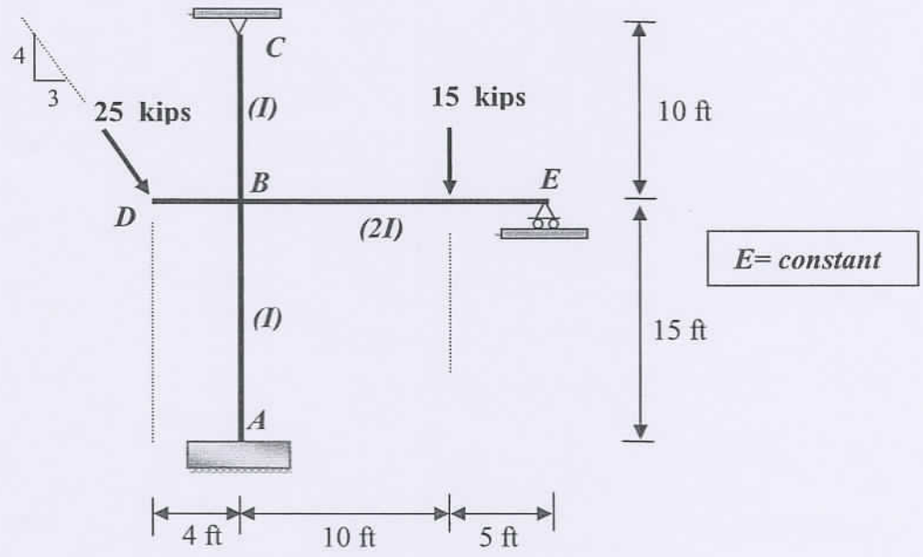
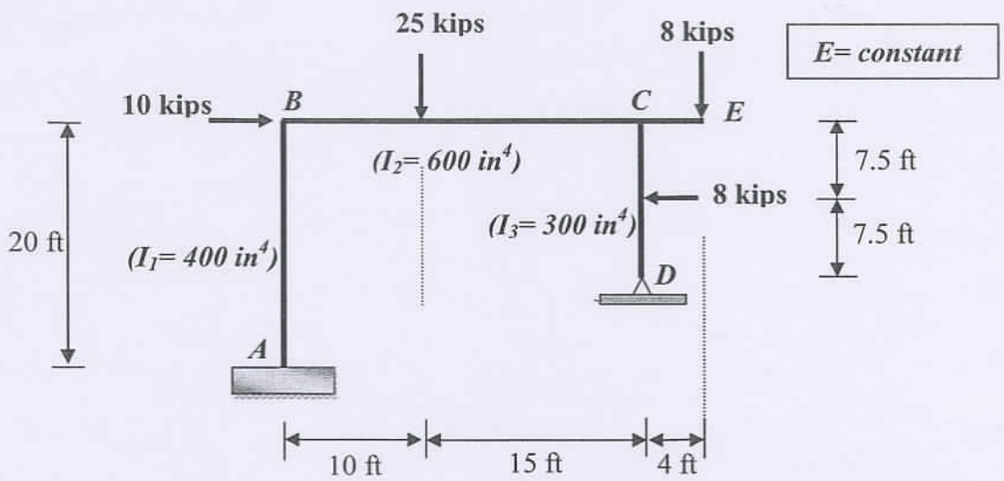
FRAMES WITH SIDE-SWAY

Analyze the following structures by the Slope-Deflection Method:

Problem [1]



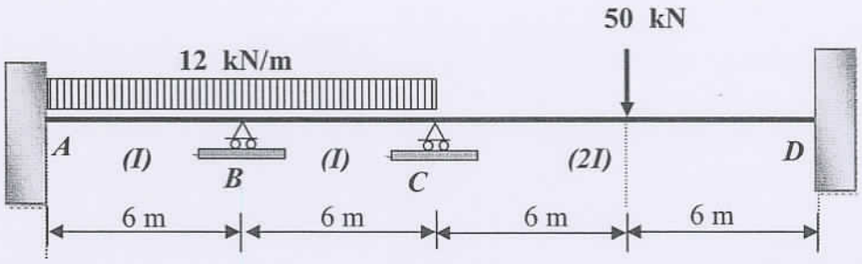
Problem [2]



