HWA CHONG INSTITUTION
C2 PRELIMINARY EXAMINATION 2022

COMPUTING
Higher 2

13 Sept 2022　　　　　　**Paper 1 (9569 / 01)**　　　　　　**1400 -- 1700 hrs**

READ THESE INSTRUCTIONS FIRST

An answer booklet will be provided with this question paper. You should follow the instructions on the front cover of the answer booklet. If you need additional answer paper ask the invigilator for a continuation booklet.

Answer *ALL* questions.

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 **8** printed pages.

1 An organization would like to develop a system using object-oriented approach to manage the information of the employees.

The system computes:
- the monthly salary of full-time employees
- the monthly overtime allowance of the full-time employees based on the hourly rate
- the monthly salary of daily-rated employees based on daily rate.

(a) Draw a class diagram, which exhibits the following:
- Suitable classes with appropriate properties and methods
- Inheritance
- Polymorphism   [6]

(b) Explain how your design in **(a)** demonstrates code reuse.   [2]

(c) Explain the term **polymorphism** and how it is applied in the design in **(a)**.   [2]

Due to temporary increase in the amount of work, the organization decided to allow daily-rated employees to receive overtime allowance based on a hourly rate.

(d) Suggest and explain the changes to the class diagram to enable the computation of daily-rated employees overtime allowance.   [3]

2 Mrs Wang is tested positive for flu on day 1 of the month. In order to protect her baby from the virus, she designs her own quarantine rule based on the government policy. For the first seven days, she must fully quarantine at home. After day 7, she performs the diagnostic test in the morning every day. If she has symptoms or tests positive in the morning, she will still go to work for the day but isolate herself at home. Only when she shows no symptoms and tests negative in the morning, she will be fully back to normal life.

(a) Create a decision table showing all the possible outcomes and results.   [4]

(b) Simplify your decision table by removing redundancies.   [2]

(c) The simplified table produced in part **(b)** is used as a design for program code. Write, **in pseudocode**, a program to display Mrs Wang's quarantine result for a particular day.   [2]

3 (a) Describe **two** reasons for layering in the TCP/IP model. [2]

(b) Describe the use of switch and router in the TCP/IP model. [4]

(c) Describe how data is transmitted in a packet switching network. Give **two** advantages of packet switching over circuit switching network. [3]

(d) Describe how a digital signature can be used to give confidence that a received message has not been altered. [6]

(e) Explain the purpose of data verification and give **one** example. [2]

(f) An SMTP server provides email services to the client.
  (i) Describe **one** disadvantage of client-server network. [1]

  (ii) Name **one** malware and describe how this malware compromise computer systems. State **one** protection scheme that can protect the server from this malware. [2]

  (iii) Describe **two** codes of conduct for the IT staff who builds and maintains the server. [2]

4 The first two items of a sequence are 2 and 3 respectively. From the third item onwards, each number is the multiplication of its two preceding items. A function, SEQ, uses recursion, to generate the n-th item of the sequence.

```
01   def SEQ(n):
02       if n < 3:
03           return 2
04       else:
05           return SEQ(n - 1) * SEQ(n - 2)
```

(a) State what is meant by recursion. [1]

(b) Explain how a stack is used when a recursive call is made. [4]

(c) State the line number that indicate function SEQ is recursive. [1]

(d) Modify line 03 to make the function work. [1]

5 A country has a number of cross-country running clubs. A database is to be created storing data about the races and runners.

- Each runner belongs to one club.
- Each race has a date and the distance.
- Each club has name and contact telephone number.
- The clubs have agreed to stage one race only on any date.

This table shows the data about the races and runners.

