16-12

F → Flexi
M → mem
S →
T → theory
N → not mention

1 (a) → theory
(b) → Flexi
2 (a) → T
(b) → F/N
3 (a) → F/N
(b) → F
4 (a) → S
5 (a) → M
(b) → M
6 (a) → M
(b) → M
7 (a) → M
(b) → S
8 (a) → S
(b) → S

S → 4
F → 4
M → 5

15-16

1 (a) → M
(b) → M
2 (a) S
(b) S
3 (a) S
(b) M
4 (a) M
(b) S
5 (a) F
(b) F
6 (a) F
(b) F
7 (a) F
(b) S
8 (a) N
(b) S

S → 5
F → 5
M → 4

14-15

1 (a) F
(b) F
2 (a) F
(b) F
3 (a) S
(b) S
4 (a) S
(b) → T
5 (a) T
(b) M
6 (a) M
(b) M
7 (a) S
(b) F
8 (a) S
(b) S

S → 6
F → 5
M → 3

13-14

1 (a) M
(b)
2 → F
3 → M
4 → F
5 → M
6 → F
7 → M
8 → S
9 → S
10 → S
11 → S
12 → S
13 → S
14 → F

S → 6
F → 4
M → 4

12-13

1 (a) M
(b) S
2 (a) M
(b) S
3 (a) S
(b) S
4 (a) S
5 (a) F
(b) F/T
6 (a) F
(b) F
7 (a) F
(b) F
8 (a) F

S → 4
F → 6
M → 2

11-12

1 (a) F
(b) S
2 (a) F
(b) S
3 (a) N
(b) S
4 → S
5 (a) M
(b) F
6 (a) scope
(b) M
7 (a) M
8 (a) scope
(b) —

S → 4
F → 3
M → 3

13-14

11 12
10 11
8 9

Nothing is certain.

2016-17

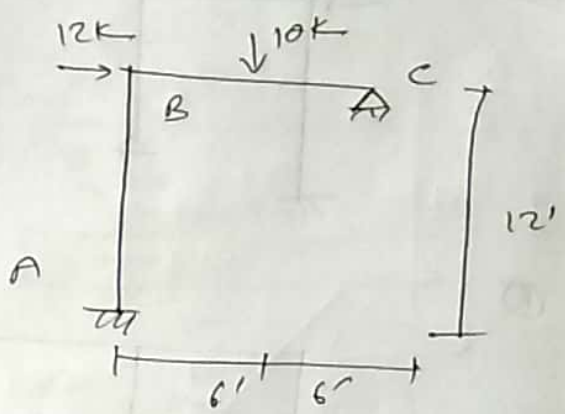
2 (b)

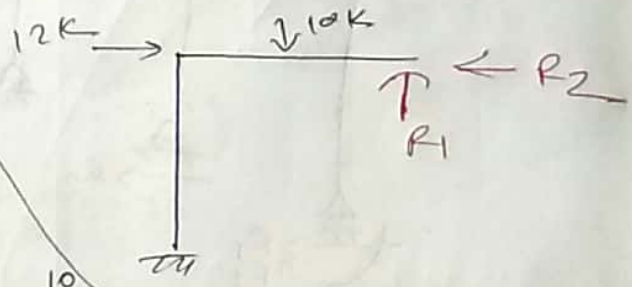
$EI = 4000$

$DOI = 3m + r - 3j$

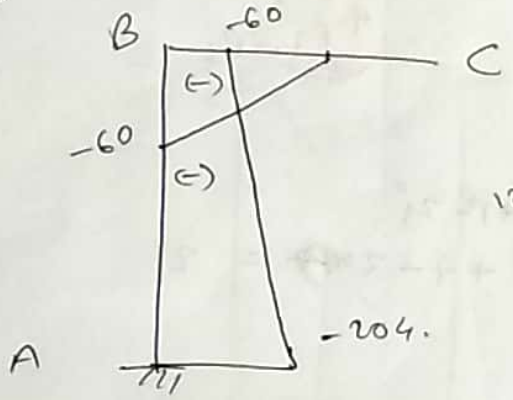
$= 3\times2 + (3+2) - 3\times3$

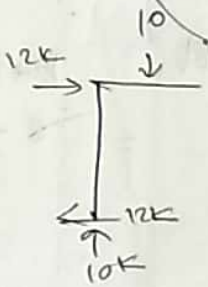
$= 2°$



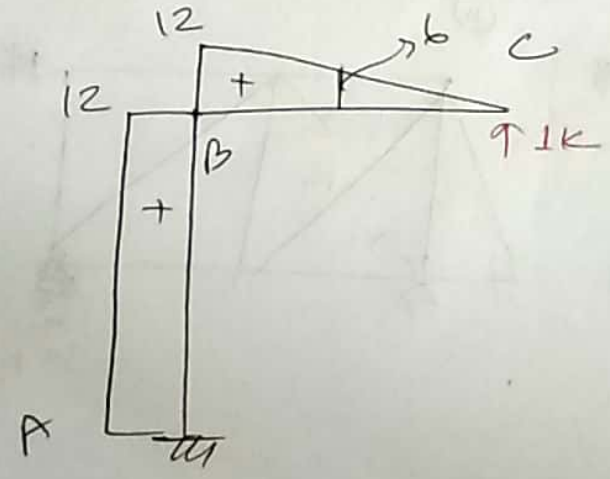


m_0

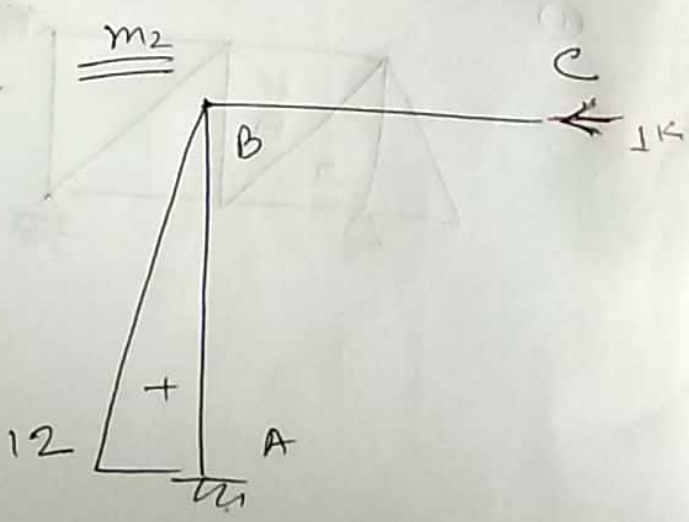




m_1



m_2



$$\Delta_{01} = \int \frac{m_0 m_1}{EI} dx$$

$$= \frac{1}{2} \times (-60 - 204) \times 12 \times 12 \times \frac{1}{EI} \quad \rightarrow AB$$

$$+ \frac{1}{6} (-60) \times (2 \times 12 + 6) \times 6 \times \frac{1}{EI} \quad \rightarrow BC$$

$$= -\frac{19008}{EI} - \frac{1800}{EI} = -5.202$$

$$\Delta_{02} = \int \frac{m_0 m_2}{EI} dx \qquad \boxed{EI = 4000}$$

$$= \frac{1}{6} \times (+12) \times (2 \times 204 - 60) \times 12 + 0$$

$$= -2.808$$

$$\delta_{11} = \int \frac{m_1 m_1 dx}{EI} = 12 \times 12 \times 12 \frac{1}{EI} + \frac{1}{3} \times 12 \times 12 \times 12 \frac{1}{EI}$$

