Name:_____ **Class:**_____

JURONG PIONEER JUNIOR COLLEGE

JC2 Year – End Examination 2024

COMPUTING **9569/01**
Higher 2 **11 September 2024**

Paper 1 (Written) **3 hours**

Additional materials: 12-page Answer Booklet

Answer **all** the questions.

Approved calculators are allowed.
You are reminded of the need for clear presentation in your answers.

Answer papers will be provided with the question paper.
Write your name and civics class on all the work that you hand in.
Write in **dark blue** or **black pen** on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Write your answers to every question **on a fresh page of paper**.
Approved calculators are allowed.

The number of marks is given in brackets **[ ]** at the end of each question or part question.
The total number of marks for this paper is **100**.

This document consists of **10** printed pages and **2** blank pages.

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1 The in-house IT department of JP Hospital was tasked to design a data structure that can store details of patients who have registered and sought medical treatment at their Accident & Emergency (A&E) department. A patient record contains information related to the patient like the national identity number, name, gender, address etc, that can be uniquely identified by a four-digit patient number. The IT department has decided to use a **zero**-based array data structure that is made up of 500 ordered memory blocks of equal sizes with each memory block capable of storing at most **two** patient records. The four-digit patient number is used as input to a hash algorithm where the hashed result gives the location to the memory block the patient record is stored. The hash algorithm is defined as follows:

1. Divide the **three** rightmost digits of the four-digit patient number by 2.
2. The integer result obtained in step (1) will be the location of memory block used to store the patient's record.

Using the hashing algorithm above, the patient record with patient number `0317` will be stored in memory location `158`. If a patient record is hashed to a memory block that is full, a sequential search will be performed repeatedly until a free area is found into which the patient record is written.

(a) State and justify a suitable data type for the four-digit patient number. [2]

(b) What is meant by a collision in this context and state the method used to resolve collisions. [2]

(c) Four new patients with patient numbers

`1422, 1425, 2422, 3423`

are added into the system in the order given above. Given that the memory blocks are all empty before the insertion, use a diagram to show where the patient records are stored in the memory blocks of the data structure after every single successful insertion. [3]

(d) Explain why a patient record can be deleted without re-organising the memory block. [2]

(e) Describe how a new patient record with a unique patient number gets inserted into a memory block. Your answer should answer how collisions are handled. [4]

To strengthen the security of patients' information, JP Hospital has decided not to store the national identity number of a patient. Instead, a new patient ID that is made up of **eight** alphanumeric characters will be used. The leftmost **three** characters of the new patient ID is obtained from the result of applying the four-digit patient number to the hash algorithm given above, followed by the rightmost four-digit taken from the patient's national identity number. The rightmost character of the new patient ID will be used as the check digit. For instance, a patient with a four-digit patient number 3425 and national identity number S1234567A has a new patient ID 21245673 as shown below:

Example:

Patient's number: 3425

hash(425) = 212

Patient's national identity number: S1234567A

Therefore new patient ID with c as check digit = 2 1 2 4 5 6 7 c

Check digit c can be obtained using the following rules:

1. Label every character of the new patient ID with a digit position, with the leftmost character as digit at position 8 and the rightmost character as digit at position 1
2. Except for the check digit, multiply each character digit of the new patient ID with its respective digit position
3. Sum all the multiplication results obtained in step (2)
4. Divide the product sum obtained in step (3) by 11 to obtain the remainder
5. Subtract the result obtained in step (4) from 11
6. Divide the result in step (5) by 11 and obtain the remainder as the check digit.

Digit position	8	7	6	5	4	3	2	1
New Patient ID	2	1	2	4	5	6	7	c
Product	16	7	12	20	20	18	14	c

Sum of products = 16 + 7 + 12 + 20 + 20 + 18 +14 = 107

Remainder of 107 divided by 11 = 8

11 – 8 = 3

c = 3 MOD 11 = 3

Therefore, new patient ID = 2 1 2 4 5 6 7 3

(f) With workings shown clearly, find the new Patient ID for the following patients with the following details:

Patient A: Patient Number = `1246`, National Identity Number = `S7654301Z`,

Patient B: Patient Number = `5323`, National Identity Number = `S8563222B`. [5]

Using the same assignment of digit position to every character of a new patient ID, the new patient ID can be validated by first obtaining the sum of product of every digit of the new patient ID and its digit position, including the rightmost check digit. The new patient ID can only be valid if the product of sum is exactly divisible by 11.

(g) With workings shown clearly, validate `Patient's C ID` = `21167892`. [2]

2 With virtual healthcare becoming increasingly popular, medical data is also growing in volume. Health data management, or the practice of collecting, sharing, and managing data in networked medical systems has become more crucial than ever.

