

Ans : 1

1

Instruction/ clock cycle	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
ADD R3, R1, R2	F	D	E	E	E	W																							
LOAD R6, [R3]	F	D			E	E	E	E	W																				
AND R1, R6, R1	F	D								E	W																		
ADD R1, R6, R0	F	D								E	E	E	W																
SUB R2, R1, R6		F	D											E	E	E	W												
AND R4, R3, 15		F	D											E	■	W													
LOAD R6, [R4]			F	D										E	E	E	E	W											
PAPERTECH				F	D									E	W														
SUB R5, R3, R4				F	D																								
ADD R0, R1, R6				F	D																					E	W		
SHL R7, R0, 8				F	D																					E	W		

$$\therefore T = \frac{2\pi}{2 \times 10^9} \text{ sec}$$

$$\therefore T = 14.5 \times 10^{-9} \text{ sec}$$

Ans

(2)

(3)

Ans: 2

: Solution not

For Machine 1

LOAD B

$A_e \leftarrow B$  10M

MUL D

$A_e \leftarrow A_e \times D$

STORE R1

$R_1 \leftarrow A_e$  M

LOAD E

$A_e \leftarrow E$  2

MUL A

$A_e \leftarrow A_e \times A$

SUB R1

$R_1 \leftarrow A_e - R_1$

LOAD D

$A_e \leftarrow D$

MUL C

$A_e \leftarrow A_e \times C$

ADD A

$A_e \leftarrow A_e + A$

DIV R1

$A_e \leftarrow A_e \div R_1$

ADD 1

$A_e \leftarrow A_e + 1$

STORE P

$P \leftarrow A_e$

For Machine2:

~~MOV P, B~~

$$P \leftarrow B$$

~~MUL B, D~~

$$P \leftarrow P \times D$$

~~MOV A, R1, E~~

$$R1 \leftarrow E$$

~~MUL A, R1, A~~

$$R1 \leftarrow R1 \times A$$

~~SUB R1, P~~

$$R1 \leftarrow R1 - P$$

~~MOV P, R1~~

$$P \leftarrow R1$$

~~MOV R1, D~~

$$P \leftarrow D \text{ SUM}$$

~~MOV P, D~~

$$P \leftarrow D \text{ SUM}$$

~~MUL P, C~~

$$P \leftarrow P \times C$$

~~DXBA → SA~~

$$P \leftarrow P + A$$

~~ADD P, A~~

$$P \leftarrow P + A$$

~~AH → SA~~

$$P \leftarrow P \div R1$$

~~DIV P, R1~~

$$P \leftarrow AP + R1$$

~~AH ÷ SA → SA~~

$$P \leftarrow AP + R1$$

~~ADD P, 1~~

$$P \leftarrow AP + R1$$

~~SA → SA~~

$$P \leftarrow AP + R1$$

~~SA → SA~~

$$P \leftarrow AP + R1$$

For Machine 3:

MUL P, E, A

$$P \leftarrow EXA$$

MUL R1, B, D

$$R1 \leftarrow BXD$$

SUB P, P, R1

$$P \leftarrow P - R1$$

MUL R1, D, C

$$R1 \leftarrow D \times C$$

ADD R1, R1, A

$$R1 \leftarrow R1 + A$$

DIV P, R1, P

$$P \leftarrow R1 \div P$$

ADD P, P, ~~R1~~

$$P \leftarrow P + 1$$

For machine 3 it will be more efficient  
than ~~for~~ machine 2 and then machine 1

Ans

Ans: 4

Iteration	Operation	Multiplicand	Multiplicand	Product
0	Initial Value	010101	<del>011011</del> 000000 011011	000000 000000
1	1: $a_1 \Rightarrow P = P + M$ 2: SHL Multiplicand 3: SHR Multiplier	010101	000000 011011 000000 110110 000000 110110	000000 011011 000000 011011 000000 011011
2	1: $0 \Rightarrow \text{No OP}$ 2: SHL Multiplicand 3: SHR Multiplier	001010	000000 110110 000001 101100 000001 101100	000000 011011 000000 011011 000000 011011
3	1: $a_1 \Rightarrow P = P + M$ 2: SHL Mt 3: SHR MR	000101	000001 101100 000011 011000 000011 011000	000010 000111 000010 000111 000010 000111
4	1: $0 \Rightarrow \text{No OP}$ 2: SHL Mt 3: SHR MR	000010	000011 011000 000110 110000 000110 110000	000010 000111 000010 000111 000010 000111
5	1: $a_1 \Rightarrow P = P + M$ 2: SHL Mt 3: SHR MR	000001	000110 110000 001101 100000 001101 100000	001000 110111 001000 110111 001000 110111

