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 2020 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 a result 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

The following is a partially completed algorithm for an applet designed to operate on a touch screen used with a product scanner at a supermarket check-out point.

The user can simply scan each item and the cost of that item will be added to the total. However, if there is a number of the same item, the user can increase (or decrease) the number of items before scanning and then the (number of items x item cost) will be added to the total.

If an error is made, the transaction type can be changed to remove. When this is done, the cost of the next scanned item will be subtracted from the total.

1. initially
2. number_of_items = 1
3. total_cost = 0
4. item_cost = 0
5. transaction = “add”

6. when “increase” button is pressed
7. number_of_items = number_of_items + 1
8. display number_of_items

9. when “decrease” button is pressed
10. number_of_items = number_of_items -1
11. display number_of_items

12. when “change” button is pressed
13. if transaction = “add”
14. transaction = “remove”
15. else
16. transaction = “add”
17. display transaction

18. when item is “scanned”
19. item_cost = value of scanned item
20. if transaction = “remove”
21. total_cost = total_cost + item_cost * number_of_items
22. else
23. total_cost = total_cost - item_cost * number_of_items
24. if total_cost < 0
25. total_cost = 0
26. display number_of_items, transaction, total_cost

Question 1 continues.
Question 1 (continued).

(a) Which line below needs to be added so that the “decrease” button cannot decrease the number of items below one? (Circle the correct answer)

After line 9 add

if number_of_items not equal to 0    if number_of_items not equal to 1
    if number_of_items equals 0        if number_of_items equals 1

(b) After what line would you add a line to check that the maximum number of same Items does not exceed 10? (Circle the correct answer)

19  1  6  7

(c) Fix the logic error in when item is “scanned”.
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(d) Modify the algorithm so that after an item has been “scanned” the default for the next scan will be to have a transaction type of “add” and the number of items set to one.
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Question 2

The following is a partially completed algorithm for an applet to be used to play the game Guess the number. The user is given ten guesses at a number and is informed of the result of each guess.

The user will be told if their guess is outside the range 1 to 100, if their guess is larger or smaller than the correct number, if the number of allowed guesses has been used or if the guess is correct. The user enters their guess into a TextField guess using a numeric keypad.

Line numbers are for reference only.

1. Initially
2. set count to 0
3. set guess to 1
4. set “guess” TextField to guess
5. set correct to a random value between 1 and 100
6. display count

7. When the “go” button is pressed
8. add one to count
9. if count is greater than 10
10. display “Out of guesses – play again”
11. set correct to a random value between 1 and 100
12. set count to 0
13. display count
14. else
15. if guess equals correct
16. set correct to a random value between 1 and 100
17. set count to 0
18. display count

19. When the “reset” button is pressed
20. set correct to a random value between 1 and 100
21. set count to 0
22. display count

23. When a number is entered into the “guess” Text Field
24. set new_guess to value from “guess” TextField
25. if new_guess is between 1 and 100
26. set guess to new_guess
27. else
28. set “guess” TextField to guess
29. display “Please enter a number between 1 and 100’
Question 2 (continued).

(a) Modify the algorithm so that the user is given twelve guesses at the correct number.

(b) The line to display that the user has guessed the number correctly is missing. Indicate where this line should be placed in the algorithm.

(c) Add to the algorithm so that the user is informed whether their guess is larger or smaller than the correct value.
An intravenous (IV) pump regularly dispenses a dosage of a solution of medicine from a 1 litre bag through a drip into a patient's arm. There are two buttons which enable the dosage to be increased and decreased. The first button, labelled “up”, increases the dosage by 5 millilitres per hour (to a maximum of 30 millilitres per hour) each time it is pressed. The second button, labelled “down”, decreases the dosage by 5 millilitres per hour (to a minimum of 0 millilitres per hour) each time it is pressed. A display indicates the current dosage.

Dispensing the drug can be started and stopped through the pressing/re-pressing of a third button, labelled “change”. If the bag containing the solution of medicine has already dispensed more than 900 millilitres when the “change” button is pressed, the machine should beep to alert the user that the bag should be changed immediately.

(a) Design a possible screen for this applet in the space below, identifying all the textfields and/or buttons to be used. You do not need to consider how the volume field is updated.

Question 3 continues.
Question 3 (continued).

