

Name: _____

Class: _____



JURONG PIONEER JUNIOR COLLEGE

2023 JC2 Preliminary Examination

COMPUTING
Higher 2

9569/01

14 September 2023

Paper 1 (Written)

3 hours

Additional materials: 12-page Answer Booklet
Cover Page

READ THESE INSTRUCTIONS FIRST

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.

Answer **all** the questions.

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**.

- 1 Students from the Robotics Club of a school learn to program robots and drones to perform tasks.

The club wants to use Object-oriented Programming to model the robots and drones.

For every robot, the following data is recorded:

- x coordinate
- y coordinate

For the robot,

- it can move forward, backward, left and right by a given distance.
Moving left and right will increase or decrease the x coordinate, while moving forward and backwards will increase or decrease the y coordinate,
- we can get its attributes, and display its location in cartesian coordinates (x, y),
- its attributes cannot be set directly.

For a drone, which can be considered a flying robot,

- its z coordinate is also recorded.

For the drone,

- it can move up and down by a given distance, in addition to moving in the directions a robot can.
Moving up and down will increase or decrease the z coordinate,
- we can get its attributes, and display its location in cartesian coordinates (x, y, z),
- its attributes cannot be set directly.

(a) For the situation described above, draw a class diagram that shows the following:

- suitable classes with appropriate properties and methods
- inheritance
- polymorphism

[6]

(b) Explain the following by using an example from the situation described above:

(i) encapsulation

[2]

(ii) inheritance

[2]

(iii) polymorphism

[2]

2 The Green Harvest agricultural cooperative is on a mission to harness technology for efficient farm management. They are planning to develop an integrated computerised data management system to effectively store and manage information related to:

- Farmers,
- Crops, and
- Harvest Records.

A relational database management system (RDBMS) will be implemented to create this integrated system.

- Each farmer will be uniquely identified by their `farmerID`.
- Each crop will have a distinctive `cropID`. The `cropID` will follow a specific format, starting with 'C' to indicate a crop, followed by two digits representing the crop type, a hyphen, and additional digits signifying the crop's specific identifier.

(a) Explain the roles and purposes of

(i) a primary key, and (ii) a foreign key.

[4]

As part of this integrated system, a module for recording harvest activities will be introduced to allow farmers to digitally log their crop harvests.

- The system will enforce strict validation to prevent duplicate entries for the same crop in a single harvest record.
- When a farmer successfully records a harvest, a harvest record will be generated.
- Each harvest record will include the harvest date and will link a farmer to the specific crop harvested.
- For example, a farmer who records harvests for three different crops will result in the creation of three separate harvest records.
- The system will also capture any relevant details related to farmers and crops.

You are appointed to be the lead programmer to develop the integrated system.

(b) Differentiate between data redundancy and data inconsistency within this context.

[4]

(c) Explain how unresolved data redundancy can lead to update anomalies and ultimately result in inconsistent data. [2]

(d) The table description can be expressed as follows:

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

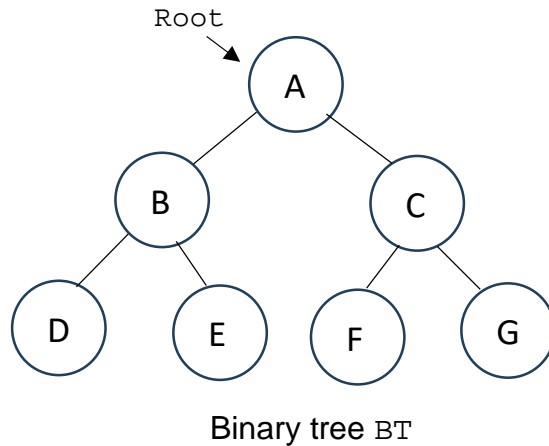
The primary key is indicated by underlining one or more attributes and the foreign key is annotated with an asterisk '*'.

