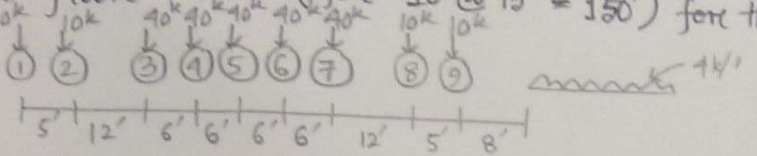
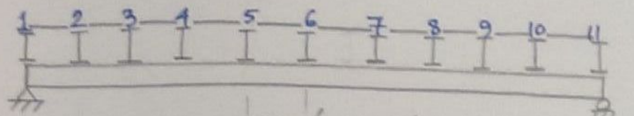
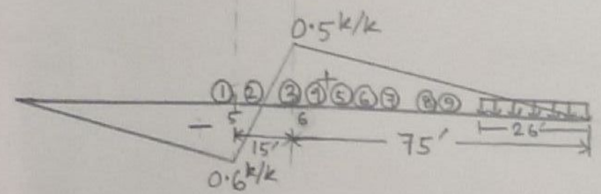
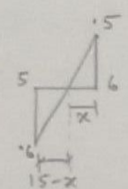
Assignment - 32: Find maximum panel shear in 5th panel of the span with floor beams (for 10 @ 15' = 150') for the loading below.





10 @ 15' = 150'





from similar △s →

$\frac{.5}{x} = \frac{.6}{15-x}$

$\Rightarrow 15 \times .5 = (.6 + .5)x$

$\Rightarrow x = 6.82'$

$\therefore 15 - x = 8.18$

Trial No.	Position of wheel		$\frac{W}{L}$		$\frac{W_1}{P}$	Remarks	Calculations
1	wheel 3 at 6	just to right	$\frac{344}{150}$	$>$	$\frac{10}{15}$	Criterion is Satisfied	$W = 1 \text{ to } 9 + 4 \times 26 = 344^k$; $W_1 = \text{wheel } 2 = 10^k$
		just to left	$\frac{344}{150}$	$<$	$\frac{50}{15}$		$W = 344^k$; $W_1 = 2 \,\&\, 3 = 50^k$

∴ Wheel 3 at 6 gives maximum panel shear.

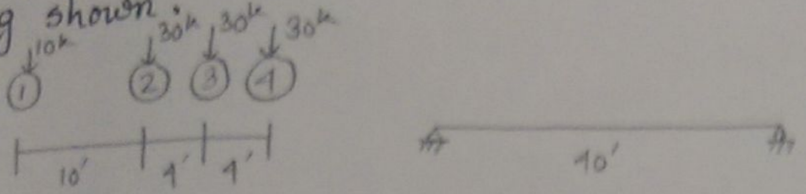
∴ Maximum Panel shear $= \frac{.5}{75}\left[(75+69+63+57+51) \times 40 + (39+34) \times 10\right] + \left(\frac{1}{2} \times 26 \times \frac{.5}{75} \times 26\right) \times 4 - \frac{.6}{60} \times 58 \times 10 - \frac{.6}{(15-6.82)} \times 5.18 \times 10$

$= 97.88 - 9.6$

$= \underline{\underline{88.28^k}}$

Ans.

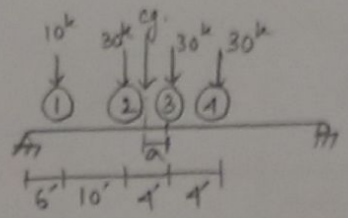
Assigment-31: Find greatest or absolute moment for 40' span for the loading shown:



Trial No	Position of wheel		W/L		W_1/a	Remarks	Calculation
1	wheel ③ at center	just to right	$\frac{100}{40}$	>	$\frac{40}{20}$	Criterion Satisfied	W = ① to ④ = 100^k; W_1 = ①, ② = 40^k
		just to left	$\frac{100}{40}$	<	$\frac{70}{20}$		W = 100^k; W_1 = ① to ③ = 70^k

∴ P = wheel ③ = 30^k

• Locating the cg of loads –



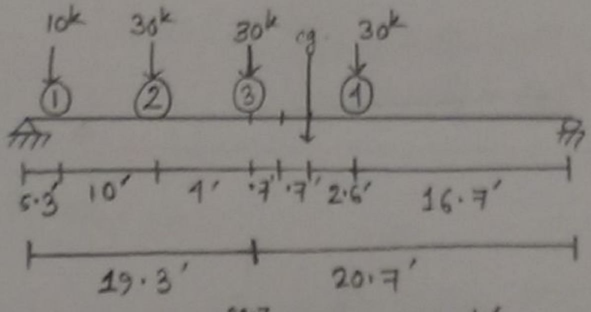
from wheel ③ →

$10\times14 + 30\times4 + 100\times a - 30\times4 = 0$

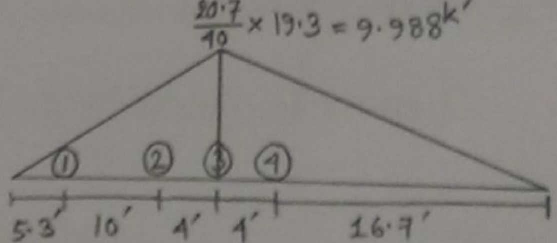
$\Rightarrow a = \frac{30\times4 - 30\times4 - 10\times14}{100}$

∴ $a = -1.4'$

∴ $\frac{a}{2} = 0.7'$



Here, $L = 40'$, $W = 100^k$, $a = 19.3'$



		$\frac{W}{L}$		$\frac{W_1}{a}$
wheel ③ at 19.3' from the left support	just to right	$\frac{100}{40}$	>	$\frac{40}{19.3}$
	just to left	$\frac{100}{40}$	<	$\frac{70}{19.3}$

∴ Greatest moment $= \frac{9.988}{20.7}\left[20.7\times30 + 16.7\times30\right] + \frac{9.988}{19.3}\left[15.3\times30 + 5.3\times10\right]$

$= 806.35^{k'}$ Ans.

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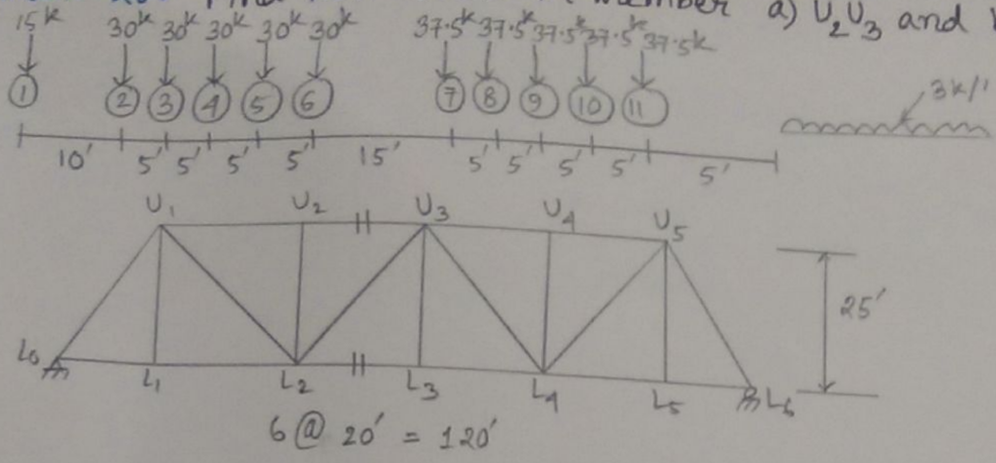
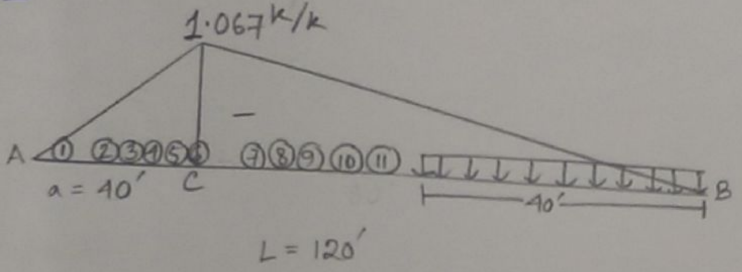
Assignment-28: Find max^m stress in member a) U_2U_3 and b) L_2L_3



a) for U_2U_3 –



$\Sigma M_{L_2} = 0 \Rightarrow \frac{4}{6} \times 40 = -F_{U_2U_3} \times 25$

$\Rightarrow F_{U_2U_3} = -1.067^k$

Trial No.	Position of wheel		W/L		W_1/a	Remarks	Calculations
1	wheel 6 at C	just to right	$\frac{472.5}{120}$	$>$	$\frac{135}{40}$	Criterion	$W = 1 \text{ to } 11 + 3\times40 = 472.5^k$; $W_1 = 1 \text{ to } 5 = 135^k$
		just to left	$\frac{472.5}{120}$	$<$	$\frac{165}{40}$	Satisfied	$W = 1 \text{ to } 11 + 3\times40 = 472.5^k$; $W_1 = 1 \text{ to } 6 = 165^k$

∴ wheel 6 at C gives max^m bar force.

∴ Max^m bar force $= \frac{1.067}{80}\left[80\times30 + (65+60+55+50+45)\times37.5\right] + \left(\frac{1}{2}\times40\times\frac{1.067}{80}\times40\right)\times3$

$+ \frac{1.067}{40}\left[(35+30+25+20)\times30 + 10\times15\right]$

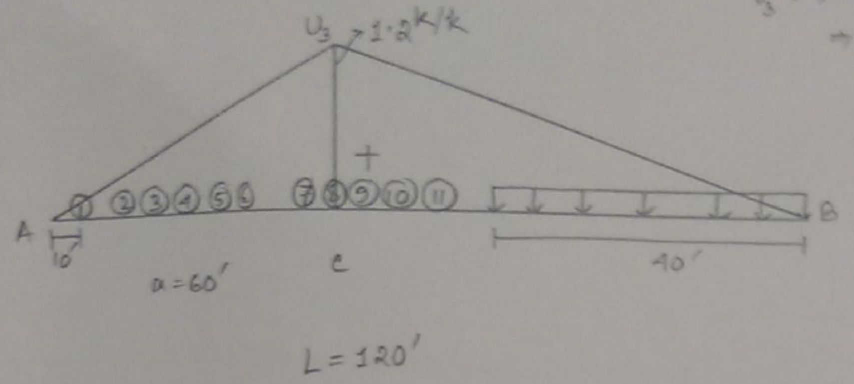
$= -293.59^k$ (compressive)

Ans.

b) for L_2L_3 —

$\Sigma M_{U_3} = 0 \Rightarrow \cdot 5 \times 60 = F_{L_2L_3} \times 25$

$\Rightarrow F_{L_2L_3} = 1\cdot 2^k$ (+)



Trial No.	Position of wheel		W/L		W_1/a	Remarks	Calculations
1	wheel 7 at C	just to right	$\frac{457\cdot 5}{120}$	>	$\frac{165}{60}$		$W = 1$ to $11 + 3 \times 35 = 457\cdot 5^k$; $W_1 = 1$ to $6 = 165^k$
		just to left	$\frac{457\cdot 5}{120}$	>	$\frac{202\cdot 5}{60}$		$W = 1$ to $11 + 3 \times 35 = 457\cdot 5^k$; $W_1 = 1$ to $7 = 202\cdot 5^k$
2	wheel 8 at c	just to right	$\frac{472\cdot 5}{120}$	>	$\frac{202\cdot 5}{60}$		$W = 1$ to $11 + 3 \times 40 = 472\cdot 5^k$; $W_1 = 1$ to $8 = 202\cdot 5^k$
		just to left	$\frac{472\cdot 5}{120}$	<	$\frac{240}{60}$		$W = 472\cdot 5^k$; $W_1 = 1$ to $8 = 240^k$

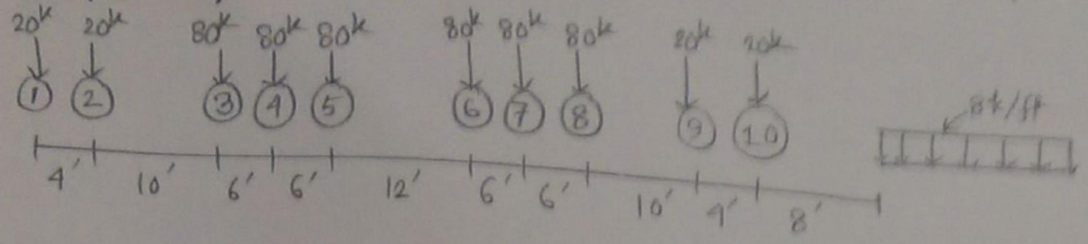
So wheel 8 at C gives maximum stress.

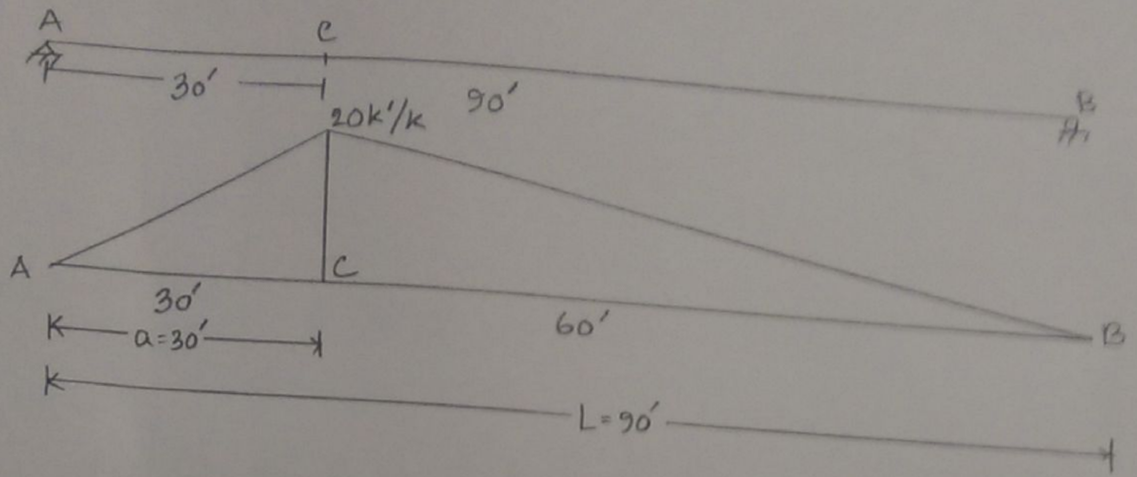
$\therefore$ Maximum stress $= \frac{1\cdot 2}{60}\Big[(60+55+50+45+55)\times 37\cdot 5 + (40+35+30+25+20)\times 30 + 10 \times 15\Big] + \left(\frac{1}{2} \times 40 \times \frac{1\cdot 2}{60} \times 40\right) \times 3$

$= \underline{\underline{339\cdot 75^k \text{ (tension)}}}$

Ans.

