NATIONAL JUNIOR COLLEGE
Mathematics Department

General Certificate of Education Advanced Level
Higher 2

COMPUTING 9597/02

Paper 2 **30 August 2019**

3 hours

Additional Materials: Pre-printed A4 Answer Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all work you hand in.

Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, glue or correction fluid.

There are 6 questions totalling 100 marks.

Answer **all** questions.

At the end of the examination, fasten your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

This document consists of **8** printed pages and **0** blank pages.

1 At Central Secondary School, the current system for tracking Co-Curricular Activity (CCA) equipment requires manual updating. More specifically, the teachers in-charge of CCAs manage printed records of their equipment inventories.

In this system, stock-taking of equipment is performed once per year, where teachers and students perform a physical count of each item on an inventory list. At this point, any damaged or lost items are flagged, and then replacements are ordered. To process orders, requests are submitted to the general office.

A new automated system that utilises Radio-frequency identification (RFID) tags has been proposed. The proposal is to use passive RFID tags, which, unlike a barcode, do not need to be within the line of sight of the reader, so it may be embedded in the tracked object.

Within the proposed system, each piece of CCA equipment will be embedded with an RFID tag, which would allow them to be easily tracked. Tracking is performed by several RFID readers that will be positioned at various venues where CCA equipment are typically stored. Teacher and staff may access this data by physically linking a computer to each RFID reader.

The main idea behind the proposed system is to have an inventory system that may be continuously updated, which would remove the need for the annual stock-taking exercise, and ensure that inventory is replenished in a timelier fashion.

(a) Describe **two** feasibility study constraints that are relevant to the above project. [2]

(b) The proposed system is a complete overhaul of the exiting system. What other alternative solutions are typically applicable to a system? Suggest one example of each such solution that would be applicable to the given context. [4]

Once the feasibility study is concluded, the school moves ahead with the project using the following schedule.

Activity	Description	Preceding Activity	Duration (weeks)		
			Worst	Expected	Best
A	Analysis of requirements	-	4	2	1
B	Design of the system	A	10	7	3
C	Writing system documentation	A	24	18	12
D	Implementation of the system	B	17	14	12
E	Unit Testing	B	12	7	4
F	Integration Testing	E	8	5	3
G	Installation of the system	D, F	10	3	2
H	Evaluation of the system	C, G	4	2	1

(c) Describe **two** things that a systems analyst might do in order to determine the requirements of the new system. [2]

(d) Draw a Data Flow Diagram (DFD) to describe the existing (manual) CCA equipment inventory system. [4]

(e) During which phases of the SDLC are DFDs utilised? Also, name the specific documentation that includes them. [4]

(f) PERT charts utilise a weighted average. Determine the weighted average for each of the activities listed. [1]

(g) Draw the network PERT chart diagram for the above project schedule. This PERT chart should clearly indicate the dummy activities within the project. [3]

(h) Draw the PERT chart for the above, completing both the forward and backward pass in order to determine the slack time for each activity. [3]

(i) For a general Systems Development project, during which phase of the SDLC are PERT and Gantt Charts typically generated? Explain why they are not generated in other phases instead. [2]

(j) During which phase is the test plan typically created? [1]

(k) When implementing the system, one of several SDLC methodologies may be adopted. List **three** such methodologies. [3]

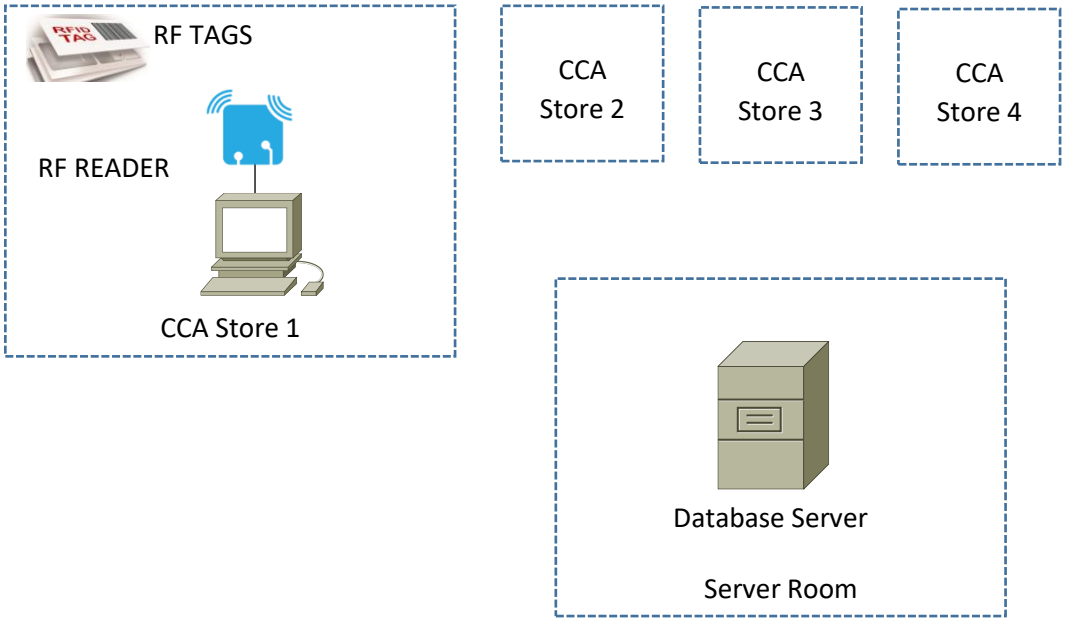
(l) Among the methodologies you have listed in your answer to part **(j)** above, pick one that is relevant to the give context. Justify your answer by contrasting your answer against the methodology proposed within the given context. [3]

