ANGLO-CHINESE JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

Higher 2

COMPUTING 9569/01

Paper 1 Written

26 August 2024

3 hours

READ THESE INSTRUCTIONS FIRST

An answer booklet will be provided with the 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 **7** printed pages and **1** blank page.

Anglo-Chinese Junior College

[Turn Over

1 The ASCII system encodes single characters into integers from 0 to 127. For example, the characters `'0'` to `'9'` are encoded into the integers 48 to 57.

    (i) Convert the integers 48 and 57 into binary, and explain how, in these particular cases, the last 4 binary digits are a helpful way to remember which character they represent.   [3]

    (ii) State the maximum number of binary digits needed to represent an ASCII character.   [1]

    (iii) In some ASCII systems, one more binary digit is added as a check digit. Explain the role of a check digit in data validation.   [2]

    (iv) Explain why ASCII is inadequate for multilingual communication between different countries.   [1]

2 A software company has two types of employees – software engineers and marketing personnel. The amount of leave each employee has depends on the type of employee they are, and whether their employment is permanent or contract-based. Permanent engineers get 28 days of leave while contract-based engineers get 21 days of leave. Marketing personnel get 18 days of leave regardless of whether they are permanent or contract-based. In addition, if any employee has been with the company for at least 15 years, they get an additional 7 days of leave.

    (a) Create a decision table to show the conditions and actions for giving leave to the employees of the software company.   [5]

The company uses Object Oriented Programming (OOP) to manage the data and calculate the salary of the employees. All employees have the following data recorded:

- Name
- NRIC/FIN number
- Date of birth
- Date employed

For all engineers, the programming language(s) they are familiar with, and the number of years of experience with that language is also recorded. In addition, for contract-based engineers, the end date of their current contract, and a list of projects they are currently working on, is recorded.

For marketing personnel, a list of clients that they sell to is recorded.

For all employees, the salary calculation is based on all the data described above.

    (b) Draw a class diagram that shows the following in the company as described above:
- The superclass;
- Any subclasses;
- Inheritance;
- Attributes;
- Appropriate methods.   [8]

    (c) Explain the purpose of inheritance using examples from the class diagram in **(b)**.   [2]

    (d) Give an example of how polymorphism is useful in this situation.   [1]

    (e) Explain which attributes, if any, should be private attributes.   [1]

    (f) Describe an effective way to store the data about the engineers' experience with programming languages.   [2]

3 People surf the internet by typing Uniform Resource Locators (URLs) into their browser, which sends a request to a local Domain Name Server (DNS) for an IP address.

(a) Describe what the local DNS does when it receives this request. [4]

(b) The IPv4 system uses 32-bit addresses. It is typically broken into four bytes of eight bits each.

(i) How many possible unique IPv4 addresses are there? [1]

(ii) In today's networked world, what issue would arise from the answer in **(i)**? [1]

(iii) The IPv6 system is intended to replace the IPv4 system. An IPv6 address consists of eight groups of four hexadecimal digits each. How does this solve the issue in **(ii)**? [1]

(c) The webpage's data is sent from the host server to the browser using packet switching.

(i) Explain what is packet switching. [3]

(ii) Describe how packet switching is resilient to damage in the network. [2]

(d) Describe how a Denial of Service (DOS) attack may be carried out against the host server. [3]

4 A computer can be compromised by malware, which may originate from the Internet.

(a) State the names of two kinds of malware. [2]

(b) State two ways in which malware may be transferred from the Internet to the computer. [2]

(c) State two ways in which a user may defend their computer against malware. [2]

A cybersecurity company specialises in selling software to users to help them defend their computers against malware.