Runner ID	Runner Name	Club ID	Club Name	Club Tel	Race Date	Race Distance
1	Smith	1	Rede2run	65442781	20-03-2022	15
2	Jones	2	Run4Life	62568892	20-03-2022	15
3	Roberts	1	Rede2run	65442781	20-03-2022	15
1	Smith	1	Rede2run	65442781	15-02-2022	18
4	Harris	3	Run4Fun	64519768	15-02-2022	18
5	Charles	4	FastWalker	64432091	18-04-2022	20
4	Harris	3	Run4Fun	64519768	18-04-2022	20
5	Charles	4	FastWalker	64432091	15-02-2022	18
6	Patel	5	Walk2Fast	62789431	20-03-2022	15
7	Harrison	5	Walk2Fast	62789431	15-02-2022	18

(a) Explain whether the above table is in first normal form (1NF). [1]

The following is an attempt to reduce data redundancy:

Table: `Race`

Race Date	Race Distance
20-03-2022	15
15-02-2022	18
18-04-2022	20

Table: `RunnerClub`

Runner ID	Runner Name	Club ID	Club Name	Club Tel	Race Date
1	Smith	1	Rede2run	65442781	20-03-2022
2	Jones	2	Run4Life	62568892	20-03-2022
3	Roberts	1	Rede2run	65442781	20-03-2022
1	Smith	1	Rede2run	65442781	15-02-2022
4	Harris	3	Run4Fun	64519768	15-02-2022
5	Charles	4	FastWalker	64432091	18-04-2022
4	Harris	3	Run4Fun	64519768	18-04-2022
5	Charles	4	FastWalker	64432091	15-02-2022
6	Patel	5	Walk2Fast	62789431	20-03-2022
7	Harrison	5	Walk2Fast	62789431	15-02-2022

(b) Explain why table `RunnerClub` is not in third normal form (3NF).   [2]

A relational database is to be used. Based on the information given above, design the database that consists of a number of tables.

(c) Draw the Entity-Relationship (E-R) diagram to show the tables in third normal form (3NF) and their relationships between them.   [4]

A table description can be expressed as:

    TableName (Attribute1, Attribute2, Attribute3, ...)

The primary key is indicated by underlining one or more attributes. Foreign keys are indicated by using a dashed underline.

The `RACE` table has been identified with the table descriptions:

    Race(RaceDate, RaceDistance)

(d) Using the information given, write table descriptions for the other tables you identified in part **(c)**.   [4]

Records have been created for all the runners registered for the race on 20-03-2022.

(e) Write an SQL query to output the runner's name, club's name of all the runners entered for this race, in descending order of runner's name, based on the table descriptions for the tables in part **(d)**.
[5]

To promote more races, the agreement between the clubs to stage one race only on any date was cancelled.

(f) Explain whether your existing table design is able to support the change and state the changes required to the design in part **(d)**. [3]

In order to notify the runners when there are new races, information such as contact numbers, addresses need to be stored in the database.

(g) State **two** actions that needs to be done regarding the collection, disclosure and use of this data under the Personal Data Protection Act. [2]

6 Following an outbreak of catpox, the National Infectious Disease Center (NCID) keeps a record of all the infection cases. The records are stored in a list sorted by their date and hour of diagnosis by a doctor.

(a) For contact tracing purposes, NCID wants to identify a patient who was diagnosed on a certain date and time. Explain whether a linear search or a binary search would be more suitable. [2]

As the number of infections increase, it was determined that storing the records in a sorted list is inefficient for contact tracing as the search algorithm is still taking too long. It was suggested to use a hash table with the date and hour of diagnosis as the hash key. For example, someone who was diagnosed at 3:15pm on 13 September 2022 would be assigned the key 13092215 where 130922 is the date and 15 is the hour of diagnosis.

(b) Explain what a hash key is and state the worst-case scenario time complexity of a hash table search. [2]

(c) Give **one** advantage and **one** disadvantage to the method provided in finding the hash key. [2]

(d) State **two** methods to resolve collisions in a hash table. Explain which method would be better suited in the context of contact tracing. [3]

7 A common way to represent negative values using a binary string is the "one's complement" method. To convert a number from its positive to negative (and vice-versa), the binary string needs to be inverted. To invert a binary string, every 0 bit is inverted to become 1 while a 1 bit is inverted to 0. For example, since 5 is 0101 in binary, inverting 0101 will give 1010 which would represent −5.

