

NATIONAL JUNIOR COLLEGE
SENIOR HIGH 2 PRELIMINARY EXAMINATION
HIGHER 2

Computing

9569/01

Paper 1 Written

13 Sep 2024

3 hours

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** the questions in the space provided.

Approved calculators are allowed.

The number of marks is given in the brackets [] at the end of each question or part question.

The total number of marks for this paper is 100.

This document consists of **14** printed pages.

1 A 1-dimensional array is used to hold a queue that stores a maximum of 100 elements.

(a) Explain the concept of a queue. [2]

(b) Queues can be either linear or circular. State two differences between a circular queue and a linear queue. [2]

A circular queue is created with an array described earlier.

A `head` pointer stores the index of the item at the beginning of the queue, and a `tail` pointer stores the index of the item at the end of the queue. A `head` pointer of `-1` represents an empty queue.

Write a pseudocode function `Q_Q()` that:

- has four parameters:
 - a queue (array of elements)
 - a value
 - the queue's `head` pointer, global
 - the queue's `tail` pointer, global
- if queue is **not** full, inserts value onto the tail of the queue and returns `True`
- otherwise, returns `False`. [4]

2 An amateur programmer is trying to make a tower defense game, a type of strategy video game where the primary objective is to prevent waves of enemies from reaching a specific point on the map, usually referred to as the "base" or "goal." Players achieve this by strategically placing defensive structures, commonly known as "towers," along the path that enemies travel. These towers automatically attack the enemies, aiming to eliminate them before they reach the base.

A key feature for a tower defense games include a choice for the player of the game to evolve the towers into different varieties, each with different abilities, attack ranges, and upgrade paths.

The programmer wishes to use object-oriented programming to model the logical behaviour of the towers and calculate the damage that the towers can deal to an enemy.

For every tower, the following items of data are recorded:

- location of the tower of the map
- effective range within which the tower can target and attack enemies
- rate at which the tower attacks
- amount of damage the tower deals to enemies with each attack
- initial cost to place the tower
- upgrade costs to evolve the tower to a more powerful version

The programmer decided to implement 2 different types of advance towers that can be evolved from the base towers.

- A thunder tower, which causes enemy to be unable to move for a certain duration. To prevent the tower from continuously stunning enemies, the tower has a cooldown, which is the time (in seconds) that must pass between consecutive stuns. This type of tower deals no damage to the enemies.
- A cannon tower, which has maximum of 3 charges. Charges are the number of times the tower can perform its attack to an enemy. Each attack by the Cannon Tower consumes one charge. The tower recharges its charges over time at some recharge rate. The amount of damage per attack of the cannon tower is the number of remaining charges multiplied with damage of the base tower.

(a) Explain the difference between a class and an object. [2]

(b) Draw a class diagram that shows the following for the situation described above:

- the superclass
- any subclasses
- inheritance
- properties
- appropriate methods. [12]

(c) Name two suitable validation techniques that might be applied to the number of charges of the cannon tower. [2]

(d) Explain inheritance using examples from this situation. [2]

(e) Explain polymorphism using examples from this situation. [2]

3 (a) A binary search tree is implemented as a 1-dimensional array of nodes.

Each node contains three items of data:

- `data` an item of data
- `left` a pointer (array index) to the left node.
- `right` a pointer (array index) to the right node

`root` is a pointer to the root node.

A value of `-1` in `root` indicates an empty tree.

A value of `-1` in both `left` and `right` pointer indicates that it is the leaf node in the binary search tree.

Write a pseudocode function `find()` that:

- has three parameters:
 - a binary search tree (array of nodes)
 - a value to find
 - the binary search tree's root pointer
- follows the pointers in the binary search tree
- returns either the pointer to the node where the value is found or `-1` if the value is not in the binary search tree.

[6]

- (b)** The array `Names` are used to store the nodes a binary search tree described in part (a). The `data` item in each node holds a name. The integer variable, `root`, holds the index of the root node.

Initially, the array `Names` has the following content:

root	Index	left	data	right
0	0	-1	Kingkaa	-1

The following names are to be inserted into the binary search tree in the same order as they are listed below.

