



GCE A LEVEL

1500U40-1



COMPUTER SCIENCE – A2 unit 4

Computer Architecture, Data, Communication and Applications

FRIDAY, 15 JUNE 2018 – MORNING

2 hours

ADDITIONAL MATERIALS

A WJEC pink 16-page answer booklet.

A calculator.

INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Write your answers in the separate answer booklet provided.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question; you are advised to divide your time accordingly.

The total number of marks available is 100.

Assessment will take into account the quality of written communication used in your answers.

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	14	
2.	9	
3.	6	
4.	13	
5.	7	
6.	6	
7.	5	
8.	10	
9.	8	
10.	12	
11.	10	
Total	100	

Answer all questions.

1. (a) Describe the function of two of the buses involved in the fetch-execute cycle. [4]
- (b) Explain the sequence of operations that will occur during the execute phase of the fetch-execute cycle, making clear the role of the Program Counter, the Memory Address Register and the Memory Data Register. [4]
- (c) An assembly language application processes the results of a laboratory experiment. A series of positive numbers is entered. A negative rogue value is used to terminate the series. The program then outputs a total and count for the data values entered.

For example:

```
input    6  3  7  9 -1
output   25
         4
```

The processor has registers R, S and T. Commands available in the assembly language are:

Assembly Language Command	Description
LOD R, X	Load register R with the numerical value X
MOV R, S	Copy the contents of register R to register S
ADD R, S	Add the contents of register R to register S, leaving the result in register R
INC R	Add 1 to the contents of register R
DEC R	Subtract 1 from the contents of register R
JGE R, LABEL	Jump to LABEL if the contents of register R are equal to or greater than zero
JLZ R, LABEL	Jump to LABEL if the contents of register R are less than zero
JMP LABEL	Jump unconditionally to LABEL
IN R	Input a numerical value and store in register R
OUT R	Output the contents of register R

Using appropriate assembly language commands from the table above, write a program to calculate the total and count of a series of input data values, terminated by a negative rogue value. [6]

2. (a) (i) A programmer chooses to use a random access file system with separate overflow area to store records.

Explain what is meant by an overflow area. [2]

- (ii) Another programmer recommends using the following progressive overflow strategy:

- If the memory location calculated for storing a record is already occupied, the record is stored within the main file in the next available empty location in the sequence.
- If the end of the main file is reached whilst searching for an available location, the search continues from the beginning of the main file.

Give **one** advantage and **one** disadvantage of using this progressive overflow strategy compared with a separate overflow area. [2]

- (b) Daily sales records are stored in a random access file. The key field of each record consists of three letters representing the month, followed by two numbers representing the day, and two numbers representing the year, e.g. a record for 8 October 2018 would have the key field: **OCT0818**

The file has 1000 memory locations, numbered 0 - 999.

A hashing method is considered for the file:

- Take the alphabet sequence number of each letter and add them together.
- Add the day number.
- Add the year number.
- Calculate the memory location using the hash function:
total MOD 1000

For example:

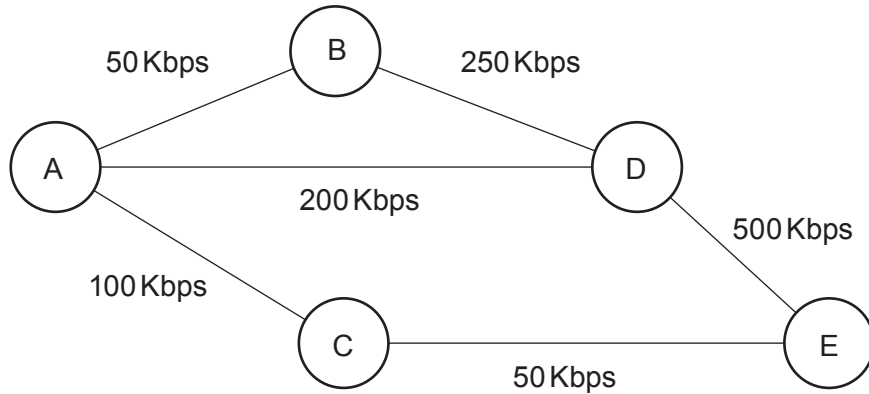
$$\mathbf{MAR2418} \Rightarrow 13 + 1 + 18 + 24 + 18 = 74$$

$$74 \text{ MOD } 1000 = 74$$

So the record is stored in location 74

- (i) The largest number generated by this hashing method is given by NOV3099. Calculate the memory location for this date. [1]
- (ii) Explain why this would be an unsuitable hashing method. [2]
- (iii) Suggest an improved hashing method for storing records with key fields in the same format e.g. OCT0322. [2]

3. The transmission speeds between the nodes of a network have the values shown in the diagram below.



A cost for routing data packets between nodes is calculated by dividing 1Mbps by the transmission speed of the link. For example:

$$\text{cost for the link A to B} = \frac{1 \text{ Mbps}}{50 \text{ Kbps}} = \frac{1\,000\,000}{50\,000} = 20$$

Packets are transmitted between source and destination by the route which has the lowest total cost.

