Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Introduction to Computer Systems

Date: Thursday 29th May 2014
Time: 14:00 - 16:00

Please answer Question ONE (worth 40% of the paper)

and

any TWO Questions from Question 2, 3, 4 and 5 (each worth 30% of the paper)

This is a CLOSED book examination

The use of electronic calculators is NOT permitted
1. **Compulsory**

   a) Give a brief description of the attributes of PROMs; also state the ways in which a PROM might be used within a computer system, and how data is loaded into them.  
      
      (2 marks)

   b) Represent the decimal integer 37\textsubscript{10} (thirty-seven) as an 8-bit (unsigned) binary integer. NOTE: To gain full marks you must show full working (e.g. Repeated division).  
      
      (2 marks)

   c) A hard disk has a rotational speed of 10,000 RPM, what is the average rotational latency of this disk? NOTE: To gain full marks you must show full working.  
      
      (2 marks)

   d) What is a ‘Program counter’ with respect to the Little Man Computer (LMC)?  
      Also state what the ‘Program counter’ in the LMC simulates in a processor.  
      
      (2 marks)

   e) Given the Little Man Computer program, depicted in figure 1.e., state what algorithmic process the program performs, listing the main steps.  
      
      (2 marks)

   f) Given a word-address in memory, briefly discuss the concept of reading and writing multiple bytes. In your answer briefly address the following issues: how the system is organised, and what address the processor specifies.  
      
      (2 marks)

   g) The Little Man Computer’s (LMC’s) instruction Sub is one of a set; explain explicitly what the LMC does when performing this instruction.  
      
      (2 marks)

   h) List and briefly explain the three issues networking supports.  
      
      (2 mark)

   (Question 1 continues on the following page)
i) Discuss what is meant by the term ‘range limitations;’ support your answer by stating the range of a 4 digits decimal number. (2 marks)

j) The operating system is software that is used by a computer system to support four main functions; briefly describe each. (2 marks)

k) In the context of an operating system and multi-user systems’, what is meant by the term ‘multi-user Systems’? (2 marks)

l) Which part of the Little Man Computer (described in the lectures) corresponds to the ‘primary memory’ part of a real computer system? In your answer briefly describe the part. (2 marks)

m) For an address bus width of 20 bits, calculate the size of the address space. NOTE: To gain full marks you must show full working. (2 marks)

n) Explain what is meant by ‘router or gateway,’ in the context of networks. (2 marks)

o) With respect to memory and a memory hierarchy, calculate the ‘Average memory cost’ given: the primary memory is 16GB and costs £120.00 and the secondary memory is 2000GB and costs £80.00. (2 marks)

p) Briefly explain what is meant by the termed ‘bus activity;’ a diagram may help you explain. (2 marks)

q) Draw and fully label an Ethernet Data Packet. (2 marks)

r) Given an example of an end-user computer, then state its capability, and state whom/what use this type of computer. (2 marks)

s) Give a brief description of an EPROM; also state the ways in which a PROM might be used within a computer system, and how data is loaded into them. (2 marks)

t) Connectivity between the processor and the memory is achieved by using a bus. Briefly differentiate between the ‘address bus’ and the ‘data bus.’ (2 marks)
2. a) Figure 2.a depicts a timing diagram for a memory. Redraw the diagram in your answer book correctly labelling the diagram, given the following labels: address, data, period, a transition, valid address, clock, address enable, and valid data. (4 marks)  

![Question figure 2.a. Diagram of a typical memory timing diagrams.](image)

b) Convert the 16-bit integer represented in hexadecimal as 0x1BC8 to a binary number. NOTE: To gain full marks you must show full working. (4 marks)

c) Knowing the size of memory you can determine the number of address lines needed to address that memory. With respect to address space size; calculate the number of address lines required for the following sizes of memory sizes.  
i) 8 Bytes; (2 marks)  
ii) 128 Bytes. (2 marks)  

NOTE: To gain full marks you must show full working.

d) Perform the following conversions:  
i) Convert the decimal numbers 17\textsubscript{10} and 6\textsubscript{10} to 8-bit, two’s complement binary integers. NOTE: To gain full marks you must show full working (e.g. Repeated division); (4 marks)  

ii) Using binary arithmetic and showing full workings, subtract 6\textsubscript{10} from 17\textsubscript{10} (i.e. 17\textsubscript{10} - 6\textsubscript{10}). NOTE: To gain full marks you must show full working; (4 marks)  

iii) Convert the binary result [in 2.d.ii.] to decimal; proving the binary arithmetic is correct. NOTE: To gain full marks you must show full working. (2 marks)

e) With reference to memory, differentiate between RAM’s and Flash memory. (8 marks)
3. The little man in the Little Man Computer (LMC) does what he is told. In fact he repeatedly steps through six sequential steps. Answer the following question on the six sequential steps:

a) Describe the six sequential steps that the little man constantly repeats. (6 marks)

b) Explain what happens during ‘store’ instructions carried out by the Little Man Computer. (3 marks)

c) Write a program for the Little Man Computer that will read three numbers from the In Basket. The three numbers are referred in the order in which they are read as No1, No2, and No3.

