Computing **9569/01**

Paper 1 Written **31 Aug 2022**

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 **13** printed pages.

1 Let `ArrInt` be a data type that can behave like an array or an integer. Study the following pseudocode:

```
01 // Array uses 0-based array indexing
02 // A[m:n] is an empty array if m > n, Len(A) gives the size of array A
03 Function Fn(A: ArrInt)
04     IF A.IsEmpty() OR A.IsInteger():
05         //IsEmpty() returns True if A is an empty array, else False
06         //IsInteger() returns True if A is an integer, else False
07         RETURN A
08     IF A[0].IsArray():
09         //IsArray() returns True if A is an array, else False
10         RETURN Fn(A[0]) + Fn(A[1:Len(A)-1])
11     RETURN [A[0]] + Fn(A[1:Len(A)-1])
```

(a) **(i)** Identify where and why this is a recursive function. [2]

   (ii) State the significance of line 04. [1]

(b) Explain the use of a stack when the recursive function `Fn` executes. [3]

(c) Draw a trace tree for the function call `Fn([1,[0,1],[2]])`. [4]

(d) Explain what the function `Fn` do. [1]

(e) Write a pseudocode for iterative version of the function `Fn`. [4]

(f) State a benefit and a drawback of using recursive approach in the context of this question. [2]

2 An enterprising student is designing a program for management of musical instruments for the members of his CCA. There are two categories of instruments he is working with, wood-winds and brass. Both Woodwinds and brass instruments are available for loan at no cost for the members of the CCA.

For all instruments, the data that will be stored include:

Instrument Registration Number (IRN)
Date loaned
Date of return
Available for loan
Total repair cost

For woodwinds instruments, the additional data stored include:

Type (clarinet, flute, piccolo, saxophone)
Amount of cork grease needed for maintainance (ml)

For brass instruments, the additional data stored include:

Type (tuba, trumpet, trombone, french horn)
Amount of valve oil needed for maintainance (ml)

When an instrument is loaned:

- date loaned is set to the current date
- return date is set to the date the instrument is expected to be returned
- available for loan is set to `FALSE`.

When an instrument is returned:

- instrument will be assessed for repair need and a repair cost for the loan will be decided.
- repair cost for this loan is added to total repair cost.
- date returned is set to the current date
- available for loan is set to `TRUE`.

Object-oriented programming will be used to model instruments.

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

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

(b) State the purpose of a superclass. Give an example of a superclass from the instrument loan example. [2]

Objects provide encapsulation of properties and methods.

(c) State the purposes of encapsulation. [2]

The CCA decided to extend the loaning to other members of the school by charging a daily loan fee for non-members of the CCA. The loan cost is returned as the daily loan fee multiplied by the number of days the instrument was loaned out by them. Furthermore, to encourage responsibility of instrument maintainance, a flat fee of $0.20 will be charged for any instrument loan from now onwards, including by members.

(d) Suggest changes to the class diagram to enable the new loaning scheme to be used for the instruments. [2]

(e) State the purpose of polymorphism. [1]

3 Student B had just learned about Media Access Control (MAC) addresses. Wanting to understand more about how it works, he collected the MAC addresses of the devices he owned in his home.

  (a) In the context of networking, what is the use of a MAC address of a device? [1]

MAC addresses is usually represented as six groups of 2 hexadecimal digits separated by a colon character `:` .

  (b) Write a pseudocode for a function `hex2dec` that takes in a string `digits` representing a hexadecimal number and output its equivalent decimal number representation in a string format. You are not allowed to use Python inbuilt converter functions in your pseudocode. [4]

  (c) Represent the MAC address `D1:32:13:26:CA:4B` in its equivalent decimal representation. [1]

  (d) Another possible way to represent MAC address is by using the binary representation. Give a reason why hexadecimal representation is used over binary or decimal representation in this case. [1]

Student B decided to use a 0-indexed 1D array, `mac_addresses`, to store the list of the MAC addresses he collected in the order given below

```
97:6E:0F:03:C9:C0
C7:A9:3E:FA:E1:7B
E1:F8:B9:2B:B4:6F
1D:DA:71:05:FD:92
7D:AC:A4:EB:06:F0
DB:96:18:67:3C:E9
8A:28:F0:81:96:E7
5F:25:D3:53:38:4E
FB:05:CD:A3:71:D4
CF:8A:48:F3:59:62
B9:C4:FC:58:45:DF
F8:A9:C7:56:AA:46
52:65:40:45:B8:33
A5:BB:FA:37:FD:90
```

(e) Using a linear search, how many comparisons are needed to find the MAC address `5F:25:D3:53:38:4E`? [1]

(f) Another algorithm to search for an element in an array is binary search. Explain why the binary search algorithm is not suitable to use in this context. [1]

(g) Write a pseudocode to make the array `mac_addresses` suitable for binary search to be used. [4]

(h) Write a pseudocode for the binary search algorithm to search the list of MAC addresses for a given MAC address `mac` which return the index of the item `mac` in the array. [4]

Student B decided to upload the MAC addresses list to his network switch manually.