$$= 0.576$$

$$\delta_{12} = \delta_{21} = \int \frac{m_1 m_2}{EI} dx = \frac{1}{2} \times 12 \times 12 \times 12 \times \frac{1}{EI} + 0$$

$$= 0.216$$

$$\delta_{22} = \frac{1}{3} \times 12 \times 12 \times 12 \frac{1}{EI} = 0.144$$

$$\Delta_C = -0.5^4$$

$$= -\frac{0.5}{12}$$

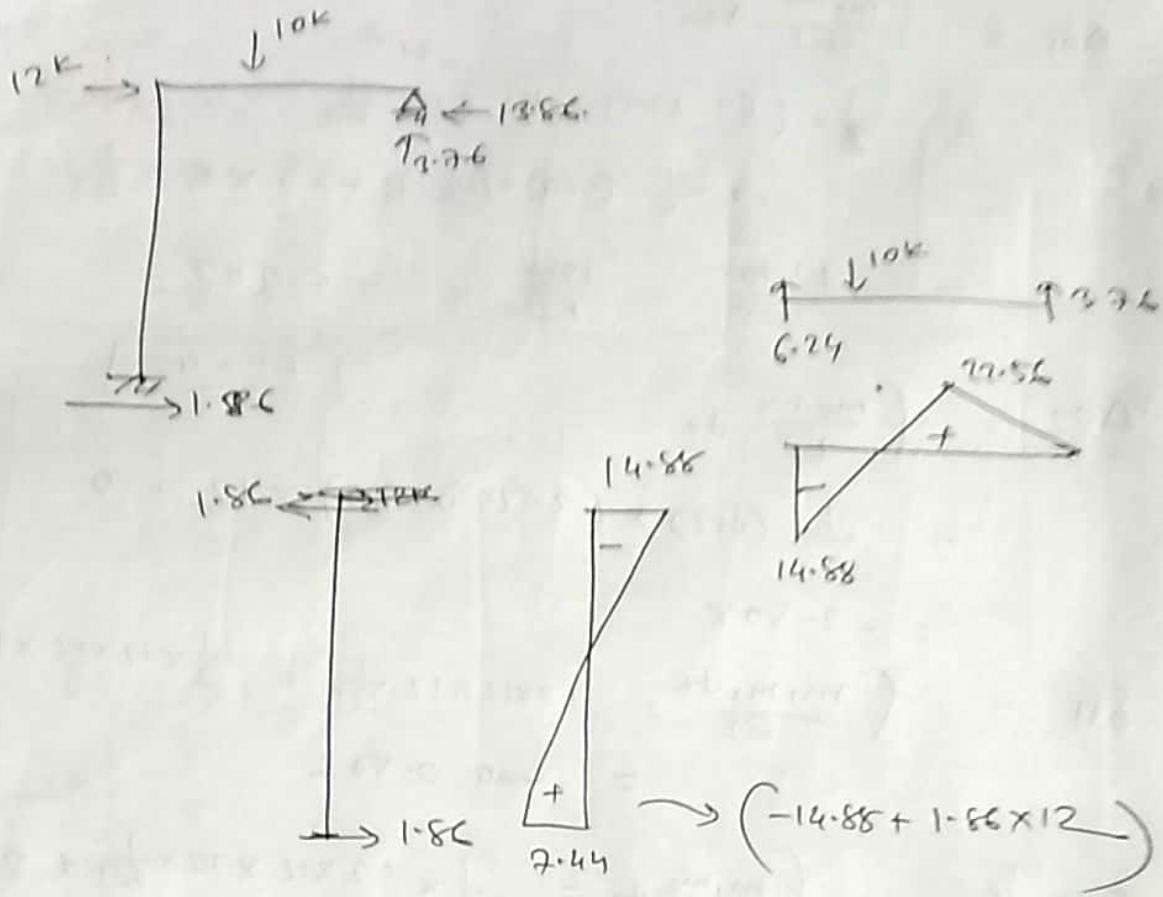
$$= -0.0417$$

$$\begin{pmatrix} \Delta_1 \\ \Delta_2 \end{pmatrix} = \begin{pmatrix} \Delta_{01} \\ \Delta_{02} \end{pmatrix} + \begin{pmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{pmatrix} \begin{pmatrix} R_1 \\ R_2 \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} -0.417 \\ 0 \end{pmatrix} = \begin{pmatrix} -5.202 \\ -2.808 \end{pmatrix} + \begin{pmatrix} 0.576 & 0.216 \\ 0.216 & 0.144 \end{pmatrix} \begin{pmatrix} R_1 \\ R_2 \end{pmatrix}$$

$$R_1 = 3.76$$

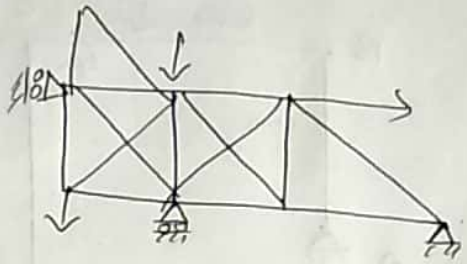
$$R_2 = 13.86.$$


12K
10K
13.86
3.76
1.86
6.24
3.76
22.56
14.88
1.86
1.86
14.88
7.44
(-14.88 + 1.86 x 12

2015-16

5 (b)

(a)

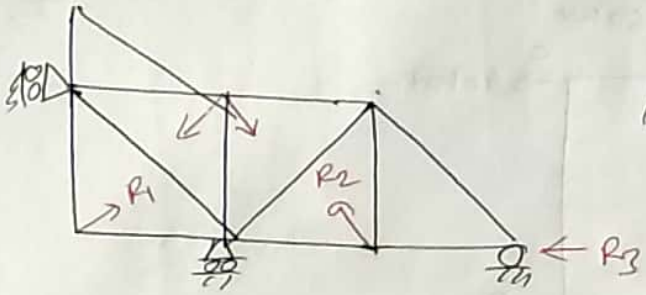


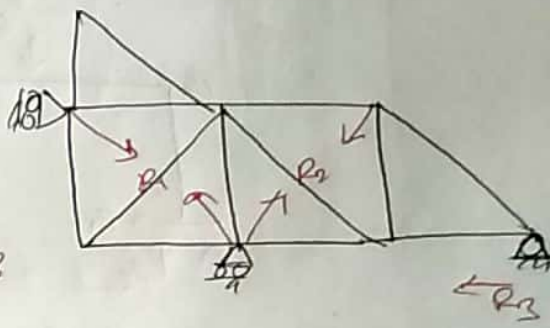
DOI = b + r − 2j

= 15 + (2+1+1) − 2×8

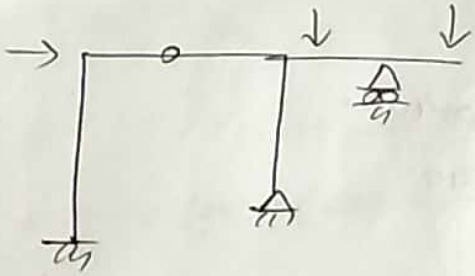
= 19 − 16 = 3°

(i)





(b)



