INSTRUCTIONS TO CANDIDATES

1. This paper consists of THREE sections.
2. Answer ONE question from EACH section.
1. (a) Data flow diagrams are typically drawn during the analysis phase of a software development project.

(i) Draw a context diagram for the following order processing system in a certain company:

Customers make orders for items sold. Customers then pay for the items and the items are shipped to the customer. To replenish its stock, items are ordered from suppliers who submit an invoice for payment. After the invoice is paid, the items are delivered to the company. [7 marks]

(ii) After the context diagram is drawn, briefly describe the process that is used to derive the remaining data flow diagrams for analysis, identifying the different types of diagrams that are drawn. [4 marks]

(iii) Explain what is wrong with the following two data flow diagrams:

[Diagram not provided in text]

[4 marks]

(b) Discuss THREE properties of well-engineered software. [9 marks]

(c) Describe THREE reasons why it is important to involve end users and management in the development of a software product. [6 marks]

Total 30 marks
2. (a) A certain software engineering firm undertakes projects involving the development of software. A project is split up into a set of tasks with attributes such as start date, end date and duration. Sometimes, one or more CASE tools may be used in a task. The firm has a number of employees who have attributes such as name and number of dependents. Employees are uniquely identified with an employee number and may be assigned to one or more tasks in a project. Note that one or more employees may be assigned to the same task.

Draw an entity-relationship model based on the above narrative. [15 marks]

(b) Discuss THREE activities that take place during the design phase in the development of a software product. [9 marks]

(c) Outline THREE guidelines for designing a user interface of a software product. [6 marks]

Total 30 marks

SECTION B

MODULE 2: PROGRAMMING LANGUAGES

Answer ONE question from this section.

3. (a) Discuss TWO advantages of a top-down approach to procedural programming. [4 marks]

(b) Consider the following recursive module:

```
MODULE MYSTERY (N: INTEGER)
IF (N > 0) THEN
    RETURN N + MYSTERY (N-1)
ELSE
    RETURN 0;
END MODULE
```

(i) What does the above recursive module return when it is called with \( n = 5 \)? Show the steps you used to arrive at your answer. [8 marks]

(ii) State generally, what the module achieves for any \( n \geq 1 \). [2 marks]

(c) Write an algorithm that reads a positive integer \( n \) and then finds and prints the sum of all the integers between 1 and \( n \) (inclusive) that are divisible by 3. [6 marks]
(d) Assume that an integer array NUM exists with locations (subscripts) from 1 to 12. Determine what the following algorithm will print, showing your working for each part of the algorithm.

```
FOR J = 1 TO 12 DO
    NUM [J] = J
END FOR

K = 0
FOR J = 5 TO 7 DO
    K = K + J
    NUM [K - J + 1] = J + K
END FOR

FOR J = 1 TO 7 DO
    PRINT ‘NUM’, J, ‘IS’, NUM [J]
END FOR
```

[10 marks]

Total 30 marks

4. (a) Briefly explain TWO advantages of the object-oriented paradigm over the procedural paradigm. [4 marks]

(b) The following algorithm is supposed to print a table of Fahrenheit degrees corresponding to Celsius degrees in the range 0 to 100, in increments of 5. However, it does not generate the desired output. Find and correct the problem in the algorithm, assuming that the conversion formula (fourth line) is correct.

```
PRINT “Celsius Fahrenheit”
celsius = 0
WHILE celsius <= 100 DO
    fahrenheit = (celsius * 9) / 5 + 32
    PRINT celsius, fahrenheit
END WHILE
```

[4 marks]

(c) The Ministry of Education in a certain Caribbean country wishes to develop an object-oriented application to maintain information on all the secondary schools in the country, the teachers and students at each school, and the use of its school buses by different schools for field trips and other activities. The application should store the name, ID, age, address and test scores of each student. The application should also store the name, qualifications, telephone number, ID number, and monthly salary of each teacher. Finally, the application must store information about school buses such as registration number, capacity, manufacturer and distance travelled (which is updated whenever it is used).
(i) Specify (but do not code) the class corresponding to SchoolBus. The specification must include instance variables and AT LEAST ONE accessor, ONE modification and ONE print method. [12 marks]

(d) Examine the following two algorithms labelled Algorithm 1 and Algorithm 2 and answer the questions that follow.