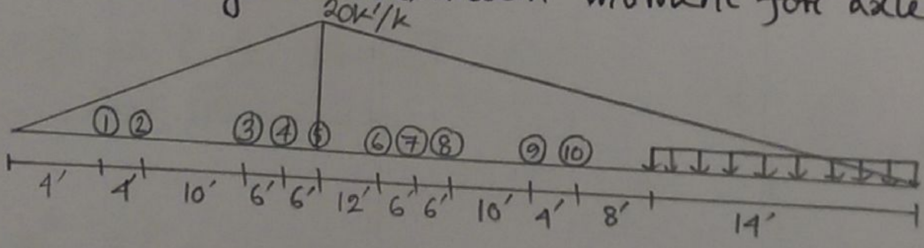
Assignment-26: Find maximum moment at one-third point of a simple span of 90′.





Trial No.	Position of wheel	Avg. load on span (W/L)		Avg. load on section (W_1/a)	Remarks	Calculations
1	wheel 5 at C — just to right	$\frac{672}{90}$	>	$\frac{200}{30}$	Criterion Satisfied	W = 1 to 10 $+ 8\times14 = 672^k$; W_1 = 1 to 4 $= 200^k$
	wheel 5 at C — just to left	$\frac{672}{90}$	<	$\frac{280}{30}$		W_1 = 1 to 5 $= 280^k$; W = 1 to 10 $+ 8\times14 = 672^k$

Hence, wheel 5 at C gives maximum moment for axle load.



$\therefore$ Max^m moment for Axle load $= \frac{20}{60}\left[60\times80+48\times80+42\times80+36\times80+26\times20+22\times20\right]$

$+\left(\frac{1}{2}\times14\times\frac{20}{60}\times14\right)\times8+\frac{20}{30}\left[24\times80+18\times80+8\times20+4\times20\right]$

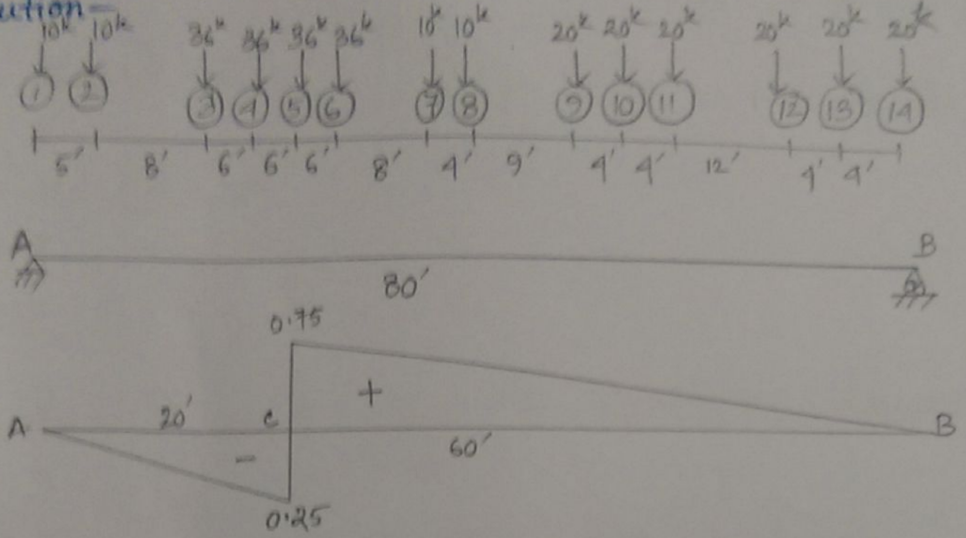
$= 7941.33^{k'}$

$\therefore$ Max^m Moment for wheel load $= \frac{7941.33}{2} = \underline{\underline{3970.67^{k'}}}$

Ans.

Assignment - 21: Find maximum shear at quarter point of a 80′ simple span.

Solution—



Trial - 1 : wheel ① at C to wheel ② at C

ΣP = wheel ① to wheel ⑪

$= 244^k$

P_1 = wheel ① $= 10^k$

$P' = 0$

$e = 0$

$P_2 = 0$

$e' = 0$

$d_1 = 5'$

$$\Delta V = \frac{\Sigma P d_1}{L} - P_1 + \frac{P'e}{L} + \frac{P_2 e'}{L}$$

$$= \frac{244 \times 5}{80} - 10 + 0 + 0$$

$$= 5.25^k \text{ (+ve, increasing)}$$

Trial - 2 : wheel ② at C to wheel ③ at C

ΣP = wheel ① to wheel ⑪

$= 244^k$

P_1 = wheel ② $= 10^k$; $P_2 = 0$

P' = wheel ⑫ $= 20^k$; $e' = 0$

$e = 1'$; $d_1 = 8'$

$$\Delta V = \frac{\Sigma P d_1}{L} - P_1 + \frac{P'e}{L} + \frac{P_2 e'}{L}$$

$$= \frac{244 \times 8}{80} - 10 + \frac{20 \times 1}{80} + 0$$

$$= 14.65 \text{ (+ve, increasing)}$$

Trial-3: wheel (3) at C to wheel (4) at C

ΣP = wheel (1) to wheel (12) ; $\Delta V = \frac{\Sigma P d_1}{L} - P_1 + \frac{P'e}{L} + \frac{P_2 e'}{L}$

$= 264^k$ $\quad = \frac{264 \times 6}{80} - 36 + \frac{20 \times 3}{80} + 0$

$d_1 = 6'$

P_1 = wheel (3) $= 36^k$ $\quad = -15.45$ (-ve, decreasing)

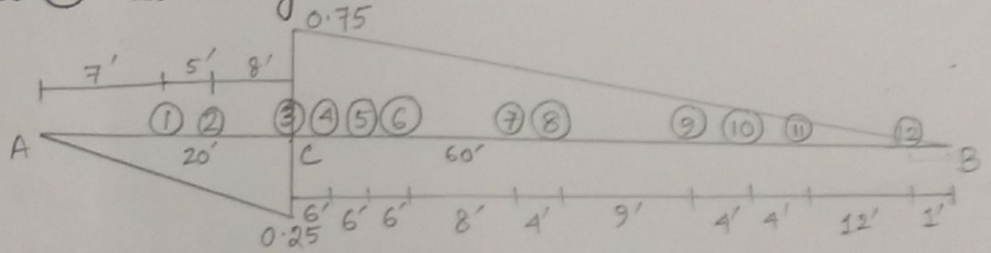
$e = 3'$

P' = wheel (13) $= 20^k$

$P_2 = 0$

$e' = 0$

So, wheel (3) at C gives the maximum shear.



$\therefore$ Maximum shear $= +\frac{0.75}{60}\Big[60\times36 + 54\times36 + 48\times36 + 34\times10 + 30\times10 + 21\times20 + 17\times20 + 13\times20 + 1\times20 + 42\times36\Big]$

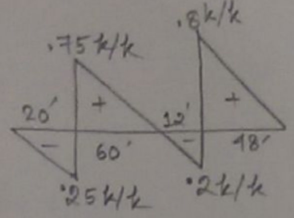
$- \frac{0.25}{20}\Big[12\times10 + 7\times10\Big]$

$= +110.425^k$

Ans.

Assignment-21: What is the maximum shear due to 5k/′ UDL and concentrated 100^k of moving load?

Solution –



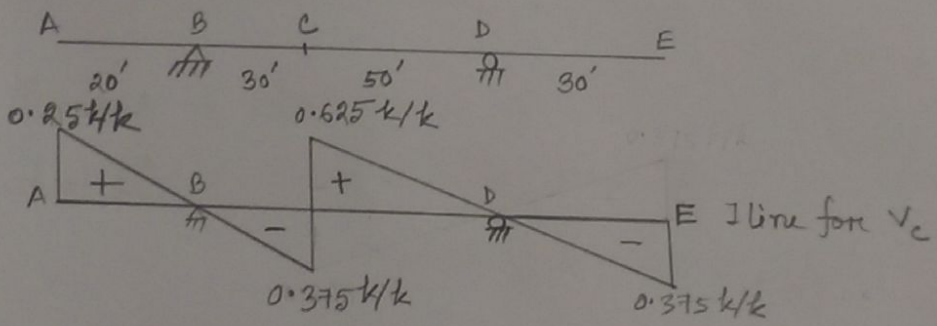
Here, maximum +ve shear $= \frac{1}{2} \times 0.8 \times 48 \times 5 + 0.8 \times 100 = 176^k$

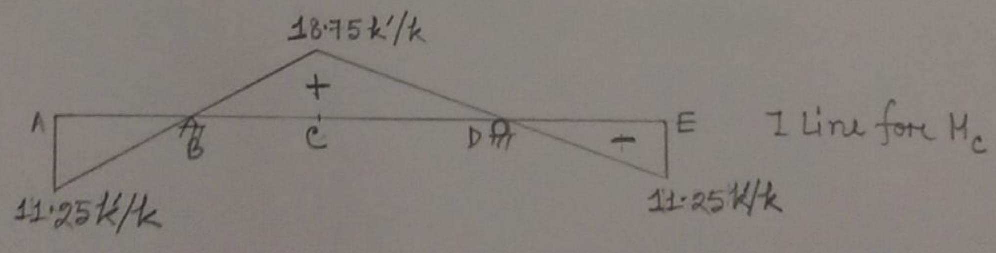
and maximum –ve shear $= \frac{1}{2} \times 0.25 \times 20 \times 5 + 0.25 \times 100 = 37.5^k$

Comparing the two, max^m shear is 176^k (positive) Ans

Assignment-22: Find maximum shear and moment at section C for an uniform moving load of 7 k/ft combined with a moving concentration of 90^k.

Solution –





Maximum shear $= \frac{1}{2} \times 80 \times 0.625 \times 7 + 0.625 \times 90 = \underline{\underline{231.25^k}} \ (+ve)$

Ans.

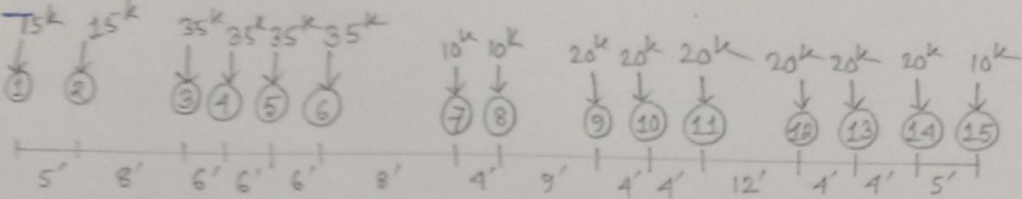
Maximum moment $= \frac{1}{2} \times 80 \times 18.75 \times 7 + 18.75 \times 90$

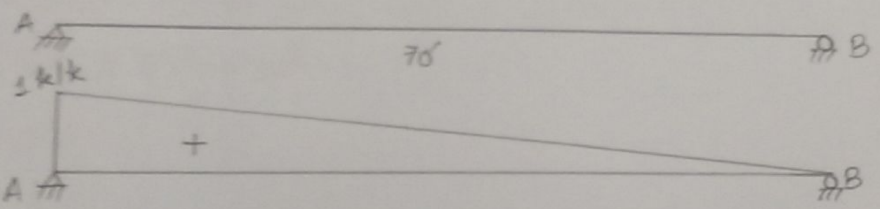
$= \underline{\underline{6937.5^{k'}}} \ (+ve)$

Ans.

Assignment-23: Find maximum reaction of a simple beam of 70' span.

Solution —





Trial-1: wheel 1 at A to wheel 2 at A

ΣP = wheel 2 to wheel 11

$= 235^k$

$P_1 = 15^k$

P' = wheel 12 $= 20^k$

$e = 3'$

$d_1 = 5'$

$$\Delta R = \frac{\Sigma P d_1}{L} - P_1 + \frac{P' e}{L}$$

$$= \frac{235 \times 5}{70} - 15 + \frac{20 \times 3}{70}$$

$= 2.64$ (+ve, increase)

Trial-2: wheel ② at A to wheel ③ at A

ΣP = wheel ③ to wheel ⑫ = 240^k

P' = wheel ⑬ = 20^k and wheel ⑭ = 20^k

$e = 7'$ for wheel ⑬ and $3'$ for wheel ⑭

P_1 = wheel ② = 15^k

$d_1 = 8'$

$$\therefore \Delta R = \frac{\Sigma P d_1}{L} - P_1 + \frac{P'e}{L} = \frac{240 \times 8}{70} - 15 + \frac{20 \times 7 + 20 \times 3}{70}$$

$$= 15 \cdot 29 \text{ (+ve, increase)}$$

Trial-3: wheel ③ at A to wheel ④ at A

ΣP = wheel ④ to wheel ⑭ = 245^k

P' = wheel ⑮ = 10^k

$e = 4'$

$d_1 = 6'$

P_1 = wheel ③ = 35^k

$$\therefore \Delta R = \frac{\Sigma P d_1}{L} - P_1 + \frac{P'e}{L} = \frac{245 \times 6}{70} - 35 + \frac{10 \times 4}{70}$$

$$= 13 \cdot 42 \text{ (-ve, decrease)}$$

$\therefore$ wheel ③ at A gives maximum reaction.

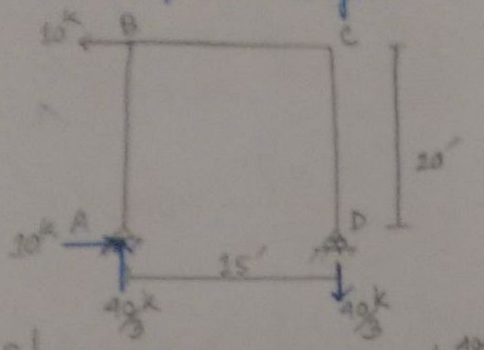
Hence,

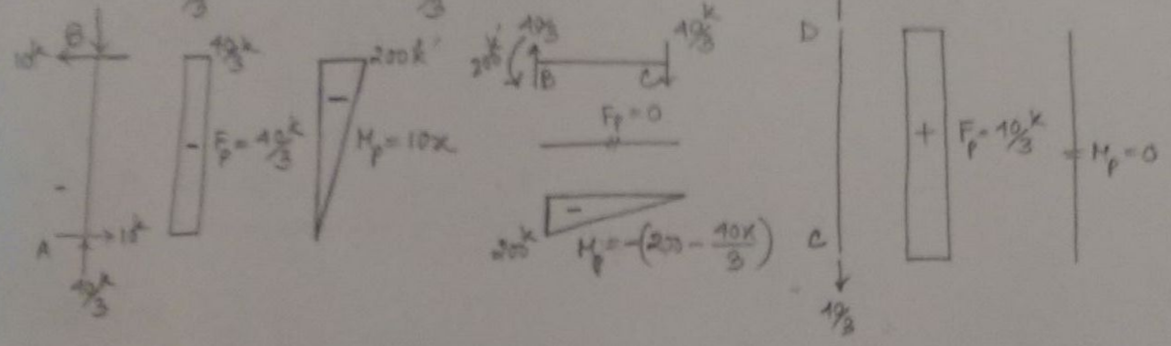
$$\text{max}^m \text{ reaction} = \frac{1}{70}\big[70 \times 35 + 64 \times 35 + 58 \times 35 + 52 \times 35 + 44 \times 10 + 10 \times 40 + 20 \times 31 + 20 \times 27 + 20 \times 23 + 20 \times 11 + 20 \times 7 + 20 \times 3\big]$$

$$= \underline{163 \cdot 14^k}$$ Ans.