DOI ~~= 3m + r − 3j~~

~~= 3 × 5 + 5 − 3 × 5 − 1~~

~~2014-15~~

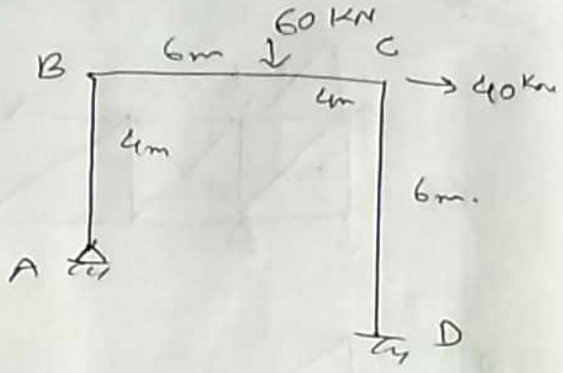
2015-16

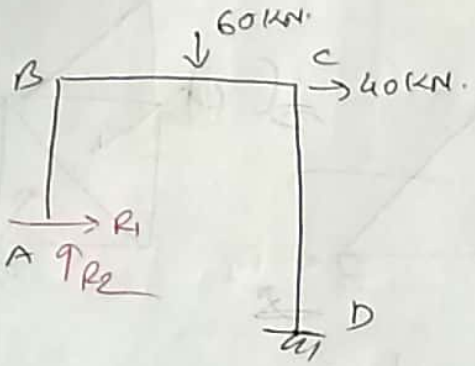
6 (b)

DOI = $3m + j - 3j$

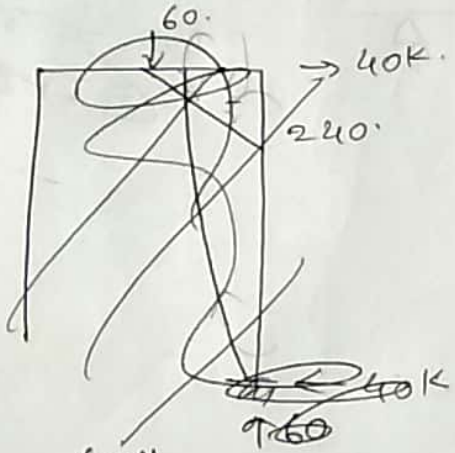
$= 3 \times 3 + 5 - 3 \times 4$

$= 14 - 12 = 2^{\circ}$.

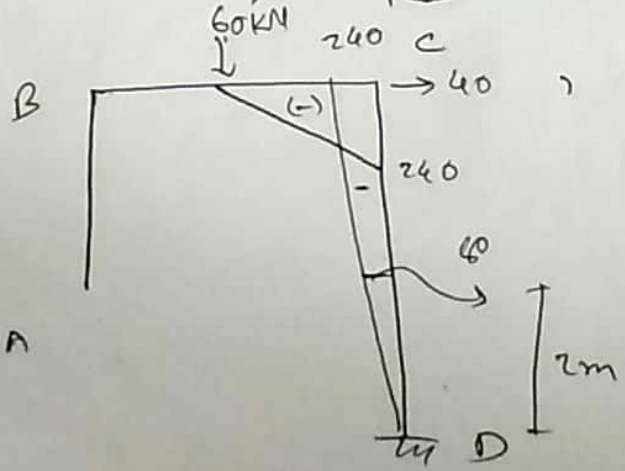




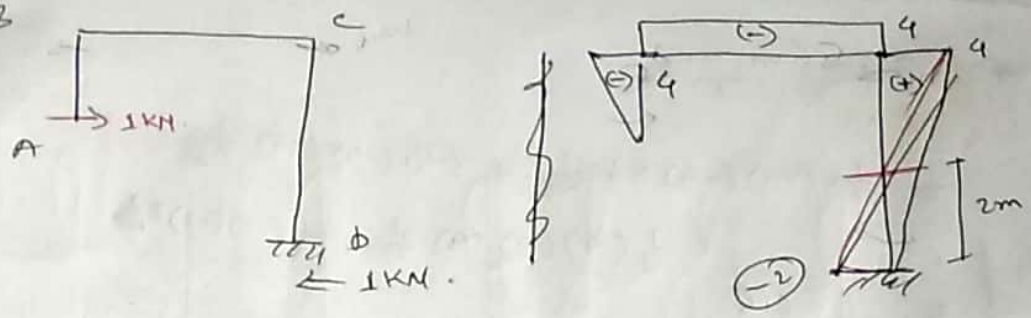
mo



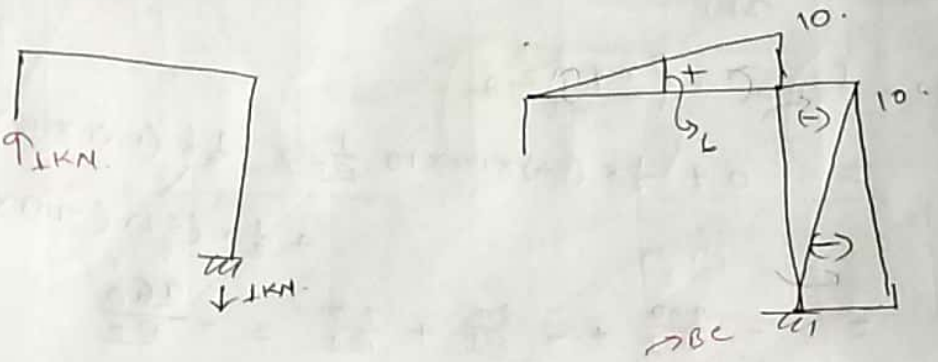
mo



m_1



m_2



$$\Delta_{01} = \int \frac{m_0 m_1}{EI}\,dx = \frac{1}{2} \times (-240) \times (-4) \times 4 \times \frac{1}{EI}$$

$$+ \frac{1}{3} \times (-240) \times (+4)$$

$$+ \frac{1}{6} \times (+4) \times (-240 \times 2 - 80) \times 4 \; \frac{1}{EI} + \frac{1}{6} \times (-80)(-2) \times 2$$

↳ CD (4m) ↳ CD (2m) $\times \frac{1}{EI}$

$$= \frac{1920}{EI} - \frac{4480}{3EI} + \frac{160}{3EI}$$

$$= \frac{480}{EI}$$

$$\Delta_{02} = \int \frac{m_0 m_2}{EI}\,dx$$

$$= \frac{1}{6} \times (-240) \times (2 \times 10 + 6) \times 4 \times \frac{1}{EI} + \frac{1}{2} \times (-240) \times (-10) \times 6 \times \frac{1}{EI}$$

$$= -\frac{4160}{EI} + \frac{7200}{EI} = \frac{3040}{EI}$$

$$\delta_{11} = \int \frac{m_1 m_1}{EI}\, dx$$

$$= \frac{1}{3}\times(-4)(-4)\times 4\,\frac{1}{EI} + (-4)(-4)(10)\,\frac{1}{EI} + \frac{1}{3}(4)(4)(4)\,\frac{1}{EI} + \frac{1}{3}(-2)(-2)^2\,\frac{1}{EI}$$

$$= \frac{616}{3EI}$$

$$\delta_{12} = \delta_{21} = \int \frac{m_1 m_2}{EI}\, dx$$

$$= 0 + \frac{1}{2}\times(-4)\times 10\times 10\,\frac{1}{EI} + \frac{1}{2}\times(+4)\times(10)\times 4\,\frac{1}{EI} + \frac{1}{2}\times(-2)(-10)\times 2\,\frac{1}{EI}$$

$$= -\frac{200}{EI} - \frac{80}{EI} + \frac{20}{EI} = -\frac{260}{EI}$$

$$\delta_{22} = \int \frac{m_2 m_2}{EI}\, dx.$$

$$= \frac{1}{3}(10)(10)\times 10\,\frac{1}{EI} + (-10)(-10)\times 6\times\frac{1}{EI}$$

