UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2002

BSc Honours Degree in Mathematics and Computer Science Part I
MSci Honours Degree in Mathematics and Computer Science Part I
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER MC110

ARCHITECTURE

Monday 22 April 2002, 16:00
Duration: 90 minutes
(Reading time 5 minutes)

Answer THREE questions

Paper contains 4 questions
Calculators required

1. Representing Numbers in Computers

a Copy out and complete the entries in the following table. All numbers have the equivalent of 8-bits of precision. Write *out-of-range* in a table cell if the value cannot be represented.

Octal, 2s Complement	Hexadecimal, Sign Magnitude	Binary, 2's Complement	Binary, 1's Complement	Binary, Excess 85
357				
	AD*H*			
		1001 1111		
				0111 1010

b Multiplication and division of binary numbers by powers of 2 can be accomplished by simply shifting the bits to the left or to the right accordingly. Describe a procedure to multiply and divide a binary 8 bit number by 2^x if the binary number is represented as (i) unsigned binary, (ii) sign-magnitude, and (iii) twos-complement.

c How do you detect overflow in each of the cases of 1b above. Give a detailed practical procedure for the overflow test for 1b(i)(ii), and (iii).

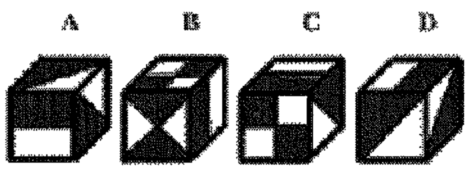
d Assume we have a novel kind of data storage technology that stores information by arranging strings of microscopic cubes so that different faces of the cube point upwards. For example, the four cubes below show such a string of cubes. Now assume we encode an "eight cube" or eight digit number by looking at the string of cubes. The value of each digit depends only on the face of the cube that points upwards.

(i) Propose a positional number system for integers that uses the cubes, i.e. decide what the most efficient base of that number system should be, and what the values of the faces (digits) are.

(ii) Convert 99 (decimal) to the above number system.

(iii) Assume each cube takes up as much space as a bit in current technology. How much more data could the cubes store on the same space compared to current technology.

Explain all your answers in detail.



The four parts carry equal marks.

2 The Memory System

a The following series of memory accesses is performed on a little endian and on a big endian machine with 16 bit words. Show the resulting values for each byte address of modified memory for the little and big endian case (assume that text characters are encoded with ASCII, hint: the character 'A' is encoded as 65).

```
write Mem[0], 5H
write Mem[Mem[0]], AH
write Mem[4], BEEFH
write Mem[1], "ABC"
write Mem[2], BADH
```

b Assume a computer system with 24 bit addresses where the processor always reads or writes chunks of 16 bytes at a time to and from memory. You have the task to design an efficient memory system for this machine using 8 chips, 128 Mbits each. Each chip provides access to 8 bits of data at a time.

(i) Do you use high or low order interleaving? Explain your answer.
(ii) How many memory banks does your memory system have? How many bits of the address are used to select a bank? How many bits of the address are not used?
(iii) Draw a block diagram of the memory system consisting of the 8 memory chips, showing the memory banks and the number of address lines that go to each chip.

c Would it be possible to support a little and a big endian mode for the computer from 2a (of course not at the same time) by using two separate ways of interconnecting the memory with the processor, and having a switch that switches between little and big endian? Explain your answer in detail.

The three parts carry marks of 25%,50%, and 25% respectively .

3 We define a new 16-bit floating point format called Mini Precision that follows the same general rules as the IEEE Single Precision format except that the Exponent field is 6 bits and the Significand field is 9 bits.

	1 bit	6 bits	9 bits
Mini Precision Format	Sign S	Exponent E	Significand M

a For this format :

i) give the formula for representing decimal values in terms of S, E and M

ii) calculate the largest normalised positive value which can be represented

iii) calculate the smallest normalised positive value larger than zero which can be represented.

For parts ii) and iii) above also convert the number to decimal.

b Interpret the 16-bit hexadecimal pattern $C1F0 as a Mini Precision number and then convert the number to decimal.

c Convert the decimal number 6.4375 to Mini Precision format showing clearly the steps taken.

d Carry out the addition of the numbers in parts b and c in Mini Precision format showing clearly the steps taken.

N.B. You do NOT need to convert the result back to decimal .

Each part carries approximately equal marks.

4a Give a 68000 assembly code skeleton (or pattern) which you would use to implement the meaning of a general high level language FOR-STEP-NEXT loop.

b Show carefully how you could modify this skeleton to implement the meaning of a hypothetical "enumerated list" loop:

For I in {2,3,5,7,11,13}

<any body instructions>

Next I

where I successively takes the values on the list each time round the loop.

c Provide commented 68000 assembly code for the assignment statement:

pos := Position ('G', Alphabet, 26)

where pos and Alphabet are global variables and Position is declared as:

```
function Position (ch : char,
                   var str : array 1..* of char,
                   len : int) : int
```

For this problem assume characters are 8-bit and integers are 16-bit. State any additional assumptions that you make. Note that *str* is a **var** parameter.

d) i/ Using a diagram and sample code, describe carefully how the parameters are accessed from within the function.

ii/ Give two reasons why parameters are usually passed on the stack?

iii/ Explain the difference between ordinary and **var** parameters and give two different situation where **var** parameters are used.

Each part carries, approximately equal marks.

/ End of Paper