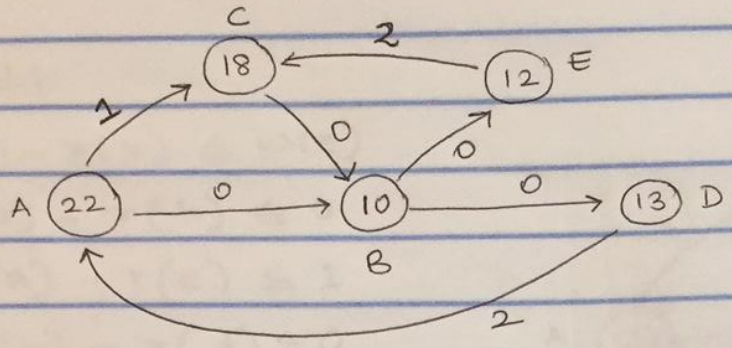
A2) a)



Retiming graph abstraction

W → weight matrix

	A	B	C	D	E
A	0	0	1	0	0
B	2	0	2	0	0
C	2	0	0	0	0
D	2	2	3	0	2
E	4	2	2	2	0

D → path delay matrix

	A	B	C	D	E
A	22	32	40	45	44
B	45	10	40	23	22
C	63	28	18	41	40
D	35	45	53	13	57
E	75	40	30	53	12

b) Before retiming, the minimum clock period at which this circuit can be run is 45.

c)

W-matrix

	A	B	C	D	E
A	0	0	1	0	0
B	2	0	2	0	0
C	2	0	0	0	0
D	2	2	3	0	2
E	4	2	2	2	0

D-matrix

	A	B	C	D	E
A	22	32	40	45	44
B	45	10	40	23	22
C	63	28	18	41	40
D	35	45	53	13	57
E	75	40	30	53	12

$\alpha = 23$

Legal:

$r(u) - r(v) \leq w(e)$

$r(a) - r(b) \leq 0$

$r(a) - r(c) \leq 1$

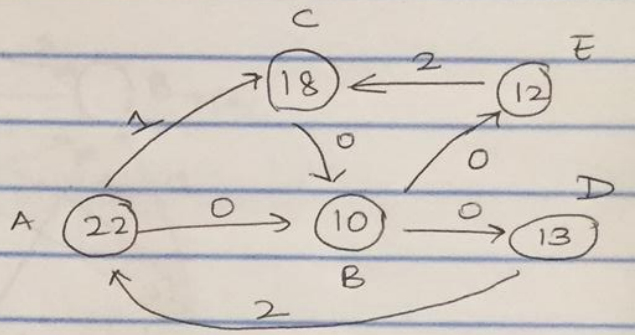
$r(b) - r(d) \leq 0$

$r(b) - r(e) \leq 0$

$r(c) - r(b) \leq 0$

$r(d) - r(a) \leq 2$

$r(e) - r(c) \leq 2$



Timing $D > 23$:

