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)

For full marks your answers should be concise as well as accurate. Marks will be awarded for reasoning and method as well as being correct.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted
Section A

1. 

a) With respect to memory and a memory hierarchy, calculate the ‘Average memory cost’ given: the primary memory is 4GB and costs £50.00 and the secondary memory is 500GB and costs £40.00. (2 marks)

b) Convert the 16-bit binary number 0101100111011000 into its hexadecimal equivalent. NOTE: To gain full marks you must show full working. (2 marks)

c) What is a ‘program counter’ with respect to the Little Man Computer? (2 marks)

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

e) For an address bus width of 16, calculate the size of the address space. NOTE: To gain full marks you must show full working. (2 marks)

f) A processor can facilitate Interactive Processing. Explain the term ‘Interactive Processing,’ plus give an example. (2 marks)

g) Give a brief description of a ROM. (2 marks)

h) 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)

i) Explain what is meant by ‘Data Transmission Protocols.’ Also in your answer briefly outline what the protocols cover. (2 marks)
j) What is implied by the term ‘physical media’? Also name three different types of physical media.  

k) The diagram below shows the start of a typical memory write timing diagram. The signal lines are labelled: signal 1, signal 2, signal 3, and signal 4. Name the four signal lines for a typical memory write timing diagram.

l) With respect to networking and communication issues; if two computers are connected, three issues have to be considered. Name the three issues and give very brief description of each.

m) The Little Man Computer’s instruction, e.g. 137, is composed of two sets of decimal numbers: the most significant digit and the two less significant digits. State what function each of these performs.

n) A hard disk has a specific format or disk organisation: two keywords are normally used when describing the disk organisation. State the two keywords and give a brief description of each.

o) Represent the decimal integer $36_{10}$ (thirty-six) as an 8-bit (unsigned) binary integer. NOTE: To gain full marks you must show full working (e.g. Repeated division).
p) Modern processors have data buses that are wider than one byte (8 bits) these are typically 4 bytes (32 bits). The diagram below depicts a 64Kbyte memory with a 16-bit word address bus and a 32-bit data bus; what are the byte addresses it receives if the processor reads from word address 0xFFF8?

(2 marks)

q) Explain what is meant by ‘hardware’ in a computer system?

(2 marks)

r) Explain how the ‘sum’ and ‘carry’ bits are calculated by drawing up a table of four columns for the ‘binary addition rules’. In the first two columns state all four possible bit [addition] combinations. In the third and fourth calculate the ‘sum’ in the third column and the ‘carry’ in the fourth column. Also, in your answer briefly explain how the ‘sum’ and ‘carry’ bits are calculated in each column.

(2 marks)

s) What is a PROM and in what type of applications is it used?

(2 marks)

t) A hard disk has a rotational speed of 7,200 RPM, what is the average rotational latency of this disk? NOTE: To gain full marks you must show full working.

(2 marks)
Section B

2. a) Convert the 16-bit integer represented in hexadecimal as 0xB25F to a binary number. NOTE: To gain full marks you must show full working. (4 marks)

b) With reference to connecting the processor to memory. Connection is achieved by using a bus. The bus is split into three smaller buses. Name and briefly explain the three buses. (6 marks)

c) Perform the following conversions:

i) Convert the decimal numbers 47₁₀ and 20₁₀ to 8-bit, two’s complement binary integers. NOTE: To gain full marks you must show full working (e.g. Repeated division); (4 mark)

ii) Using binary arithmetic and showing full workings, subtract 20₁₀ from 47₁₀ (i.e. 47₁₀ - 20₁₀). NOTE: To gain full marks you must show full working; (4 mark)

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

d) With reference to Random Access Memories (RAMs), differentiate between Static RAMs and Dynamic RAMs; SRAMs and DRAMs. (6 marks)

e) Knowing the size of memory you can determine the number of address lines needed to address that memory. With respect to address space size; state the number of address lines required for the following sizes of memory sizes?

i) 512Bytes; (2 mark)

ii) 16Bytes. (2 mark)

NOTE: To gain full marks you must show full working.
3. 

a) Explain what is meant by ‘seek time’ in the context of read from or write to a disk. (4 marks)

b) How many distinct integer values can be transmitted over buses with the following widths (numbers of wires) – or what is the maximum number of different values that can be transmitted, this question assumes binary encoding on each wire:

i) 4? (2 mark)
ii) 7? (2 mark)

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

c) With reference to processor interaction with memory and the diagram below.

i) State what an area marked by ‘cross-hatching’ implies? (2 marks)
ii) What do the t1, t2, & t3 symbolic labelling imply? (2 marks)

[Diagram of the start of a typical memory read timing diagram]

d) 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, indicate the frequency at which the clock is running:
10 ms (milliseconds)
and
2 μs (microseconds); (4 marks)

ii) For the following clock frequencies, indicate [calculate] the clock period:
100 kHz
and
200 MHz (4 marks)
e) A two-level memory system consists of fast memory (M1) with an access time of 50ns and a slower memory (M2) with an access time of 5ms. 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 below) M1 has a cost of 200p/MB, a size of 256MB and an access time of 2ns. M2 has a cost of 10p/MB, a size of 4GB and an access time of 20ns. M3 has a cost of 0.2p/MB, a size of 256GB 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)
4. In the context of networking:

a) There are nominally four network topologies. Name and briefly describe each network topology

b) Given the two network topologies below (1. & 2.) name and briefly explain the Local Area Network (LAN) protocols that utilise these network topologies.

c) The diagram below depicts a LAN protocol. Give a description of the transmission of data utilising the depicted network LAN protocol [steps (1) to (5)]. Please also name the LAN protocol and give the names of the items transmitted in your description.
d) An Amplitude Shift Keying (ASK) modulation scheme is used to transmit a 6-bit data block with the binary value 010010_2. Sketch the waveform that will be transmitted. State any assumptions that you make. (6 marks)

e) One of the means of transmitting data in a computer system is Ethernet transmission; one of the LAN protocols. While transmitting by this LAN protocol a collision may occur. State the four steps taken by the Ethernet LAN protocol to deal with collisions. (4 marks)
5. 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) The LMC inputs data and outputs data utilising three items in the LMC. Name the three items in the LMC that are directly involved with inputting data and outputting data. 
(3 marks)

c) The LMC inputs data and outputs data utilising three items in the LMC. Describe how the LMC inputs and outputs data. In your description also name the LMC instructions that are used and what form the data takes. 
(6 marks)

d) 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 four 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). 
(8 marks)

e) Given the algorithm above [re. question 5.e.] draw up a table, similar to the one below, 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>
<th>Calculator</th>
<th>IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Mnemonic</td>
<td>98</td>
<td>99</td>
<td></td>
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<td>000</td>
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END OF EXAMINATION