(i) State the function of a network switch. [1]

(j) Explain how the MAC addresses will be used by the network switch. [1]

(k) To prevent the switch from malfunctioning due to invalid MAC addresses. The manufacturer of the network switch had an inbuilt program to check the data that is being entered.

State two type of validation that are appropriate for this context and explain their working with examples. [4]

4 A client-server model is a way to set up computers in a network.

   (a) Explain what client-server network means. [1]

   (b) State another way to set up a network. [1]

   (c) Describe one benefit and one drawback of a client-network compared to the type of network you suggest in part (b). [2]

In the basic client-server model, clients which simultaneously trying to connect a server could be put into a queue.

   (d) Explain how a queue can be used in this context. [1]

This queue can be implemented in object-oriented programming as a data structure. The implementation of this queue requires two integer variables and an array.

   (e) Describe the purpose of the integer variables in the implementation of this queue class.

   [1]

   (f) Describe the purpose of the array in the implementation of this queue class. [1]

Some servers offer a service where paying customers will receive a priority when sending requests to the server.

Consider the following scenario:

- A_0, B_0 and C_0 are all non-paying customers initially trying to connect to the server in that order,

- A_1, a paying customer, tries to connect to the server and since this customer gets a priority, the queue now goes in the order A_1, A_0, B_0, C_0.

- B_1, another paying customer, joins the queue after A_1 and the queue is now A_1, B_1, A_0, B_0, C_0.

(g) Write a pseudocode for a function `dequeue()` that returns the first element in the queue.

[2]

(h) Write a pseudocode for a function `enqueue(client)` that insert `client` to the queue based on whether the customer is a paying or non-paying customer. You may assume that the queue never reached its maximum capacity. [5]

[Turn Over

5 A teacher-in-charge of managing student examination results is designing a database to store data about:

- students
- courses/subjects
- teachers
- class

He is working with the following constraints:

- each student takes four courses
- each teacher may teach more than one course
- a subject may be taught by more than one teacher.
- the grade a student get for a subject is dependent on the score the student receives according to the following list:
  - less than 40 : Ungraded
  - 40 to 44 : S
  - 45 to 49 : E
  - 50 to 54 : D
  - 55 to 59 : C
  - 60 to 69 : B
  - 70 and above : A

His first attempt is represented by the following table:

Student ID	Student Name	Class Name	Subject ID	Subject	Score	Grade	Teacher ID	Teacher Name
9107	Jamil	22SH91	GEO2	H2 Geography	47	E	GB	Goh Bee
			HI2	H2 History	48	E	WM	Wong My
			GP1	H1 General Paper	60	B	XO	Xin Ong
			EL2	H2 Literature	48	E	MC	Matcher
9202	Ah Seng	22SH92	GEO2	H2 Geography	68	B	GB	Goh Bee
			MA2	H2 Maths	60	B	LS	Leeson
			EC1	H1 Economics	46	E	JS	Jesel
			GP1	H1 General Paper	56	C	WB	Woeber
9323	Yee Yee	22SH93	BENG1	H1 Bengali	63	B	AD	Aaditri
			EC2	H2 Economics	53	D	JS	Jesel
			GEO2	H2 Geography	65	B	GB	Goh Bee
			GP1	H1 General Paper	60	B	WB	Woeber

(a) Explain why this table is not in first normal form (1NF).   [2]

Using the information from the table above, he created the following tables.

Student

Student ID	Student Name	Class Name
9107	Jamil	22SH91
9202	Ah Seng	22SH92
9323	Yee Yee	22SH93

Subject

Subject ID	Subject	Teacher ID	Teacher Name
GEO2	H2 Geography	GB	Goh Bee
HI2	H2 History	WM	Wong My
GP1	H1 General Paper	XO	Xin Ong
EL2	H2 Literature	MC	Matcher
MA2	H2 Maths	LS	Leeson
EC1	H1 Economics	JS	Jesel
BENG1	H1 Bengali	AD	Aaditri
EC2	H2 Economics	JS	Jesel
GP1	H1 General Paper	WB	Woeber

Score

Student ID	Subject ID	Score	Grade
9107	GEO2	47	E
9107	HI2	48	E
9107	GP1	60	B
9107	EL2	48	E
9202	GEO2	68	B
9202	MA2	60	B
9202	EC1	46	E
9202	GP1	56	C
9323	BENG1	63	B
9323	EC2	53	D
9323	GEO2	65	B
9323	GP1	60	B

(b) Give suitable primary keys for each of the following three tables.

   (i) Student [1]

   (ii) Subject [1]

   (iii) Score [1]

(c) Create an entity-relationship (ER) diagram showing the degree of all relations. [3]

(d) Is the table Score in third normal form (3NF)? Explain your answer. [3]

(e) A table description can be expressed as:

`TableName (Attributel, 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 the required tables in the database so they are in third normal form (3NF). [7]

(f) Explain data redundancy and the reasons for reducing data redundancy in a relational database, using examples from the context above. [4]

(g) Write an SQL query to output the subjects names, name of the teacher teaching the subject, scores and grades for the subjects taken by the student with Student ID of 9107.

The table output is to be sorted in descending alphabetical order of subject grades. [5]

END