Question 1

M = 1011, −M = 11110101

Q = 10010011

A = 0

n = 8

→ Initialize:

M = 00001011, A = 00000000, Q = 10010011

→ Shift left:

M = 00010110, A = 00000001, Q = 0010011_

→ A = A − M:

M = 00010110, A = 11110110, Q = 0010011

→ Q[0] = 0, restore A = A + M

M = 00010110, A = 00000001, Q = 00100110

n = 7

→ Shift left:

M = 00101100, A = 00000010, Q = 0100110_

→ A = A − M:

M = 00101100, A = 11110111, Q = 0100110_

→ Q[0] = 0, restore A = A + M

M = 00101100, A = 00000010, Q = 01001100

n = 6

→ Shift left:

M = 01011000, A = 00000100, Q = 1001100_

→ A = A − M

M = 01011000, A = 11111001, Q = 1001100_

→ Q[0] = 0, restore A = A + M

M = 01011000, A = 00000100, Q = 10011000

n = 5

→ Shift left

M = 10110000, A = 00001001, Q = 0011000_

→ A = A - M

M = 10110000, A = 11111110, Q = 0011000_

→ Q(0) = 0, restore A

M = 10110000, A = 00001001, Q = 00110000

n = 4

→ Shift left

~~M = 10 01100000, A = 000~~

M = 01100000, A = 00010010, Q = 01100000_

→ A = A - M

M = 01100000, A = 00000111, Q = 0110000_

→ Q(0) = 1

M = 01100000, A = 00000111, Q = 01100001

n = 3

→ Shift left

M = 11000000, A = 00001110, Q = 1100001_

→ A = A - M

M = 11000000, A = 00000011, Q = 1100001_

→ Q(0) = 1

M = 11000000, A = 00000011, Q = 11000011

n = 2

→ Shift left

M = 10000000, A = 00000111, Q = 1000011_