BEAMS AND FRAMES WITHOUT SIDE-SWAY

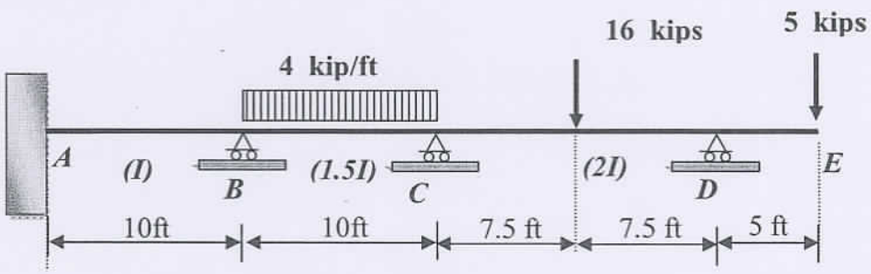
Analyze the following structures by the Moment Distribution Method:

Problem [3]



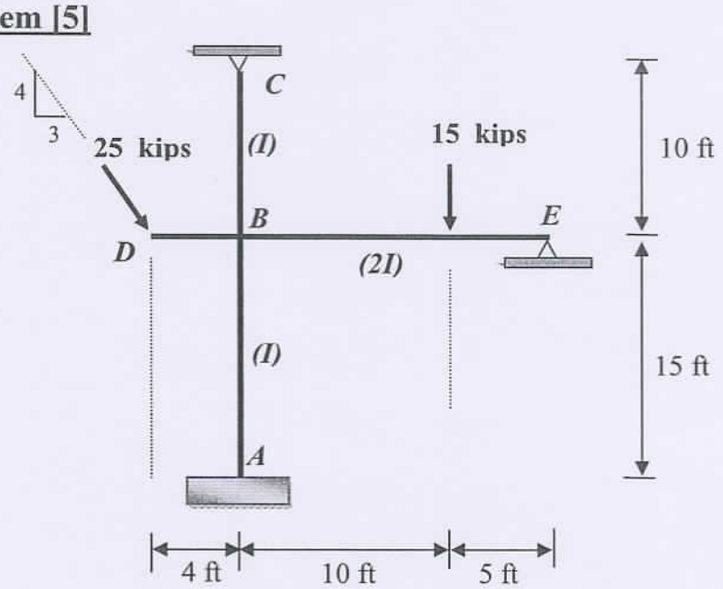
E= constant

Problem [4]



E= constant

Problem [5]