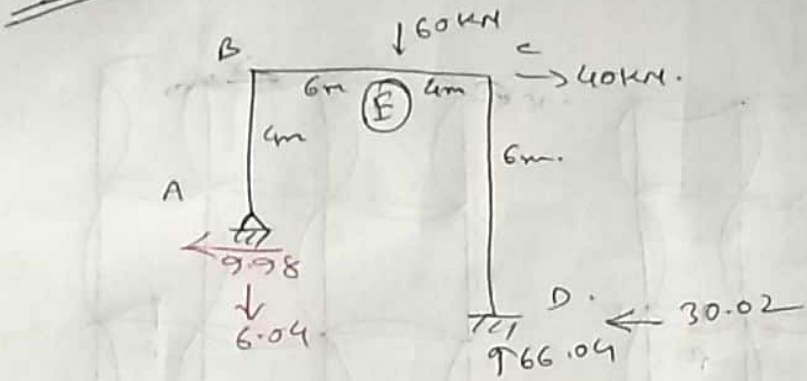
$$= \frac{2800}{3EI}$$

$$\begin{pmatrix}\Delta_1\\ \Delta_2\end{pmatrix} = \begin{pmatrix}\Delta_{01}\\ \Delta_{02}\end{pmatrix} + \begin{pmatrix}\delta_{11} & \delta_{12}\\ \delta_{21} & \delta_{22}\end{pmatrix}\begin{pmatrix}R_1\\ R_2\end{pmatrix}$$

$$\Rightarrow \begin{pmatrix}0\\ 0\end{pmatrix} = \begin{pmatrix}\frac{480}{EI}\\ \frac{3040}{EI}\end{pmatrix} + \begin{pmatrix}\frac{616}{3EI} & -\frac{260}{EI}\\ -\frac{260}{EI} & \frac{2800}{3EI}\end{pmatrix}\begin{pmatrix}R_1\\ R_2\end{pmatrix}$$

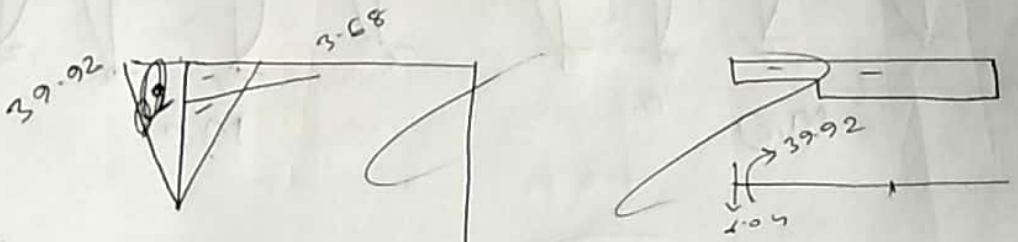
$$R_1 = -9.98$$

$$R_2 = -6.04$$

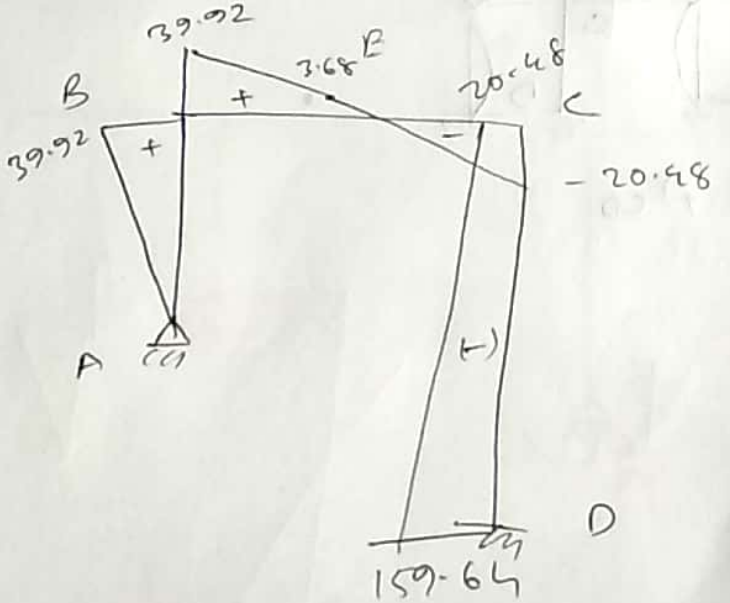


$+9.98 \times 4 + M_0 = 0$

$M_0 = -39.92$

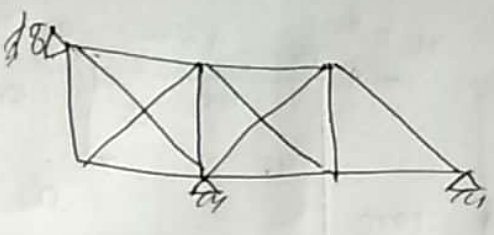


$$\begin{bmatrix} M_A \\ M_B \\ M_C \\ M_D \\ M_E \end{bmatrix} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -240 \\ 0 \end{Bmatrix} + \begin{bmatrix} 0 & 0 \\ -4 & 0 \\ -4 & +10 \\ -2 & -10 \\ -4 & +6 \end{bmatrix} \begin{bmatrix} -9.98 \\ -6.04 \end{bmatrix} = \begin{bmatrix} 0 \\ +39.92 \\ -20.48 \\ -159.64 \\ 3.68 \end{bmatrix}$$



2014-15

1 (b)



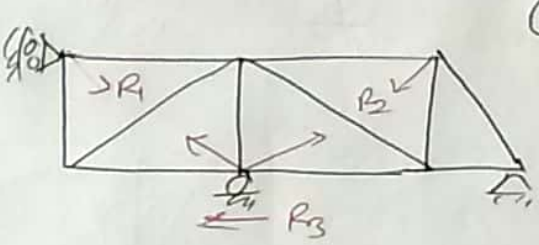
$b + r - 2j$

$= 7 + (2+2+1) - 2 \times 7$

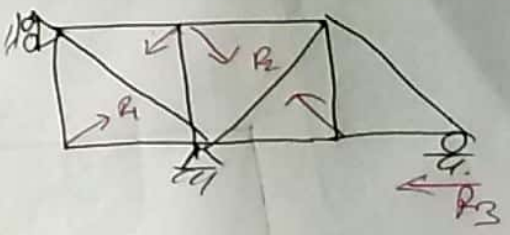
$= 13$

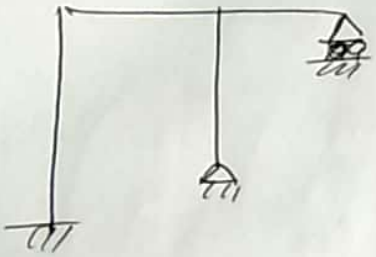
$= 3^\circ$

(a)



(c)

