

2.1 Data struc	tures,	Name:	
abstract data	types part 2	Class:	
		Date:	
Time:	271 minutes		
Marks:	178 marks		
Comments:			

Q1.

- (a) In the context of data structures what is meant by the terms:
- (i) FIFO; _______ (ii) LIFO?

(2)

(b) Queue and stack are examples of data structures. Tick in the following table to indicate whether they are FIFO or LIFO data structures.



Q2.

The following algorithm uses an array Values that contains the integers 4,7,9.

- (a) Dry run this algorithm by using the trace table below.
- Last \leftarrow 3
- New \leftarrow 6
- Ptr 🔶 1

Values[Ptr] - New

New	Last	Ptr			Values		
			[1]	[2]	[3]	[4]	[5]
6	3	1	4	7	9		
				_			

(6)

(b) What is the purpose of this algorithm?



(Total 7 marks)

Q3.

Processes are rated in priority according to their expected running times. Processes with the shortest running times are given top priority. A process joining the list will be placed immediately after all other processes of equal or higher priority. The name of the process indicates the order in which it joined the list. Process6 joined the list before Process7.

The table below contains for each process its name, the memory address of its process control block, its expected running time and a pointer to the position in the table of the next process to be executed.

Processes are entered in the table wherever there is a free slot.

(i) Complete the pointer column after the following processes have been placed in the table:

HeadPointer = 6

Position	Name	Running Time	Address	Pointer
1	Process6	7	01400	
2				
3	Process7	17	01700	
4	Process2	17	02300	
5	Process9	45	04100	
6	Process5	2	01200	
7				
8	Process19	5	01900	

(3)

(ii) The scheduler program is written in a high level language. Name and describe a suitable data structure for this table.

(2)

(iii) The Computer System Manager may wish to view the current order in which the runnable processes are predicted to run. Write an algorithm that will print the process names in runnable order.

(4)

(iv) Name another list of processes that must be maintained by the operating system.

Explain why the processes are in this list.

 	 	·	 	 	 	
		· · · · · · · · · · · · · · · · · · ·				

(Total 11 marks)

Q4.

A multi-storey car park is controlled by a computer system as follows.

For a vehicle arriving at the barrier-controlled entrance:

- the computer system generates an integer number at random from a set of unused numbers which identifies the vehicle to the system
- the vehicle's driver collects a ticket containing this number from a machine at the barrier
- after a short interval a barrier is raised to enable the car to enter the car park
- the computer system remembers the current date, the arrival time and the randomly generated number.

If the car park is full a sign is lit to indicate the situation and no vehicle is allowed to enter the car park.

For a vehicle arriving at the barrier-controlled exit.

the ticket is presented to a machine which reads the number on the ticket

• the computer system determines the length of time the vehicle has been parked in the car park and calculates the amount to pay

- the amount to pay is displayed on the machine
- the driver inserts the correct money into the machine
- the computer system records the length of time in minutes and the amount to pay in pence
- after a short interval the barrier is raised to enable the vehicle to exit.

(a) Taking account of the technology that could be used for ticket production at the entrance barrier, describe **two** different ways for the number assigned to the ticket to be submitted to the computer system at the exit barrier. Your answer should include a reference to the relevant input/output hardware used.

1._____

 	· · · · ·		· · · · ·	 	 	_
		 		 		_
		 		 		_
		 		 		_

(b) Using the table below, construct an appropriate record structure for the computer system to use to record the relevant car parking details for one vehicle. Data types should be given that would be available in a third generation programming language.



Q6.

~

The list **Days** contains the following representation of the days of the week.

[Sun, Mon, Tue, Wed, Thu, Fri, Sat]

The table below shows some functions which take a list as their single argument and

return a result which is either an element of a list, another list, or a Boolean value.