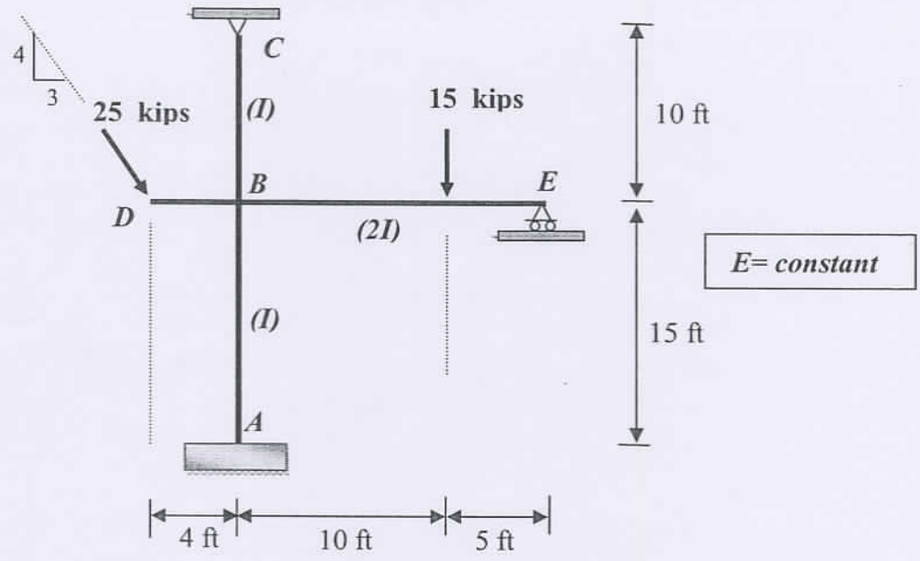


E= constant

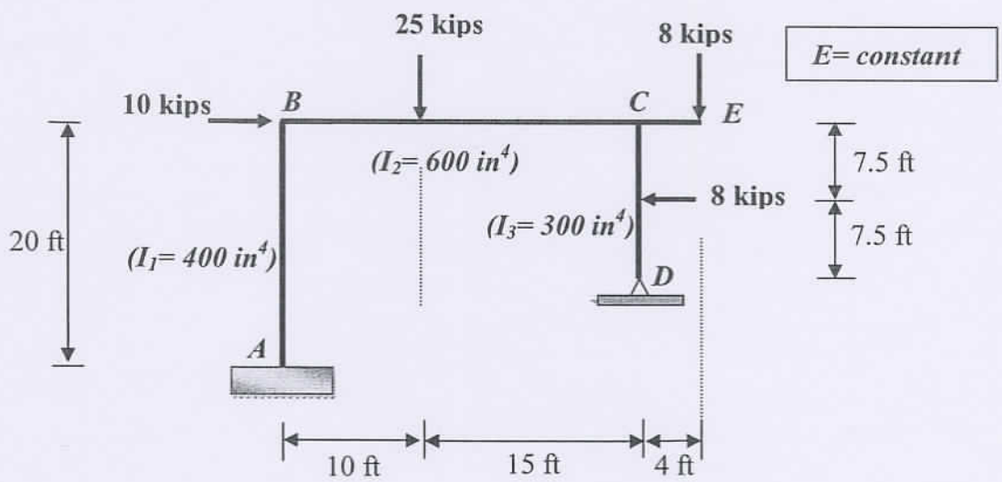
FRAMES WITH SIDE-SWAY

Analyze the following structures by the Moment Distribution Method:

Problem [6]

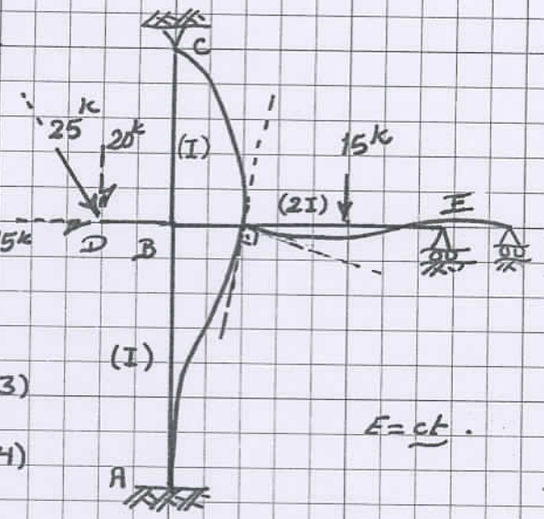


Problem [7]



Good Luck & Best Wishes
Dr. Hisham S. Basha, Ph.D.

Frames With Sidesway By Slope-Deflection



$$M_{AB} = \frac{2EI}{15}(\theta_B - 3\psi_{AB}) \quad \ldots(1)$$

$$M_{BA} = \frac{2EI}{15}(2\theta_B - 3\psi_{AB}) \quad \ldots(2)$$

$$M_{BE} = \frac{3(2EI)}{15}(\theta_B) - 33.33 \quad \ldots(3)$$

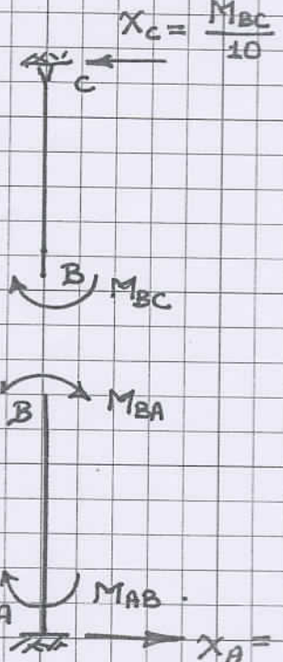
$$M_{BC} = \frac{3EI}{10}\left(\theta_B + \frac{3}{2}\psi_{AB}\right) \quad \ldots(4)$$