(a) Describe how a cybercriminal can carry out a distributed denial-of-service (DDoS) attack and explain its impact. [3]

(b) Explain how medical confidentiality can be breached when patient's information gets transmitted over the internet from one device to another without any forms of encryption. [2]

(c) A digitally signed message that contains patient's medical information is to be sent over the network,

(i) Describe the steps involved in the sender's process of sending the digitally signed message. [3]

(ii) Explain how integrity and authenticity can be ensured when the receiver receives the digitally signed message. [4]

(d) Explain the purpose of having a backup file and an archive file in this context. [2]

Patient's information will be subjected to validation and verification whenever it is entered into a health data management system.

(e) Explain the difference between data validation and data verification. [2]

(f) Use **one** example in each instance to describe how data validation and data verification can be applied to the patient's information before it gets keyed into a health data management system. [2]

3 The IT department of JP Hospital decides to write a program using object-oriented programming language to store billing information of its patients. The following information will be stored each time a patient is billed

Patient ID
Name
Address
Contact number
Cost of doctor's consultation
Cost of medicine

The hospital further classifies patients into **two** different subsidised categories, Tier-1 subsidised patients and Tier-2 subsidised patients. Tier-1 patient subsidy offers a 40% discount off the total medical bill. Tier-1 subsidised patients need to be referred to the hospital by a local polyclinic, have an average household monthly income per person not more than $1200 and the annual value of the patient's home must be less than $20000. If a patient has a referral to the hospital by a local polyclinic but satisfies either one out of the two conditions, this patient will be offered Tier-2 subsidy instead. Under Tier-2, patients will get a subsidy of 20% off their total medical bill. In addition, Tier-2 patient subsidy also covers patients who are not referred to the hospital by a local polyclinic but have an average household monthly income per person not more than $1200 and the annual value of the patient's home must be less than $20000. Any patient who has a household monthly income per person of more than $1200 and home annual value of $20000 and above will receive no patient subsidy.

It is also given that information like the name of the polyclinic referral, average household monthly income per person, annual value of home will be captured for both Tier-1 and Tier-2 patients.

(a) Draw a class diagram, with base class `PATIENT`, showing:

- appropriate subclass(es)
- inheritance,
- encapsulation
- polymorphism
- the properties required
- appropriate methods, including one pair of get and set methods for one of the properties for every class. [4]

(b) **(i)** State the **three** types of access modifiers used in encapsulation. [1]

(ii) Explain encapsulation using the examples from this situation [2]

.

(c) **(i)** Create a decision table showing all the possible outcomes and results. [3]

(ii) Simplify your decision table by removing redundancies. [1]

4 A specialist clinic in JP Hospital plans to store the registration information of patients for the day in a linked list data structure. When a patient arrives and registers at the counter of the specialist clinic, the registration time and name of a patient will be stored as a tuple in a node of the linked list.

(a) Explain why a linked list does not allow direct access to any individual element it stores. [2]

The linked list data structure used to store the registration details of patients. An array is used to implement **two** different linked lists. The data linked list will contain the name of registration time of a patient, while the free space linked list manages the unused space allocated for this data structure.

`Head` is a pointer in the data linked list that references to the first node element of the data linked list, while `NextFree` is a pointer in the free space linked list that references to the next available free node to be inserted into the data linked list. When a node is deleted from the data linked list, the deleted node will be returned and referenced to the tail of the free spaces linked list. The nodes in the data linked list are ordered chronologically by the patient's registration time.

Below shows the memory diagram when the data linked list and the free space linked list are loaded into the memory:

location	data	nextPointer
1	(1600, Pete Tsai)	3
2	(1300, Annie How)	A
3	(1500, Michael Tan)	6
4	(1630, Lucy Leow)	B
5	(1100, Chew Eng Giam)	C
6	(1200, Lester Moh)	0
7	(0900, Cindy Koo)	D
8	(1759, Phua Peh Sim)	1
9	(1500, Boh Tee Chu)	E
10	(1400, Paul Chan)	F

Head: 7
NextFree: 8

(b) It is known that patient `Cindy Koo` was the first patient to register on a particular day, deduce and write down the values for `A, B, C, D, E,` and `F.` [2]

(c) Draw the linked list diagram for the data linked list and the free space linked list. [3]

(d) Draw the linked list diagrams for data linked list and the free space linked list immediately after each of the following operation has been performed:

(i) add patient with name `Gina See` who registered at timing `1130`. [1]

(ii) remove patient `Annie How` from data linked list. [2]

5 JP Hospital would also like to design a database to store data on its patients who are asked to be warded where they are required to stay overnight. A relational database is used to store the information of the patients and wards:

- A patient is uniquely identified by his/her unique Patient ID.
- Each patient's name, gender, address, contact number, medical history stored in the database.
- A doctor is uniquely identified by his/her unique Staff ID.
- Each doctor's name, gender, department and appointment details recorded.
- A ward is uniquely identified by its unique Ward ID.
- Each ward's information related to its speciality, capacity, number of beds occupied, and doctor in-charge of the ward.