→ A = A - M

M = 10000000, A = 11111100, Q = 1000011_

→ Q(0) = 0, restore A

M = 10000000, A = 00000111, Q = 10000110

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n = 1

→ Shift left

M = 0000 0000, A = 0000 1111, Q = 0000 110_

→ A = A - M

M = 0000 0000, A = 0000 0100, Q = 0000 110_

→ Q(0) = 1

M = 0000 0000, A = 0000 0100, Q = 0000 1101

M = 1011 = 11

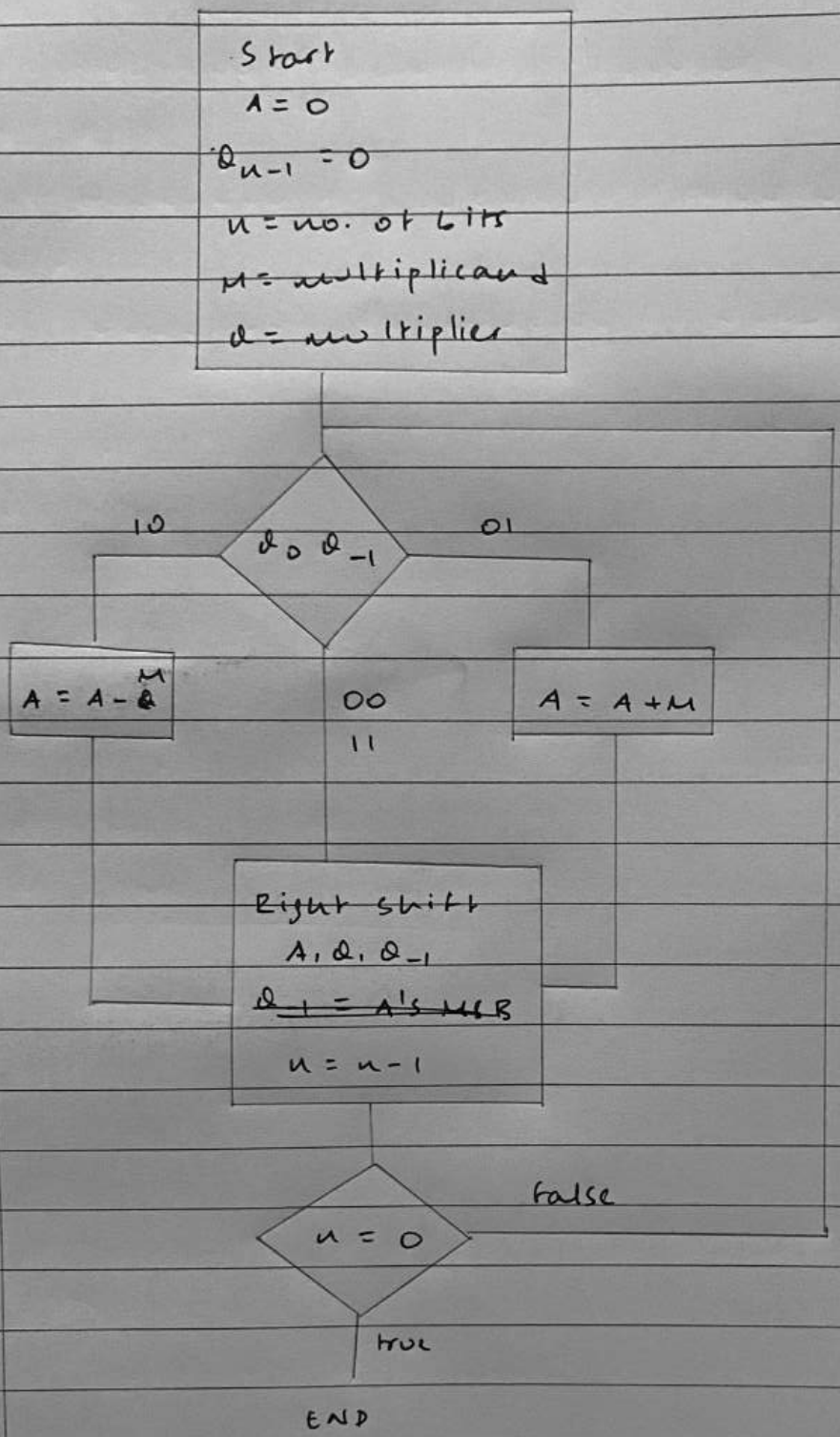
Q = 147

$$\frac{Q}{M} = \frac{147}{11} = 13 + \frac{4}{11}$$

A = 100 = 4 (remainder)

Q = 1101 = 13 (quotient)

Question 2



M = -9 = 10111 , -M = 01001

Q = -12 = 10100

Q_{-1} = 0

n = 5

→ $Q_0 Q_{-1}$ = 00 , shift right

A = 00000, Q = 01010, Q_{-1} = 0

n = 4

→ $Q_0 Q_{-1} = 00$, shift right

A = 00000, Q = 00101, $Q_{-1} = 0$

n = 3

→ $Q_0 Q_{-1} = 10$, A = A - M

A = 01001, Q = 00101, $Q_{-1} = 0$

→ shift right

A = 00100, Q = 10010, $Q_{-1} = 1$

n = 2

→ $Q_0 Q_{-1} = 01$, A = A + M

A = 11011, Q = 10010, $Q_{-1} = 1$

→ shift right

A = 11101, Q = 11001, $Q_{-1} = 0$

n = 1

→ $Q_0 Q_{-1} = 10$, A = A - M

A = 00110, Q = 11001, $Q_{-1} = 0$

→ shift right

A = 00011, Q = 01100, $Q_{-1} = 1$

AQ = mult result

M x Q = -9 x -12 = 108 = 01101100

AQ = 0001101100

= 01101100

= 108

Question 3

3-address machine	Fetch	Exec.	Memory Traffic
SUB A, B, C	4	3	7
MPY A, A, D	4	3	7
	8	6	14