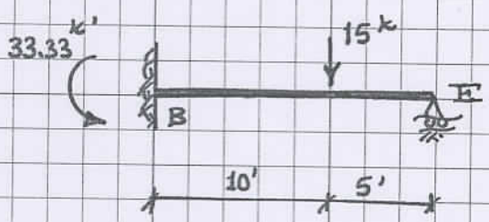
$E = c.t.$

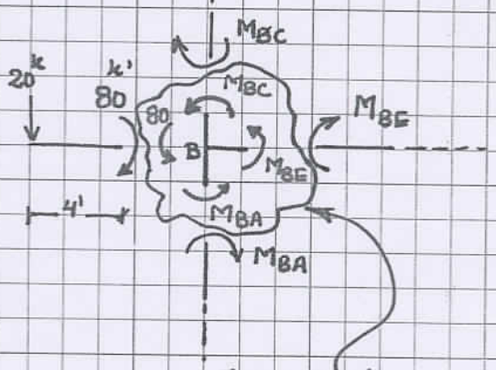
$$\psi_{AB} = \frac{\Delta}{15}$$

$$\psi_{BC} = -\frac{\Delta}{10}$$

$$\Rightarrow \boxed{\psi_{BC} = -\frac{3}{2}\psi_{AB}}$$







$\Sigma X = 0$

$$\Rightarrow \boxed{15 + \frac{M_{AB}+M_{BA}}{15} - \frac{M_{BC}}{10} = 0} \quad \ldots(6).$$

$$\Rightarrow \boxed{80 + M_{BA} + M_{BC} + M_{BE} = 0} \quad \ldots(5)$$

Eqn. (5) $\Rightarrow 80 + \frac{4EI}{15}\theta_B - \frac{6EI}{15}\psi_{AB} + \frac{3EI}{10}\theta_B + \frac{9EI}{20}\psi_{AB} + \frac{6EI}{15}\theta_B - 33.33 = 0.$

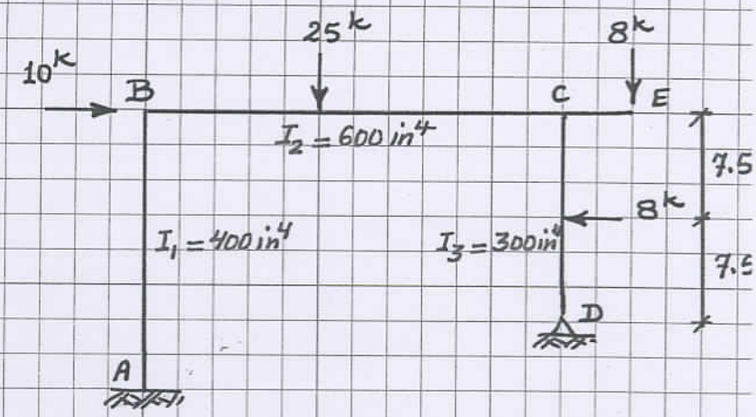
$$\frac{29}{30}EI.\theta_B + \frac{1}{20}EI.\psi_{AB} + 46.67 = 0.$$

$$\Rightarrow \boxed{29\theta_B + 1.5\psi_{AB} = -1400.1/(EI).} \quad \ldots(5')$$

Eqn. (6) multiply × 15 $\Rightarrow 15 * 15 + M_{AB} + M_{BA} - \frac{3}{2}M_{BC} = 0$

3
12

Frame With Sidesway By Moment Distribution



$E = ct$ let $I = I_3$.

$I_1 = \frac{4}{3}I$; $I_2 = 2I$.

Distribution Factors ; (d).

20'

Joint (B) :-

$$d_{BA} = \frac{K_{BA}}{K_{BA} + K_{BC}} = \frac{4(\frac{4}{3}I)/20}{4(\frac{4}{3}I)/20 + 4(2I)/25}$$

$$= \frac{4/60}{4/60 + 2/25} = 0.4545.$$

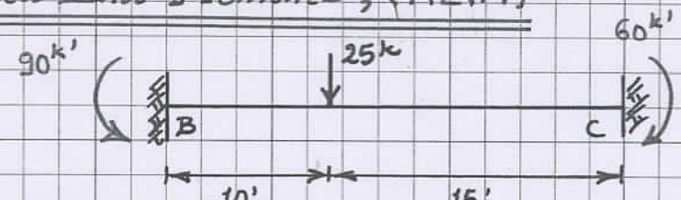
$$d_{BC} = \frac{K_{BC}}{K_{BA} + K_{BC}} = 0.5455.$$