Using the provided data model, create fully normalized table descriptions for the following tables:

- (i) Farmer, and Crop, suggesting **two** additional attributes most appropriate for each table.
- (ii) HarvestRecord, considering that no additional unique keys will be generated by the system to differentiate records in HarvestRecord. [9]

(e) Draw an entity-relationship (ER) diagram illustrating the essential three tables and the relationships between them. [6]

- 3 A binary tree can be implemented using an **array of nodes**, where each node contains an item `Data`, and two integer pointers `LeftPtr` and `RightPtr`, pointing to the array index of the left and right nodes respectively. A pointer `Root` indicates the index of the root node. The following shows the conceptual diagram of the binary tree `BT`.



`BT(pointer)` returns the node stored at the location `pointer` in the array of the binary tree `BT`. A value of -1 in the pointer indicates `NULL`.

- (a) Procedure `X` is written to operate on the global binary tree, `BT`. The procedure has a single integer parameter, `CurrPtr`. The pseudocode for procedure `X` is as follows,

```

PROCEDURE X(CurrPtr)
  IF CurrPtr <> -1
    X(BT(CurrPtr).LeftPtr)
    PRINT(BT(CurrPtr).Data)
    X(BT(CurrPtr).RightPtr)
  ENDIF
ENDPROCEDURE

```

- (i) Write down the output of `X(Root)` in the order they were printed. [2]
- (ii) State the purpose of procedure `X`. [1]

- (b) Using pseudocode, write a function to count the number of nodes in the global binary tree `BT` including the root node and return an integer sum. The function header is as follows:

```
FUNCTION Count(CurrPtr) RETURNS INTEGER
```

The function will be called using `Count(Root)`.

[5]

- 4 The Fibonacci numbers are the integers in the following sequence:

$$f(n) = \begin{cases} 0, & n = 0 \\ 1, & n = 1 \\ f(n-1) + f(n-2), & n = 2, 3, 4, \dots \end{cases}$$

The following pseudocode is a recursive function that returns the n^{th} term of a Fibonacci sequence. You may assume n is larger or equals to zero.

```
FUNCTION Fib(n: INTEGER) RETURNS INTEGER
    IF n = 0 THEN
        RETURN 0
    ENDIF

    RETURN Fib(n-1) + Fib(n-2)

ENDFUNCTION
```

- (a) By analysing the provided pseudocode, identify, and explain **one** potential issue. Suggest an improvement to the pseudocode to address the issue. [3]
- (b) Design a set of **three** test cases to test the `Fib` function. Explain why each test case is important and what it checks. [3]
- (c) Write the descriptive algorithm of an **iterative** solution to find the n^{th} term of a Fibonacci sequence, where n is larger or equals to zero. [5]

- 5 The merge sort algorithm is used to sort some integers of an array. The pseudocode is given as follows.

```

PROCEDURE MergeSort(arr: ARRAY, left: INTEGER, right: INTEGER)
  IF left < right
    mid ← left + INTEGER((right - left) / 2)

    MergeSort(arr, left, mid)
    MergeSort(arr, mid + 1, right)

    Merge(arr, left, mid, right)
  ENDIF
ENDPROCEDURE

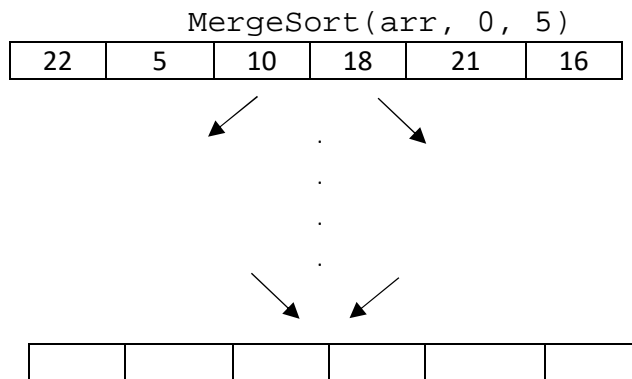
// main
CALL MergeSort(arr, 0, 5)

```

It is given that $\text{arr} = [22, 5, 10, 18, 21, 16]$.