(m) User and support staff training is an important part of the SDLC. Which phase includes such training? [1]

(n) The maintenance phase, while not included in the given schedule, is important to a project. Describe two forms of maintenance that would be relevant to the proposed system. Justify each choice. [2]

The proposed network design for the RFID CCA Inventory system is as follows:

Each CCA Store room will have a set of RFID-Reader linked to a desktop computer. The computers in every CCA Store need to be able to access a centralised database server to update the inventory records. The database server is physically located in another room in the same building as all the CCA store rooms.



(o) Based on the diagram above, draw a network diagram to include the physical/wireless connections and network equipment/s required to implement the physical network. Label the equipment and connections used in the diagram [2]

(p) Describe the transmission mode used between RF Reader and the RF TAGS in terms of how data is transferred between them. Justify your answer. [1]

After the proposed system has been implemented successfully, the school is considering a Phase 2 implementation to include embedding RFID tags to the school badges worn by the students and placing RFID readers in different locations within the school compound. This will allow attendance to be taken automatically and to track the movement of students in the school.

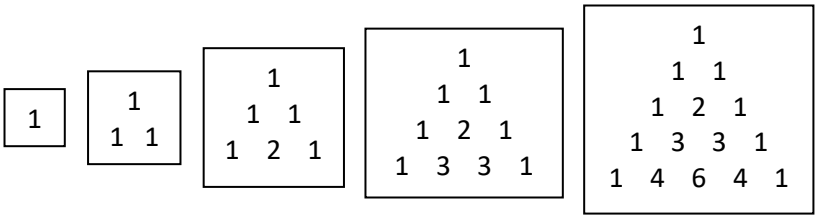
Given the fact that passive RFID tags do not have any access control system, any commercially available RFID reader sold in the market, is capable of accessing the information stored in the RFID tags.

(q) As a project manager for this project, you are to list and describe two ethical implications in the proposed Phase 2 implementation. [2]

2 **(a)** Command line interfaces and graphical user interfaces are two common forms of user interface. Explain the difference between the two, emphasising when each is more applicable. [2]

(b) There are typically eight qualities that good interfaces possess. List and describe four. [4]

3 Pascal's Triangle follows the pattern below.



These correspond to the Pascal's Triangles for `n` = 1 (leftmost) to `n` = 5 (rightmost).

(a) Write the Pseudocode for a function that will iteratively (i.e., not recursively) print the Pascal's Triangle of depth `n`, where `n` is the only parameter of this function. You may **not** use the binomial coefficient formula or use factorial calculations within this implementation.

Note that in your implementation, you need not worry about the centring the triangle. For example, when `n` = 5, you may instead output:

.

```
1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
```

[4]

(b) Design a valid boundary test case for the function implemented in **(a)**. [1]

(c) Re-write your function such it is now fully recursive (i.e., does not utilise any loops). [4]

(d) Trace your recursive implementation for `n` = 3. [3]

4 **(a)** Stacks and queues may be implemented using a Singly-linked Linked List (LL) if we desire them to be dynamically sized.

(i) Using Object Oriented Programming (OOP), design a fully modular implementation for a linked list and the corresponding stack and queue structures. You need only specify the UML Class Diagrams for all the necessary classes. All necessary attributes and methods must be listed, and your solution must indicate any inheritance and polymorphism that is necessary to achieve full modularity. [4]

(ii) Explain why a Singly-linked linked list is used, instead of a Doubly or Doubly-circular linked list. [1]

(b) When implementing a Hash Table, it is typically necessary to ensure that your implementation also includes collision resolution. Two categories of collision resolution mechanisms for Hash Tables are Open Addressing and Separate Chaining.