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

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6. All written responses must be in English.

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

**Criterion 2** Create programs in a high level programming language.
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.

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Show the methods used in deriving answers.

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If you DO use the spare answer page, you MUST indicate you have done so in your answer to that question.
Question 4

(a) Circle the correct answer for the following questions:

(i) What will be the value of $y$ after the following code is executed?

```java
double y;
y = 15 / 3 * 4;
```

(circle the correct answer)

| 1.25 | 20 | 1 | 20.0 |

(ii) What will be the value of $b$ after the following code is executed?

```java
double b;
b = 5.0 + Math.pow(2.0,3.0);
```

(circle the correct answer)

| 12.0 | 13.0 | 14.0 | 15.0 |

(iii) What will be the value of $c$ after the following code is executed?

```java
int c = 3;
int x = 9;
if (x > 6)
{
    c = c + 3;
    if (x < 9)
    {
        c = c + 4;
    }
}
```

(circle the correct answer)

| 3 | 6 | 9 | 13 |

Question 4 continues.
Question 4 (continued).

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

```c
int f;
f = -4 + 15 / 5 + 7;
```

Value of f: ......................................................................................................................

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

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

```c
int j;
j = 56 % 5;
```

Value of j: ......................................................................................................................

Explanation: ...................................................................................................................
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(iii) Trace the following code and find the final value of the variable x.

```c
int x = 1;
for (int i=0; i<=3; i++)
{
    if (x == i - 1)
        x = x * 3;
}
```

Trace:

<table>
<thead>
<tr>
<th>x</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tbody>
</table>

Final value of x: .............................................................................................................
Question 5

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

```java
double f = 9.0;
if ((f < 5.0) || (f > 8.0)) {
    f = f - 1.0;
    if ((f >= 4.0) && (f <= 8.0)) {
        f = f * 3.0;
    } else {
        f = f * 4.0;
    }
}
```

Value of \( f \): .................................................................

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

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(b) \textbf{data} is an int[6] 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>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Trace the following code and find the final value of the variable \textit{mult}.

```java
int place = 5;
int mult = 0;
for(int i=1; i<=5; i++)
    if (data[i] == data[place])
        mult = mult + 1;
```

Use the trace table below.

<table>
<thead>
<tr>
<th>place</th>
<th>mult</th>
<th>i</th>
<th>data[i]</th>
<th>data[place]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Question 5 continues.
(c) Use the array diagram below to trace this code and find the final values in the array $m$.

```java
int[][] m = new int[3][4];
for (int i = 0; i < 3; i++)
{
    for (int j = 0; j < 4; j++)
    {
        if (i == j)
            m[i][j] = i * 2;
        else
            m[i][j] = j + 3;
    }
}
```

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
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For Marker Use Only
Question 6

(a) What will be displayed when the applet on the following page is executed?

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(b) List the modifications that would be required if the \texttt{separate_odd_even} method were to be made \texttt{void}?

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(c) In both the original and modified program, the final values within the \texttt{nums[]} array are different from the starting values. Using your knowledge of how parameters are passed, explain why this is the case.

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Question 6 continues.
import java.awt.*;
import java.applet.*;

public class Question6 extends Applet {
    int nums[] = {20, 12, 23, 17, 7, 8, 10, 2, 1, 0};
    int result[];

    public int[] separate_odd_even(int arr[]) {
        int left_side = 0, right_side = arr.length - 1;
        while (left_side < right_side) {
            while (arr[left_side] % 2 == 0 && left_side < right_side)
                left_side++;
            while (arr[right_side] % 2 == 1 && left_side < right_side)
                right_side--;
            if (left_side < right_side) {
                int temp = arr[left_side];
                arr[left_side] = arr[right_side];
                arr[right_side] = temp;
                left_side++;
                right_side--;
            }
        }
        return arr;
    }

    public String display(int[] input) {
        String str = "";
        for (int i = 0; i < input.length; i++)
            str = str + input[i] + " ";
        return str;
    }

    public void paint(Graphics g) {
        g.drawString("Before - " + display(nums), 20, 20);
        result = separate_odd_even(nums);
        g.drawString("After - " + display(result), 20, 60);
    }
}

The numbers on the left are not part of the program and are provided for reference purposes.
SPARE ANSWER SHEET IF REQUIRED

Question Number: _____

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

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

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Question 7

(a) Circle the correct answer for each question.