Assignment - 20: Find δ_{BH}, δ_{CH}, θ_B, θ_C for the following frame.
Given, $E = 30\times10^3$ psi, $I = 8000$ in^4, $A = 20$ in^2

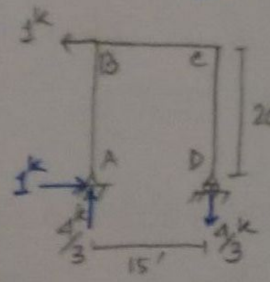
Solution — P force analysis:

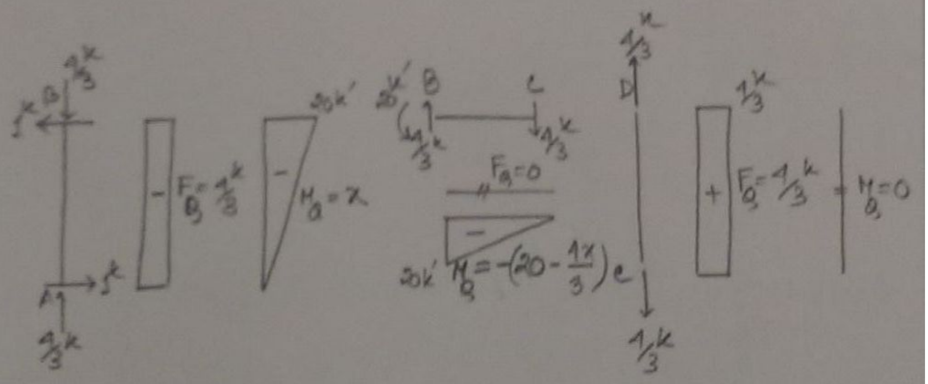




Q forces analysis:

- for δ_{BH} —





Segment AB ($0 < x \leq 20'$)	Segment BC ($0 < x \leq 15'$)	Segment CD ($0 < x \leq 20'$)
$M_Q = -x$, $F_Q = -\frac{1}{3}^k$	$M_Q = -(20 - \frac{1x}{3})$; $F_Q = 0$	$M_Q = 0$, $F_Q = \frac{1}{3}^k$
$M_P = -10x$, $F_P = -\frac{40}{3}$	$M_P = -(200 - \frac{40x}{3})$, $F_P = 0$	$M_P = 0$, $F_P = \frac{40}{3}^k$

Using principle of virtual work,

$$EI\delta_{BH} = \int_0^{20} \frac{10x^2}{EI}dx + \frac{(-\frac{4}{3})\times(-\frac{40}{3})\times 20}{AE} + \int_0^{15}\frac{(20-\frac{4x}{3})(200-\frac{40x}{3})}{EI}dx + \frac{\frac{4}{3}\times\frac{40}{3}\times 20}{AE}$$

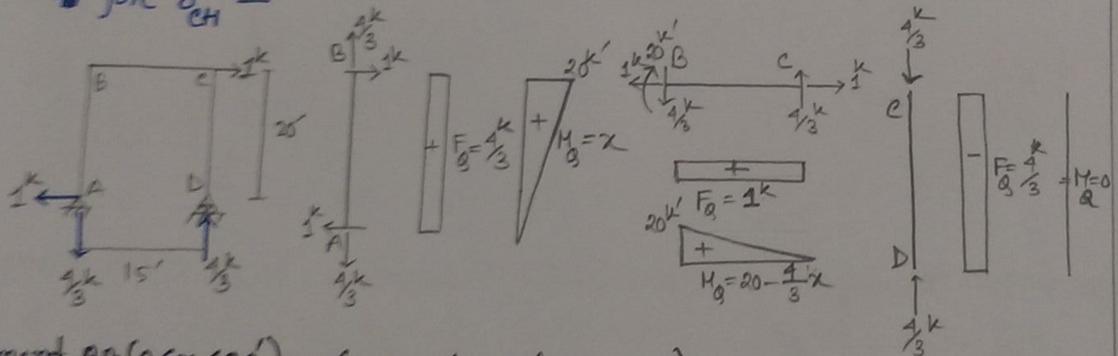
$$= \frac{2\times 20\times \frac{4}{3}\times \frac{40}{3}}{20\times 30000} + \frac{1}{EI}\cdot\frac{10}{3}x^3\Big|_0^{20} + \frac{1}{EI}\int_0^{15}\left(4000-\frac{1600}{3}x+\frac{160}{9}x^2\right)dx$$

$$= 0.0012 + \frac{\frac{10}{3}\times 20^3\times 144}{30\times10^3\times 8000} + \frac{1}{EI}\left(4000x - \frac{800}{3}x^2 + \frac{160}{27}x^3\right)\Big|_0^{15}$$

$$= 0.0012 + \frac{2}{125} + \frac{\left(4000\times15 - \frac{800}{3}15^2 + \frac{160}{27}15^3\right)\times144}{30\times10^3\times 8000}$$

$\therefore \delta_{BH} = 0.0292'$ (left)

For δ_{CH} –



Segment AB $(0<x\leq20')$; Segment BC $(0<x\leq15')$; Segment CD $(0<x\leq20')$

Segment AB	Segment BC	Segment CD
$M_Q = x$; $F_Q = \frac{4}{3}^k$	$M_Q = 20-\frac{4}{3}x$, $F_Q = 1^k$	$M_Q = 0$, $F_Q = -\frac{4}{3}^k$
$M_P = -10x$, $F_P = -\frac{40}{3}^k$	$M_P = -200+\frac{40x}{3}$, $F_P = 0$	$M_P = 0$, $F_P = \frac{40}{3}^k$

Using principle of virtual work −

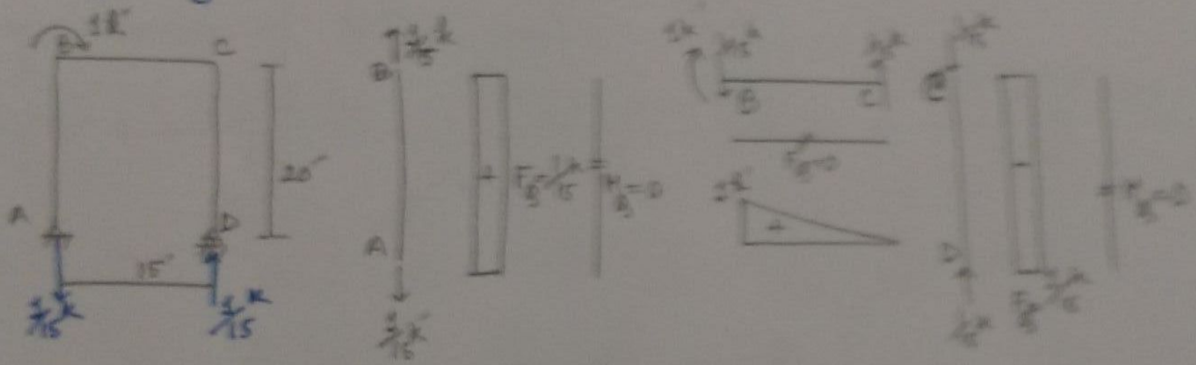
$$\Sigma \delta S_{CH} = \int_0^{20} \frac{x(-10x)}{EI}dx + \frac{\frac{4}{3}\left(-\frac{40}{3}\right)20}{AE} + \int_0^{15}\frac{\left(20-\frac{4}{3}x\right)\left(\frac{40}{3}x-200\right)}{EI}dx + \frac{\left(-\frac{4}{3}\right)\left(\frac{40}{3}\right)20}{AE}$$

$$= \frac{-2\times\frac{4}{3}\times\frac{40}{3}\times 20}{20\times 30000} - \frac{10}{3EI}x^3\Big|_0^{20} + \frac{1}{EI}\int_0^{15}\left(\frac{1600}{3}x - 4000 - \frac{160}{9}x^2\right)dx$$

$$= -0.0012 - \frac{2}{125} + \frac{\left(\frac{1600}{3\times 2}\times 15^2 - 4000\times 15 - \frac{160}{27}\times 15^3\right)\times 144}{30\times 10^3\times 8000}$$

$\therefore \delta_{CH} = -0.0292''$ (leftward)

for θ_B −



Segment AB $(0<x\leq 20')$; Segment CB $(0<x\leq 15')$; segment CD $(0<x\leq 20')$

$M_Q = 0$; $F_Q = \frac{1}{15}k$	$M_Q = \frac{x}{15}$; $F_Q = 0$	$M_Q = 0$; $F_Q = -\frac{1}{15}k$
$M_P = -10x$; $F_P = -\frac{40}{3}k$	$M_P = -\frac{40}{3}x$; $F_P = 0$	$M_P = 0$; $F_P = \frac{40}{3}k$

Using principle of virtual work −

$$\Sigma Q\theta_B^2 = \frac{\left(-\frac{40}{3}\right)\frac{1}{15}\times 20}{AE} + \int_0^{15}\frac{\frac{x}{15}\left(-\frac{40}{3}x\right)}{EI}dx + \frac{\left(-\frac{1}{15}\right)\left(\frac{40}{3}\right)\times 20}{AE}$$

$$= -\frac{\frac{40}{3}\times\frac{1}{15}\times 20\times 2}{20\times 30000} - \frac{8\times 144\times 15^3}{9\times 30\times 10^3\times 8000\times 3} = -\frac{1}{16875} - \frac{3}{5000}$$

$\therefore \theta_B^2 = -6.59\times 10^{-4}$ radian (anticlockwise)

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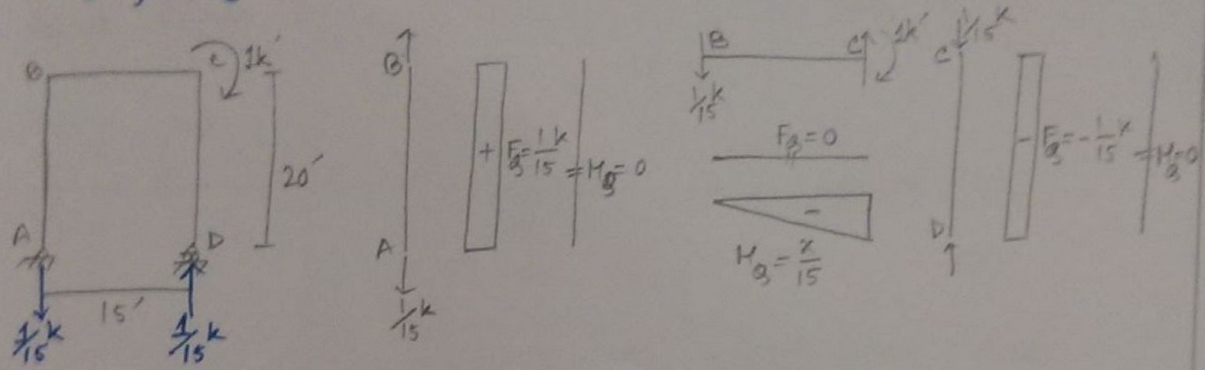
For θ_c —



Segment AB $(0 < x \leq 20')$; Segment BC $(0 < x \leq 15')$; Segment CD $(0 < x \leq 20')$

Segment AB	Segment BC	Segment CD
$M_Q = 0$; $F_Q = \frac{1}{15}k$	$M_Q = \frac{-x}{15}$; $F_Q = 0$	$M_Q = 0$; $F_Q = -\frac{1}{15}k$
$M_p = -10x$; $F_p = -\frac{40}{3}$	$M_p = -200 + \frac{40x}{3}$; $F_p = 0$	$M_p = 0$; $F_p = \frac{40}{3}k$

Using principle of virtual work —

$$\Sigma Q\,\theta_c^{\curvearrowright} = \frac{\left(-\frac{40}{3}\right)\left(\frac{1}{15}\right)20}{AE} + \int_0^{15} \frac{\left(-\frac{x}{15}\right)\left(-200 + \frac{40x}{3}\right)}{EI}\,dx + \frac{\left(-\frac{1}{15}\right)\left(\frac{40}{3}\right)20}{AE}$$

$$= -\frac{\left(\frac{40}{3}\right)\left(\frac{1}{15}\right)\times 20 \times 2}{20 \times 30 \times 10^3} - \frac{1}{EI}\int_0^{15}\left(-\frac{200x}{15} + \frac{40}{45}x^2\right)dx$$

$$= -\frac{1}{16875} - \frac{1}{EI}\left(-\frac{40}{3}\cdot\frac{x^2}{2} + \frac{8}{9}\cdot\frac{x^3}{3}\right)\Bigg|_0^{15}$$

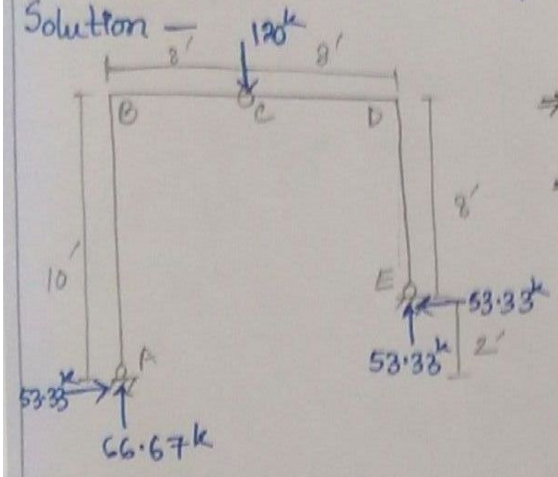
$$= -\frac{1}{16875} - \frac{\left(\frac{8}{27}\times 15^3 - \frac{20}{3}\times 15^2\right)\times 144}{30\times 10^3 \times 8000}$$

$$= -\frac{1}{16875} + \frac{3}{10000}$$

$\therefore \theta_c^{\curvearrowright} = 2.4 \times 10^{-4}$ radian (clockwise)

18. Compute change in slope for the cross section on left of hinge. Given, $E = 30\times10^3$ ksi, $A = 20$ in^2, $I = 2500$ in^4.