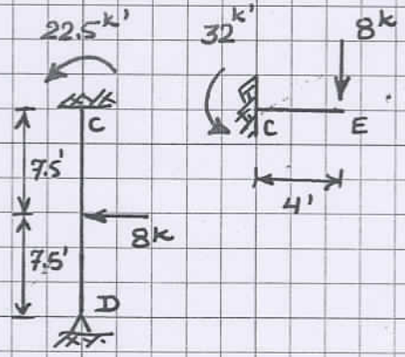
Joint (C) :-

$$d_{CB} = \frac{K_{CB}}{K_{CB} + K_{CD}} = \frac{4(2I/25)}{4(2I/25) + 3(I/15)} = 0.6154.$$

$$d_{CD} = \frac{K_{CD}}{K_{CB} + K_{CD}} = 0.3846$$

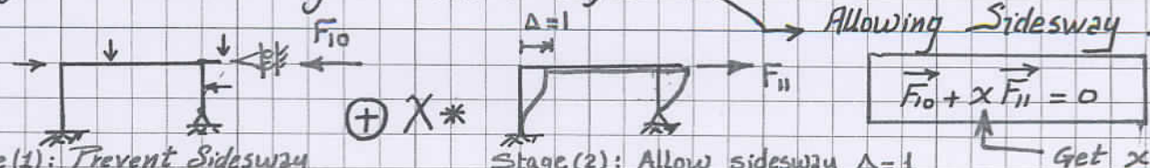
Fixed End Moments ; (F.E.M)





- $FEM_{BC} = \frac{Pab^2}{L^2} = \frac{25(10)(15)^2}{25^2} = 90$ k.ft.
- $FEM_{CB} = \frac{Pa^2b}{L^2} = \frac{25(10)^2(15)}{25^2} = 60$ k.ft.
  - $FEM_{CD} = \frac{3PL}{16} = 22.5$ k.ft
    (or $1.5\frac{PL}{8} = 22.5$ k.ft).
  - $FEM_{CE} = 8^k * 4' = 32$ k.ft.

The Frame will be analyzed in two Stages → Preventing Sidesway. / Allowing Sidesway.



Stage (1): Prevent Sidesway $\vec{F_{10}} = \checkmark$

Stage (2): Allow sidesway $\Delta = 1$ $\vec{F_{11}} = \checkmark$

Stage [1] :- Preventing Sideway.

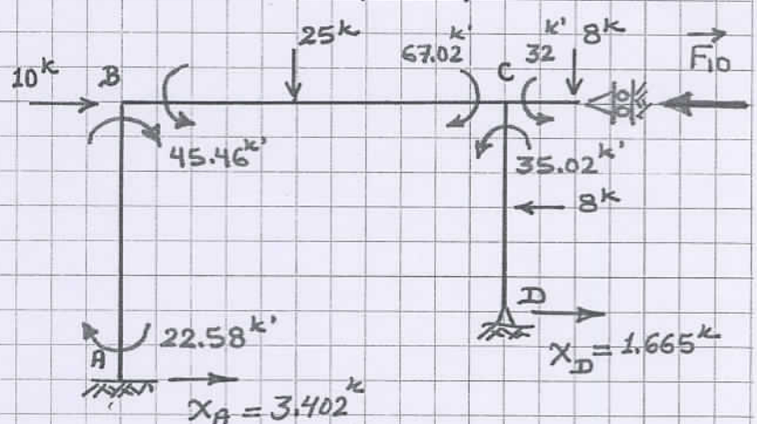
Moment Distribution Table.

(Atve)

	Fix	A		B		C		
		AB	BA	BC	CB	CD	CE	
(d) :	1	0	0.4545	0.5455	0.6154	0.3846	—	
FEM :	0	0	0	-90	+60	-22.5	-32	cycle (1)
DM :	0	0	+40.9	+49.1	-3.4	-2.1	0	
C.O.M :	0	+20.45	0	-1.7	+24.55	0	0	cycle (2)
DM :	-20.45	0	+0.77	+0.93	-15.11	-9.44	0	
C.O.M :	0	+0.38	0	-7.55	+0.46	0	0	cycle (3)
DM :	-0.38	0	+3.43	+4.12	-0.28	-0.18	0	
C.O.M :	0	+1.71	0	-0.14	+2.06	0	0	cycle (4)
DM :	-1.71	0	+0.07	+0.07	-1.27	-0.79	0	
C.O.M :	0	+0.04	0	-0.64	+0.04	0	0	cycle (5)
D.M :	-0.04	0	+0.29	+0.35	-0.03	-0.01	0	
M_o =	-22.58	+22.58	+45.46	-45.46	+67.02	-35.02	-32	

$\overrightarrow{F_{10}} = ?$.