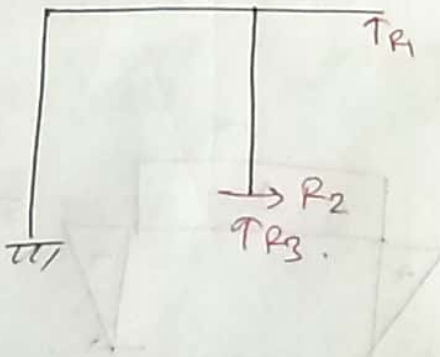


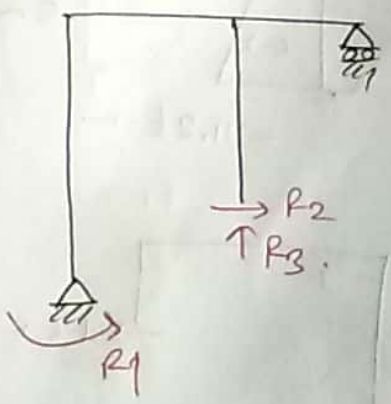


$3m + r - 3j$

$= 3 \times 4 + (2+1+3) - 3 \times 5$

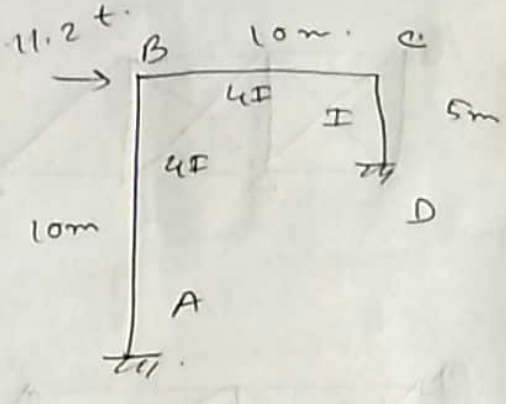
$= 12 + 6 - 15 = 3^\circ$





2014-15

2(a)

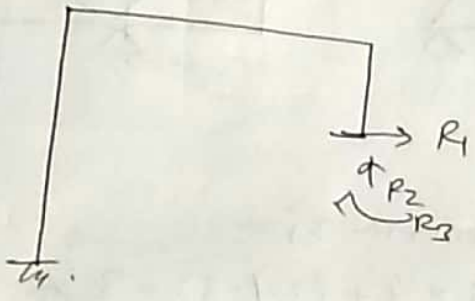


DOI

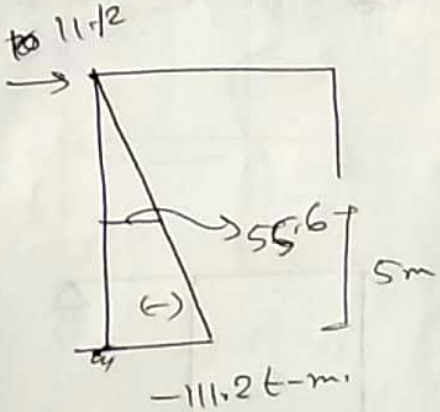
$= (3+3) + (3\times3) - (4\times3)$

$= 3m + r^o - 3j$

$= 3^o$

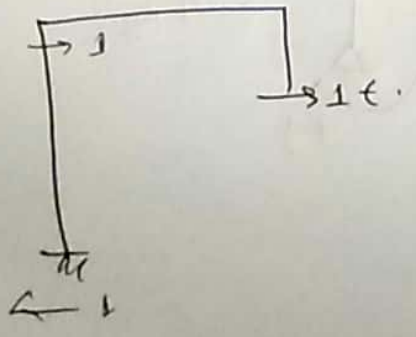


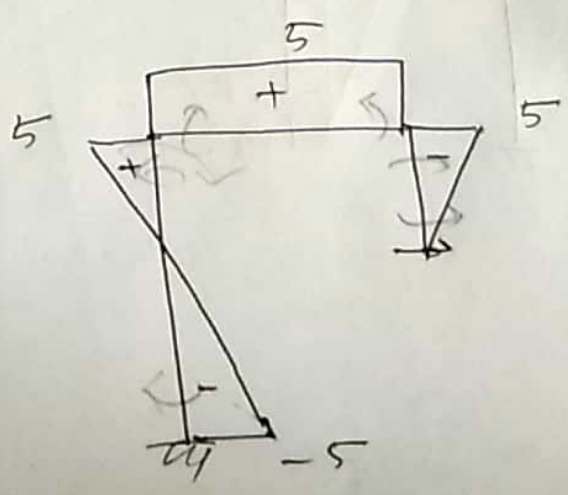
m0



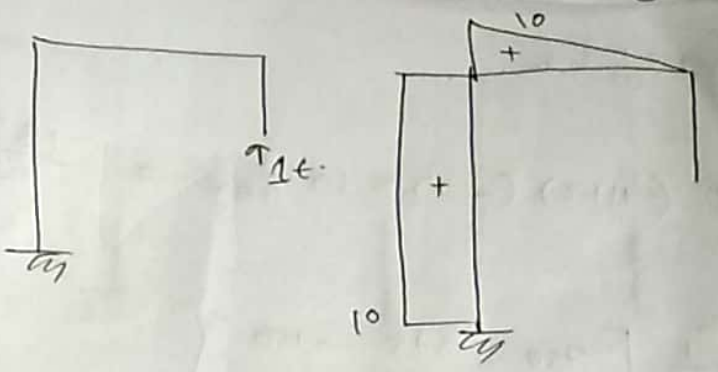
-111.2 t-m.

m1

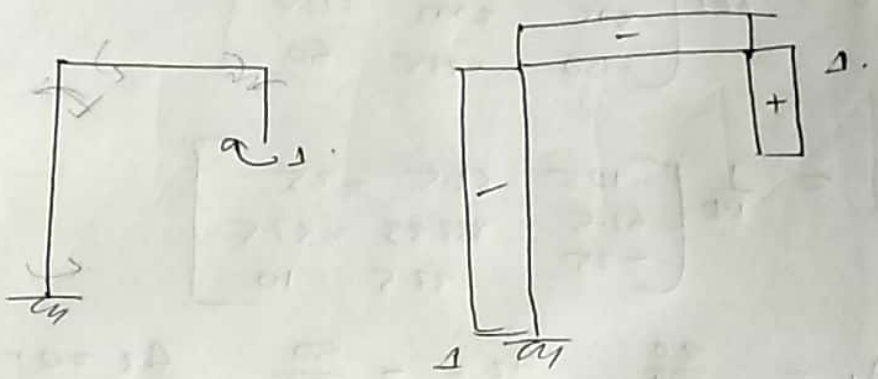




m_2



m_3



$$\Delta_{10} = \int \frac{m_0 m_1}{EI}\, dx$$

$$= \int \frac{1}{6}(-55.6)(+5) \times 5 \frac{1}{4EI} + \frac{1}{6}(-5)\left(2 \times (12.2) + (-55.6)\right) \times 5 \times \frac{1}{4EI}$$

$$= \frac{859}{EI} - \frac{175}{3EI} + \frac{3505}{12EI} = \frac{935}{4EI}$$

$$= \frac{699}{12EI} = \frac{695}{3EI}$$

$$\Delta_{20} = \int \frac{m_0 m_2\, dx}{EI}$$

$$= \frac{1}{2} \times (-117.2) \times (10) \times 10 \frac{1}{4EI} = -\frac{1390}{EI}$$

$$\Delta_{03} = \int \frac{m_0 m_3}{EI} dx.$$

$$= \frac{1}{2}(-111.2)(-1) \times 10 \frac{1}{4EI} = \frac{139}{EI}$$

$$\delta = \frac{1}{6EI}\begin{bmatrix} 750 & 375 & -150 \\ 375 & 2000 & -225 \\ -150 & -225 & 60 \end{bmatrix}$$

$$= \frac{1}{EI}\begin{bmatrix} 125 & 62.5 & -25 \\ 62.5 & 333.33 & -37.5 \\ -25 & -37.5 & 10 \end{bmatrix}$$

$$\Delta_1 = \frac{20}{EI} \quad \Delta_2 = -\frac{50}{EI} \quad \Delta_3 = 20.$$