Solution —



P-force analysis:

$\Sigma M_A = 0$ ↻+

$\Rightarrow R_{E_y}\times16 + R_{E_x}\times2 - 120\times8 = 0$

$\Rightarrow R_{E_x} + 8R_{E_y} = 480$ ....(1)

Taking the right part and

$\Sigma M_c = 0$ ↻+ $\Rightarrow R_{E_y}\times8 - R_{E_x}\times8 = 0$

$\Rightarrow R_{E_x} = R_{E_y}$

$\therefore$ From eq^n (1) $\rightarrow$ $R_{E_y} + 8R_{E_y} = 480$

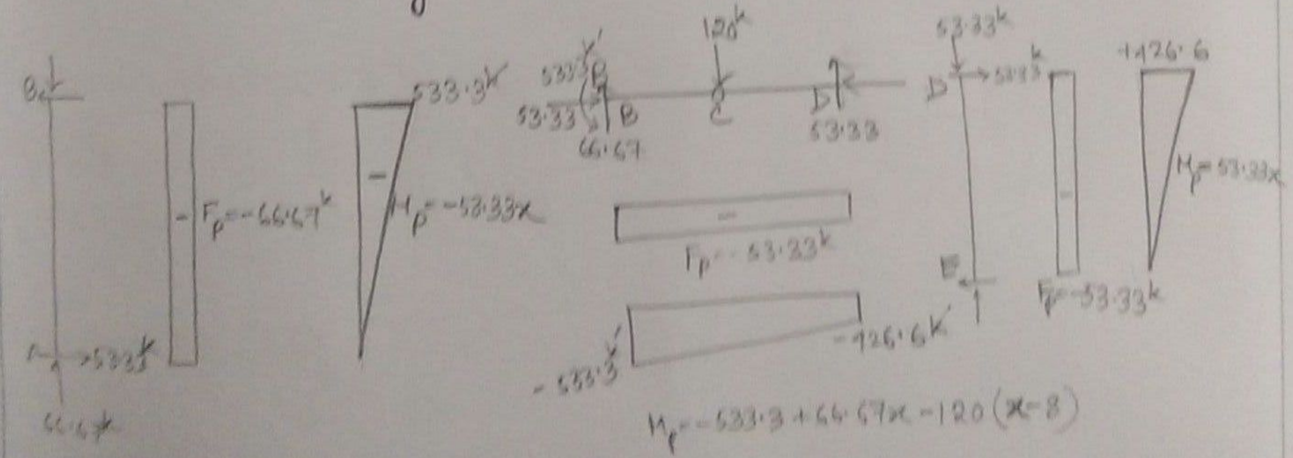
$\Rightarrow R_{E_y} = \frac{480}{9} = 53.33^k$ | $\therefore R_{E_x} = 53.33^k$

Now, $\Sigma F_x = 0 \Rightarrow R_{E_x} = R_{A_x} = 53.33^k$

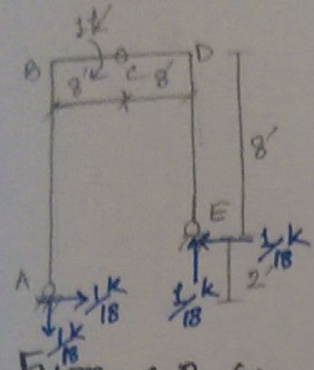
and $\Sigma F_y = 0 \Rightarrow R_{Ay} + R_{Ey} - 120 = 0$

$\Rightarrow R_{Ay} = 120 - 53.33$

$\therefore R_{Ay} = 66.67^k$



Q-force analysis :



$\Sigma M_A = 0 \Rightarrow 1 - R_{E_y} \times 16 - R_{E_x} \times 2 = 0$

$\Rightarrow 16R_{E_y} + 2R_{E_x} = 1 \quad \text{---} (1)$

Considering right part of the hinge and taking-

$\Sigma M_C = 0 \Rightarrow R_{E_x} \times 8 - R_{E_y} \times 8 = 0 \Rightarrow R_{E_x} = R_{E_y}$

From eq^n (1) $\Rightarrow \quad 18R_{E_y} = 1 \Rightarrow R_{E_y} = \frac{1}{18}k$

$\therefore R_{E_x} = \frac{1}{18}k$

Now, $\Sigma F_x = 0$

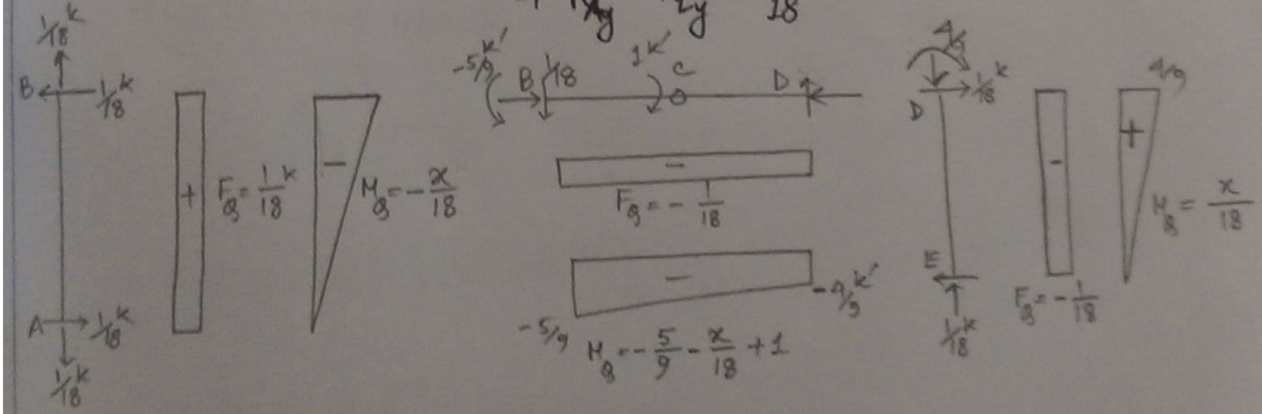
$\Rightarrow R_{E_x} - R_{Ax} = 0$

$\Rightarrow R_{Ax} = R_{E_x} = \frac{1}{18}k$

and $\Sigma F_y = 0$

$\Rightarrow R_{E_y} - R_{Ay} = 0$

$\Rightarrow R_{Ay} = R_{E_y} = \frac{1}{18}k.$



Segment AB ($0 < x \leqslant 16'$); Segment BD ($0 < x \leqslant 16'$);

$M_Q = -\frac{x}{18}$; $F_Q = \frac{1}{18}$ | $M_Q = -\frac{5}{9} - \frac{x}{8} + 1$, $F_Q = -\frac{1}{18}$

$M_p = -53.33x$; $F_p = -66.67$ | $M_p = -533.3 + 66.67x - 12(x-8)$; $F_p = -53.33$

Segment ED ($0 < x \leqslant 8'$);

$M_Q = \frac{x}{18}$, $F_Q = -\frac{1}{18}$

$M_p = 53.33x$; $F_p = -53.33$

Using Principle of virtual work -

$$\Sigma Q\theta_{c_2}^{v} = \int_0^{10} \frac{53.33x \cdot \frac{x}{18}}{EI} dx + \int_0^{16} \frac{\left(-\frac{5}{9} - \frac{x}{18} + 1\right)\left\{-533.3 + 66.67x - 120(x-8)\right\}}{EI} dx$$

$$+ \int_0^{8} \frac{53.33x \cdot \frac{x}{18}}{EI} dx + \frac{\frac{1}{18}(-66.67)\times 10}{AE} + \frac{\left(-\frac{1}{18}\right)(-53.33)\times 16}{AE} + \frac{\left(-\frac{1}{18}\right)(-53.33)\times 8}{AE}$$

$$= \frac{53.33\times 10^2 \times 144}{18\times 2\times 30\times 10^3\times 2500} + \frac{53.33\times 8^2\times 144}{18\times 2\times 30\times 10^3\times 2500} + \frac{\frac{1}{18}\times 53.33\times 24}{20\times 30\times 10^3} - \frac{\frac{10}{18}\times 66.67}{20\times 30\times 10^3}$$

$$+ \int_0^{16} \frac{\left(\frac{4}{9} - \frac{x}{18}\right)(426.7 - 53.33x)}{EI} dx$$

$$= 2.84\times 10^{-4} + 1.82\times 10^{-4} + 1.19\times 10^{-4} - 0.62\times 10^{-4}$$

$$+ \int_0^{16} \left(189.64 - 47.41x + 2.96x^2\right) dx \times \frac{1}{EI}$$

$$= 5.23\times 10^{-4} + \frac{\left(189.64\times 16 - \frac{47.41}{2}\times 16^2 + \frac{2.96}{3}\times 16^3\right)\times 144}{30\times 10^3\times 2500}$$

$$= 5.23\times 10^{-4} + 19.34\times 10^{-4}$$

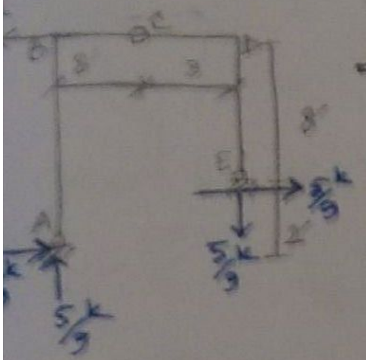
$$= 24.57\times 10^{-4} \text{ radian}$$

$$\therefore \theta_{c_2}^{v} = \underline{\underline{0.0025 \text{ radian (clockwise)}}}$$

Ans.

ssignment-19: Determine horizontal deflection at B.

lution – Q force analysis:



$\Sigma M_A = 0$ ↻+

$\Rightarrow -1\times 10 + R_{E_x}\times 2 + R_{E_y}\times 16 = 0$

$\Rightarrow R_{E_x} + 8R_{E_y} = 5$ ---(1)

Considering right part of the hinge and taking, $\Sigma M_c = 0$ ↻

$\Rightarrow R_{E_y}\times 8 - R_{E_x}\times 8 = 0$

$\Rightarrow R_{E_x} = R_{E_y}$

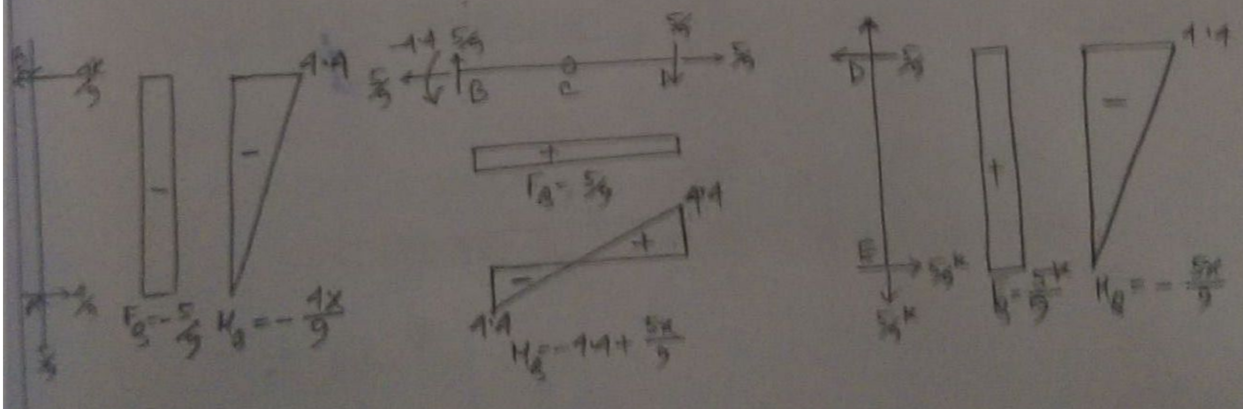
From eqn (1) $\Rightarrow 9R_{E_y} = 5 \Rightarrow R_{E_y} = \frac{5}{9}^k$

$\therefore R_{E_x} = \frac{5}{9}^k$

Now, $\Sigma F_x = 0 (\rightarrow) \Rightarrow \frac{5}{9} + R_{A_x} - 1 = 0$ and $\Sigma F_y = 0$ ↑+

$\Rightarrow R_{A_x} = 1 - \frac{5}{9} = \frac{4}{9}^k$ $\Rightarrow R_{E_y} - R_{A_y} = 0$

$\Rightarrow R_{A_y} = R_{E_y} = \frac{5}{9}^k$



Segment AB $(0<x\leq 10')$;

$M_Q = -\frac{4x}{9}$; $F_Q = -\frac{5}{9}$

$M_P = -53.33x$; $F_P = -66.67$

Segment BD $(0<x\leq 16')$;

$M_Q = -4.4 + \frac{5x}{9}$; $F_Q = 5/9$

$M_P = -533.3 + 66.67x - 120(x-8)$; $F_P = -53.33$

$= 426.7 - 53.33x$

Segment ED $(0<x\leq 8')$;

$M_Q = -\frac{5x}{9}$; $F_Q = \frac{5}{9}$

$M_P = 53.33x$; $F_P = -53.33$

Using principle of virtual work –

$$EQ\delta_{BH}^{\leftarrow} = \int_0^{10} \frac{\left(-\frac{4x}{9}\right)(-53.33x)}{EI}dx + \frac{(-5/9)(-66.67)10}{AE} + \frac{(5/9)(-53.33)16}{AE}$$

$$+ \frac{(5/9)(-53.33)8}{AE} + \int_0^{8} \frac{(-5x/9)(53.33x)}{EI}dx + \int_0^{16} \frac{\left(-4.4+\frac{5x}{9}\right)(426.7-53.33x)}{EI}dx$$

$$= \frac{53.33\times 4\times 10^3\times 144}{9\times 3\times 30\times 10^3\times 2500} + \frac{5/9\times 66.67\times 10}{20\times 30\times 10^3} - \frac{5/9\times 53.33\times 24}{20\times 30\times 10^3}$$

$$- \frac{5\times 53.33\times 8^3\times 144}{9\times 3\times 30\times 10^3\times 2500} + \int_0^{16}\frac{(-1877.48 + 471.71x - 29.63x^2)}{EI}dx$$

$$= 5.1\times 10^{-3} + 0.62\times 10^{-3} - 1.2\times 10^{-3} - 9.7\times 10^{-3}$$

$$+ \frac{\left(-1877.48\times 16 + 471.71\frac{16^2}{2} - 29.63\times\frac{16^3}{3}\right)\times 144}{30\times 10^3\times 2500}$$

$$= -5.18\times 10^{-3} - 0.0194$$

$$\therefore \delta_{BH}^{\leftarrow} = -0.0246' \text{ (rightward)}$$

Ans.

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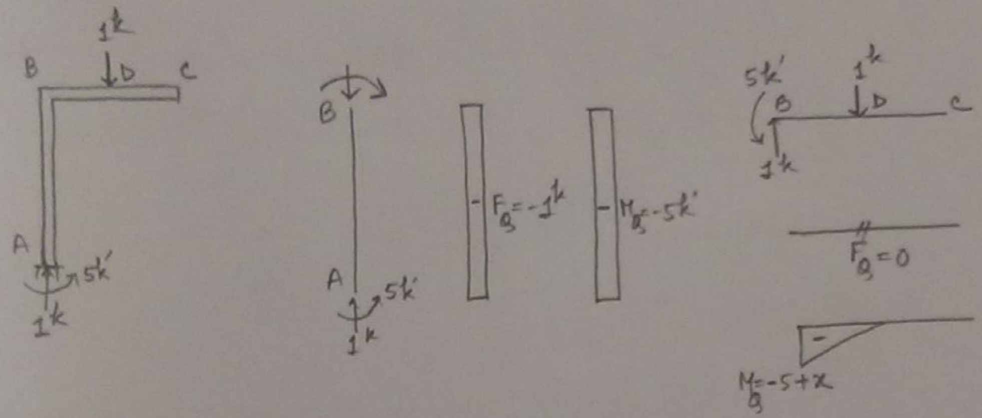
ssignment-17: Compute vertical deflection at mid point of BC.

olution –



For segment AB ($0<x\leq 20'$): and for segment BD ($0<x\leq 5'$):

$M_Q = -5k'$; $F_Q = -1^k$ $\qquad$ $M_P = -200+20x$; $F_P = 0$

$M_P = -200k'$; $F_P = -20^k$ $\qquad$ $M_Q = -5+x$; $F_Q = 0$

Using principle of virtual work,

$$\Sigma Q\delta_D^{\downarrow} = \int_0^{20} \frac{(-5)(-200)}{EI_1}dx + \frac{1\times 20\times 20}{A_1 E} + \int_0^5 \frac{(20x-200)(x-5)}{EI_2}dx$$

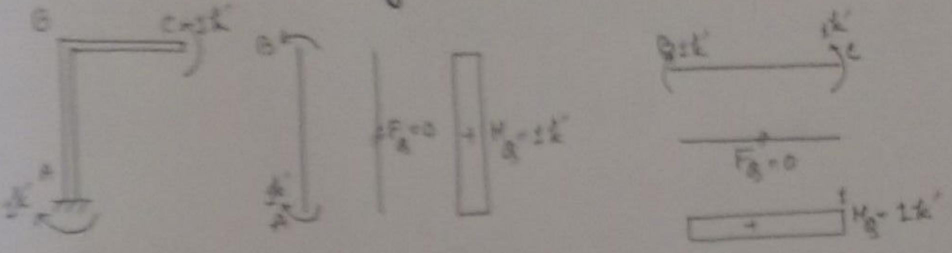
$$= \frac{1000\times 20}{30\times 10^3\times 144\times \frac{200}{144^2}} + \frac{400}{15\times 30000} + \frac{1}{EI_2}\left(\frac{20}{3}x^3 - 150x^2 + 1000x\right)\Big|_0^5$$

$$\Rightarrow \delta_D^{\downarrow} = \frac{12}{25} + \frac{1}{1125} + \frac{1}{15}$$

$$\therefore \delta_D^{\downarrow} = 0.55' \text{ (down)}$$

Assignment – 16: Compute change in slope at "C". Given, same as assignment 15.