$r(u) - r(v) \leq w(u,v) - 1$

$r(a) - r(b) \leq -1$

$r(a) - r(c) \leq 0$

$r(a) - r(d) \leq -1$

$r(a) - r(e) \leq -1$

$r(b) - r(a) \leq 1$

$r(b) - r(c) \leq 1$

$r(c) - r(a) \leq 1$

$r(c) - r(b) \leq -1$

$r(c) - r(d) \leq -1$

$r(c) - r(e) \leq -1$

$r(d) - r(a) \leq 1$

$r(d) - r(b) \leq 1$

$r(d) - r(c) \leq 2$

$r(d) - r(e) \leq 1$

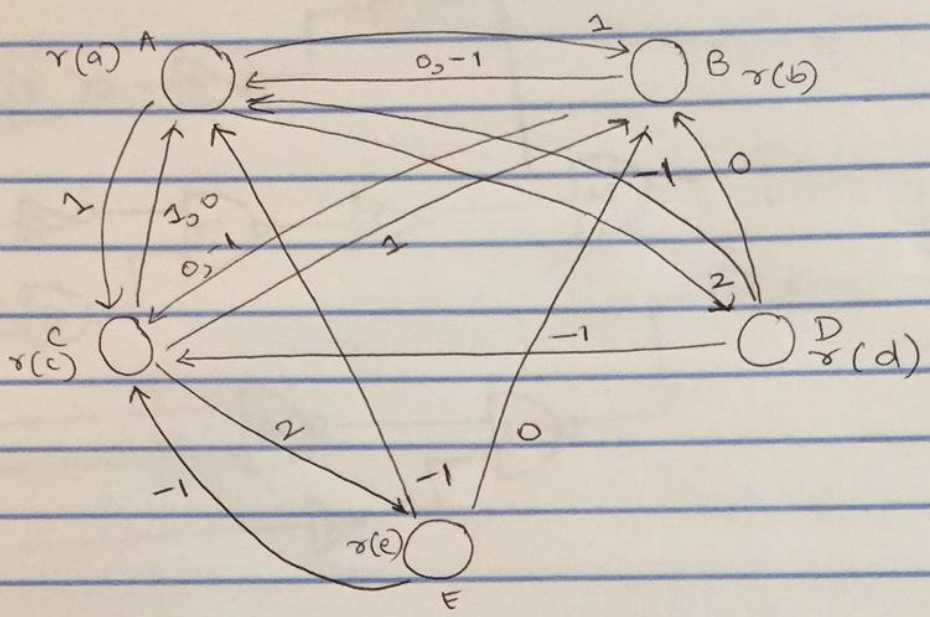
$r(e) - r(a) \leq 3$

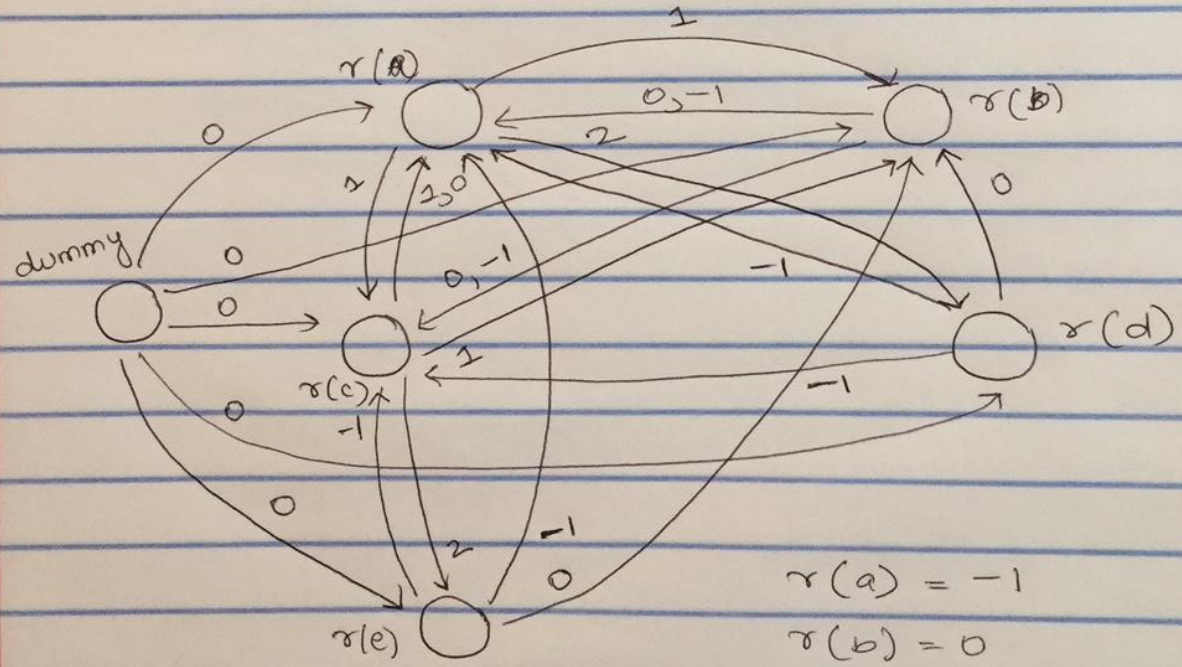
$r(e) - r(b) \leq 1$

$r(e) - r(c) \leq 1$

$r(e) - r(d) \leq 1$

Constraint Graph $r(U) - r(V) \leq c$ $r(U)$ $\overset{c}{\longleftarrow}$ $r(V)$





