Question 6 (continued)

(c) The programmer wishes to eliminate the use of class variables within the countOdd() method. Show how this can be accomplished by using a parameter and a return value. Rewrite line 70 to correctly call the new version of this method.
Question 6 (continued)

1 import java.applet.Applet;
2 import java.awt.*;
3 
4 public class Question6 extends Applet 
5 {
6   int numbers[] = new int[5];
7   int answer;
8 
9   public void fillArrayWithRandom(int array[])
10   {
11     final int MAXNUMBER = 10;
12     
13     for (int i=0; i<array.length; i++)
14     {
15       array[i] = (int) (Math.random() * MAXNUMBER) + 1;
16     }
17   }
18 
19   public boolean isOdd(int number)
20   {
21     return (number % 2 != 0);
22   }
23 
24   public void countOdd()
25   {
26     int count = 0;
27     for (int i=0; i<numbers.length; i++)
28     {
29       if (isOdd(numbers[i]))
30       {
31         count++;
32       }
33     }
34     answer = count;
35   }
36 
37   public int sumEven(int array[])
38   {
39     int sum = 0;
40     for (int i=0; i<array.length; i++)
41     {
42       if (isOdd(array[i]))
43       {
44         sum = sum + array[i];
45       }
46     }
47     return sum;
48   }
49 

Question 6 continues
Question 6 (continued)

50     public boolean ascending(int array[])
51     {
52         boolean inOrder = true;
53         int i = 0;
54         while (i<array.length-1 && inOrder)
55         {
56             if (array[i] > array[i+1])
57             {
58                 inOrder = false;
59             }
60             i++;
61         }
62         return inOrder;
63     }
64
65     public void paint(Graphics g)
66     {
67         fillArrayWithRandom(numbers);
68         if (ascending(numbers))
69             { countOdd();
70         }
71     else
72             { answer = sumEven(numbers);
73                 g.drawString("The answer is " + answer, 10, 50);
74         }
75     }
76     }
77     }
78
79     }
On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course document:

**Criterion 3** Use appropriate objects in the design of programs.
Additional Instructions for Candidates

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Question 7

(a)  What will be drawn in the applet’s window after the following code is executed?

```
g.drawString("Answer is " + 12, 2, 20);
```

(Circle the correct answer.)

Answer is 34 "Answer is “ Answer is 12 Answer is 14

ii. What is the name of the variable in the following code?

```
TextField data = new TextField(10);
```

(Circle the correct answer.)

TextField data new 10

iii. What will the applet’s window look like after the following code is executed?

```
g.drawOval(20, 20, 160, 50);
```

(Circle the correct answer.)

A B C D

Question 7 continues
Question 7 (continued)

(b) The following diagram shows an applet window with a button (buttonPlay) and three TextFields (textA, textB, textWin).

The ActionListener has been added to textA, textB and buttonPlay.

![Diagram showing an applet window with a button (buttonPlay) and three TextFields (textA, textB, textWin).]

The `actionPerformed` method for the applet is as follows:

```java
public void actionPerformed(ActionEvent e)
{
    if (e.getSource() == buttonPlay)
    {
        if (textA.getText().equals(textB.getText()))
            textWin.setText("no winner");
    }
    if (e.getSource() == textA)
    {
        if (textA.getText().equals("GREEN")&& textB.getText().equals("RED"))
            textWin.setText("B wins");
        if (textA.getText().equals("BLUE")&& textB.getText().equals("RED"))
            textWin.setText("A wins");
    }
}
```

Assume that the values stored in the text fields are as shown in the diagram. What will be displayed in the `textField textWin` after each of the following actions is executed in sequence?

i. The user clicks on `buttonPlay`.

(circle the correct answer)

- no winner
- A wins
- B wins
- empty

ii. The user enters “RED” into `textB` and then hits enter.

(circle the correct answer)

- no winner
- A wins
- B wins
- empty

iii. The user enters “BLUE” into `textA` and then hits enter.