2-address machine	Fetch	Exec.	Memory Traffic
MOV T1, B	3	2	5
SUB T1, C	3	3	6
MPY T1, D	3	3	6
MOV A, T1	3	2	5
	12	10	22

1-address machine	Fetch	Exec.	Memory Traffic
LOAD B	2	1	3
SUB C	2	1	3
MPY D	2	1	3
STORE A	2	1	3
	8	4	12

0-address machine	Fetch	Exec.	Memory Traffic
PUSH B	1	0	1
PUSH C	1	0	1
SUB	0	0	0
PUSH D	1	0	1
MPY	0	0	0
POP A	1	0	1
	4	0	4

Question 4

4, 2, 0, 1, 2, 6, 1, 4, 0, 1, 0, 2, 3, 5, 7

i. FIFO

Access	Cache	
4	4	Miss
2	4, 2	Miss
0	4, 2, 0	Miss
1	4, 2, 0, 1	Miss
2	4, 2, 0, 1	Hit
6	4 2, 0, 1, 6	Miss
1	2, 0, 1, 6	Hit
4	0, 1, 6, 4	Miss
0	0, 1, 6, 4	Hit
1	0, 1, 6, 4	Hit
0	0, 1, 6, 4	Hit
2	1, 6, 4, 2	Miss
3	6, 4, 2, 3	Miss
5	4, 2, 3, 5	Miss
7	2, 3, 5, 7	Miss

ii. Optimal / LFU

Access	Cache	
4	4	Miss
2	4, 2	Miss
0	4, 2, 0	Miss
1	4, 2, 0, 1	Miss
2	4, 0, 1, 2	Hit
6	0, 1, 2, 6	Miss

Access	Cache	
1	0, 6, 1, 2	Hit
4	6, 4, 1, 2	Miss
0	4, 0, 1, 2	Miss
1	4, 0, 2, 1	Hit
0	4, 0, 2, 1	Hit
2	4, 0, 2, 1	Hit
3	3, 0, 2, 1	Miss
5	5, 0, 2, 1	Miss
7	7, 0, 2, 1	Miss

iii. LRU

Access	Cache	
4	4	Miss
2	4, 2	Miss
0	4, 2, 0	Miss
1	4, 2, 0, 1	Miss
2	4, 0, 1, 2	Hit
6	0, 1, 2, 6	Miss
1	0, 2, 6, 1	Hit
4	2, 6, 1, 4	Miss
0	6, 1, 4, 0	Miss
1	6, 4, 0, 1	Hit
0	6, 4, 1, 0	Hit
2	4, 1, 0, 2	Miss
3	1, 0, 2, 3	Miss
5	0, 2, 3, 5	Miss
7	2, 3, 5, 7	Miss

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Question #5

$T_c = 100\ ns$

$T_m = 1000\ ns$

80% read, 20% write

Hit ratio for read = $0.9 = h$

write through

$T_A = h\,T_c + (1-h)(T_m + T_c)$

$\Rightarrow T_A = 0.9 \times 100 + 0.1 \times (1000 + 100)$

$= 90 + 110$

$= 200\ ns$ for reads

Total access time $= \frac{80}{100} \times 200 + \frac{20}{100} \times 1000$

$= 160 + 200$

$= 360\ ns$ for read + write

Hit ratio including writes $= 0.8 \times 0.9$

$= 0.72$

Question 6

Address space = 24 bits
= 3 bytes

Memory space = 16 bits
= 2 bytes

No. of words = $\frac{2^n}{\text{size of word}}$

n = 16, because memory is what decides how many words are addressable

No. of words = $\frac{2^{16}}{16}$

= 4096 words

No. of pages = $\frac{2^{24}}{2k} = \frac{2^{24}}{2^{k+11}} = 2^{13}$

= 8k

No. of blocks = $\frac{2^{16}}{2k} = \frac{2^{16}}{2^{11}} = 2^5$
= 32