When a patient is asked to be admitted to wards by the doctor, the admin staff of the hospital will proceed to admit the patient to the respective ward where a new inpatient admission will be recorded in the database. It is also given that:

- An inpatient transaction should produce information of the patient and the ward he/she is assigned, the date of admission, and the date of discharge.
- A patient can only be admitted to exactly one ward at any one time but can be admitted to different wards over a period.
- Not every doctor will be assigned to be a Ward IC, but every ward will have a one fixed doctor assigned to as the Ward IC.

Relational database aims to address data redundancy and data integrity issues that are common to older flat file databases.

(a) What is the purpose of normalisation? [1]

(b) Explain how data redundancy issues can impact the stored data of JP Hospital in the future if left unattended. [2]

(c) Draw an Entity-Relationship (E-R) diagram show the degree of all relations. [3]

A table description can be expressed as:

```
Tablename( Attribute1, Attribute2, Attribute3,…)
```

The primary key is indicated by underlining **one** or more attributes.

(d) Write table descriptions for the required tables in the relational database so they fully normalised. [4]

6 Primary school students were taught to use the acronym 'PEMDAS' to help them recall the order of precedence for commonly used mathematical operators when evaluating an arithmetic expression. '**PEMDAS**' stands for **P**arenthesis, **E**xponents, **M**ultiplication and **D**ivision, **A**ddition and **S**ubtraction performed from the left to the right of the expression.

Computers on the other hand evaluate infix expressions by first converting its postfix equivalence.

(a) Draw a binary expression tree to represent the infix expression

```
9 + ( 4 – 1 ) /  3 ^ 2
```

[3]

(b) Write down the pre-order and post-order tree traversal of the binary expression tree obtained in **(a)**. [2]

(c) Explain why it is more efficient to evaluate an arithmetic expression in postfix than it is in infix. [2]

(d) Describe step by step in details how the postfix expression can be evaluated by the computer by using a stack. [3]

7 Procedure A is a recursively defined and takes in a single integer parameter x as input. The operations y `MOD` x and y `DIV` x calculate the remainder and quotient results of dividing y by x.

```
Line 1:    PROCEDURE A(x : INTEGER)
Line 2:        IF x=0 OR x=1
Line 3:          THEN
Line 4:             OUTPUT(x)//converts x to STRING & prints x
Line 5:          ELSE
Line 6:             CALL A(x DIV 2)
Line 7:             x ← x MOD 2
Line 8:             OUTPUT(x)//converts x to STRING & prints x
Line 9:        ENDIF
Line 10:   ENDPROCEDURE
```

(a) State the **three** basic programming constructs. [1]

(b) **(i)** State **two** ways that a coder could visually enhance the code readability. [2]

(ii) State the line of code where **b(i)** could be applied. [1]

(c) Explain what it means by recursively defined. [1]

(d) State the line number that defines procedure A to be recursive. [1]

(e) Explain why a stack is used to execute recursive routines. [2]

The table given below allows procedure `A` to be dry-run when `CALL A(43)` is executed in the main program. **[Turn over**

(f) Copy and use the table below to dry-run the recursive procedure `A(43)` when it is called, showing clearly the values of the parameters and the consolidated printed output. [4]

Call procedure	x = 0 or x =1?	x DIV 2	x MOD 2	x	OUTPUT(x)
.....	.....	.....	.....	.....	.....

(g) What does recursive procedure A do? [1]

8 A one-dimensional array `ar` with index locations 1 to 7 stores integers as shown below:

ar[1]	ar[2]	ar[3]	ar[4]	ar[5]	ar[6]	ar[7]
18	39	6	44	41	5	30

The insertion sort can be used to arrange the integers of `ar` a predefined order.

(a) Describe with the aid of diagrams how the insertion sort algorithm can be used to sort all elements of `ar` into ascending order. [3]

(b) State the worst-case time complexity for insertion sort and describe how this can happen. [2]

After arranging the integers in `ar` into ascending order, a binary search function `bin(ar, x)` will only return TRUE if integer `x` is found in the array of integers `ar`.

ar[1]	ar[2]	ar[3]	ar[4]	ar[5]	ar[6]	ar[7]
5	6	18	30	39	41	44

(c) Write down the value of the items **in the order they were accessed** when `bin(ar, 26)` is executed. [2]

(d) State the worst-case time complexity for binary search. [1]

END OF PAPER

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