(circle the correct answer)

- no winner
- A wins
- B wins
- empty

Question 7 continues
(c)

i. Show the value of the variable `string1` after the execution of the following section of code.

```java
String string1 = "a stitch in time";
string1 = string1.replace('i','2');
```

Final value of `string1`: .................................................................................................................................

...........................................................................................................................................................................

ii. Show the value of the variable `string2` after the execution of the following section of code.

```java
String string2 = "How much longer";
string2 = string2 + "=" + string2.length();
```

Final value of `string2`: ............................................................................................................................................

...........................................................................................................................................................................

iii. Show the value of the variable `string3` after the execution of the following section of code.

```java
String string1 = "This situation is concerning";
int p = string1.indexOf("i",15);
string3 = string1.substring(p, p + 7);
```

Final value of `string3`: ............................................................................................................................................

...........................................................................................................................................................................
Question 7 (continued)

(d) The following section of code uses the `drawPolygon` method from the `Graphics` class.

```java
int xpoints[] = {50, 150, 50, 150, 50};
int ypoints[] = {50, 50, 150, 150, 50};
int npoints = 5;
g.drawLine(xpoints, ypoints, npoints);
```

In the 800 x 600 applet window below, draw the applet window as it would appear after the section of code has been executed.

A grid has been added to the applet window display to assist with this question.
Question 8

This question relates to the class definition below. It defines an employee in a class and some of their employee details.

```java
public class Employee {
    String name;
    int age;
    String role;
    double salary;

    public Employee(String newName, int newAge, String newRole, double newSalary) {
        this.name = newName;
        this.age = newAge;
        this.role = newRole;
        this.salary = newSalary;
    }

    public void employeeAge(int empAge) {
        age = empAge;
    }

    public void employeeRole(String empRole) {
        role = empRole;
    }

    public String getEmployeeRole() {
        return role;
    }

    public void employeeSalary(double empSalary) {
        salary = empSalary;
    }
}
```

Question 8 continues
Question 8 (continued)

(a) Using the class definition, write code to declare and instantiate two variables, one for Mike Smith who is 35 years old, has a role of Business Manager and has a salary of $90,000 and one for Sophie Jones who is 37 years old, has the role of Vice President of Marketing and has a salary of $110,000.

(b) All employees have just been given a 3% pay rise. Write code that uses variables created in part (a) and the methods within the class, to change the salaries of Mike and Sophie.

(c) Write code that uses the variables created in part (a) and the methods within the class to display the role of each employee.
Question 9

A class is needed to process data related to student exam results.

The information to be processed is as follows:

<table>
<thead>
<tr>
<th>Data item</th>
<th>Type of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark</td>
<td>This is an integer between 0 and 100</td>
</tr>
<tr>
<td>Highest Mark</td>
<td>This is an integer between 0 and 100</td>
</tr>
<tr>
<td>Lowest Mark</td>
<td>This is an integer between 0 and 100</td>
</tr>
<tr>
<td>Spread</td>
<td>This is an integer between 0 and 100</td>
</tr>
</tbody>
</table>

The class will contain the following methods:

- A constructor method that will set the initial value for Mark using a parameter. The **Highest Mark** and **Lowest Mark** should be set to **Mark**.
- A method that will set the value of **Spread** within the class using the following formula:
  \[
  \text{Spread} = (\text{Highest Mark} - \text{Lowest Mark})
  \]
- A method that will return the current value of **Spread**.
- A method that will set **Mark** to a value given as a parameter to the method. The method will also set Highest Mark and Lowest Mark as described below:
  
  *If Mark is greater than Highest Mark it will become the new Highest Mark.*
  *If Mark is less than the Lowest Mark it will become the new Lowest Mark.*

Create a class to hold the specified data that contains the methods specified.
On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course document:

**Criterion 4**  Describe and apply knowledge of computer architecture.
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Question 10

(a)  

i. Complete the following truth table by selecting the correct answer:

(Circle the correct answer.)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>A AND B</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
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<td>T</td>
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</tbody>
</table>

(Circle the correct answer.)