Solution – Q-force analysis:



For segment AB ($0<x\leq 20'$): and for segment BC ($0<x\leq 10'$):

$M_Q = +1k'$; $F_Q = 0$ $\qquad$ $M_Q = +1k'$; $F_Q = 0$

$M_P = -200k'$; $F_P = -20^k$ $\qquad$ $M_P = -20x$; $F_P = 0$

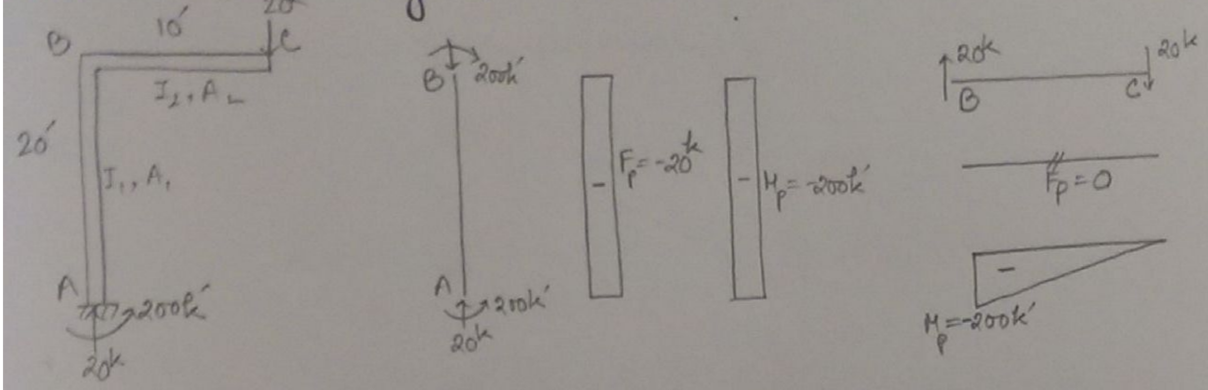
Using principle of virtual work,

$$\Sigma Q\delta_c^5 = \int_0^{20} \frac{(-200)(1)}{EI_1}dx + \int_0^{10} \frac{(-20x)(1)}{EI_2}dx$$

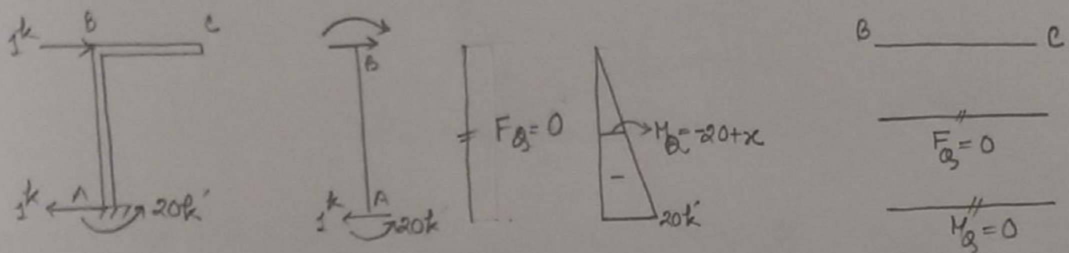
$$= -\frac{200\times 20}{30\times 10^3\times 144\times \frac{200}{144^2}} - \frac{10\times 10^2}{30\times 10^3\times 144\times \frac{150}{144^2}}$$

$\therefore \delta_c^5 = -$ 0.128 radian (clockwise) ssignment – 15 : Compute horizontal deflection at "B". Given, $= 200\ in^4$, $I_2 = 150\ in^4$, $A_1 = 15\ in^2$, $A_2 = 10\ in^2$, $E = 30\times10^3$ ksi.

lution – P force analysis :



Q-force analysis :



Now, Segment CB $(0 < x \leq 10)$: and Segment AB $(0 < x \leq 20)$:

$M_Q = 0$; $F_Q = 0$ $\qquad$ $M_Q = -20 + x$; $F_Q = 0$

$M_p = -200k'$; $F_p = 0$ $\qquad$ $M_p = -200k'$; $F_p = -20^k$

Using principle of virtual work –

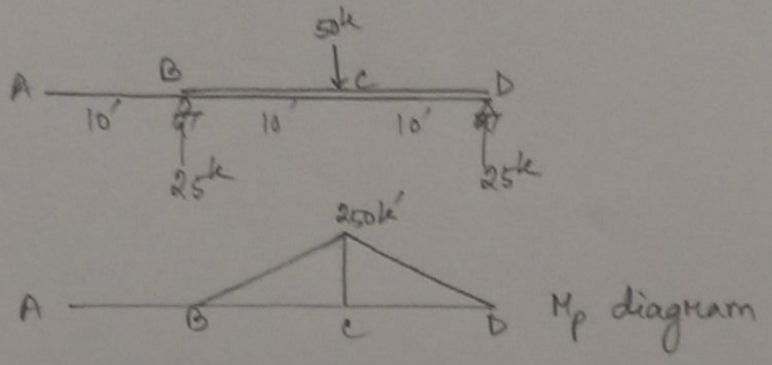
$$\Sigma Q\delta_B^{\rightarrow} = \int_0^{20} \frac{4000 - 200x}{EI_1}\,dx = \frac{1}{EI}\left(4000\times20 - 100\times20^2\right)$$

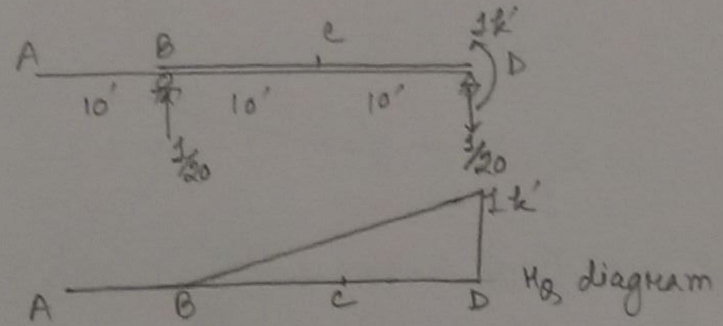
$$\Rightarrow \delta_B^{\rightarrow} = \frac{40000}{30\times10^3\times144\times\frac{200}{144^2}}$$

$$\therefore \delta_B^{\rightarrow} = \underline{0.96'}\ \text{(Rightward)}$$

Assignment - 14: Find change in slope at "D." Given, $E = 200$ 'm'!

Solution —





Segment AB $(0 < x \leq 10)$; Segment BC $(0 < x \leq 10)$; Segment DC $(0 < x \leq 10)$

$M_Q = 0$ $\qquad$ $M_Q = \frac{x}{20}$ $\qquad$ $M_Q = -\frac{x}{20} + 1$

$M_p = 0$ $\qquad$ $M_p = 25x$ $\qquad$ $M_p = 25x$

Using principle of virtual work,

$$\Sigma Q \delta_D^{\theta} = 0 + \frac{1}{2EI}\left[\int_0^{10} \frac{5}{4} x^2 dx + \int_0^{10} \left(25x - \frac{5}{4}x^2\right) dx\right.$$

$$\Rightarrow \delta_D^{\theta} = \frac{1250 \times 144}{2 \times 30 \times 10^3 \times 200}$$

$$\therefore \delta_D^{\theta} = \underline{0.01 \text{ radian}} \text{ (counter-clockwise)}$$

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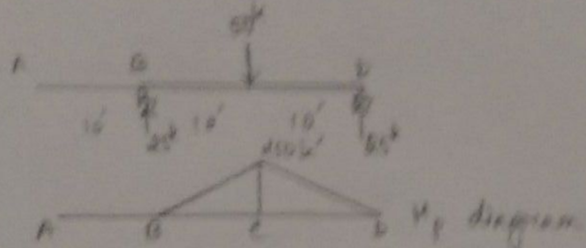
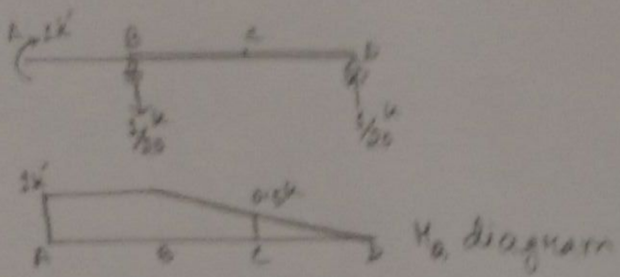
Assignment-13 : Find change in slope at 'A'. Given, I = 200 in^4.

Solution -





Segment AB$(0<x\leq 16)$; Segment BC$(0<x\leq 10)$; Segment DC$(0<x\leq 10)$

$M_\theta = 1k'$ $M_\theta = 1 - \frac{x}{40}$ $M_\theta = \frac{x}{20}$

$M_P = 0$ $M_P = 25x$ $M_P = 25x$

Using the principle of virtual work,

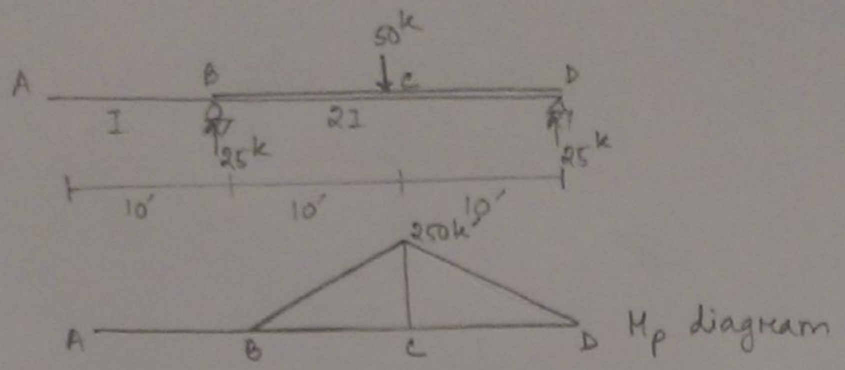
$$E\theta\,\delta\theta_A = 0 + \frac{1}{2EI}\left[\int_0^{10}\left(25x - \frac{5}{4}x^2\right)dx + \int_0^{10}\frac{5}{4}x^2\,dx\right]$$

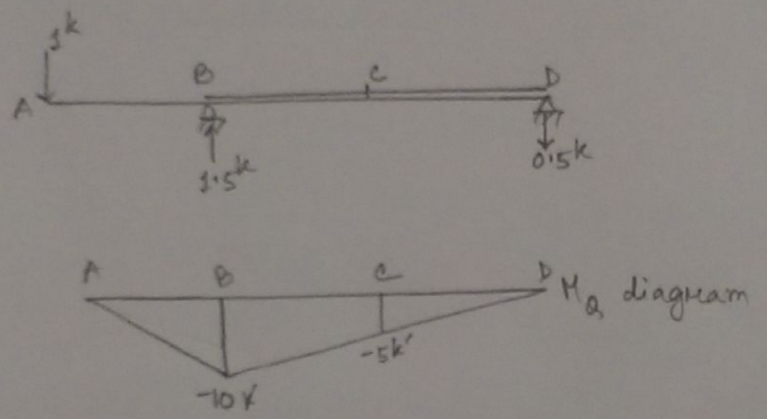
$$= \frac{1250}{2\times 30\times 10^3\times 144\times \frac{200}{144^2}}$$

$$\therefore \delta\theta_A = \underline{0.01\,\text{rad (clockwise)}}$$

ssignment-12: Find vertical deflection at "A". Given, I = 200 in⁴

olution –





Segment AB ($0<x\leq 10'$) ; Segment BC ($0<x\leq 10'$) ; Segment DC ($0<x\leq 10'$)

$M_p = 0$; $M_p = 25x$; $M_p = 25x$

$M_Q = -x$; $M_Q = -10+0.5x$; $M_Q = -0.5x$

Using the principle of virtual work,

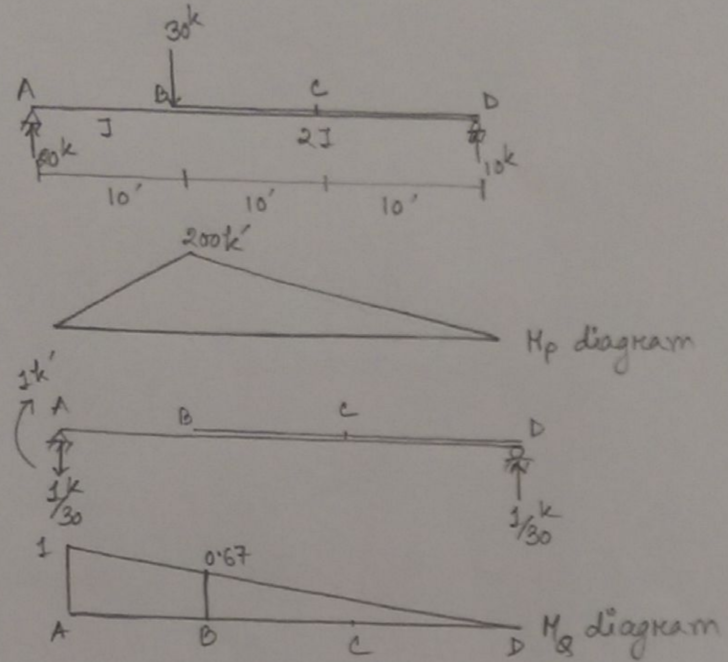
$$\Sigma Q\delta_A = \int \frac{M_Q M_p dx}{EI} = \frac{1}{2EI}\left[\int_0^{10}(-250x+12.5x^2)dx + \int_0^{10} -12.5x^2 dx\right]$$

$$\Rightarrow \delta_A = -6250 \times \frac{1}{EI} = -\frac{6250}{30\times 10^3 \times 144 \times \frac{200}{144^2}}$$

$$\therefore \delta_A = \underline{\underline{-0.1'}}\ (\text{up})$$

Assignment-11: Find the change in slope at "A". Given, $E = 30\times10^3$ ksi and $I = 300$ in^4.