(i) What will be drawn in the applet's window after the following code is executed?
   
   \[ g\text{.drawString} \left( "Answer is \left( 10 + 3 \right), 20, 20 \right); \]

   Answer is 13  Answer is 13
   "Answer is"  "Answer is"  Answer is 20  Answer is 103

(ii) What is the name of the variable in the following code?

   \[ \text{Label } x = \text{new Label("Data");} \]

   Label  new  x  Data

(b) The following diagram shows an applet window with two text fields (textA, textB). The 
   ActionListener has been added to textA and textB.

   ![Diagram of applet window with two text fields](image)

   The \textit{actionPerformed} method for the applet is as follows:

   ```java
   public void actionPerformed(ActionEvent e)
   {
     if (e.getSource() == textA)
     {
       String hold1 = \"\", hold2 = \"\";
       hold1 = textA.getText();
       hold2 = textB.getText();
       textA.setText(hold2);
       textB.setText(hold1);
     }
     if (e.getSource() == textB)
     {
       textA.setText(textB.getText().toUpperCase());
     }
   }
   ```

Question 7 continues.
Question 7 (continued).

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

(i) The user enters “grape” into textA. \(\text{Circle the correct answer}\)

| TextA = banana | TextA = banana | TextA = pear | TextA = pear |
| TextB = pear   | TextB = grape  | TextB = grape | TextB = banana |

(ii) The user enters “kiwi fruit” into textB. \(\text{Circle the correct answer}\)

| TextA = kiwi fruit | TextA = grape  | TextA = KIWI FRUIT | TextA = KIWI FRUIT |
| TextB = pear       | TextB = kiwi fruit | TextB = pear        | TextB = kiwi fruit |

(c) (i) Show the value of the variable \textit{string3} after the execution of the following section of code.

```java
String string3 = "The cat sat on the mat";
int p = string3.indexOf("s",1);
string1 = string3.substring(p, p + 7);
```

Final value of \textit{string1}: ................................................................................................

(ii) Show the value of the variable \textit{string2} after the execution of the following section of code.

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

Final value of \textit{string2}: ................................................................................................

Question 7 continues.
Question 7 (continued).

(iii) Show the value of the variable `string3` each time it changes during the following section of code.

```java
String string1 = "Twitter";
String string2 = "John";
String string3 = "";
string3 = string1.substring(4,string1.length());
string3 = string3 + string2.toLowerCase();
```

first value of string3: ...........................................................
second value of string3: ...........................................................
third value of string3: ...........................................................
EXAM CONTINUES OVER THE PAGE
Question 8

This question relates to the class definition below. It defines a vehicle in a class and some of the vehicles details to be used in a used car sales application.

```java
public class Car {
    String make, model;
    int year;
    String colour;
    double salePrice;

    public Car(String make, String model, int year, String colour, double salePrice) {
        this.make = make;
        this.model = model;
        this.year = year;
        this.colour = colour;
        this.salePrice = salePrice;
    }

    public void setMake(String make) {
        this.make = make;
    }

    public void setModel(String model) {
        this.model = model;
    }

    public void setYear(int year) {
        this.year = year;
    }

    public void setSalePrice(double salePrice) {
        this.salePrice = salePrice;
    }

    public double getSalePrice() {
        return salePrice;
    }

    public void setDiscount(double discount) {
        this.salePrice = (100 – discount) / 100 * salePrice;
    }

    public void setColour(String colour) {
        this.colour = colour;
    }

    public String getCarDetails() {
        String str = make + "," + model + "," + year + "," + colour + "," + cost;
        return str;
    }

    // Question 8 continues.
}
```
Question 8 (continued).

(a) (i) Using the class definition, write code to declare and instantiate two variables:

- Holden 2007 Red Commodore with sale price $3000 AND
- Ford 2006 Blue Falcon with sale price $2500.

(ii) This weekend the car yard is having a sale. Write code using the methods within the class to discount each car by 10%.

(iii) Write code that uses the methods within the class to display all the stored information about each of the two cars.

(iv) The Holden has just been repainted in black. The dealer has now increased its sale price by $1000. Write code to enact these changes.
Question 9

A class is needed to process rental properties being managed by a real estate firm.