Head(list) - returns the element at the head of **list** (e.g. Head(Days) \rightarrow Sun) if **list** is non empty otherwise it reports an error. **Tail(list)** - returns a new list containing all but the first element of the original list (e.g. Tail(Days) \rightarrow [Mon, Tue, Wed, Thu, Fri, Sat]) if **list** is non-empty otherwise it reports an error. **Empty(list)** - returns True if **list** is the empty list or False otherwise. The empty list is denoted by[] (a) What result is returned when the following function calls are made? (i) Head (Tail(Days)) (1) (ii) Tail ([(Head(Days)])___ (1) Empty(Tail(Tail(Tail(Days)))) (iii) (1) Explain why it is faster to access these elements if the above data is stored as a one (b) dimensional array. XAM PAPERS PRAC (2)

Q7.

The algorithm below re-arranges numbers stored in a one-dimensional array called List. Ptr is an integer variable used as an index (subscript) which identifies elements within List. Temp is a variable, which is used as a temporary store for numbers from List.

(Total 5 marks)

```
Ptr 🔶 I
While Ptr < 10 Do
 If List [Ptr] > List [Ptr+ 1] Then
    Temp ← List [Ptr]
    List [Ptr] ← List [Ptr+1]
    List [Ptr+1] ← Temp
 Endif
 Endwhile
```

(a) Dry-run the algorithm by completing the table below,

It is only necessary to show those numbers which change at a particular step.



What will happen when **Ptr**= 10?

(1)

(c) If the whole algorithm is now applied to this rearranged list, what will be the values of:

(i) List[1]_____

(b)

(ii) List[9] ______ (iii) List[10]? ______ (3)

(Total 11 marks)

Q8.

(a) (i) The birds Pheasant, Teal, Widgeon, Partridge, Woodpigeon are entered, in the order given, into a linked list so that they may be processed alphabetically. Draw this linked list.



(2)

(b) This linked list is said to be a *dynamic structure*. What is meant by the term dynamic structure?

(2)

(c) Explain how memory was allocated for the two additional data items.

(2) (Total 8 marks)

Q9.

The following data is input to a program, in alphabetical order, and is stored.

Anne Bob Claire Dean

- (a) Draw a diagram to show how this data is stored for:
- (i) a stack;



(b) One item is retrieved from these data structures for processing, and Eden is input.

Draw the diagrams of this new situation for:

(i) the stack;

(ii) the queue.

(c) Why are queues in computer systems usually implemented as circular queues?



borrower code. This code is encoded magnetically on to an identity card issued to each borrower when they join the library. The code is read from the identity card by swiping it through a machine connected to the library's computer system. The code is also printed on the card in human-readable form.





Reason: _____

Each book is allocated a unique book code. The book code together with other details as shown in **Figure 2** are pasted on to the inside cover of the book. When a borrower borrows a book the book code is scanned into the computer system so that the loan can be recorded.





(1)

(d) Name the device used to scan the book code into the computer system.

(e)	Each loan is recorded in a separate record. All loan records are stored in a Loans	(1)
file.		
The	loan record includes the following fields:	
Boo Borr Date	kCode owerCode eBookToBeReturnedBy	
(i)	What is meant by primary key?	
		(1)
(ii)	Which of the above fields should be chosen as the primary key?	
(iii) orga	Each new loan can only be recorded at the end of the Loans file. What type of file inisation does the Loans file use?	(1)
		(1)
(f) Boo copy	At the end of each day the information stored in the Loans file is transferred to the ks file using sequential file access. The Books file contains a separate record for each of a book that the library stocks.	
The	book record includes the following fields:	
Boo Borr Loar Date	kCode owerCode nStatus eBookToBeReturnedBy	
The not a	Books file is organised sequentially. The field LoanStatus is used to record whether or a book is currently on loan.	
(i)	Suggest a suitable field on which the Books file would be sorted.	

(1)

(ii) Why should the Loans file be sorted and in what order, before the Books file is updated?