Solution –



Segment AB ($0<x\leq10'$): $M_P = 20x$, $M_Q = 1-\frac{x}{30}$

Segment DB ($0<x\leq20'$): $M_P = 10x$, $M_Q = \frac{x}{30}$

Using principle of virtual work,

$$\Sigma Q\delta_A = \frac{1}{EI}\int_0^{10} M_P M_Q\,dx + \frac{1}{2EI}\int_0^{20} M_P M_Q\,dx$$

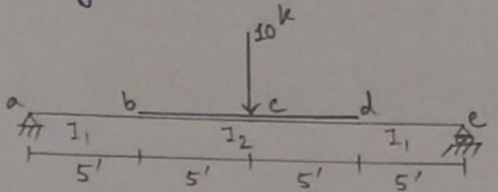
$$= \frac{1}{EI}\int_0^{10}\left(20x-\frac{2}{3}x^2\right)dx + \frac{1}{2EI}\int_0^{20}\frac{1}{3}x^2\,dx$$

$$= \frac{1}{EI}\left(10x^2-\frac{2}{9}x^3\right)\Big|_0^{10} + \frac{1}{2EI}\left(\frac{1}{9}x^3\right)\Big|_0^{20}$$

$$= \frac{11000}{30\times10^3\times144\times200\div144^2}$$

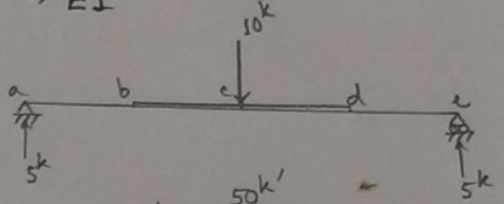
$$\therefore \delta_A = \underline{0.0293\text{ rad}}\text{ (clockwise)}$$

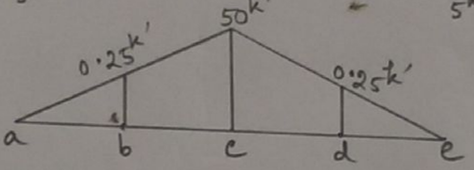
Assignment-10 : Compute the change in slope of the cross-section a
oint "a" caused by the load shown. $E = 30 \times 10^3$ ksi, $I_1 = 150$ in^4,
$I_2 = 200$ in^4.



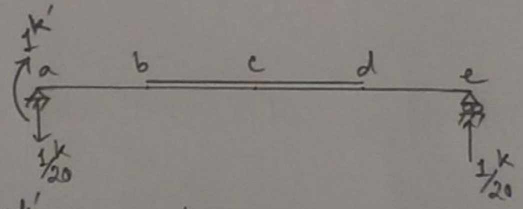
olution :

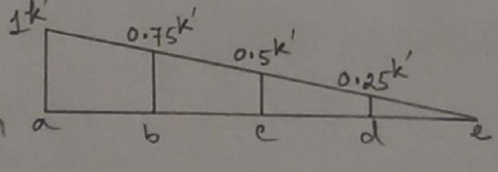
We know, $\Sigma Q \delta = \int M_P M_Q \frac{dx}{EI}$ ------(1)





M_P diagram





M_Q diagram

- For segment ab $(0 < x \leq 5')$:

  $M_P = 5x$; $M_Q = 1 - \frac{x}{20}$

- For segment cb $(0 < x \leq 5')$:

  $M_P = 5(10 - x) = 50 - 5x$

  $M_Q = 1 - \frac{1}{20}(10 - x) = 0.5 + \frac{x}{20}$

• For segment dc $(0<x\leq 5')$:

$$M_p = 5(15-x) - 10(5-x) = 5x+25$$

$$M_Q = 1 - \frac{1}{20}(15-x) = 0.25 + \frac{x}{20}$$

• For segment ed $(0<x\leq 5')$:

$$M_p = 5(20-x) - 10(10-x) = 5x$$

$$M_Q = 1 - \frac{1}{20}(20-x) = \frac{x}{20}$$

Now from eq^n (1) ⇒

$$EQ\delta = \int_a^b \frac{1}{EI_1} 5x\left(1-\frac{x}{20}\right)dx + \int_c^b \frac{1}{EI_2}(50-5x)\left(0.5+\frac{x}{20}\right)dx + \int_d^c \frac{1}{EI_2}(5x+25)\left(.25+\frac{x}{20}\right)dx$$

$$+ \int_e^d \frac{1}{EI_1} 5x\left(\frac{x}{20}\right)dx$$

$$\text{or, } \delta = \frac{1}{EI_1}\int_0^5 \left(5x - 0.25x^2 + 0.25x^2\right)dx + \frac{1}{EI_2}\int_0^5 \left(25 - 0.25x^2 + 2.5x + 6.25 + 0.25x^2\right)dx$$

$$= \frac{1}{EI_1}\int_0^5 5x\,dx + \frac{1}{EI_2}\int_0^5 (31.25 + 2.5x)\,dx$$

$$= \frac{2.5x^2\big|_0^5}{EI_1} + \frac{31.25x + 1.25x^2\big|_0^5}{EI_2}$$

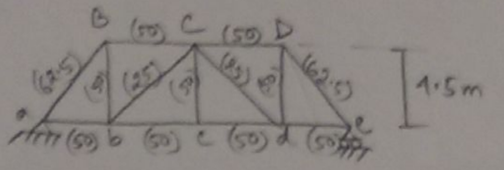
$$= \frac{62.5}{30\times10^3\times144\times\frac{150}{144^2}} + \frac{187.5}{30\times10^3\times144\times\frac{200}{144^2}}$$

$$= \left(2\times10^{-3} + 4.5\times10^{-3}\right) \text{ radian}$$

$$\therefore \delta = \underline{\underline{+0.0065 \text{ radian}}} \text{ (clockwise)}$$

Ans.

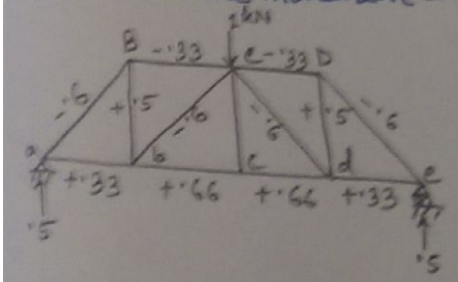
signment-9: Determine vertical and horizontal deflection at 'c' (op chord). Given, vertical and horizontal movement of "a" e 0.8" (down) and 0.6" (right) and vertical movement of "c" is 4" (down).



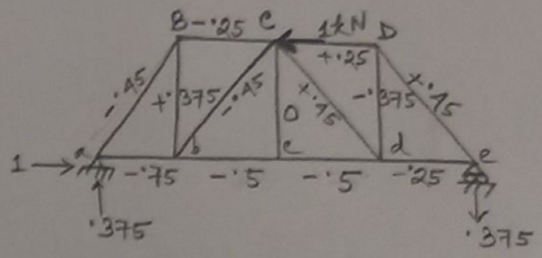
1@3 m = 12m ; areas are in cm².

olution: As no external loading, so only virtual load analysis will be one for horizontal and vertical deflections.

• For vertical movement –



• For horizontal movement –



Bar	L	F_Q (kN)		t	$F_Q tL$ (kN°Fcm)	
	cm	Ver. Deflectⁿ	Hor. Deflectⁿ	°F	Vertical	Horizontal
ab	300	+·33	−·75	−10	−990	+2250
bc	300	+·66	−0·5	−10	−1980	+1500
cd	300	+·66	−0·5	−10	−1980	+1500
de	300	+·33	−·25	−10	−990	+750
BC	300	−·33	−·25	+40	−3960	−3000
CD	300	−·33	+·25	+40	−3960	+3000
					Σ=−13860	Σ=+6000

Here,

$$1\delta_c^{\downarrow} + 0 - .5\times .8\times 2.54 - .5\times .4\times 2.54 = -\frac{13860}{75000}$$

$\therefore \delta_c^{\downarrow} = 0.0134$ m (up)

Ans.

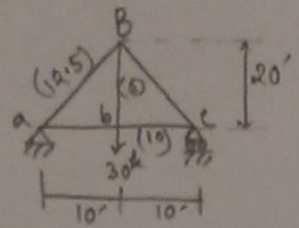
Again,

$$1\delta_c^{\leftarrow} + .6\times 2.54 - .375\times .8\times 2.54 + .375\times .4\times 2.54 = \frac{6000}{75000}$$

$\therefore \delta_c^{\leftarrow} = 0.0106$ m (left)

Ans.

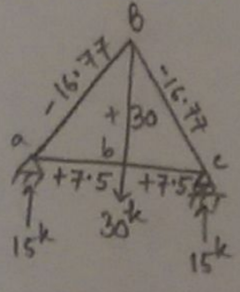
Assignment - 8 : Compute horizontal deflection of joint B. Given, support movements of 'a' - hor. 0·6"(right), ver. 0·8"(down) and 'c' - ver. 0·5" (down).

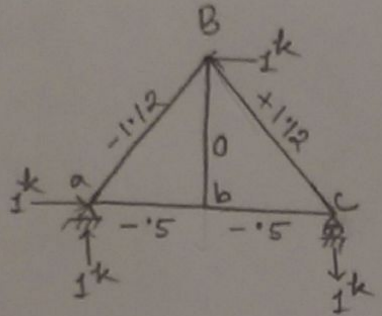


areas are in (inch)^2.

Solution :

- For real load -





Bar	L	A	L/A	F_P	F_Q	$F_P F_Q L/A$	t	$F_Q tL$
	(′)	(in^2)	1/in^2	k	k	k^2/in^2	°F	k°F′
ab	10	10	1	+7·5	-·5	- 3·75	0	0
bc	10	10	1	+7·5	-·5	- 3·75	0	0
aB	22·36	12·5	1·79	-16·77	-1·12	+ 33·62	0	0
Bc	22·36	12·5	1·79	-16·77	+1·12	- 33·62	0	0
						Σ = - 7·5		Σ = 0

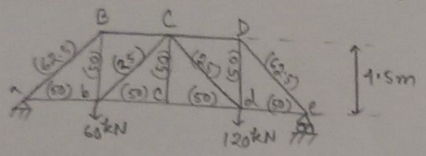
We know, $W_s + W_R = W_d \Rightarrow Q\delta_{B}^{\leftarrow} + R_{Ax}\Delta_{Ax} + R_{Ay}\Delta_{Ay} + R_{cy}\Delta_{cy} = \Sigma F_P F_Q L/AE$

$$\Rightarrow Q\delta_{B}^{\leftarrow} + 1 \times \frac{·6}{12} - 1 \times \frac{·8}{12} + 1 \times \frac{·5}{12} = - \frac{7·5}{29 \times 10^3}$$

$$\Rightarrow \delta_{B}^{\leftarrow} = \underline{0·0253'} \text{ (Right)}$$

Ans.

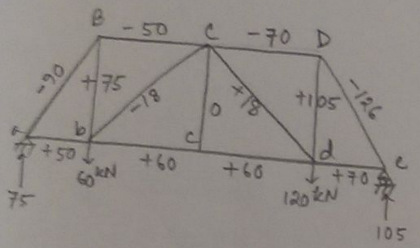
Assignment-7: Find the rotation of the Bar BC of the following truss.



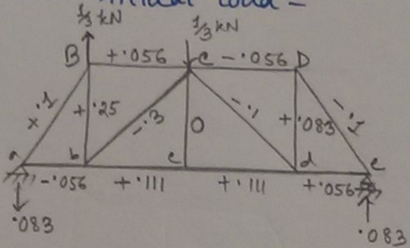
4 @ 3m = 12m ; areas are in cm^2

Solution:

• For real load –



• For virtual load –



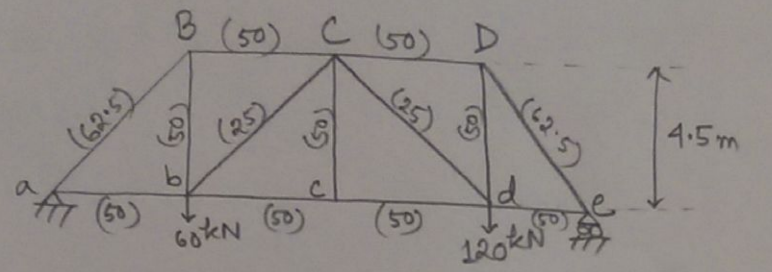
Bar	L	A	L/A	F_P	F_Q	$F_P F_Q L/A$	t	$F_Q t L$
	cm	cm^2	cm/cm^2	kN	kN	$(kN)^2/cm$	°F	KN°Fcm
ab	300	50	6	+50	−.056	−16.8	−10	+168
bc	300	50	6	+60	+.111	+40	−10	−333
cd	300	50	6	+60	+.111	+40	−10	−333
de	300	50	6	+70	+.056	+23.52	−10	−168
BC	300	50	6	−50	+.056	−16.8	+40	+672
CD	300	50	6	−70	−.056	+23.52	+40	−672
aB	540	62.5	8.64	−90	+.1	−77.76	0	0
bC	540	25	21.6	−18	−.3	+116.84	0	0
Cd	540	25	21.6	+18	−.1	−38.88	0	0
De	540	62.5	8.64	−126	−.1	+108.86	0	0
Bb	450	50	9	+75	+.25	+168.75	0	0
Dd	450	50	9	+105	+.083	+78.75	0	0
						$\Sigma = +450$		$\Sigma = -666$

Rotation of Bar BC, $Q\delta_{\overset{\curvearrowright}{B-C}} = \Sigma F_P F_Q L/AE + \Sigma F_Q \alpha_t t L = \dfrac{450}{20.7\times10^3} - \dfrac{666}{75000}$

$\therefore \delta_{\overset{\curvearrowright}{B-C}} = \underline{\underline{1.29\times10^{-4}\, m}}$ (clockwise)

Ans.

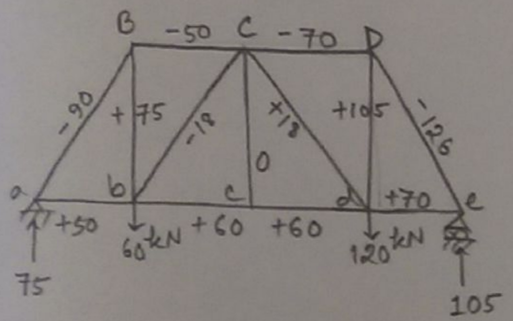
Assignment – 6: Find relative deflection of joints Bd of the following truss.