Ans

(X)

Ans: 5

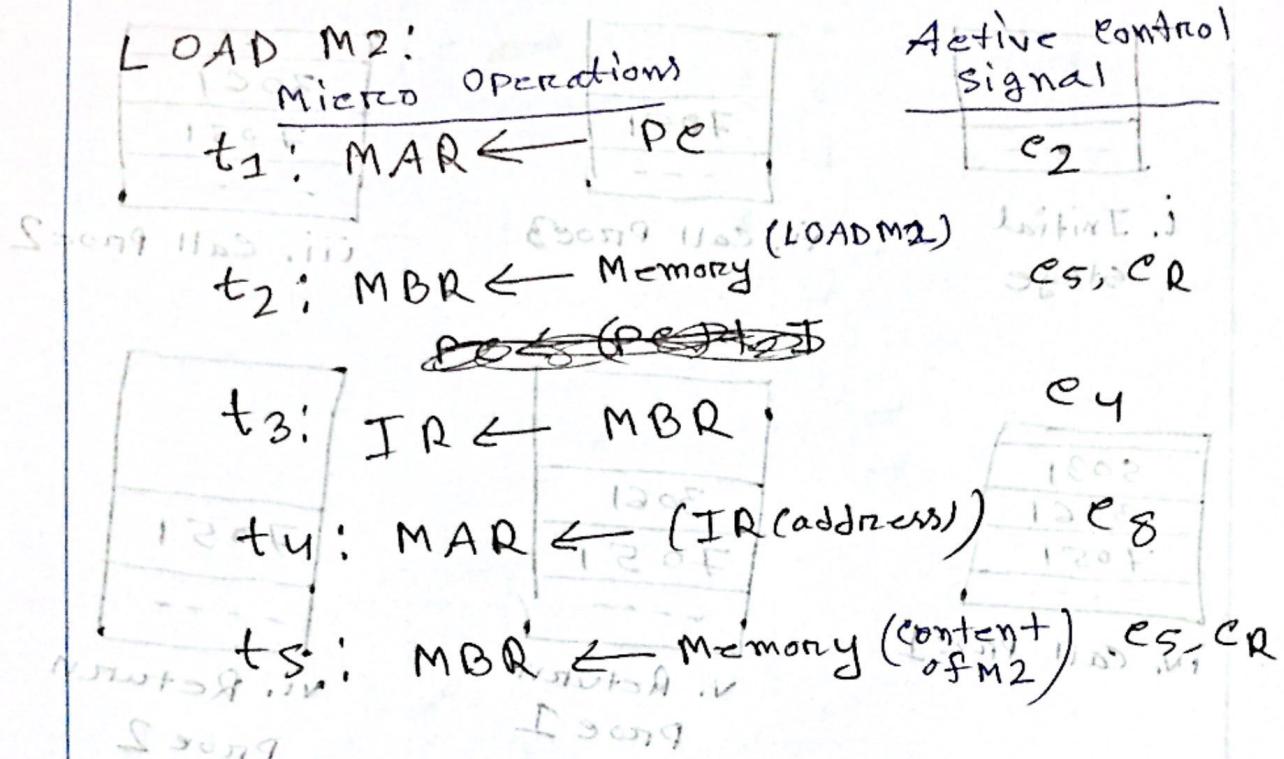
A	Q	Q-1	M	Comments
0000	1010	0	0111	Initiate
0000	0101	0	0111	Arithmetic shift Right } First cycle
1001	0101	0	0111	$A \leftarrow A - M$ } 2nd cycle
1100	1010	1	0111	ASHR }
0011	1010	1	0111	$A \leftarrow A + M$ } 3rd cycle
0001	1101	0	0111	ASHR }
1010	1101	0	0111	$A \leftarrow A - M$ } 4th cycle
1101	0110	1	0111	ASHR }