- $x_D = \frac{8}{2} + \left(\frac{-35.02}{15}\right) = \underline{1.665^k}$
- $x_A = \frac{45.46 + 22.58}{20} = \underline{3.402^k}$



Now, $\Sigma X = 0$

$\Rightarrow \overrightarrow{F_{10}} = 10 + 3.402 + 1.665 - 8$

$\Rightarrow \boxed{\overrightarrow{F_{10}} = 7.07^k \leftarrow}$

$\overrightarrow{F_{10}}$ is the holding force on the frame. In this stage all rotational kinematic degrees of freedom are considered. In stage(2), the translational degree of freedom (sidesway) will be considered alone. Note that, in problems with more than one degree of sidesway, each degree of sway should be considered individually.

$$\Rightarrow M_{AB} + M_{BA} - \frac{3}{2} M_{BC} = -225.$$

$$\Rightarrow \frac{2}{15} EI.\theta_B - \frac{6}{15}\psi_{AB} + \frac{4EI}{15}\theta_B - \frac{6EI}{15}\psi_{AB} - \frac{9EI}{20}\theta_B - \frac{27}{40}EI\,\psi_{AB} = -225$$

$$\Rightarrow -\frac{EI}{20}\theta_B - \frac{59}{40} EI.\psi_{AB} = -225.$$

$$\times\left(\frac{-20}{EI}\right) \Rightarrow \boxed{+\theta_B + 29.5\psi_{AB} = +4500/(EI} \quad \text{---- (6').}$$

Solving (5') & (6') for θ_B & ψ_{AB}.

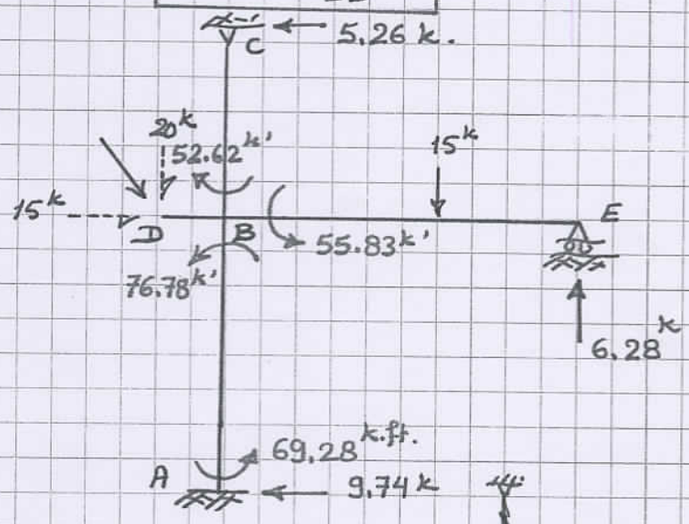
$$\boxed{\theta_B = -\frac{56.26}{EI}} \quad \text{and} \quad \boxed{\psi_{AB} = \frac{154.45}{EI}}.$$

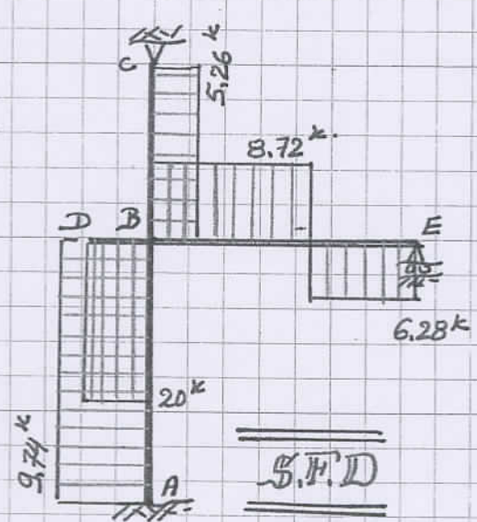
$\Rightarrow M_{AB} = -69.28$ k.ft.