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>streetAddress</td>
<td>String E.g. 3 Cross Street</td>
</tr>
<tr>
<td>suburb</td>
<td>String E.g. New Town</td>
</tr>
<tr>
<td>numberOfBedrooms</td>
<td>This is an integer between 1 and 5</td>
</tr>
<tr>
<td>rentalCost</td>
<td>This is a decimal number between 0 and 1000.0</td>
</tr>
<tr>
<td>isRented</td>
<td>True / False</td>
</tr>
</tbody>
</table>

The class will contain the following methods:

- A constructor method that will set the initial value for each property using parameters with the data item listed in the table above.
- An overloaded constructor method that will set only the street address and suburb.
- A method that will return all of the information about the property.
- A method that will enable the rentalCost to be modified.
- A method that will enable the isRented to be adjusted.

Create a class to hold the specified data and that contains the methods specified.

Question 9 continues.
COMPUTER SCIENCE

(ITC315118)

SECTION D

Time recommended for this section: 36 minutes

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6. All written responses must be in English.

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

Criterion 4   Describe and apply knowledge of computer architecture.
Additional Instructions for Candidates

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Show the methods used in deriving answers.

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If you DO use the spare answer page, you MUST indicate you have done so in your answer to that question.
Question 10

(a) Circle the correct answer in the following questions.

(i) Fill in the table and circle the correct answer below.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>(~A \land B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
</tbody>
</table>

(ii) Circle the simplified expression for \(~ (A \lor B)\).

\[ ~A \lor ~B \quad T \quad ~A \land ~B \quad ~A \lor B \]

(iii) The logic expression for H in this circuit is:

\[ ( ( ~A \land B ) \lor ( B \lor C ) ) \land ( ~ ( ~A \land B ) \lor ( B \lor ~C ) ) \]

\[ ( ( ~A \land B ) \land ( B \lor ~C ) ) \quad ( ~ ( A \land ~B ) \lor ( B \lor ~C ) ) \]

Question 10 continues.
Question 10 (continued).

(b) (i) Complete the truth table for the logic expression:

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

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

(ii) Complete the logic expression for F in the following truth table:

\[ F \equiv \ldots \]

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

(c) (i) Draw the logic circuit for the expression below:

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

Question 10 continues.
Question 10 (continued).

(ii) Give the logic expression for E in the following circuit:

(d) Most processor CPUs do not have a multiplication circuit. Using the example of 5 x 7 (ie multiply 5 times 7) explain how this could be evaluated without using multiplication circuits.
Question 11

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

(ii) Use logic laws to simplify the following logic expression:

$$D \equiv \neg (\neg A \land \neg C) \lor \neg C$$

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

(b) (i) The $\text{sub}$ instruction is a TOY instruction with pseudocode of $R[d] \leftarrow R[s] - R[t]$.

Describe the movement of data within the CPU during the execution of this instruction.
Question 11 (continued).

(ii) Early electronic computing devices like ENIAC were programmed by physically re-wiring the computer. What change occurred to the way programs were modified when computers began using the Von Neumann architecture?

What is the main benefit that the modern computer inherits from this architecture?

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Question 12

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

```java
int j = 100;
for (int i = 0 ; i < 3 ; i++ )
   j = j / 2;
```

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>Contents</th>
<th>Pseudocode</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>0000</td>
<td>data</td>
<td>Used for variable i</td>
</tr>
<tr>
<td>02</td>
<td>0064</td>
<td>data</td>
<td>Used for variable j (decimal 100)</td>
</tr>
<tr>
<td>03</td>
<td>0001</td>
<td>data</td>
<td>Constant decimal 1</td>
</tr>
<tr>
<td>04</td>
<td>0003</td>
<td>data</td>
<td>Constant decimal 3</td>
</tr>
<tr>
<td>10</td>
<td>8A01</td>
<td>R[A] &lt;- mem[01]</td>
<td>i =0</td>
</tr>
<tr>
<td>11</td>
<td>8B02</td>
<td>R[B] &lt;- mem[02]</td>
<td>j = 100</td>
</tr>
<tr>
<td>12</td>
<td>8C03</td>
<td>R[C] &lt;- mem[03]</td>
<td>Constant 1</td>
</tr>
<tr>
<td>13</td>
<td>8D04</td>
<td>R[D] &lt;- mem[04]</td>
<td>Constant 3</td>
</tr>
</tbody>
</table>

Question 12 continues.
Question 12 (continued).