(d) State three ethical guidelines the company should follow when developing, advertising and selling their product to customers. [3]

5 The pseudo-code for an insertion sort algorithm is shown below. The indices in the array start from 1.

```
01 PROCEDURE InsertionSort(Arr: ARRAY OF INTEGER)
02      ... (A) ...
03
04     FOR i ← 2 TO N
05          ... (B) ...
06          j ← i - 1
07
09          WHILE j > 0 AND Arr[j] > key
10              Arr[j + 1] ← Arr[j]
11              ... (C) ...
12          ENDWHILE
13
13          ... (D) ...
15     ENDFOR
16 ENDPROCEDURE
```

(a) Write the correct pseudo-code for **(A)**, **(B)**, **(C)** and **(D)** in the algorithm above. [4]

(b) State the worst-case time complexity of insertion sort. [1]

(c) State, with reasons, the best-case scenario for this version of insertion sort. [2]

The pseudo-code for a variant of insertion sort, called binary insertion sort, is shown below.

```
01 PROCEDURE BinaryInsertionSort(A: ARRAY OF INTEGERS)
02     N ← LENGTH(A)
03     i ← 2
04
05     WHILE i <= N DO
06         key ← A[i]
07         left ← 1
08         right ← i - 1
09
10         WHILE left <= right DO
11             mid ← (left + right) DIV 2
12             IF A[mid] > key THEN
13                 right ← mid - 1
14             ELSE
15                 left ← mid + 1
16             ENDIF
17         ENDWHILE
18
19         j ← i - 1
20         WHILE j >= left DO
21             A[j + 1] ← A[j]
22             j ← j - 1
23         ENDWHILE
24
25         A[left] ← key
26         i ← i + 1
27     ENDWHILE
28 ENDPROCEDURE
```

(d) Copy and fill in the trace table below for `BinaryInsertionSort([3,1,6,5,4,2,7])`. [4]

i	key	left	right	mid	A	j

(e) Explain how `BinaryInsertionSort` is better than `InsertionSort`. [3]

(f) The algorithm sorts the array in ascending order. State the changes that need to be made to sort the array in descending order instead. [1]

(g) State the time complexity of `BinaryInsertionSort`. [1]

(h) `BinaryInsertionSort` can be implemented either in-place or not in-place. Explain the differences between an algorithm which is in-place and one that is not in-place. [2]

(i) State one advantage and one disadvantage of an algorithm that is in-place. [2]

6 A company would like to store sales records of its employees. The sales records would need to be frequently accessed and modified. You may assume the number of employees in the company is fixed and would not change.

Binary search trees and hash tables are two data structures that can be used to store the data.

(a) Explain whether binary search tree or hash tables is the more appropriate choice. [3]

(b) Hash functions are used to calculate the index of a hash table from a record key. State two features of a good hash function. [2]

A binary search tree is implemented using a 2-dimensional array. The free nodes are linked through the `Left` pointer. The contents of a particular binary search tree `myarray` are shown below.

myarray

	Data	Left	Right
[0]	30	4	2
[1]		3	None
[2]	40	None	None
[3]		None	None
[4]	10	None	None
[5]	80	None	7
[6]		1	None
[7]	90	None	None
[8]	50	0	5

RootPointer = 8

FreePointer = 6

(c) State the data values accessed in a post-order traversal. [2]

(d) Using pseudo-code, write a recursive function `search(arr, Root, target)` that takes in an array `arr`, root pointer `Root`, and search value `target`. The function checks if `target` can be found in the binary search tree stored in `arr` that is descended from `Root`, and returns `True` or `False` accordingly. [4]

(e) Draw a trace diagram for a recursive function call of `search(myarray, 8, 10)`, where `myarray` is the example array given above. [2]

(f) A binary search can be implemented either as a recursively or an iteratively. Explain how an iterative implementation could be better than a recursive implementation. [2]

7 A running club stores information about the events it organizes and the members of the club in a database.

Each event has a unique name, a distance and a location. The top three runners of every event is also recorded. Members who are in the top three are awarded a score in the range of 1 to 3 inclusive, with the top runner scoring 3 points. Each event has an organizer, who is a member of the club.

Each member has a unique member ID, name, email address, phone number. The events that each member has taken part in, and the number of accumulated points of each member, are also stored.

(a) 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.

Write table descriptions for **all** the required tables in the database so that they are in third normal form (3NF). [4]

(b) Explain the purpose of any foreign keys that have been used from your table descriptions in **(a)**. [2]

(c) Draw the entity-relationship (ER) diagram of the above database. [4]

(d) A table in 3NF must have all data being atomic. State two more conditions for a table to be in 3NF. [2]

(e) Write an SQL query to output all the names of the runners who took part in the "Charlestown Marathon 2002" and have accumulated points below 20. [3]