- (a) Calculate the costs for each of the remaining 5 links in the network. [2]
- (b) Copy and complete the table below to show the routes that would be taken by packets from node A to each of the other nodes B to E. [4]

Destination node	Route, listing any intermediate nodes	Total cost
B		
C		
D		
E		

4. (a) The table below shows a design for storing hotel bookings in a database.

Name	Address	Date	Room
John Smith	27 High Street, Bala	16 April 2018	102
Anita Patel	Ty Gwyn, Porthmadog	29 April 2018	216
John Smith	7 Laurel Drive, Bolton	4 May 2018	133, 134
...

- (i) This table is not in normal form. Explain why there may be problems when searching or sorting this table. [2]
- (ii) Re-design the table so that it is in first normal form. [2]
- (b) A local community group organises volunteer drivers to collect elderly residents from their homes and take them on trips. The group has a number of minibuses available which can be allocated for trips on particular dates. Each trip has one driver allocated.
- (i) Produce an entity-relationship diagram to show the relational links between drivers, residents, vehicles and trips. [3]
- (ii) Assume residents individually book seats on trips. Design a database in third normal form for this situation. [6]

5. Staff working in a factory can report an IT problem to a help desk where details are recorded in a database. An engineer can then be allocated to resolve the problem.

Two tables in the database are:

PROBLEM

IncidentID	Date	Location	ProblemDescription	EngineerID
1866	02-May-18	Room A6	printer not working	228
1867	04-May-18	Workshop 4	hard drive fault	182
1868	12-May-18	Room B22	keyboard faulty	228
1869	14-May-18	Warehouse 3	software fault	304
1870	14-May-18	Office C19	computer overheating	182

ENGINEER

EngineerID	Surname	Initial	PhoneExtension
182	Hughes	P	387
228	Sanderson	T	459
304	Wong	K	239

- (a) Write an SQL command to output the IncidentID and ProblemDescription only for all of the problems. [1]
- (b) Write an SQL command to output the Location for all problems allocated to the engineer with EngineerID 228. [1]
- (c) Write an SQL command to reallocate the problem with IncidentID 1866. This problem has now been assigned to the engineer with EngineerID 304. [1]
- (d) Write an SQL command to output the Date and Location for all problems allocated to the engineer with Surname Wong and Initial K. [2]
- (e) Write an SQL command to create a new table DEVICE to contain the IPAddress and DeviceDescription for each electronic device connected to the factory network. [2]

6. (a) Explain, giving an example, how an integer can be subtracted from another integer using two's complementation. [3]
- (b) Identify **three** types of error that could occur when performing logical left shifts on a number in two's complement form. [3]

7. In a certain computer system, real numbers are stored in floating point form using two's complementation, a 10 bit mantissa and a 6 bit exponent.

- (a) Calculate the denary number represented by the floating point number:

0110 1101 00	0001 11
--------------	---------

[3]

- (b) State the effect on the result in question 7(a) if 1 is subtracted from the value of the exponent to give:

0110 1101 00	0001 10
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Calculate the denary number represented by the new floating point number. [2]

8. (a) (i) State a security problem that may arise if a single key (symmetric) encryption method is used. [1]

(ii) An asymmetric encryption method makes use of a private and public key pair. Explain how these could be used in the safe transfer of data over the internet. [3]

(b) A method of encrypting text is the Caesar cypher. Each letter is moved forward in the alphabet by a fixed number of places using modulo 26 arithmetic. For example, using a shift of 5 places, W becomes B.

State why messages using the Caesar cypher can be decrypted easily by an unauthorised person. [1]

(c) Two members of staff in a law firm decide to exchange a confidential message over the Internet using a stream cypher method:

- Letters in the original message are shifted forward by a specified number of positions in the alphabet using modulo 26 arithmetic, but each character in the message is moved forward by a different number of letters.

- The shifts for the first two letters in the message have been agreed:

$$\text{shift}[1] = 4$$

$$\text{shift}[2] = 3$$

- The letter shifts for each following letter in the message are calculated with the formula:

$$\text{shift}[N+2] = \text{shift}[N] + 2 \text{ times } \text{shift}[N+1]$$

where $N = (\text{position of the letter in the message}) - 2$

In this way, for the third letter,

$$\text{shift}[3] = \text{shift}[1] + 2 \times \text{shift}[2] = 4 + (2 \times 3) = 10$$

- Modulo 26 arithmetic is again used. For example, a shift calculated as 30 places would become a shift of $(30-26) = 4$ places.

(i) Calculate the letter shifts for the characters in the fourth and fifth positions. [2]

(ii) Encrypt the word ZEN using this cypher. [3]

9. A large and complex computing task needs to be carried out. Programmers consider two possible solutions:

- using parallel processing on a large computer
- using distributed processing on smaller computers.

(a) Explain what is meant by parallel processing and distributed processing. [4]

(b) Discuss the factors that the programmers might consider when making a choice between parallel processing and distributed processing. [4]

10. (a) Explain what is meant by the term biometric data. [2]
- (b) Describe **two** examples of biometric data. [2]
- (c) Explain using an example how biometric data can permit access to a secure area or system. [4]
- (d) Explain why there may be objections to the use of biometric data. [4]

11. Large organisations use database management systems.

Explain what is meant by a database management system and discuss the tasks carried out by the Information Technology staff who operate the database management system. [10]

END OF PAPER

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