Reason:											
	·		·		·		. <u></u>	·		·	
Order:											

(2)

(g) At the end of each day overdue books are identified. State the processing steps that need to be executed in the library's computer system to extract the loan details of books that have not been returned by the date recorded in the Books file and to record these details in a separate OverDueBooks file. State clearly the data that will be extracted.

Steps: _											_	
											_	
											_	
											_	
			_		_						_	
					- 8	_	-8.					
								-			_	
				_								
											_	
											_	
				_							_	
	V A	N.A				C	D		~ /	T	CE	(4)
	ΛА		PF	1	СК	()		K/	4(- 1		
Data:								·······			_	
											_	
											_	(2)
										(T .	tal 10	(J) (J)
										(10	Dtai 18 ma	irks)

Q11.

The list Ports contains the following names:

[Southampton, Barcelona, Athens, Alexandria, Tunis, Lisbon]

The table below shows some functions which take a list as their single argument and return a result which is either an element of a list or a boolean value.



(d) For the procedure call P(Ports) give the PRINTed output in the order in which it is produced.

(e) Complete the table to show the list Ports as a linked list so that the ports can be accessed in alphabetical order.

1	Southampton	 		Head Pointer
2	Barcelona			
3	Athens			
4	Alexandria	E		
5	Tunis			
6	Lisbon			

EXAM PAPERS PRACT(Total 14 marks)

Q12.

(a) An example of an iteration in Pascal is:

FOR x : = 1 TO 10 DO writeln ('Hello');

In a high level programming language you are familiar with, using the correct syntax, give an example of:

(i)	declaration;	(2)
(ii)	assignment;	
(iii)	selection.	

(4)

(b) A one-dimensional array q contains the following characters:



(i) Dry run the following algorithm, recording your results in the diagram.

FOR pointer \leftarrow 1 to	5	
s[pointer] ← q[poi	nter]	
END FOR		
pointer1 \leftarrow 1		
pointer2 ← 5 REPEAT		
q[pointerl] ←s[poi	nter2]	
pointer1 ← pointer pointer2 ← pointer		PRACTICE
UNTIL pointer $2 = 0$		

q q s [5] [5] D [5] [4] [4] Κ [4] [3] С [3] [3] Т [2] [2] [2] [1] Μ [1] [1]

(10)

(ii) What is the purpose of the above algorithm?

(1) (Total 16 marks)

Q13.

Players, in a national lottery, show their selection of different numbers by placing marks on an entry form similar to the one shown in **Figure 1.** The entry form is then inserted into a machine at the point of sale and the numbers are read.

	National	Lottery E	ntry Form	n	
Which draw?	- 1 -	- 2 -	- 3 -	-4-	- 5 -
Wed	- 6 -	- 7 -	- 8 -	-9-	-10-
	-11-	-12-	-13-	-14-	-15-
Sat ——	-16-	-17-	-18-	-19-	-20-
	-21-	-22-	-23-	-24-	-25-
Both	-26-	-27-	-28-	-29-	-30-
	-31-	-32-	-33-	-34-	-35-
	-36-	-37-	-38-	-39-	-40-
	-41-	-42-	-43-	-44-	-45-
	-46-	-47-	-48-	-49-	

Figure 1

(a) Name the method being used to read the data.

The data are transmitted to a central computer which allocates a unique transaction code. This code is relayed back to the point of sale where a machine prints the chosen numbers and a transaction code onto the ticket similar to the one shown in **Figure 2**.





(b) Each transaction code includes a check digit. What is a check digit and why is it used?

	_	 	 	 	 	
		 	 	 	 	 ·

(c) Each transaction is recorded in a separate record. All transaction records for a particular lottery draw are stored in a single transaction file.

The transaction record includes the following fields:

Date of Purchase				
Point of Sale Identification Co Transaction Code Chosen Numbers	de			
(i) What is meant by prima	ary key?			
(ii) Which of the above field	ds should be ch	nosen as the primar	y key?	(1)

EXAM PAPERS PRACTICE(1)

(iii) What would be a suitable file organisation for the transaction file if it is required that the ticket(s) with the winning numbers is to be found? Justify your choice.