$r(a) = -1$

$r(b) = 0$

$r(c) = -1$

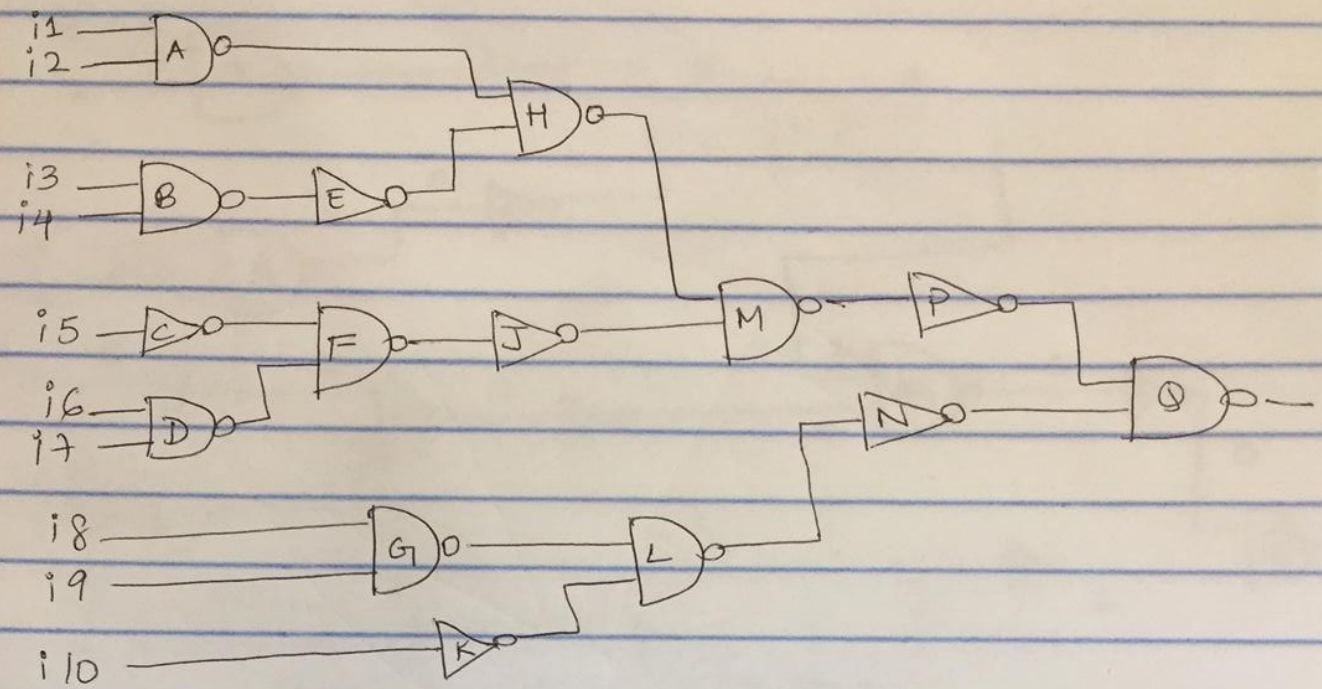
$r(d) = 0$

$r(e) = 0$

$\therefore$ Yes, retiming exists.