<table>
<thead>
<tr>
<th>A AND B</th>
<th>A AND B</th>
<th>A AND B</th>
<th>A AND B</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>F</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

ii. The simplified expression for $A \lor \neg A$ is:

(Circle the correct answer.)

$$A \quad \text{T} \quad \neg A \quad \text{F}$$

iii. The logic expression for $H$ in this circuit is:

(Circle the correct answer.)

$$P \lor \neg((Q \land \neg R) \lor (R \land \neg P))$$

$$P \lor ((Q \lor R) \lor (R \lor P))$$

$$(P \lor ((Q \lor R) \lor (R \lor P)))$$

$$(P \lor ((Q \lor R) \lor (R \lor P)))$$

Question 10 continues
Question 10 (continued)

(b)

i. Complete the truth table for the logic expression:

\[ D \equiv (\sim A \lor B) \land (A \land C) \]

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>\sim A</th>
<th>\sim A \lor B</th>
<th>A \land C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

ii. Complete the logic expression for \( D \) in the following truth table:

\[ D = \ldots \]

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>0</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

(c)

i. Draw the logic circuit for the expression below:

\[ D = (\sim (A \lor B) \land (A \land \sim B)) \lor C \]
Question 10 (continued)

ii. Give the logic expression for \( F \) in the following circuit:

\[
F = \text{.........................................................} \\
\]

(d) Analyse the following TOY code program to determine the final value stored in Register A.

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>Contents</th>
<th>Pseudocode</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>0005</td>
<td>data</td>
<td>Contains the value 5</td>
</tr>
<tr>
<td>02</td>
<td>0002</td>
<td>data</td>
<td>Contains the value 2</td>
</tr>
<tr>
<td>10</td>
<td>8A01</td>
<td>( R[A] \leftarrow \text{_mem[01]} )</td>
<td>Set register A to the contents of location 01</td>
</tr>
<tr>
<td>11</td>
<td>8B02</td>
<td>( R[B] \leftarrow \text{_mem[02]} )</td>
<td>Set register B to the contents of location 02</td>
</tr>
<tr>
<td>12</td>
<td>5AAB</td>
<td>( R[A] \leftarrow R[A] \ll R[B] )</td>
<td>Set register A to register A left shifted 2 places</td>
</tr>
</tbody>
</table>

Final value stored in Register A: ........................................................................
Question 11

(a) Produce a simple logic expression for $H$ from the following Karnaugh map.

\[
\begin{array}{c|cc|cc}
 & 0 & 0 & 1 & 1 \\
\hline
0 & 1 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 1 \\
1 & 1 & 1 & 0 & 0 \\
D & 0 & 1 & 1 & 1 \\
\end{array}
\]

```
H = ...
```

ii. Use logic laws to simplify the following logic expression:

\[
D \equiv \sim (\sim A \lor \sim B) \land (C \lor \sim C)
\]

Indicate which logic law(s) were applied to each stage of your answer.

```
```

(b) Explain why TOY uses two different formats for instructions, as per the following table. Use examples to explain your answer.

<table>
<thead>
<tr>
<th></th>
<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format 1</td>
<td>opcode</td>
<td>destination (d)</td>
<td>source (s)</td>
<td>source (t)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Format 2</td>
<td>opcode</td>
<td>destination (d)</td>
<td>address (addr)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

```

Question 11 continues
Question 11 (continued)

(c) The Central Processing Unit (CPU) carries out instructions such as:

**8A02 Load R[B] ← mem[02]**

The process for this particular instruction can be described in the following three steps:

1. The control unit sends the number 02 to the Memory Address Register.
2. The contents of location 02 in the memory is transferred via a bus to the Memory Buffer Register (MBR).
3. The contents of the MBR is transferred to the Register B in the CPU.

Explain the following four terms:

**Control unit:** ........................................................................................................
........................................................................................................................................
........................................................................................................................................
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........................................................................................................................................

**Memory:** ................................................................................................................
........................................................................................................................................
........................................................................................................................................
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**Bus:** .........................................................................................................................
........................................................................................................................................
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**Register:** ..................................................................................................................
........................................................................................................................................
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........................................................................................................................................
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Question 12

(a) Complete the following TOY program so that it will implement the Java code below.