(2)

(iv) If individual records need to be accessed quickly what file organisation should be used? Justify your choice.

(d) After a draw, some lottery prize-winners can check their tickets at any lottery point of sale machine. State the processing steps required by the lottery's computer system to check if the ticket is a winning ticket.

									(Total	(4) 13 marks)
Q14					E	=	L		(1012	10 110110)
The r addre	memory of a	a compu er inforn	iter holds a nation.	an array of	f records,	each of	which i	ncludes	name,	
(a) corre	What conc ctly?	dition is r	necessary	for the bir	nary searc	h (binar <u>y</u>	y chop)	process	s to work	
E	XA	Μ	PA	PE	RS	P	R	4 C	TIC	CE
										(2)
(b)	Describe t	his proc	ess to find	the position	on in the a	array of t	the reco	ord conta	aining a	(2)

given name.



All the trains operate the same cycle (sequence) of journeys, given by the algorithm below. The algorithm is intended to ensure that:

1. trains are serviced as soon as possible after covering 135 km, and

2. each train will have travelled in both directions along each track at least once in the cycle.

The algorithm relates to three arrays called *station*, *journey* and *km*. The contents of these arrays are shown below.

Subscript Station 0 Mong Kok depot (MK) 1 Tsuen Wan (TW) 2 Quarry Bay (QB) 3 Sheung Wan (SW) Chai Wan (CW) 4 5 Hong Kong Central (HK) Subscript Journey 0 3 1 4 2 3 S PRACTICE EXA 3 4 5 5 2 6 3

The 6×6 two-dimensional array **km**, representing the distance between stations (in kilometres), contains

	r irst subscript							
	km	0	1	2	3	4	5	
	0	0	22	28	15	36	12	
Second	1	22	0	50	37	58	34	
Subscript	2	28	50	0	43	64	40	
	3	15	37	43	0	27	3	
	4	36	58	64	27	0	24	
	5	12	34	40	3	24	0	

First subscript

The proposed algorithm is:

org:=0 last := 1 dest:= 3 maintain := FALSE start := station[org] finish := station[dest] totalkm := km [org, dest] org := dest while(TRUE) **n** := 0 repeat n := n + 1 if (maintain = TRUE) then APERS PRACTICE n := last totalkm := 0 maintain := FALSE endif

dest := journey [n]
if (totalkm > 135) then

dest := 0 last := n maintain := TRUE

endif

```
start := station[org]
finish := station[dest]
totalkm := totalkm + km[org, dest]
org := dest
```

until n >= 6

endwhile

(a) What is the effect of the instructions **while**(TRUE) and **endwhile**?

(1) (b) For each of the variables *maintain* and *n*, state with a reason what data type it should be. (4)

(c) Copy and complete the trace table below, for one iteration of the outer (**while** **endwhile**) loop.

	Λ	M	D			DAC	TIC	
n	org	dest	last	Start	Finish	Totalkm	maintain	comments
	0							
			1					
		3					FALSE	
				MK				
					SW			
						15		
	3							

(d) An objective of the algorithm is that each train has travelled in both directions along every track at least once in the cycle. Using your trace table, state, with reasons, whether this objective has been achieved.



Q16.

Data is held in a linked list. The array animals contain records with the content shown.

EXAM	Subscript	Data	Pointer	CTICE
	1	Elephant		
	2	Deer		
	3	Bear		
	4	Rabbit		
	5	Cow		
	6			

(a) Give the values that would be needed in the pointer field of each non-empty record to produce a list in alphabetical order. A pointer value of zero indicates the end of the list.

(b) The variables *Start* and *Freestorage* are used to point to the start of the list and the next free space, respectively. What values should they contain?

(2)

(2)

(c) Describe the steps needed to add "Monkey" to the list.



(3)

(b) Write an algorithm to show how a data item is added to a queue. Take into account the possibility that the queue is full.