The program should then place the result of: No1 + No2 - No3 in the Out Basket. Your answer should be tabulated as a set of columns: the first [Left hand column] is the program mailbox Address; the second the Opcode, the third the assembly language [Mnemonic], and the fourth Comments. Store data in mailbox addresses 97 (No1), 98 (No2) and 99 (No3); as is depicted in table in figure 3.c. (9 marks)

<table>
<thead>
<tr>
<th>Address</th>
<th>OpCode</th>
<th>Mnemonic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question figure 3.c. Tabulation of: Address, Opcode, Mnemonic, and Comments.

d) Given the algorithm above [re. question 3.c.] draw up a table, similar to the one depicted in table in figure 3.d, which has the seven columns: address, Mnemonic, two for mailbox 98 and 99, one for the calculator, one for IN and one for OUT basket. The variables take on the values: No1 = 2, No2 = 4 and No3 = 3. Draw up this table to depict the process of reading in and then adding then subtraction a sequence of three numbers No1, No2 & No3 using the data structure below; filling in the columns with the appropriate numbers. Again, store data in mailbox addresses 97 (No1), 98 (No2) and 99 (No3). (7 marks)

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Mailbox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Mnemonic</td>
</tr>
<tr>
<td>000</td>
<td></td>
</tr>
</tbody>
</table>

Question figure 3.d. Tabulation of: Address, Opcode, Mnemonic, and Comments.

(Question 3 continues on the following page)
(Question 3 continues from the previous page)

e) A number of components make up the Little Man Computer (LMC). One of the components is a set of mailboxes. Answer the following questions; about mailboxes:

i) State what element the mailboxes hold; (2 marks)

ii) Mailboxes hold two different types of information. Explain the differences between the two different types of information. (3 marks)

4. a) An Amplitude Shift Keying (ASK) modulation scheme is used to transmit a 6-bit data block with the binary value 010010₂. Sketch the waveform that will be transmitted. State any assumptions that you make. (6 marks)

b) In the context of networking; differentiate between: 1. Packet Switching; and 2. Virtual Circuit switching. (5 mark)

c) Given the two network topologies in figure 4.c. (1. & 2.) name and briefly explain the Local Area Network (LAN) protocols that utilise these network topologies. (4 marks)

d) One of the means of transmitting data in a computer system is Token ring transmission; one of the LAN protocols. While transmitting by this LAN protocol a data transmission sequence of five steps is utilised. Briefly describe the five steps. (7 marks)

e) Name and describe two network types which enable computers to be connected, specifically, to a network so that they can communicate with other computers. (8 marks)
5. a) How many distinct integer values can be transmitted over buses with the following widths (numbers of wires)?

i) 15; and  

ii) 9. (2 mark)

NOTE: To gain full marks you must show full working.

b) Explain the basic organisation of a hard disk. Then explain, in detail, the two-step process of read from/write to a disk; naming the delays incurred during each step. (4 marks)

c) The frequency (f) of the clock (i.e. the number of times it repeats each second) is expressed in Hz (Hertz); the frequency is directly related to the clock period.

i) For the following clock periods, calculate the frequency at which the clock is running:

15 μs (microseconds) 

and 

5 ms (milliseconds); (4 marks)

ii) For the following clock frequencies, calculate the clock period:

10 MHz 

and 

25 kHz (4 marks)

d) With reference to processor interaction with memory and the diagram figure 5.d.

i) State what an area marked by ‘[dotted] straight-lines’ [prior to T1 and after T3] implies? (2 marks)

ii) What do the T1, T2, & T3 symbolic labelling imply? (2 marks)

Question figure 5.d. Diagram of two typical memory read/write timing periods.
(Question 5 continues from the previous page)

e) A two-level memory system consists of fast memory (M1) with an access time of 12ns and a slower memory (M2) with an access time of 15ms. M1 services 90% of the memory accesses, what is the average access time of the two-level memory system? NOTE: To gain full marks you must show full working. (3 marks)

f) A computer systems has a three-level memory hierarchy (see figure 5.f.)

M1 has a cost of 20p/MB, a size of 512MB and an access time of 2ns.
M2 has a cost of 1p/MB, a size of 8GB and an access time of 20ns.
M3 has a cost of 0.1p/MB, a size of 2000GB and an access time of 200ns.

Compute the average cost of the memory system expressing your answer in £/GB (pounds per Gigabyte). NOTE: To gain full marks you must show full working. (7 marks)

![Question figure 5.f. A three-level memory hierarchy.](image)