$\text{Merge}(\text{arr}, \text{left}, \text{mid}, \text{right})$ will sort and combine the elements to form a sorted array in ascending order.

The following diagram traces the array of numbers undergoing the merge sort procedure when $\text{MergeSort}(\text{arr}, 0, 5)$ is called. The diagram is incomplete.



- (a) Copy and complete the diagram, showing the intermediary and final values of the elements when $\text{MergeSort}(\text{arr}, 0, 5)$ is called. [4]
- (b) Label in your diagram in part (a) a trace tree of all the MergeSort procedure calls that were made starting from $\text{MergeSort}(\text{arr}, 0, 5)$. [4]

No need to label the Merge procedure calls.

- (c) Explain why a bubble sort **may** be faster than a merge sort in a **mostly sorted** array. [2]

- 6 (a) The TCP/IP protocol is divided into layers. Describe **two** advantages of layering. [2]
- (b) The transport layer is one of the layers in the TCP/IP model. Name and describe one of the protocols in the transport layer. [3]
- (c) A router is a device that allows the connection of a LAN to the internet.
Explain how the router directs an arriving packet to the correct device on the LAN using the Network Access Translation (NAT) table. [2]
- (d) The network service of the Internet Service Provider JPNet was down due to a distributed denial of service (DDoS) attack.
- (i) Explain how the DDoS attack could have been carried out causing the situation described above. [3]
- (ii) Explain two preventive measures against DDOS attacks. [4]
- (e) A check digit serves as an additional digit incorporated into a sequence of numbers with the primary intent of detecting errors. In this instance, a check digit is added to the hexadecimal value $22A01_{16}$. The assigned weights, in denary form, commence from the leftmost position with the values 2, 3, 4, 5, and 6.

Calculate the check digit using the following algorithm:

1. convert each hexadecimal digit to a denary number,
2. multiply the denary number with its weight,
3. sum all the products,
4. divide the sum by 16, and
5. the check digit is the remainder in hexadecimal form.

Determine the check digit for $22A01_{16}$, showing clear working. [4]

- 7 A company customers' personal data of a company was breached. The data was stolen and put up for sale on an online forum.
- (a) Define what is meant by a data breach. [1]
- (b) Discuss the **three** causes that could have led to the data breach listed below.
- One cause due to a perpetrator from within the company,
 - one from outside of the company, and
 - the last can be from within or outside the company. [3]
- (c) For each of the **three** causes that are mentioned in part (b), discuss a measure that can be taken to prevent it from happening in the future. [3]
- (d) In the customers' data that was stolen, the hackers realised the users' login password could not be read. Explain why it is so. [2]
- (e) Explain **one** code of conduct for the IT staff who builds and maintains the database that stored customers data. [1]

- 8 Imagine you are working as a software developer for a company that specializes in developing mobile applications. Your team is currently tasked with creating a new social networking app. As part of this project, you encounter a real-life scenario that requires you to make critical decisions about the use of static and dynamic memory stacks.

The social networking app you are building has a feature called "Timeline" where users can view posts from their friends. Each post contains text, images, and user information. To optimize performance, your team decides to implement a memory management strategy.

Static Memory Stack: You are considering using a static memory stack for storing user profiles and basic information like usernames, profile pictures, and user IDs. The idea is to allocate a fixed amount of memory for each user when they create an account. This memory is never deallocated or resized unless the user chooses to delete their account.

Dynamic Memory Stack: On the other hand, you are planning to use a dynamic memory stack for storing the posts themselves. This stack will allocate memory for each post as it is created and release the memory when the post is deleted or goes out of scope (e.g., when the user scrolls past it in the Timeline).

- (a) Discuss an advantage and a disadvantage of using a static memory stack for storing user profiles in this scenario. Hence, how would the user experience be impacted? [3]
- (b) Similarly, discuss an advantage and a disadvantage of employing a dynamic memory stack for storing posts in the Timeline. Additionally, what challenge may arise in terms of memory management? [3]

END OF PAPER