Algorithm 1

```
FOR X = 1 TO 5 DO
    READ X
END FOR
```

Algorithm 2

```
SUM = 0
READ X
WHILE X > 0 DO
    SUM = SUM + X
    READ X
END WHILE
```

(i) Which of the algorithms above, if any, illustrates bounded iteration? Explain your answer.

(ii) Which of the algorithms above, if any, illustrates unbounded iteration? Explain your answer. [6 marks]
SECTION C

MODULE 3: PROGRAM DEVELOPMENT

Answer ONE question from this section.

5. (a) A stack of integers, stack1, is implemented using an array and is arranged as follows:

```
stack1
8
7
9
6
8
5
7
4
6
3
5
2
4
1
```

![Figure 1](image)

(i) Assume that stack1 was initially empty. What sequence of statements would cause the stack to have the values shown in Figure 1 above? Note: you need to use stack operations in your response e.g. push, pop. [4 marks]

(ii) Assume that another stack, stack2 exists, and is currently empty.

Write programming code to take the elements of stack1, remove them one by one, and add them to stack2. Note that after your statements are executed, stack1 would be empty. [5 marks]

(iii) Write statements to remove the elements of stack2 one by one and display each element as it is removed. Write down the output displayed. [4 marks]

(b) You have been asked by the principal of a secondary school to develop an application using an **object-oriented programming language**, which processes information on students (data entry and data query). The program must employ a graphical user interface in an event-driven environment.
A description of some of the features required follows.

**Data Entry**

The name, age, and address must be stored on each student. After the data for each student is entered, it should be saved. All new student data entered is also displayed. Note that there may be a lot of student data that cannot be displayed on a single window.

**Data Query on Student performance**

A student’s name can be entered and a breakdown of his/her test scores in different subjects can be displayed.

(i) Identify THREE types of graphical user interface objects (other than window) that should be present in the “Data Entry” user interface and explain why EACH one is used. 

(ii) Briefly discuss TWO events that the “Data Query” interface should anticipate.

(iii) Design the layout of the “Data Query” interface, clearly labelling the controls used.

6. A company that manufactures different kinds of pens wishes to keep information on the pens that it manufactures. For each type of pen, the following data must be stored:

| id: The identification number of the pen |
| brandName: The brand name of the pen |
| price: The price of the pen |
| onSale: A boolean variable that indicates if the pen is currently on a sale |

(a) Write the code for a `Pen` class that includes the instance variables named above. The `Pen` class must provide a suitable constructor, accessors (getters) for the instance variables, and a `toString()` method that returns a string containing all the data stored within a `Pen` object. In addition, the `Pen` class must provide the following two methods:

<table>
<thead>
<tr>
<th>Method</th>
<th>Parameters</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>sale()</td>
<td>discount</td>
<td>reduces the price of a pen by <code>discount %</code> as long as the price is not less than $5.00; updates the <code>onSale</code> variable to indicate pen is on sale.</td>
</tr>
<tr>
<td></td>
<td>(a real number)</td>
<td></td>
</tr>
<tr>
<td>shortage()</td>
<td>none</td>
<td>increases price of a pen by 10%.</td>
</tr>
</tbody>
</table>
(b) Write a fragment of code to:

(i) Create TWO (2) *Pen* objects using data of your choice and store them in separate object variables. [2 marks]

(ii) Create or instantiate a NAMED data structure for storing all the *Pen* objects in the application, and then put the two *Pen* objects created in 6 (b) (i) in this data structure. [3 marks]

(iii) Print out the names and sales prices of all the *Pen* objects that are on sale. [5 marks]

(c) The company wishes to start manufacturing a new type of pen, the *SmartWriter*. The *SmartWriter* pen has all the functionality of the other pens, but has additional properties and functionality. Explain what is the easiest way to implement the corresponding *SmartWriter* class. [4 marks]

Total 30 marks

END OF TEST