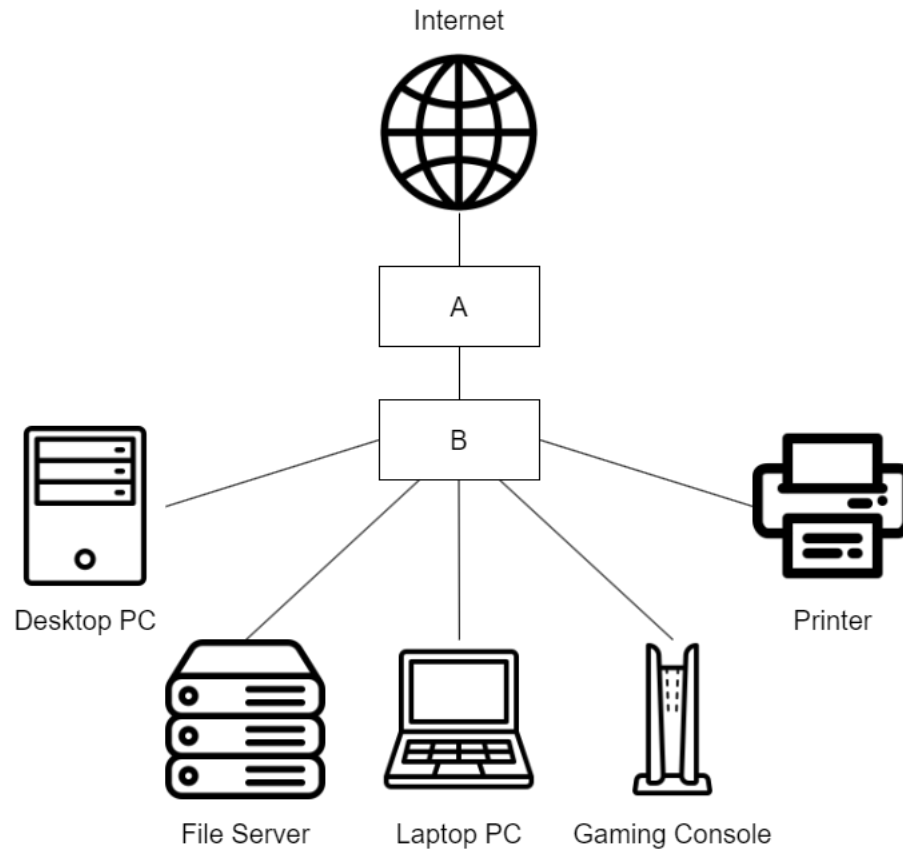
Jashuo, Gongment, Heewin, Vane, Nerray, Zaica

Show the changes to the array `Names` after all the insertions. [3]

- (c)** Draw the binary search tree represented by the data in the array `Names` and the value in `root` from part (b). [2]

- (d)** State the pre-order sequence of the binary search tree from part (b). [1]

- 4 A student is helping to set up a home network for her family. The following diagram shows the configuration of the student's home network.



- (a) This network uses both a switch and a router to transfer data. State which of the pieces of equipment labelled A and B is the switch. Explain your answer. [2]
- (b) State the type of data transfer method the internet uses. [1]
- (c) Explain the method you identified in part (b). [3]

The student decided to allow access to the files in the file server from the internet via a web browser. When she tried to access the files the next day, she received a respond '503 Service Unavailable'. She suspected that a denial of service (DOS) attack is being carried out on her file server.

(d) Explain how a DOS attack operates. [2]

(e) Explain how a firewall can be used to prevent DOS attacks on her file server. [2]

(f) The student is concerned about possible data loss in her file server after the attack. Describe a strategy that could be used to prevent data loss. [2]

5 A league of amateur tennis players has competitive events throughout the year. Each event is scored. Every player represents only one club. The club with the highest score at the end of the year is declared the league champion.

A database is to be used to store the data required about the players, their clubs and events. Each player has a unique player id. The name of the players, together with the name of their clubs are stored.

Each club has a unique club name. The name and email address of the club secretary is stored.

Each event has a unique event number. The date, start time and location of each event is stored.

Each event is limited to a maximum of 128 players with a maximum of 8 players for each club. When a player enters an event, their name and club name are recorded, and they are assigned a unique competitor number in the range 1 to 128 inclusive. For each event, the players will play matches against other players.

