Answer ANY THREE questions.
If you answer more, the best three answers will be taken into account.

1. (a) Give the common diagrammatic representations for the following gates:

(i) AND

(ii) OR

(iii) Inverter (NOT)

(iv) XOR (Exclusive OR) [4 marks]

(b) What small symbol, when attached to the input or output of a gate, is used as an alternative to the Inverter gate? Give the common diagrammatic representations for the following gates using this symbol:

(i) NAND (Not AND)

(ii) NOR (Not OR) [3 marks]

(c) Draw the gate diagram for the circuit described as follows:
There are two circuit inputs named C and D and two circuit outputs named P and Q. The outputs P and Q are additionally fed back into the circuit, so that P depends on Q and Q depends on P. The circuit implements the following expressions:

P = (D NOR C) NOR Q

Q = (C NOR (NOT D)) NOR P [10 marks]

(d) Assume that at time t = 0, P = 1 and Q = 0. Copy and complete the table below by calculating the values of the outputs P and Q at each of the times t = 2, t = 3, ..., t = 9, using in each case the tabulated input values C and D at time t, and the values of P and Q at time (t - 1). (Remember that the output of a NOR gate is 1 if and only if both inputs are 0).

Time	C	D	P	Q
0	-	-	1	0
1	1	1	1	0
2	1	0		
3	0	0		
4	1	1		
5	0	1		
6	1	1		
7	0	1		
8	0	0		
9	1	0		

[16 marks]
[Total 33 marks]
[TURN OVER]

2. (a) Consider a word comprising 32 bits. This collection of bits might represent many different things; give seven different possibilities for a MIPS architecture. [7 marks]

(b) How does the computer decide between the different possible interpretations of a bit-pattern? [5 marks]

(c) Show how to evaluate the following two subtractions in two's complement arithmetic assuming a word length of 4:

5 - 3

3 - (-5)

What can you say about the correctness of the answers obtained? [6 marks]

(d) Consider the following one word bit-pattern:

00000000001000100100000000100000

Assuming that this bit-pattern is a MIPS instruction, what structure does the bit-pattern have in terms of the meanings of the different bits? What MIPS assembler instruction does this bit-pattern represent? [15 marks]

[Total 33 marks]

3. (a) Why is a stack important for the implementation of procedures? For what information is the stack typically used? Which MIPS registers are typically involved? [8 marks]

(b) What is a recursive procedure and how might a recursive procedure encounter a problem related to the stack? [3 marks]

(c) The factorial function is defined by:

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factorial(0) = 1
factorial(n) = n * factorial(n-1)
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Give a MIPS assembler program which evaluates factorial(4) by using a *recursive* procedure. Your program should make appropriate use of the stack and should include comments. Minor errors in syntax will not be penalised. [22 marks]

[Total 33 marks]

[CONTINUED]

4. (a) Explain what is meant by the "principle of locality" in memory systems, and why is it important? What is meant by the terms "cache hit" and "cache miss" in the context of memory hierarchy? [10 marks]

(b) There is an 8 word direct mapped cache, with a word length of 8 bits. The cache block size is one word. Initially the cache is empty, and the following sequence of memory addresses are referenced for reading: 17, 6, 22, 8, 17, 24. Show the state of the cache after each read, using this to explain how such a system works. How would such a system need to be amended to fully take account of the principle of locality? [15 marks]

(c) Explain what is meant by "virtual memory" and in particular how a virtual address is mapped to a physical address. [8 marks]

[Total 33 marks]

5. (a) Draw a diagram of the main functional components of a computer system. Your diagram should include any necessary communications lines and should include the floating point co-processor. [11 marks]

(b) What is the purpose of the floating point co-processor and what does it contain? [3 marks]

(c) Under what circumstances might floating-point arithmetic in the floating-point co-processor give a wrong answer? Are correct answers always precise? [3 marks]

(d) What decimal number does the binary number 0.010011 represent, and how would you express this binary number in *normalised binary scientific notation*? What is the *significand* and what is the *exponent* for this number? [6 marks]

(e) Explain, *with examples*, the internal representation of a floating point number. You should include in your explanation (i) how many bits are used for the various components (ii) how both negative and positive exponents are expressed, and (iii) both *how* and *why* part of the number is regarded as "implied" rather than directly expressed. Do *not* attempt to explain overflow. [10 marks]

[Total 33 marks]

[END OF PAPER]