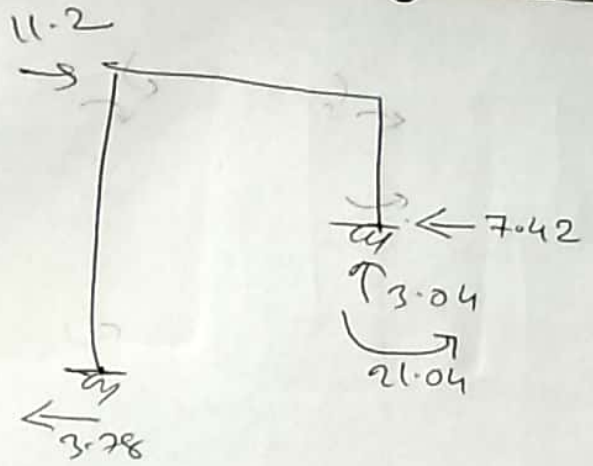
$$\begin{pmatrix} \Delta_1 \\ \Delta_2 \\ \Delta_3 \end{pmatrix} = \begin{pmatrix} \Delta_{01} \\ \Delta_{02} \\ \Delta_{03} \end{pmatrix} + \begin{pmatrix} \delta_{11} & \delta_{12} & \delta_{13} \\ \delta_{21} & \delta_{22} & \delta_{23} \\ \delta_{31} & \delta_{32} & \delta_{33} \end{pmatrix} \begin{pmatrix} R_1 \\ R_2 \\ R_3 \end{pmatrix}$$

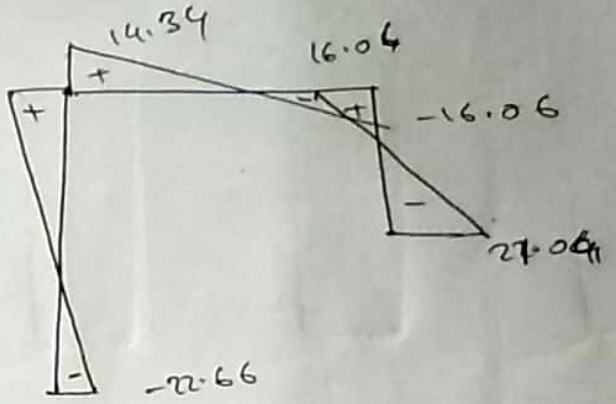
$$\Rightarrow \begin{pmatrix} \frac{20}{EI} \\ -\frac{50}{EI} \\ 0 \end{pmatrix} = \begin{pmatrix} \frac{695}{3EI} \\ -\frac{1390}{EI} \\ \frac{139}{EI} \end{pmatrix} \begin{pmatrix} 125 & 62.5 & -25 \\ 62.5 & 333.33 & -37.5 \\ -25 & -37.5 & 10 \end{pmatrix} \begin{pmatrix} R_1 \\ R_2 \\ R_3 \end{pmatrix}$$

$R_1 = -7.42$ t

$R_2 = 3.04$ t

$R_3 = -21.04$ t-m

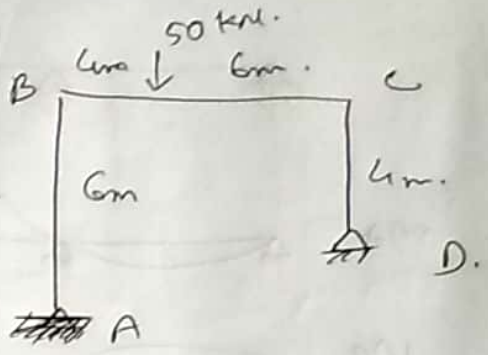

11.2
7.42
3.04
21.04
3.78


14.34
16.04
-16.06
27.04
-22.66

Frame- problem

2012-13

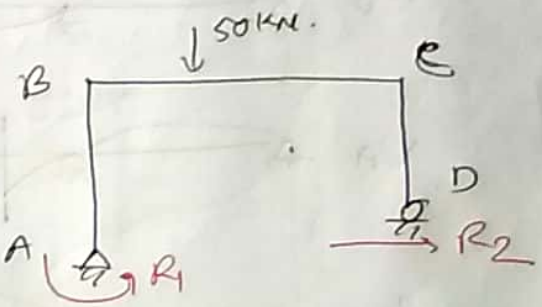
5 (a)