```
x = 3;
if ( x >= 0 )
    y = 5;
else
    x = x * 2;
```
Question 12 (continued)

(b) Complete a trace of your program showing all the registers used and the values of the variables $x$ and $y$.

<table>
<thead>
<tr>
<th>Mem addr</th>
<th>contents</th>
<th>x</th>
<th>y</th>
<th>R[ ]</th>
<th>R[ ]</th>
<th>R[ ]</th>
<th>R[ ]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Question 12 continues
Question 12 (continued)

(c) Below are two sections of code (Code A and Code B). Both sections of code have the same number of instructions and both are designed to swap two values. However, one section of code will operate much faster than the other.

Explain why this is the case and also explain why this is an example of the Von Neumann bottleneck.

<table>
<thead>
<tr>
<th>Code A</th>
<th>Code B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Load) R[A] ← mem[00]</td>
<td>(Set value) R[3] ← 0</td>
</tr>
<tr>
<td>(Store) mem[00] ← R[B]</td>
<td>(Add) R[A] ← R[B] + R[0]</td>
</tr>
</tbody>
</table>

Code A and Code B both aim to swap the values in R[A] and R[B]. However, Code B involves an add operation which incurs the Von Neumann bottleneck, while Code A does not. This is why Code B is slower.
Question Number: ____________

(Please write the number of the question you are answering above)

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On the basis of your performance in this examination, the examiners will provide results on the following criterion taken from the course document:

**Criterion 5** Analyse how data are represented and stored.
To be considered for a ‘C’ rating on a criterion, you must provide a satisfactory answer to at least the first question of the relevant section.

To be considered for a ‘B’ rating on a criterion, you must provide a satisfactory answer to at least the first TWO questions of the relevant section.

To be considered for an ‘A’ rating on a criterion, you must provide a satisfactory answer to all THREE questions of the relevant section.

Show the methods used in deriving answers.

Take care with the presentation of your answers, which should be complete and to the point.

Diagrams should be used where appropriate.

Complete sentences should be used in questions involving explanations.

You are reminded that poor handwriting, spelling and expression that make it difficult for the examiners to understand what you mean may lead to lower marks.

A spare answer page has been provided in the back of the answer booklet for you to use if required.

If you DO use the spare answer page, you MUST indicate you have done so in your answer to that question.
Question 13

(a) Circle the correct answer for each question.

i. When $5E_{16}$ is converted to binary the value is:

\[
101_2 \quad 01000100_2 \quad 1011110_2 \quad 1000110_2
\]

ii. When $1011_2$ is converted to decimal the value is:

\[
3 \quad 11 \quad 13 \quad 70
\]

iii. What is the ASCII code (in decimal) for the character ‘A’?

\[
4 \quad 16 \quad 65 \quad 83
\]

(b) Fill in the FOUR missing bits in the following binary addition.

\[
\begin{array}{cccc}
1 & 1 & 0 & 1 \\
+ & 1 & 0 & 1 \\
\hline
1 & 1 & 1 & 0
\end{array}
\]

(c) 

i. What is the representation of $-7$ using 6 bit two’s complement representation?

ii. Examine the following Java fragment:

```java
byte i = 127; // byte is an 8 bit two's complement data type
i++;
g.drawString("i = " + i, 20, 20);
```

When the program is run, the output is -128. Explain this result.
Question 13 (continued)

(d)

i. Java uses Unicode to represent characters. Why was it important to ensure that all the characters represented by a character code in ASCII have the same character codes in Unicode? How is this achieved?

ii. What is the minimum storage required to store the value of a boolean variable?
Question 14

(a) A student writes a simple Java program which contains the following fragments shown below:

```java
double x = 0.0;
x = x + 0.1;
g.drawString(x, 20, 20);
x = x + 0.1;
g.drawString(x, 20, 40);
x = x + 0.1;
g.drawString(x, 20, 60);
x = x + 0.1;
g.drawString(x, 20, 80);
x = x + 0.1;
g.drawString(x, 20, 100);
```

When the program is run it produces the following output:

0.1
0.2
0.30000000000000004
0.4
0.5

Use this output to explain why it is not advisable to test for the equality of variables of type double e.g. `if (x==y)`

Give a more reliable way of comparing the value of two variables `x` and `y` of type `double`.

Question 14 continues
Question 14 (continued)

(b) An operation that can be used on a register is the left shift. Show what this does to the value stored in the register, using the following example left shifted by 2.

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

What is the effect of left shift 2 on the number stored in the register?

..........................................................................................................................................................................................

(c)

i. A floating point number has a 5 bit mantissa, what would be the result of adding?

```
0.75 + 0.03125
```

..........................................................................................................................................................................................

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ii. Would the result be different using a 4 bit mantissa? Explain.

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Question 15

An image has a resolution 1600 x 1200 pixels stored in 24 bit true colour (RGB) with 8 bits each for red, blue and green components.

(a)

i. How many bytes are required to store this image?

ii. If a colour lookup table (CLUT) is used to convert the image using 3000 selected colours, an index could be used to reference each of these colours in the table:

<table>
<thead>
<tr>
<th>Index</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>......</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2999</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How many bits are required for the index?

iii. How many bytes are required to store the CLUT table?

iv. If the CLUT is used to reference each pixel value in the file, how many bytes are now required to store the image?

v. Explain whether this image reconstruction would be lossy or lossless.

Question 15 continues
Question 15 (continued)

(b) An array is declared and instantiated as follows:

\[ \text{int} \ [ ] \ [ ] \text{a} = \text{new} \ \text{int} \ [2] \ [4]; \]

i. Draw a diagram representing the array \( \text{a} \) that shows the links between all its components. On your diagram, indicate the effect of the following java statement:

\[ \text{a}[1][2] = 7; \]

ii. The array has now been initialised with the following values:

\[
\begin{align*}
    \text{a}[0][0] &= 3; \quad \text{a}[0][1] = 6; \quad \text{a}[0][2] = 9; \quad \text{a}[0][3] = 12; \\
    \text{a}[1][0] &= 4; \quad \text{a}[1][1] = 8; \quad \text{a}[1][2] = 12; \quad \text{a}[1][3] = 16;
\end{align*}
\]

The array variable \( \text{a} \) holds the base address of the memory location that contains the length of the array. The memory locations after this address contain the contents of the array. Using the memory map below fill in the values needed to show how the above array could be stored in the memory of a computer.

The base value of array variable \( \text{a} = \) .................................................................

<table>
<thead>
<tr>
<th>Mem addr</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC00</td>
<td></td>
</tr>
<tr>
<td>AC01</td>
<td></td>
</tr>
<tr>
<td>AC02</td>
<td></td>
</tr>
<tr>
<td>AC03</td>
<td></td>
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<td>AC04</td>
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<td>AC05</td>
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<td>AC06</td>
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<td>AC07</td>
<td></td>
</tr>
<tr>
<td>AC08</td>
<td></td>
</tr>
<tr>
<td>AC09</td>
<td></td>
</tr>
</tbody>
</table>
This examination paper and any materials associated with this examination (including answer booklets, cover sheets, rough note paper, or information sheets) remain the property of the Office of Tasmanian Assessment, Standards and Certification (TASC).