(a) State the 4-bit binary string that represents −2. [1]

(b) Using **pseudocode**, write a function inv(bin_str) which inverts the 4-bit binary string bin_str. [2]

A function add(num1,num2) calculates the sum of the values represented by the 4-bit binary strings num1 and num2. The algorithm is given as follows:

```
01   def add(num1,num2):
02       ret = "
03       carry = 0
04       for i in range(3,-1,-1):
05           x = int(num1[i])
06           y = int(num2[i])
07           value = x + y + carry
08           if value <= 1:
09               carry = 0
10           else:
11               carry = 1
12               value -= 2
13           ret = str(value) + ret
14       return ret
```

(c) Explain the purpose of lines 07 to 12. [3]

(d) The 4-bit binary strings bit2 and bit4 have numerical values of 2 and 4. Hence, using the functions defined in the question and variables bit2 and bit4, write down the statement to calculate 2 − 4. [2]

(e) Using a suitable example, explain how a miscalculation may occur for the function add(). [2]

8 A data analyst is developing a database of shapes so that different shapes can be recognised using artificial intelligence. Eight different shapes are stored using a binary search tree as shown below.
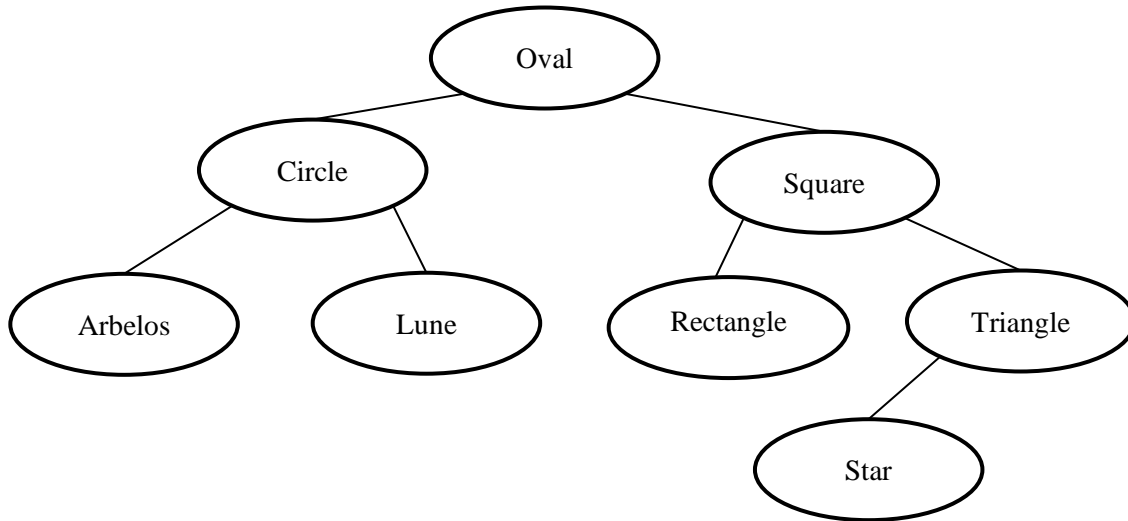
(a) State the output if a preorder traversal algorithm is used to display the tree. [1]

(b) Draw the resulting tree after the following 3 steps:
  - insert 'Geoid'
  - delete 'Arbelos'
  - delete 'Square' [3]

The binary search tree can be implemented using object-oriented programming. Each node comprises three attributes: a `left` pointer, the `data` and a `right` pointer. `None` indicates there are no further nodes in a particular direction.

(c) Write, **in pseudocode**, a recursive procedure that takes the `root` node and outputs the result of an inorder traversal. [2]

(d) Write, **in pseudocode**, a recursive procedure that takes the `root` node, the `target` data and return `True` if `target` data is found in the tree or `False` otherwise. [4]