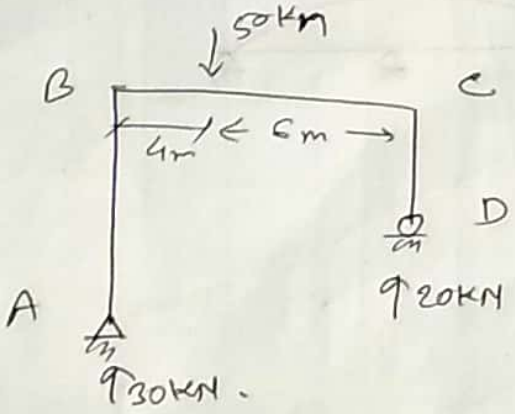
DOI = $3m + r - 3j$

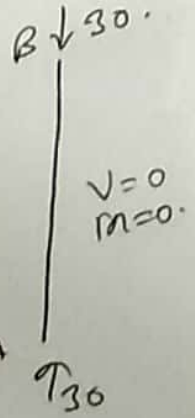
$= 3 \times 3 + (2+2) - 3 \times 4$

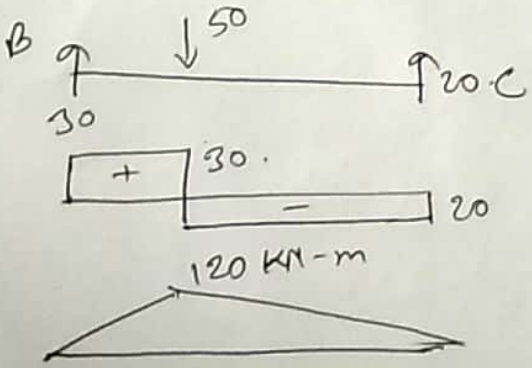
$= 14 - 12 = 2^{\circ}$

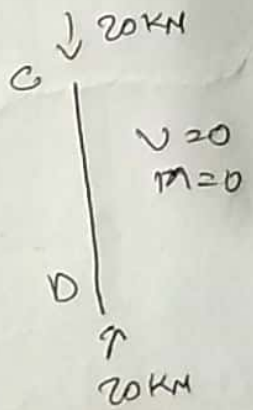


mo

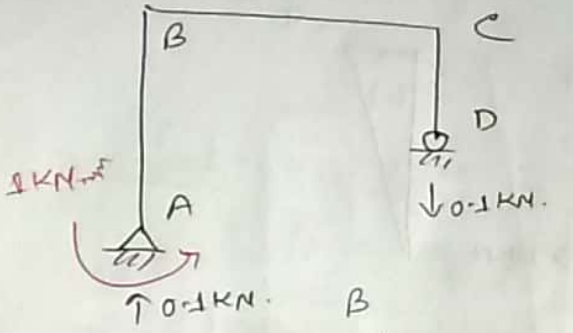


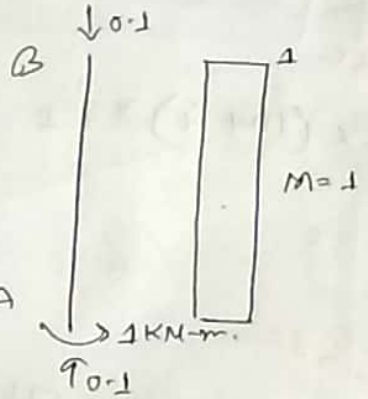


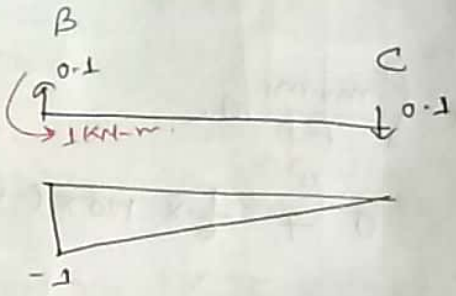


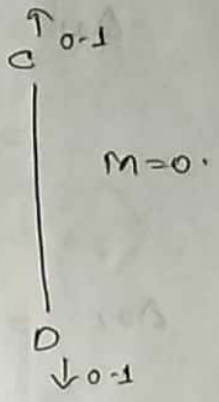


m1

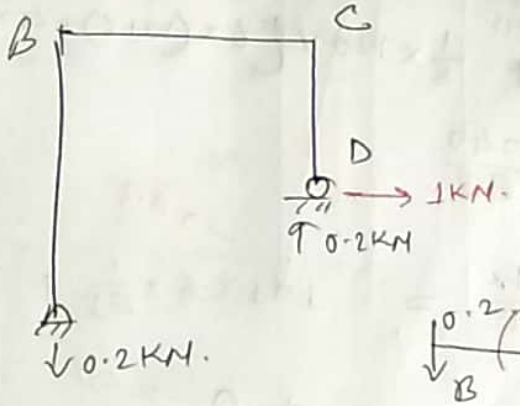

B
C
D
1KN-m
A
0.1KN.
0.1KN.

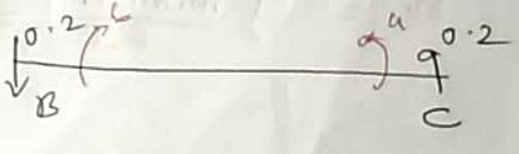

0.1
B
1
M=1
A
1KN-m.
0.1

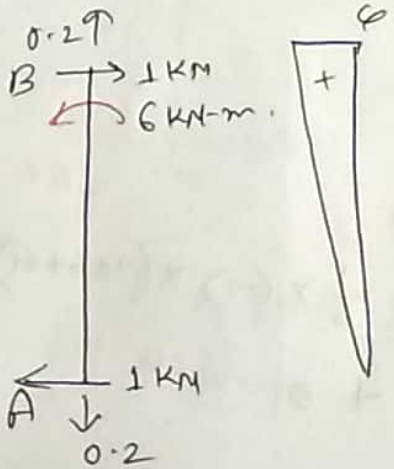

B
0.1
C
0.1
1KN-m.
-1

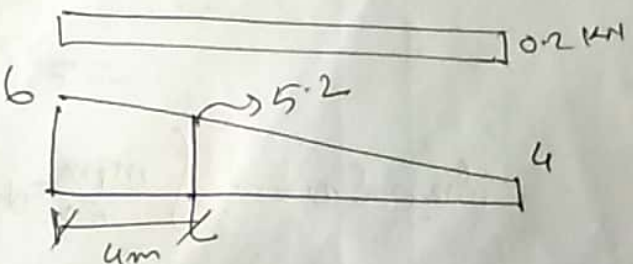

0.1
C
M=0.
D
0.1

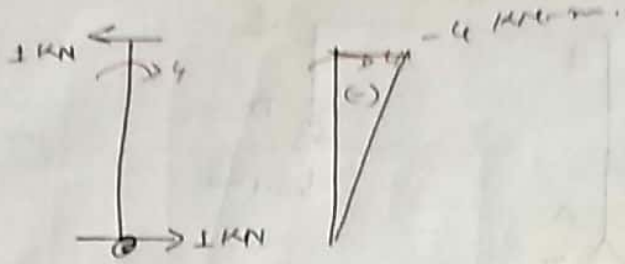
m2


B
C
D
1KN.
0.2KN
A
1KN
0.2KN.


0.2
B
C
0.2


0.2
B
1KN
6KN-m.
A
1KN
0.2


0.2KN
6
5.2
4
4m



$$\Delta_{01} = \int \frac{m_0 m_1}{EI} dx$$

$$= 0 + \frac{1}{6} \times 120 \times (-1) \times (10+4) \times \frac{1}{EI} + 0$$

(AB → BC → CD)

$$= -\frac{280}{EI}$$

$$\Delta_{02} = \int \frac{m_0 m_2}{EI} dx$$

$$= 0 + \frac{1}{6} \times 720 \times \left[6 \times (10+6) + 4 \times (10+4)\right] \frac{1}{EI} + 0$$

(AB → BC → CD)

$$= \frac{3040}{EI}$$

$$\delta_{11} = \int \frac{m_1 m_1 dx}{EI} = 1 \times 1 \times 6 \times \frac{1}{EI} + \frac{1}{3}(-1)(-1) \times 10 \frac{1}{EI} + 0$$

(AB → BC → CD)

$$= \frac{28}{3EI}$$

$$\delta_{12} = \delta_{21} = \int \frac{m_1 m_2}{EI} dx$$

$$= \frac{1}{2} \times 6 \times 1 \times 6 \frac{1}{EI} + \frac{1}{6} \times (-1) \times (2 \times 6 + 4) \times 10 \frac{1}{EI} + 0$$

(AB → BC → CD)

$$= -\frac{26}{3EI}$$

$$\delta_{22} = \int \frac{m_2 m_2 \, dx}{EI}$$

$$= \frac{1}{3}\times 6\times 6\times 6\,\frac{1}{EI} + \frac{1}{6}\times\left[6\times(2\times 6+4)+4\times(2\times 4+6)\right]\times 10\times\frac{1}{EI} + \frac{1}{3}\times(-4)(-4)\times 4\,\frac{1}{EI}$$

(AB, BC, CD)