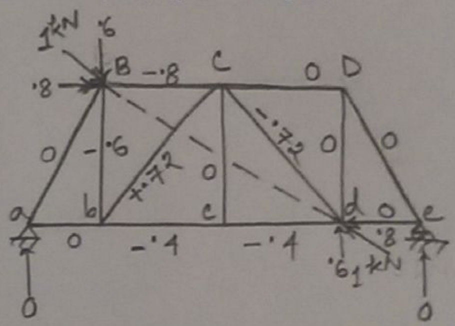
4 @ 3 m = 12 m ; areas are in cm²

Solution:

- For real load:



For virtual load:



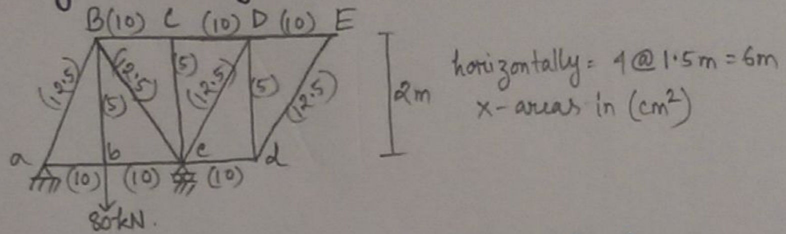
Bar	L	A	L/A	F_P	F_Q	$F_P F_Q L/A$	t	$F_Q t L$
	cm	cm²	cm/cm²	kN	kN	(kN)²/cm	°F	kN°Fcm
BC	300	50	6	−50	−.8	+240	+10	−9600
bc	300	50	6	+60	−.4	−144	−10	+1200
cd	300	50	6	+60	−.4	−144	−10	+1200
Bb	450	50	9	+75	−.6	−405	0	0
bC	540	25	21.6	−18	+.72	−279.94	0	0
Cd	540	25	21.6	+18	−.72	−279.94	0	0
						Σ = −1012.8		Σ = −7200

We know, $Q\delta_{B-d} = \Sigma F_Q F_P L/AE + \Sigma F_Q \alpha_t t L = -\frac{1012.8}{20.7\times10^{3}} - \frac{7200}{75000}$

$\therefore \delta_{B-d} = 4.707\times10^{-4}$ m (apart)

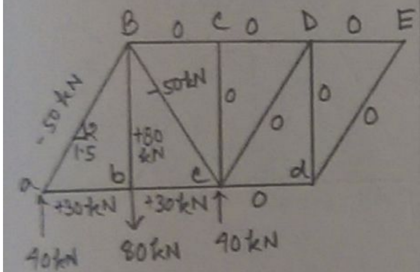
Ans.

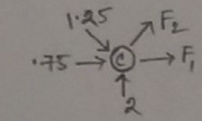
Assignment-5: Find vertical deflection at point "E" of the following truss due to the given 80 kN load and due to a decrease of temperature of 40°F in diagonals only. $E = 20{\cdot}7 \times 10^3$ kN/cm² and $\alpha_t = 1/150{,}000$ per°F.



Solution:

- For real load –





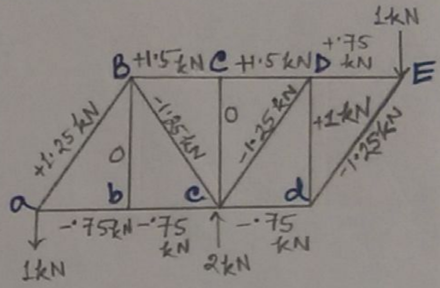
$\Sigma F_y = -{\cdot}8 \times 1{\cdot}25 + 2 + {\cdot}8 \times F_2 = 0$

$\Rightarrow F_2 = -\frac{1}{{\cdot}8} = -1{\cdot}25$ kN

$\Sigma F_x = -{\cdot}8 \times 1{\cdot}25 + {\cdot}8 \times 1{\cdot}25 + {\cdot}75 + F_1 = 0$

$\Rightarrow F_1 = -{\cdot}75$ kN

- For virtual load –



Bar	L	A	L/A	F_P	F_Q	$F_PF_Q L/A$	t	$F_Q tL$
	cm	cm²	cm/cm²	kN	kN	kN²cm/cm²	°F	kN°Fcm
ab	150	10	15	30	-.75	-337.5	0	
bc	150	10	15	30	-.75	-337.5	0	
cd	150	10	15	0	-.75	0	0	
BC	150	10	15	0	1.5	0	0	
CD	150	10	15	0	1.5	0	0	
DE	150	10	15	0	.75	0	0	
aB	250	12.5	20	-50	1.25	-1250	-40	-12500
Bc	250	12.5	20	-50	-1.25	1250	-40	12500
cD	250	12.5	20	0	-1.25	0	-40	12500
dE	250	12.5	20	0	-1.25	0	-40	12500
Bb	200	5	40	80	0	0	0	
Ce	200	5	40	0	0	0	0	
Dd	200	5	40	0	1	0	0	
						Σ = -675		Σ = 25000

We know, $Q\delta = \Sigma F_P F_Q \frac{L}{AE} + \Sigma F_Q \alpha_t t L$

$$= \left[(-675) \times \frac{1}{20{\cdot}7 \times 10^3} + \frac{25000}{150{,}000}\right] \text{kNcm}$$

$$\therefore \boxed{\delta = 0{\cdot}134\text{cm (down)}}$$ Ans.

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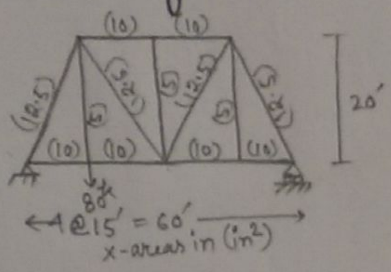
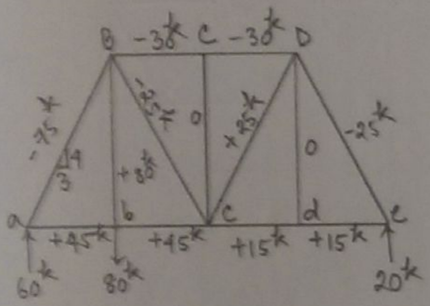
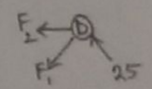
Assignment-4: Find horizontal deflection at point "D" of following truss due to 80^k load and due to a decrease of temperature of $50°F$ in the bottom chord only. $E = 30\times10^3$ kip/in² and $\alpha_t = 1/150{,}000$ per °F.



Solution :

- For true load –





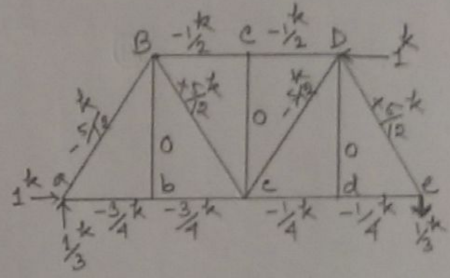
$\Sigma F_y = \cdot8\times25 - \cdot8\times F_1 = 0$

$\Rightarrow F_1 = +25^k$

$\Sigma F_x = -\cdot6\times25 - \cdot6\times25 - F_2 = 0$

$\Rightarrow F_2 = -30^k$

- For virtual load –



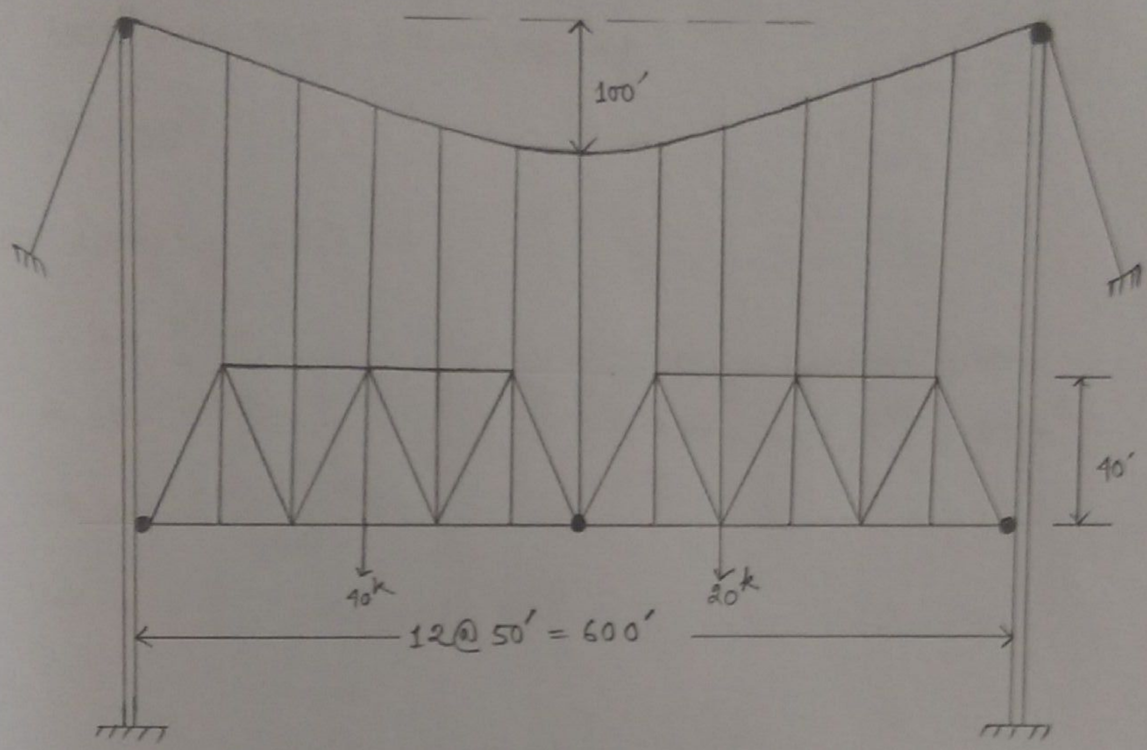
Bar	L	A	L/A	F_P	F_Q	F_PF_QL/A	t	$F_Q tL$
	ft	in²	ft/in²	kip	kip	k²ft/in²	°F	k°F ft
ab	15	10	1.5	45	−.75	−50.625	−50	562.5
bc	15	10	1.5	45	−.75	−50.625	−50	562.5
cd	15	10	1.5	15	−.25	−5.625	−50	187.5
de	15	10	1.5	15	−.25	−5.625	−50	187.5
BC	15	10	1.5	−30	−.5	22.5	0	0
CD	15	10	1.5	−30	−.5	22.5	0	0
aB	25	12.5	2	−75	−.4167	62.505	0	0
Bc	25	12.5	2	−25	.4167	−20.835	0	0
cD	25	12.5	2	25	−.4167	−20.835	0	0
De	25	12.5	2	−25	.4167	−20.835	0	0
Bb	20	5	4	80	0	0	0	0
Cc	20	5	4	0	0	0	0	0
Dd	20	5	4	0	0	0	0	0
						Σ=−67.5		Σ= 1500

We know, $Q\delta = \Sigma F_P F_Q \frac{L}{AE} + \Sigma F_Q \alpha_t t L$

$$= \left[-(67.5)\times\frac{1}{30\times10^3} + 1500\times\frac{1}{150{,}000}\right] \text{ft-k}$$

$\therefore \boxed{\delta = 7.75\times10^{-3} \text{ ft (left)}}$ Ans.

Assignment-3: Determine the hanger force and the two member forces 'a' and 'b' of the following suspension bridge.

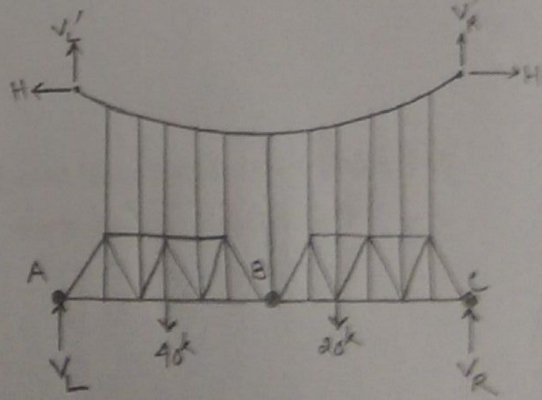


Solution:

$\Sigma M_A = 0$

$\Rightarrow (V_R + V_R') \times 600 = 40 \times 150 + 20 \times 400$

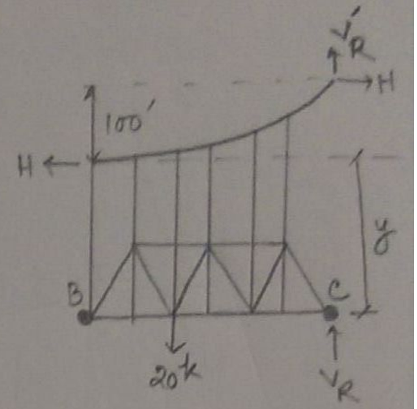
$\Rightarrow V_R + V_R' = 23.333$ ----(1)



Here,

$\Sigma M_B = 0$

$\Rightarrow H(100+y) - Hy - (V_R + V_R') \times 300 + 20 \times 100 = 0$



$\Rightarrow 100H - 23.333 \times 300 + 2000 = 0$

$\Rightarrow H = 50^k$

Now applying G.C.T →

$H = \dfrac{wL^2}{8h}$

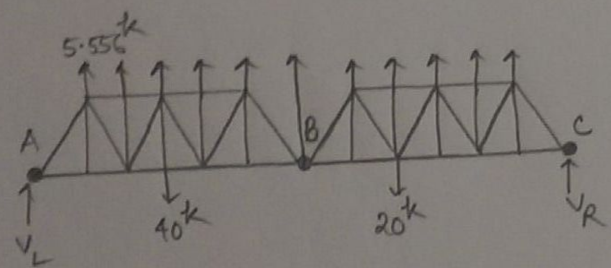
$\Rightarrow w = \dfrac{8hH}{L^2}$

$\Rightarrow w = \dfrac{8 \times 100 \times 50}{600^2}$

$\Rightarrow w = \dfrac{1}{9}{}^k$/horizontal foot

∴ Hanger tension force,

$HF = \dfrac{1}{9} \times 50^k = 5.556^k$



For this figure →

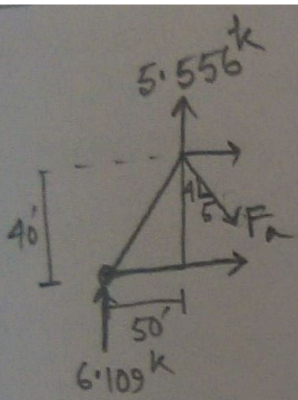
$\Sigma M_A = 0$ ↻

$\Rightarrow 40 \times 150 + 20 \times 400 - V_R \times 600 - 5.556[50 + 100 + 150 + 200 + 250 + 300 + 350 + 400 + 450 + 500 + 550] = 0$

$\Rightarrow V_R = -7.225^k (\downarrow)$

And $\Sigma F_y = 0 \uparrow \Rightarrow V_L + V_R - 40 - 20 + 5.556 \times 11 = 0$

$\Rightarrow V_L = 6.109^k (\uparrow)$

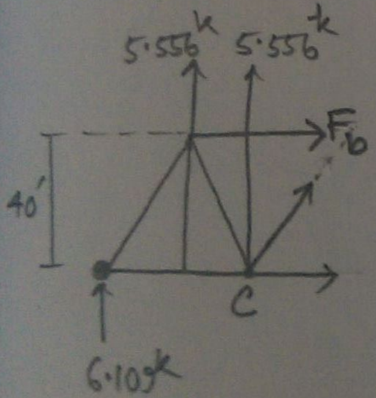


Here, $\Sigma F_y = 0$ ↑

$\Rightarrow 5.556 + 6.109 - \frac{4}{\sqrt{41}} F_a = 0$

$\Rightarrow F_a = 18.673^k$

Ans.