$$\therefore \text{Product} = 1101 \quad 0110 \\ = -42$$

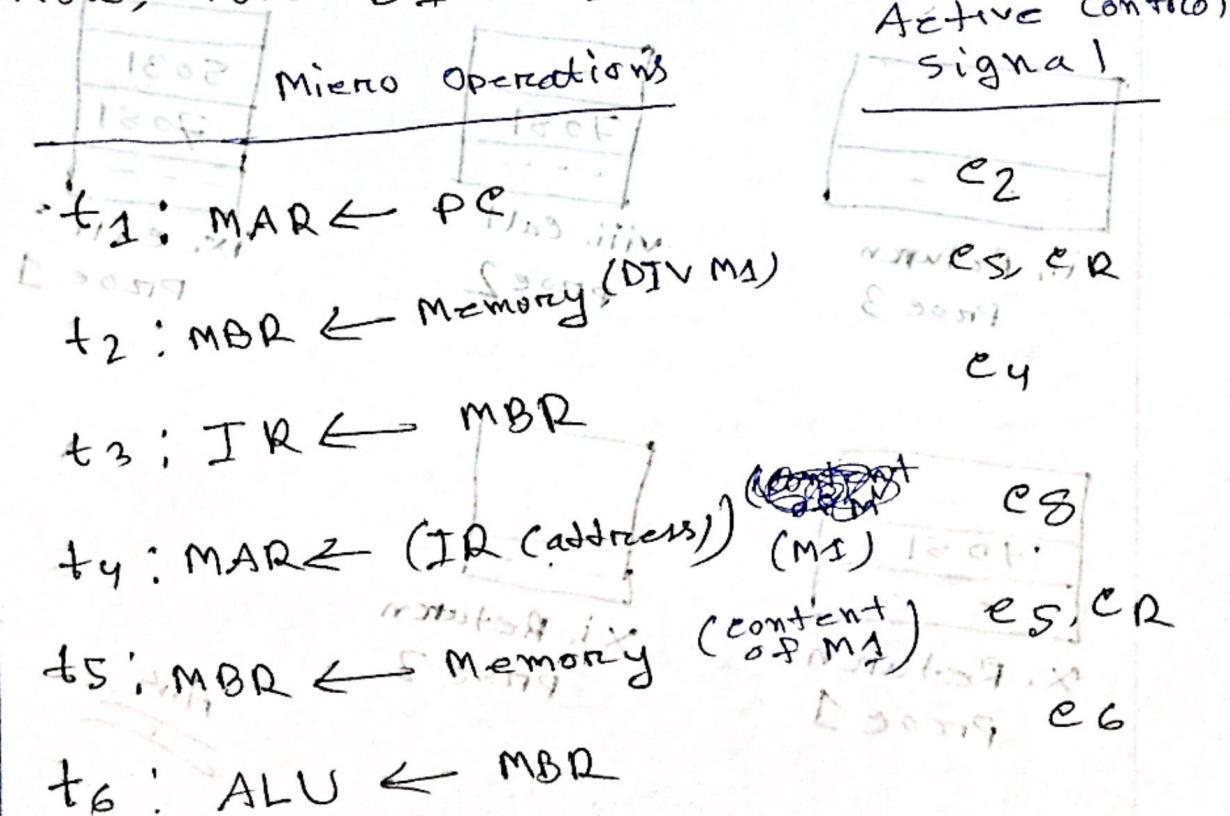
Ans

(8)

### Bonus question - 1



Now, For DIV M1



(9)

$t_7: ALU \leftarrow AC$  ~~MBR~~

e7

$t_8: ALU \leftarrow AC \div MBR$

e16

$t_9: AC \leftarrow ALU$  (Quotient)

e9

$t_{10}: MBR \leftarrow AC$  <sup>(Quotient goes to MBR)</sup>

e11

$t_{11}: Memory(M_2) \leftarrow MBR$  <sup>(quotient stored in M2)</sup>

e9

$t_{12}: MBR \leftarrow AC$  <sup>(remainder goes to MBR)</sup>

e11

$t_{13}: Memory(M_3) \leftarrow MBR$  <sup>(remainder stored in M3)</sup>

e12, e13

AM

(10) (10)

A~~ns~~:

### Bonus Question - 2

Micro Operations

control signal

~~t1~~

t1: MAR  $\leftarrow$  (PC)

c<sub>3</sub>, c<sub>4</sub>

t2: MBR  $\leftarrow$  Memory (MUL M1) e<sub>R</sub>

t3: IR  $\leftarrow$  MBR

c<sub>6</sub>, c<sub>1</sub>

t4: MAR  $\leftarrow$  (IR (address)) (M1) e<sub>R</sub>

t5: MBR  $\leftarrow$  Memory (content of M1) e<sub>R</sub>

t6: ALU  $\leftarrow$  MBR

c<sub>6</sub>, c<sub>10</sub>

t7: ALU  $\leftarrow$  AC

c<sub>8</sub>

t8: ALU  $\leftarrow$  AC + MBR

t9: Z  $\leftarrow$  ALU

c<sub>11</sub>, c<sub>7</sub>

t10: AC  $\leftarrow$  Z

Ans