

A=analysis, D=design, C=calculated solution using taught theory, B=bookwork  
 NB - marking will be 1 mark for every 2% indicated on question paper (max 50 marks) so marks here are half of marks on question paper.

### Solution to Question 1

36 minutes for the question => 9 minutes each part

a)

i) 1074.75

ii) 270F

iii) 112

iv) -1

v) 1023

[1 mark each, except iv & v 1 mark if both right]

[4C]

b)

see eeee emmm mmmm mmmm mmmm mmmm mmmm

(i)  $s=0$ ,  $e=158$ ,  $m=0 \Rightarrow \text{exp}=31$ ,  $\text{mant}=1 \Rightarrow 2^{31}=2147483648$  [2 marks]

(ii)  $s=1$ ,  $e=125$ ,  $m=10001\dots \Rightarrow \text{exp}=2^{-2}$ ,  $\text{mant}=1.001 \Rightarrow -1.125/4=0.2812$  [2 marks]

Unsigned exponent => 31 bit unsigned comparison can be used on floating point, and combine with sign bit [2 marks]

[6C/A]

c)

R0=2

R1=4

R2=2-32=-30

R3=6

R4=0

Timing:

0: 0-3

4: 1-4

8: 2-6

C: 4-7

[4A]

d)

(i)  $-28 \times x$

(ii)

RSB R1, R0, R0 lsl 3; R1 := R0\*7

RSB R1, R1, R1 lsl 4; R1 := R1\*15

(iii)

$\text{floor}((2^{31}-1)/105) = 20452225$  (allow approximations)

[6A/D]

## Solution to Question 2

27 minutes for the question

*This tests ability to understand low-level operation of ARM assembler instructions*

**For each part, deduct 1 mark for each column wrong down to minimum of 0 marks, except in allow consequent errors in memory write data.**

**Assume  $\text{mem}_8 = \text{mem}_{32}$ . Ignore entries in n/a columns**

	r0	r1	r2	r3	r4	NZCV	Memory
a)	-2	3	&100 256	1	-3 &FFFFFFFD	1000	$\text{mem}_{32}[\&104] = 3$ 260
b)	&10B 267	1	&01020304 16909060	1	n/a	n/a	$\text{mem}_8[\&1] = 1$
c)	&FC 252	$2^{31}+2^8$ &80000100 2147483904	$2^9$ &200 512	$2^{10}+1$ &401 1025	&01000000 $2^{24}$ 16777216	0011	$\text{Mem}_{32}[\&100]=\&401$

[5A+5A+5A]

**Solution to Question 3**

27 minutes for the question

*This questions tests understanding of the operation of different types of direct-mapped caches.*

a)

each line has two words

i	tag	index	word sel	type
1	0	0	0	M
2	0	0	1	H
3	0	1	0	M
4	0	1	1	H
5	1	0	0	M

14,18,14,10, c, 8, 4, 0, 4, 8, c  
 H, M,H, H, M,H, M,H, H,H,H,

[5A]

b)

i	tag	index	word sel	type
1	0	0	0	M
2	0	1	0	M
3	0	2	0	M
4	0	3	0	M
5	1	0	0	M

M,M,H,H,H,M,M,M,H,H,H

[5A]

c)

1 R0,R4  
 2 none  
 3 R8, RC  
 4 none  
 5 W0,W4, R10,R14  
 6 none  
 7 none  
 8 none  
 9 W10,W14,R0,R4

[5A]

**Solution to Question 4**

*This question tests whether the student understands the ARM conditional instructions and pipeline, and implications for code timing.*

27 minutes for the question

```

TEST
    CMP R1, R0
    CMPEQ R3, R2
    BEQ T1
    RSB R5, R4, #0
    B T2

T1
    MOV R5, R4

T2

```

- a)  
if (R1=R0) and (R3=R2) then R5 := R4 else R5 := -R4

Either the BEQ branch is executed or the B branch is taken. The taken branch has execution time 4 cycles, all other instructions one cycle.

[4A]

- b)

```

TEST
    CMP R1, R0
    CMPEQ R3, R2
    BEQ T1
    RSBNE R5, R4, #0
    MOVEQ R5, R4

```

[4D]

- c) F=Fetch, D=Decode, E=execute

1F	1D	1E						
	2F	2D	2E					
		3F	3D	3E				
			4F (aborted)	S	S	4F	4D	4E

[4B]

- d)  
 $100\text{MHz} * 1/(1+BPL) = 100/(1+0.25*0.4*5) = 66.6\text{MHz}$ . Must assume branch latency = pipeline length

[3C]