COMPUTER SCIENCE – A2 unit 4
Computer Architecture, Data, Communication and Applications

FRIDAY, 15 JUNE 2018 – MORNING

2 hours

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	

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.

*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:
MAR2418 => 13 + 1 + 18 + 24 + 18 = 74
74 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.
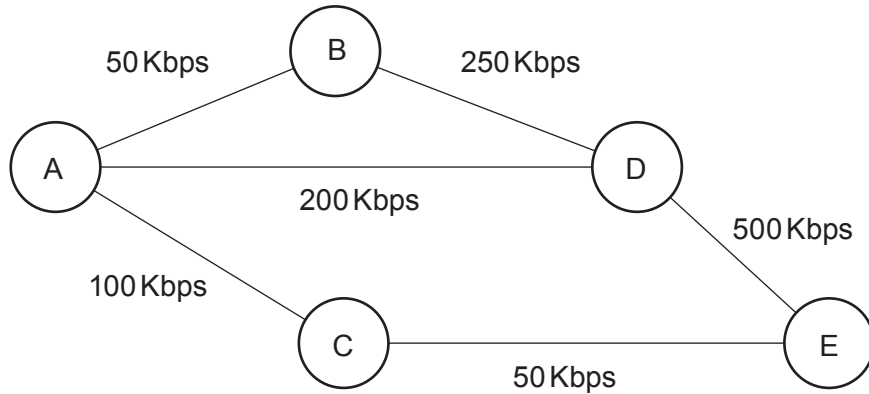
A cost for routing data packets between nodes is calculated by dividing 1Mbps by the transmission speed of the link. For example:

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

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

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:
$$shift[1] = 4$$
$$shift[2] = 3$$

- The letter shifts for each following letter in the message are calculated with the formula:
$$shift[N+2] = shift[N] + 2 \text{ times } shift[N+1]$$
where N = (position of the letter in the message) −2
In this way, for the third letter,
$$shift[3] = shift[1] + 2 \times shift[2] = 4 + (2 \times 3) = 10$$

- 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

BLANK PAGE

BLANK PAGE