Ans

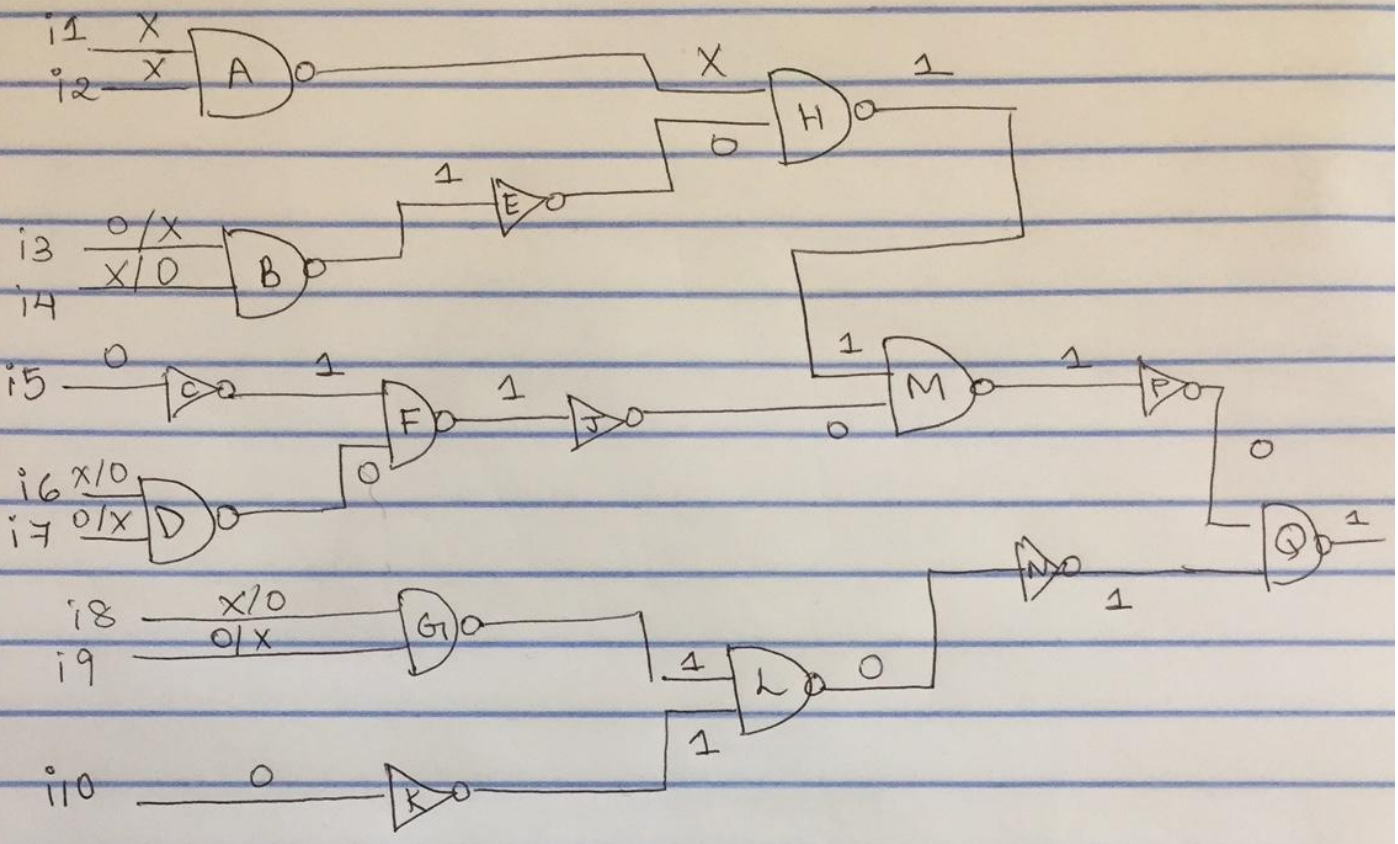
A3)



The critical paths are BEHMPQ and DFJMPQ with 19 units delay.

The gates which make up BEHMPQ path are B (Nand gate), E (Not gate), H (Nand gate), M (Nand gate), P (Not gate) and Q (Nand gate).

The gates which make up DFJMPQ path are D (Nand gate), F (Nand gate), $\bar{J}$ (Not gate), M (Nand gate), P (Not gate) and Q (Nand gate).



More are various combinations of i/p vector and the critical path BEHMPQ is sensitizable. Input vector is XX0X0X0X00.