$M_{BA} = -76.78$ k.ft.

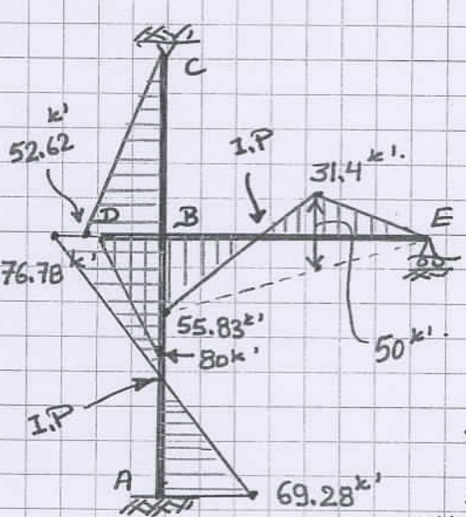
$M_{BE} = -55.83$ k.ft.

$M_{BC} = +52.62$ k.ft.

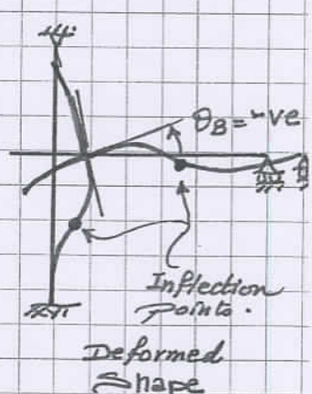




S.F.D



B.M.D

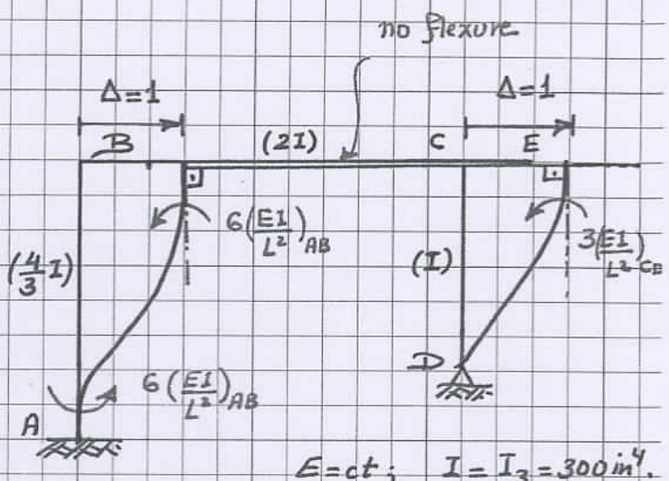


Moments are Plotted From Comp. Side.

Stage [2]: Allowing Side Sway.

Allow the Frame to Sway

$\Delta = 1$.



Fixed End Moments :-

$$M_{AB} = M_{BA} = \frac{6E(4I/3)}{(20)^2} = 0.02\,EI.$$

$$M_{CD} = \frac{3E(I)}{(15)^2} = 0.01333\,EI.$$

$E = ct$; $I = I_3 = 300\,in^4$.