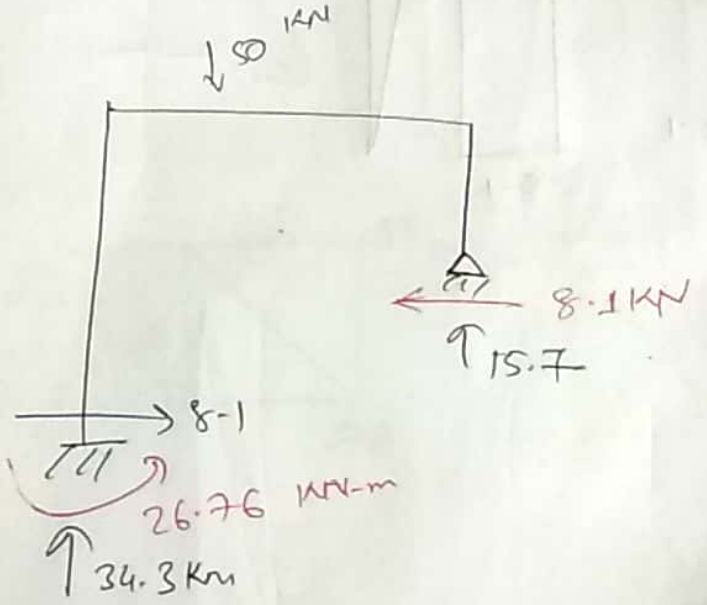
$$= \frac{1040}{3EI}$$

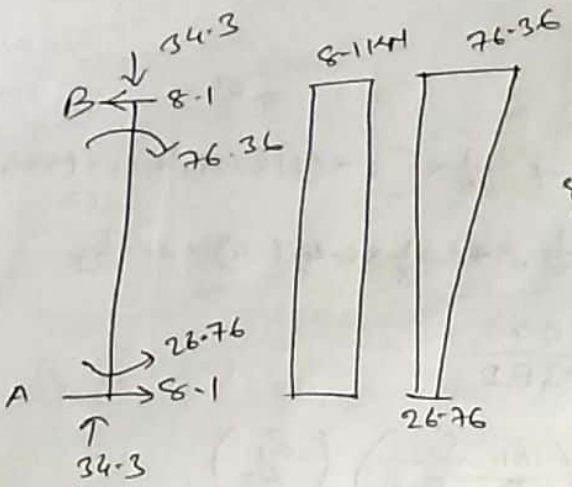
$$\begin{pmatrix}\Delta_1\\ \Delta_2\end{pmatrix} = \begin{pmatrix}\Delta_{01}\\ \Delta_{02}\end{pmatrix} + \begin{pmatrix}\delta_{11} & \delta_{12}\\ \delta_{21} & \delta_{22}\end{pmatrix}\begin{pmatrix}R_1\\ R_2\end{pmatrix}$$

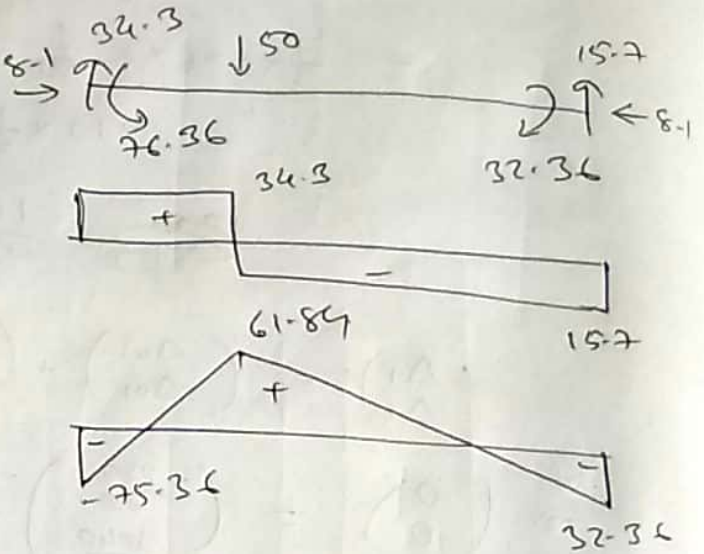
$$\Rightarrow \begin{pmatrix}0\\ 0\end{pmatrix} = \begin{pmatrix}-\frac{280}{EI}\\ \frac{3040}{EI}\end{pmatrix} + \begin{pmatrix}\frac{28}{3EI} & -\frac{26}{3EI}\\ -\frac{26}{3EI} & \frac{1040}{3EI}\end{pmatrix}\begin{pmatrix}R_1\\ R_2\end{pmatrix}$$

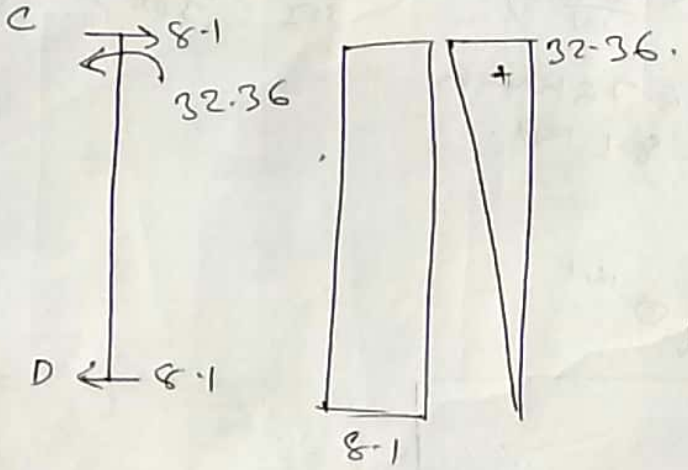
$R_1 = 26.76$ KN-m

$R_2 = -8.1$ KN



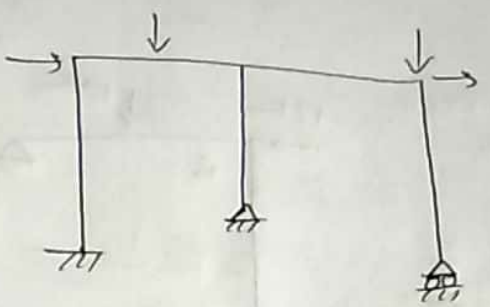

34.3
B
8.1
76.36
26.76
A
8.1
34.3
8.144
76.36
26.76


34.3
8.1
50
15.7
8.1
76.36
32.36
34.3
+
−
61.84
15.7
+
−
−
−75.36
32.36


C
8.1
32.36
D
8.1
32.36.
+
8.1

2012-13

5 (b)

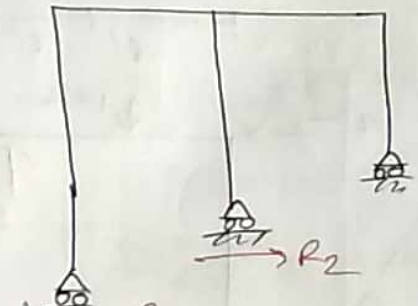


$3m+r-3j$

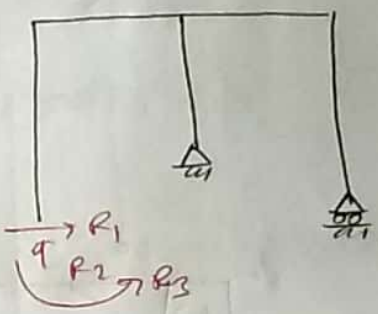
$= 3\times5+6-3\times6$

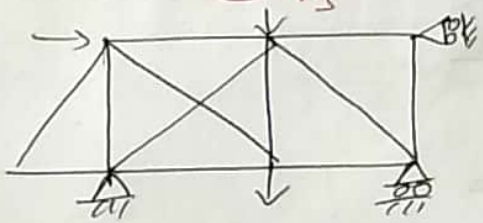
$= 3^\circ$

(i)



(ii)

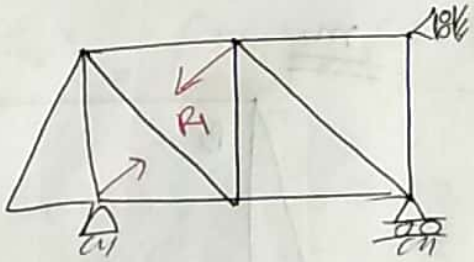




$b+r-2j$

$= 12+4-2\times6 = 2^\circ$

(i)



(ii)