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>8A01</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>8B02</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>8C03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>8D04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Question 12 continues.
Question 12 (continued).

(b) Consider the instructions in TOY which have an opcode of 1, 2, 3, 4, 5 and 6. Explain, based on your understanding of the fetch/decode/execute cycle, how it would differ if instructions could be used that specify the memory locations instead of the current process used by the TOY machine to perform the same operation.
Question Number: _____

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

**ITC315118**

**SECTION E**

**Time recommended for this section:** 36 minutes

| Pages: 12 | Questions: 3 | Attachment: Information Booklet |

## 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 2020 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 a result on the following criterion taken from the course document:

**Criterion 5**  Analyse how data are represented and stored.
Additional Instructions for Candidates

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Question 13

(a) Circle the correct answer in each section.

(i) What is the value when $3C_{16}$ is converted to binary?

\[
\begin{array}{cccc}
011_2 & 00111100_2 & 1100011_2 & 10001110_2 \\
\end{array}
\]

(ii) What is the value when $10101_2$ is converted to decimal?

\[
\begin{array}{cccc}
3 & 11 & 21 & 25 \\
\end{array}
\]

(iii) What is the ASCII code (in decimal) for the character 'f'?

\[
\begin{array}{cccc}
6 & 69 & 97 & 102 \\
\end{array}
\]

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

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

(c) (i) What is the representation of $-13$ using 8 bit twos complement representation?

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(ii) Explain why $0.101_2$ is equal to $0.625_{10}$.

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Question 13 continues.
Question 13 (continued).

(d) (i) A 4-bit word using an unsigned integer representation can represent values ranging from 0 to 15. How would the range of values change if the word size was increased by two bits to 6?

(ii) Use the following table to convert 0.67 to binary to six places.

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.67 x 2</td>
<td>1.34</td>
</tr>
<tr>
<td>0.34 x 2</td>
<td>0.68</td>
</tr>
<tr>
<td>0.68 x 2</td>
<td>1.36</td>
</tr>
<tr>
<td>0.36 x 2</td>
<td>0.72</td>
</tr>
<tr>
<td>0.72 x 2</td>
<td>1.44</td>
</tr>
<tr>
<td>0.44 x 2</td>
<td>0.88</td>
</tr>
<tr>
<td>0.88 x 2</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Question 14

(a) Using a 16 bit twos complement representation, we can represent the numbers -32768 to +32767.

Explain how a floating point representation with the same number of bits (16) can represent numbers much larger than 32767 and much smaller than -32768.

Question 14 continues.
Question 14 (continued).

(b) A standard card deck is made up of four sets of 13 cards. An applet for a card game needs to store the value and suit of a card using the minimum number of bits. The value and suits are to be stored using the indexes in the following tables.

<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>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>A</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>J</td>
<td>Q</td>
<td>K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Spades</td>
<td>Clubs</td>
<td>Diamonds</td>
<td>Hearts</td>
</tr>
</tbody>
</table>

(i) What is the minimum number of bits required to store the data for a card?
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..................................................................................................................................

(ii) How many bits would be required to store the whole deck?
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..................................................................................................................................
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(c) Give an example of two integers that when added together would cause an overflow error to occur in a 5 bit twos complement representation. Demonstrate this by performing the addition of the two selected numbers.
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Question 15

(a) A weather collection station samples wind speed, wind direction and temperature data every minute. The wind speed can range from 0 to 200 km/h, the direction is either N, N/W, W, S/W, S, S/E, E, N/E and the temperature can range from -20 to +50 degrees Celsius.

(i) What would be the minimum number of bits required to store each sample? Show your working.

(ii) How many bytes of data would be required to store the sample data collected in a 24 hour period?

Question 15 continues.
Question 15 (continued).

(b) Examine the following Java code fragment:

```java
double sum = 0.0;
for ( int i = 0 ; i < 10 ; i++ )
    sum = sum + 0.1;

System.out.println("sum = " + sum);
```

When this fragment is executed, the display on the screen is:

![Image of display showing sum = 0.9999999999999999]

Using your knowledge of how floating point numbers are stored, explain this result.