(i) Describe the algorithm for the opening addressing mechanism of quadratic probing. [3]

(ii) Describe the difference between linear probing and quadratic probing, and explain why one might wish to use quadratic probing instead of linear probing. [2]

A computer scientist has implemented the following `INSERT` function for a Hash Table.

```
FUNCTION INSERT(hashTable: ARRAY OF OBJECT, data: OBJECT)
RETURNS ARRAY OF OBJECT
      DECLARE hashValue, step: INTEGER
      IF ISFULL(hashTable) THEN
            OUTPUT "Hash Table full. Unable to insert."
            RETURN NULL
      ENDIF
      hashValue ← HASH(data) % hashTable.SIZE()
      step ← -1
      WHILE hashTable[hashValue] <> NULL DO
            hashValue ← hashValue + step
            IF hashValue < 1 THEN
                  hashValue ← hashTable.SIZE()
            ELSE IF hashValue > hashTable.SIZE() THEN
                  hashValue ← 1
            ENDIF
            step ← step * (-2)
      ENDWHILE
      hashTable[current] ← data
      RETURN hashTable
ENDFUNCTION
```

(iii) Determine if the collision resolution method utilised in the `INSERT` function defined above is valid. Justify your answer. [2]

5 A proprietary network system is to be designed and built for streaming high definition digital live video feeds from a number of CCTV cameras in a multi-storey building within a prison facility. The video feeds are to be accessed on computers within the building as well as in a remote location linked by a private communication link.

(a) A data-link layer protocol needs to be designed and implemented. A decision has to be made as to whether to use a synchronous or asynchronous protocol.

Explain the differences between the synchronous and asynchronous mode in data communications. [2]

(b) When designing protocols, we often use a layered model approach. In the open standard-based TCP/IP network model there are four layers. Name these four layers and briefly describe their functionalities, clearly elaborating on the form of addressing and/or an example of a protocol within each layer. [4]

(c) The video feeds need to be streamed at a constant rate of 8 Mbps.

(i) If the transceiver on the system can send/receive two million signals per second (2M baud), what is the number of required signal levels to achieve a data transfer rate of 8 Mbps? [1]

(ii) What type of network system would allow us to guarantee a minimum data transfer rate? [1]

(iii) Explain how the system you described in **3(c)(ii)** works. [2]

(d) An application programmer can use the socket API to write code that uses the TCP/IP communication stack of protocols.

(i) In socket programming, what does the term socket mean? [1]

(ii) When implementing a live video streaming application using the socket API, the programmer can choose whether to use a TCP or a UDP socket. Which one should the programmer use and why? [2]

(e) For the remote transmission, the video stream needs to be encrypted when moving from sender to receiver. List and describe two cryptography techniques that may be used for this transmission. [2]

6 At ABC Secondary School, extensive student records are kept. The following is an example of one record.

Student ID	T0400000G
Student Name	John Snow
Student Contact Number	12345678
Student Address	123-456 Castle Black, The Wall 123456
Parent Name	Eddard Stark
Parent Relationship	Father
Parent Contact Number	23456789
Parent Email Address	winter.tis.here@gmail.com
Student Homeroom Class	3A
Student Subject Classes	(EN, 3EN2); (MA, 3MA3); (AM, 3AM4); (PH, 3PH1); (CH, 3CH1); (GE, 3GE1); (HI, 3HI2); (MT, 3MT4)

A few additional assumptions regarding the data are as follows:

- Each student will have a unique Student ID
- Student Name, Contact Number, and Address, may not be unique
- Parent Name and Contact may not be unique; a parent may have more than one child at the school
- A student may only belong to a single Homeroom Class in each academic year; the Homeroom Class identifier may be reused in each new academic year
- Student Subject Classes are assigned at the beginning of an academic year, but may be changed during the course of the year, each subject class is a 2-tuple with the following properties:
    - Subject Code – these are unique for each academic level, but may exist more than once across different academic levels
    - Subject Class Code – these are unique within the school for an academic year, but may not be unique across different academic years

It should also be noted that the school also stores two other sets of records, which are as follows.

Teacher ID
Teacher Name
Teacher Address
Teacher Contact Number

Subject
Level
Subject Description

Each class (subject or homeroom) is assigned one teacher.

(a) Draw an Entity-Relationship Diagram (ERD) that depicts this data in 3NF. [4]

(b) Describe these 3NF relations using the format RelationName(Attribute1, Attribute2,..)

The primary key is indicated by underlying one or more attributes. Foreign keys are indicated by an asterick(*). [6]

(c) The DDL and DML are two features of a Relational Database Management System (RDBMS). What is the difference between DDL and DML? [1]

(d) Another part of a RDBMS is the data dictionary. Provide **four** reasons why it is important. [4]