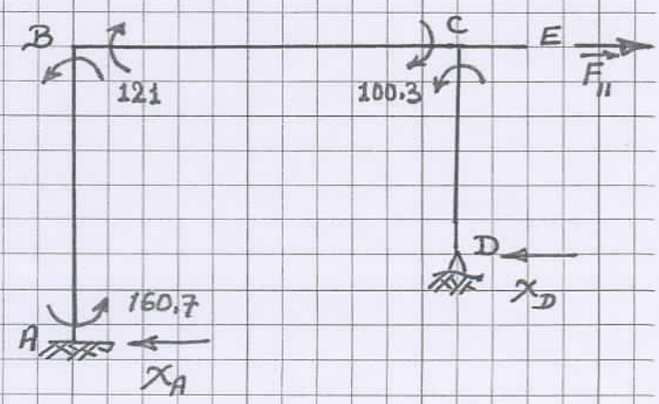
Moment Distribution Table

+ve $* \frac{10,000}{EI}$

	Fix	AB	BA	BC	CB	CD	CE	
	(A)		(B)			(C)		
(d) :	1	0	0.4545	0.5455	0.6154	0.3846	~	
F.E.M :	0	-200	-200	0	0	-133.3	0	cycle [1]
DM :	+200	0	+90.9	+109.1	+82.1	+51.2		
C.O.M :	0	+45.5	0	+41	+54.6	0		cycle [2]
DM :	-45.5	0	-18.6	-22.4	-33.6	-21		
C.O.M :	0	-9.3	0	-16.8	-11.2	0		cycle [3]
DM :	+9.3	0	+7.6	+9.2	+6.9	+4.3		
C.O.M :	0	+3.8	0	+3.4	+4.6	0		cycle [4]
D.M :	-3.8	0	-1.5	-1.9	-2.8	-1.8		
C.O.M :	0	-0.7	0	-1.4	-0.9	0		cycle [5]
D.M :	+0.7	0	+0.6	+0.8	+0.6	+0.3		
M_1 =	+160.7	-160.7	-121	+121	+100.3	-100.3		

+ve $* \frac{EI}{10,000}$

* All ouput values must be multiplied by $* \frac{EI}{10,000}$.



- $\vec{F_{11}} = ?$.

$$X_D = \frac{100.3}{15} = 6.687$$

$$X_A = \frac{121 + 160.7}{20} = 14.085.$$

$\rightarrow \Sigma X = 0 \rightarrow \vec{F_{11}} = 20.772 \rightarrow$.

$\rightarrow \boxed{\vec{F_{11}} = 0.0020772\,EI \rightarrow}$

Compatibility Requires :- $\vec{F_{10}} + x\vec{F_{11}} = 0$.

$$\Rightarrow x = -\frac{\vec{F_{10}}}{\vec{F_{11}}}$$

assuming $\xrightarrow{+VE}$.

$\Rightarrow F_{10} = -7.07^{k}$.

and $F_{11} = +0.0020772\,EI$.

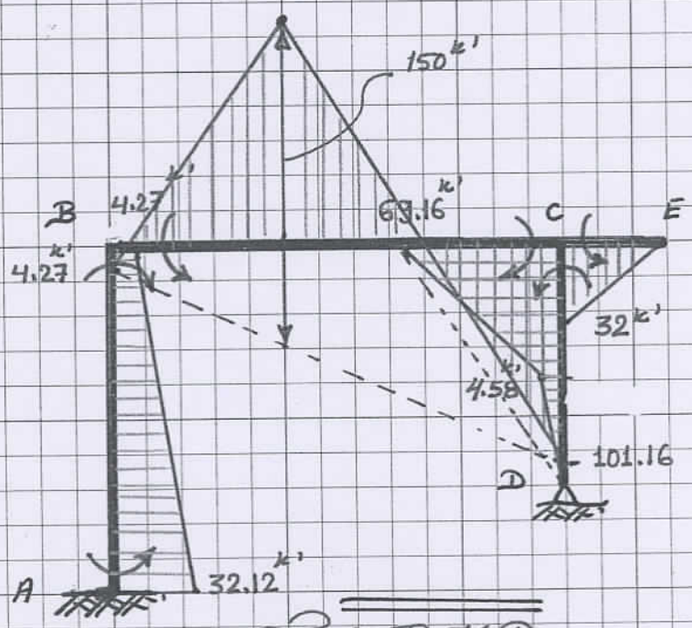
$$\Rightarrow x = -\frac{-7.07}{0.0020772\,EI} = \frac{3,403.62}{EI}$$

$$\Rightarrow \boxed{x = 0.3404 * \left(\frac{10,000}{EI}\right)}.$$

$M_{f\,final} = M_0 + x.M_1$

All must be $\frac{EI}{10000}$

	(A)		(B)		(C)		
	Fix	AB	BA	BC	CB	CD	CE
$M_1 =$	160.7	-160.7	-121	+121	+100.3	-100.3	~
$x.M_1 =$	54.70	-54.70	-41.19	+41.19	+34.14	-34.14	
$M_0 =$	-22.58	+22.58	+45.46	-45.46	+67.02	-35.02	-32
$M_f = M_0 + xM_1 =$	32.12	-32.12	+4.27	-4.27	+101.16	-69.16	-32



Final B.M.D.

All moments are plotted From Compression Side.