Here, $\Sigma M_c = 0$ ↺

$\Rightarrow F_b \times 40 + 5.556 \times 50 + 6.109 \times 100 = 0$

$\Rightarrow F_b = - 22.2175^k$

Ans.

ssignment-1 : For the following figure, determine –

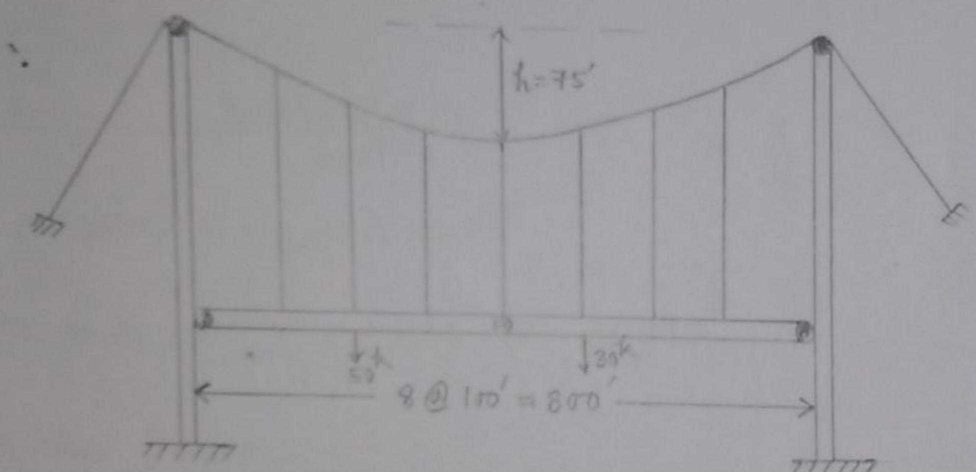
a) Hanger force

b) Draw shear force and bending moment diagram f stiffening girder

c) Maximum tension of cable

d) Stressed and unstressed length

e) Stretch of the cable



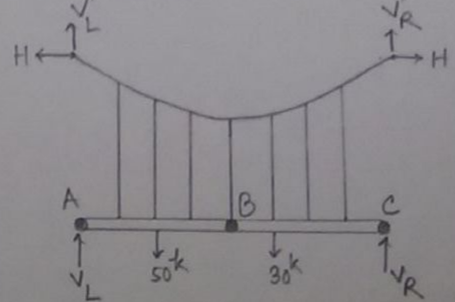
Solution :

From the free body diagram of the whole structure, we can find by taking moment about point A.

$\because \Sigma M_A = 0$ ↻+ve

$\Rightarrow (V_R + V_R') \times 800 = 50 \times 200 + 30 \times 500$

$\Rightarrow V_R + V_R' = 31.25^k$ ------ (1)



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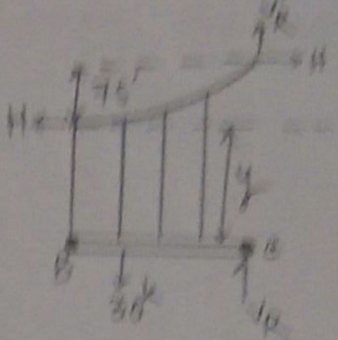
Now from the free body diagram of the right stiffening girder we get



$\Sigma M_B = 0$ ↻ +ve

$\Rightarrow H(75+y) - Hy + 30\times100 - (V_R + V_R')\,400 = 0$

$\Rightarrow 75H = (V_R + V_R')\,400 - 30\times100$

$\Rightarrow 75H = 31.25\times400 - 30\times100$; [from (1)]

$\therefore H = 126.67^k$

pplying general cable theorem (GCT),

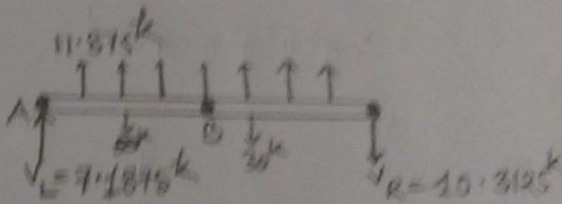
$$h = \frac{wL^2}{8H}$$

$$\Rightarrow w = \frac{8Hh}{L^2} = \frac{8\times126.67\times75}{800^2}$$

$\Rightarrow w = 0.11875^k/$ horizontal foot

$\therefore$ Hanger force, $H.F = 0.11875\times100 = 11.875^k$

ow from this figure,



$M_A = 0$ ↻ +ve

$V_R\times800 = 11.9(100+200+300+400+500+600+700) - 30\times500 - 50\times200$

$V_R = 10.3125^k(\downarrow)$

ow, $\Sigma F_y = 0$ ↑+ve

$\Rightarrow V_L = -V_R + 11.9\times7 - 80$

$\Rightarrow V_L = -7.1875^k(\uparrow)$

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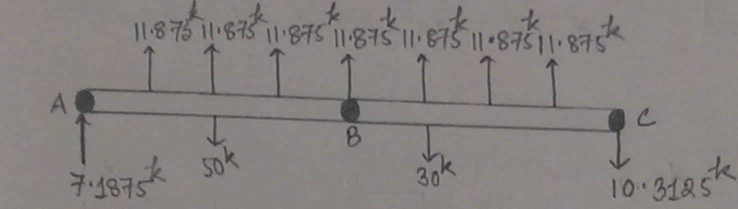
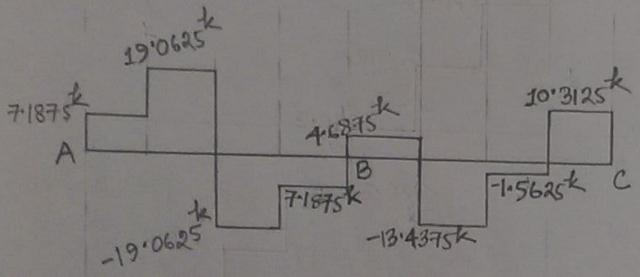
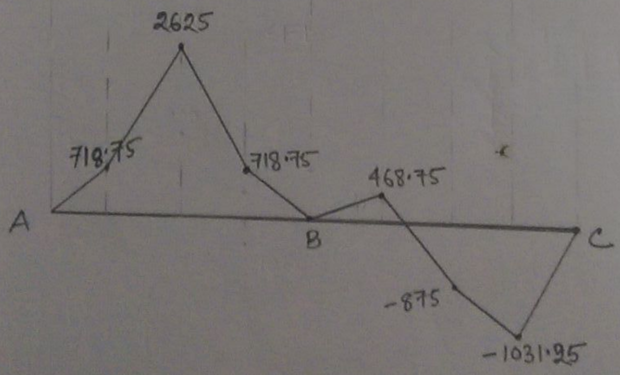
Here, for the shear force and bending moment diagram of the stiffening girder –





SFD



BMD (kip-ft)

(c) Here, $\gamma = 0$ and $\theta = \frac{h}{L} = \frac{75}{800} = 0.09375$

$$T_{max} = H(1+16\theta^2)^{1/2}$$

$$= 126.67\left(1 + 16 \times (.09375)^2\right)^{1/2}$$

$$= 135.28^k$$

(d) Cable length,

$$S = \frac{L}{2}(1+16\theta^2)^{1/2} + \frac{L}{8\theta}\ln\left[4\theta + (1+16\theta^2)^{1/2}\right]$$

$$= \frac{800}{2}\left[1 + 16\times(.09375)^2\right]^{1/2} + \frac{800}{8\times .09375}\ln\left[4\times .09375 + \{1+16\times(.09375)^2\}^{1/2}\right]$$

$$= 818.373'$$

Stretch, $\Delta S = \frac{HL}{AE}\left[1 + \frac{16}{3}\theta^2\right]$

$$= \frac{126.67 \times 800}{50 \times 27 \times 10^3}\left[1 + \frac{16}{3}(.09375)^2\right]$$; [Assuming $A = 50\ in^2$ and $E = 27 \times 10^6\ psi$]

$$= 0.0786'$$

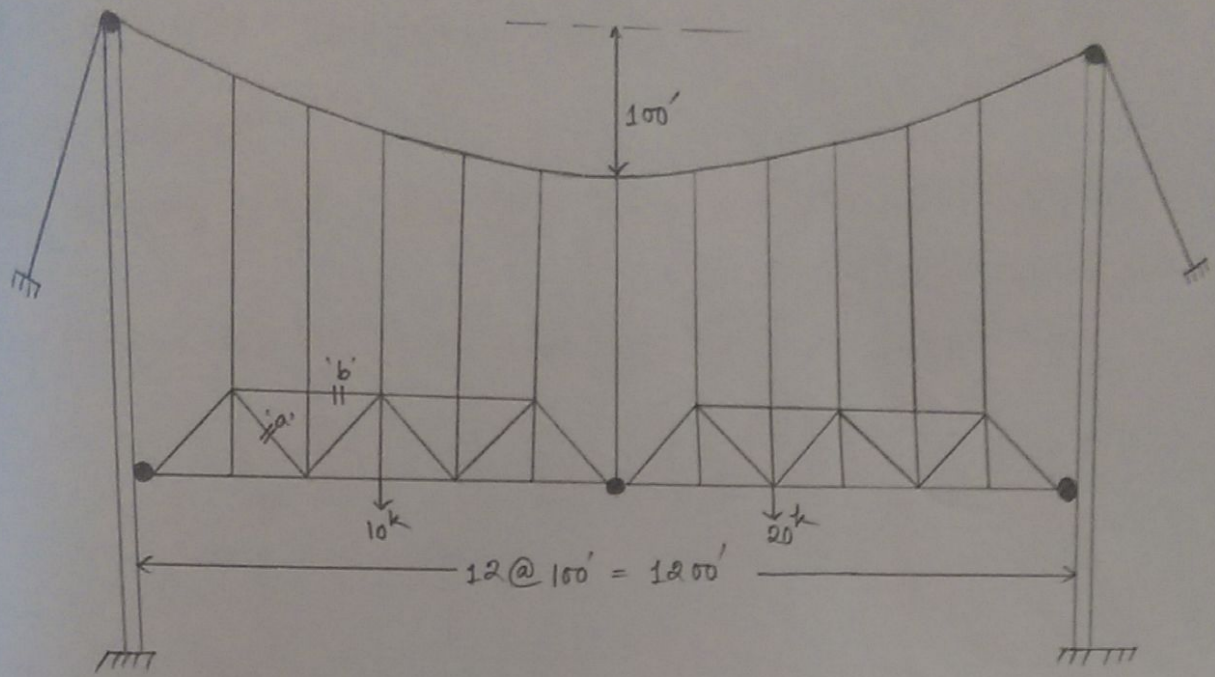
$\therefore$ Unstressed Length $= S - \Delta S$

$$= (818.373 - 0.0786)'$$

$$= 818.29'$$

Assignment - 2 :

Determine the hanger force and the two member forces 'a' and 'b' of the following suspension bridge.



Solution :

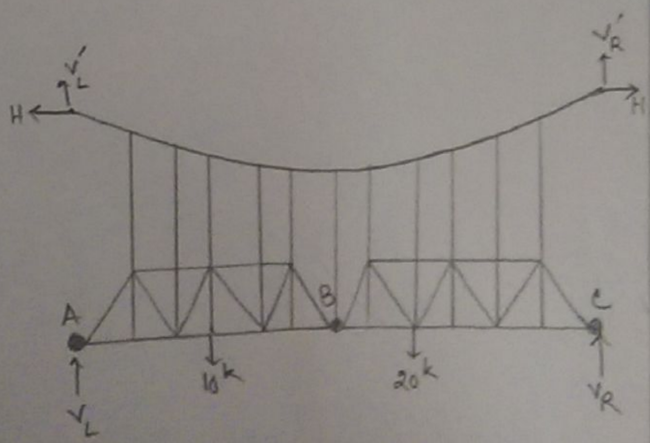
$\Sigma M_A = 0$

$\Rightarrow (V_R + V_R') \times 1200 = 10 \times 300 + 20 \times 800$

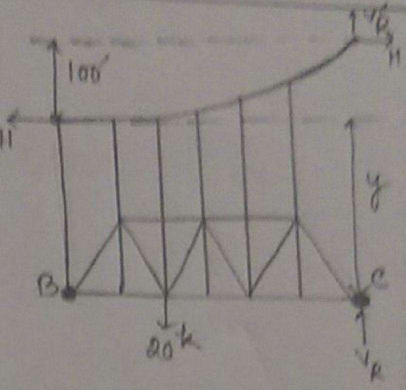
$\Rightarrow V_R + V_R' = (3000 + 16000) \times \frac{1}{1200}$

$\Rightarrow V_R + V_R' = 19000 \times \frac{1}{1200}$

$\therefore V_R + V_R' = 15.833$ ------ (1)



Here,



$\Sigma M_B = 0$ ↻+ve

$\Rightarrow H(100+y) - Hy + 20\times 200 - (V_R + V_R') \times 600 = 0$

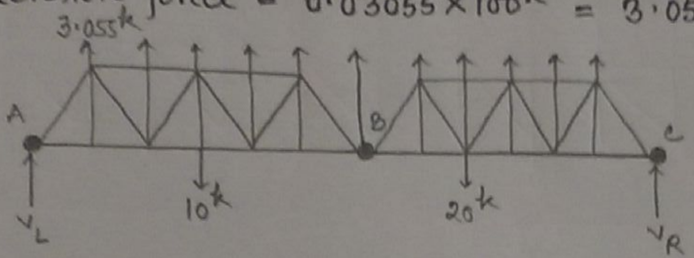
$\Rightarrow 100H + 4000 - 15.833 \times 600 = 0$

$\Rightarrow H = 54.998^k$

Now applying G.C.T, $h = \frac{wL^2}{8H} \Rightarrow w = \frac{8Hh}{L^2} = \frac{8\times 54.998 \times 100}{1200^2}$

$\Rightarrow w = 0.03055^k$/horizontal foot

$\therefore$ Hanger tension force $= 0.03055 \times 100^k = 3.055^k$



For this figure,

$\Sigma M_A = 0$ ↻+ $\Rightarrow 10\times 300 + 20 \times 800 - V_R \times 1200 - 3.055(100 + 200 + 300 + 400 + 500 + 600 + 700 + 800 + 900 + 1000 + 1100) = 0$

$\Rightarrow V_R = -0.969^k$ (↓)

And, $\Sigma F_y = 0$ ↑+ve

$\Rightarrow V_L + V_R + 3.055 \times 11 - 30 = 0$

$\Rightarrow V_L = -2.636^k$ (↓)

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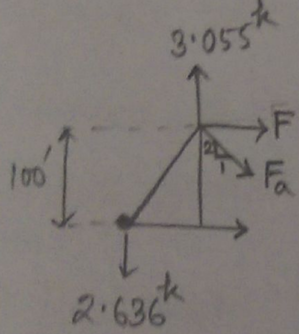
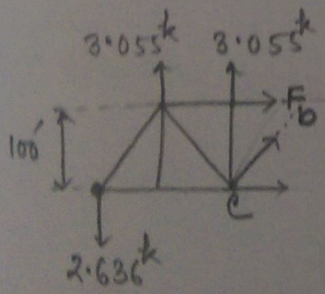


Here,

$\Sigma F_y = 0 \quad \uparrow +$

$\Rightarrow 3{\cdot}055 - 2{\cdot}636 - \frac{2}{\sqrt{5}} F_a = 0$

$\Rightarrow F_a = 0{\cdot}468^k$



Here, $\Sigma M_c = 0 \quad \circlearrowright +ve$

$\Rightarrow F_b \times 100 + 3{\cdot}055 \times 100 - 2{\cdot}636 \times 200 = 0$

$\Rightarrow F_b = 2{\cdot}217^k$