When an event is over, the number of points won by each players throughout the matches are recorded.

The event organiser calculates a score of a club by summing the number of points won by all the players from the club participating in the matches in the event. The club name, the event number and the club score are recorded.

Five entities

- Player
- Club
- Event
- EventCompetitor
- EventClubScore

are to be used to define the data needs of the league. The database has not been normalised.

(a) Draw the entity-relationship (ER) diagram and show the relationships between the entities. [4]

(b) Write table definitions, indicating the primary key, for each of the tables listed below. Use the format:

TableName(Attribute1, Attribute2, Attribute3 , etc.)

For foreign key, do a dotted underline below the attribute name.

(i) Player [2]

(ii) Club [2]

(iii) Event [2]

(iv) EventCompetitor [2]

(v) EventClubScore [2]

(c) After each event, an report is produced to be sent to each club's secretary. The report displays, for all competing clubs: the club's name, the club's score for the event, the secretary's name and the secretary's email address. Write an SQL query that will output the required data for an event with the event number 1.

The output must list the clubs in the order of highest score to lowest score. [6]

(d) Normalisation is a process used when designing database tables.

State **two** aims of the normalisation process.

[2]

(e) Assume that a table is already in first normal form (1 NF).

State **two** other requirements of a table being in third normal form (3NF).

[2]

- 6 The recursive binary search function z takes three integer parameters, low , $high$, $seek$ and returns an integer value. It operates on the values in the elements of the array A . The incomplete pseudocode is given below.

```

01 FUNCTION z(low, high, seek, A) RETURNS INTEGER
02     IF low > high THEN
03         RETURN -1
04     ENDIF
05     mid <- ...X...
06     IF seek = A[mid] THEN
07         RETURN mid
08     ELSE
09         IF ...Y... THEN
10             RETURN z(low, mid - 1, seek, A)
11         ELSE
12             RETURN z(mid + 1, high, seek, A)
13         ENDIF
14     ENDIF
15 ENDFUNCTION

```

- (a) Write the pseudocode for X and Y in the partially completed algorithm above. [2]
- (b) (i) State what is meant by **recursive function**. [1]
- (ii) State the line numbers that indicate function z is recursive. [1]
- (iii) State the significance of lines 02 and 06. [1]
- (c) Explain how a stack is used when a recursive call is made. [4]
- (d) State three features of a successful recursive function. [3]

To test the function, a student used the following array A to seek for the value 96. The values in each of the eight elements in the array are.

Element	0	1	2	3	4	5	6	7
Value	8	-3	500	144	96	15	412	101

(e) Copy and then complete the trace table for the instruction:

OUTPUT $z(0, 7, 96, A)$

Function call	low	high	seek	mid	A[mid]	OUTPUT
1	0	7	96			

⋮

[2]

(f) Explain why the binary search function z is unable to locate the value 96 in the array.[1]

(g) The number of elements in array A may be very large.

Explain why a programmer might prefer to use an iterative approach rather than the one used in function z .

[2]

- 7** An online shopping company stores data of its huge base of customers including: name, address and credit card number. It identifies its customers by their unique 4 digit ID number. They are to be stored in a hash table. The hashing algorithm to be used is given below.

```

01 FUNCTION hash(a) RETURNS INTEGER
02     IF a < 3:
03         RETURN a
04     ELSE
05         RETURN hash(a - 3)
06     ENDIF
06 ENDFUNCTION

```

(a) State two ID numbers that gets hashed to the same location. [1]

(b) Explain how two different records hashing to the same location can be managed. [2]

The legal team of the company advises the company director to ascertain that the data stored complies with the Personal Data Protection Act (PDPA) in Singapore.

(c) Describe two ways that can be undertaken by the company to comply with the PDPA. [2]

A database administrator is conducting routine testing and discovers that data breaches have occurred, potentially compromising sensitive customer information. The manager reports the breach to their team leader, who brushed off the report, as they are currently occupied with another project. He proposed to the database administrator to complete the current project and address the breach only after the project completion.

(d) Discuss whether the team leader is abiding by the code of ethics of a computer professional. [2]