BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Civil Engineering

ASSIGNMENT

CE 311

Structural Analysis and Design I

- **Submitted to: Dr. Md. Zakaria Ahmed**

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- **Level: 3**
- **Term: 1**
- **Sec: B**
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Submission Date: 21/12/2015

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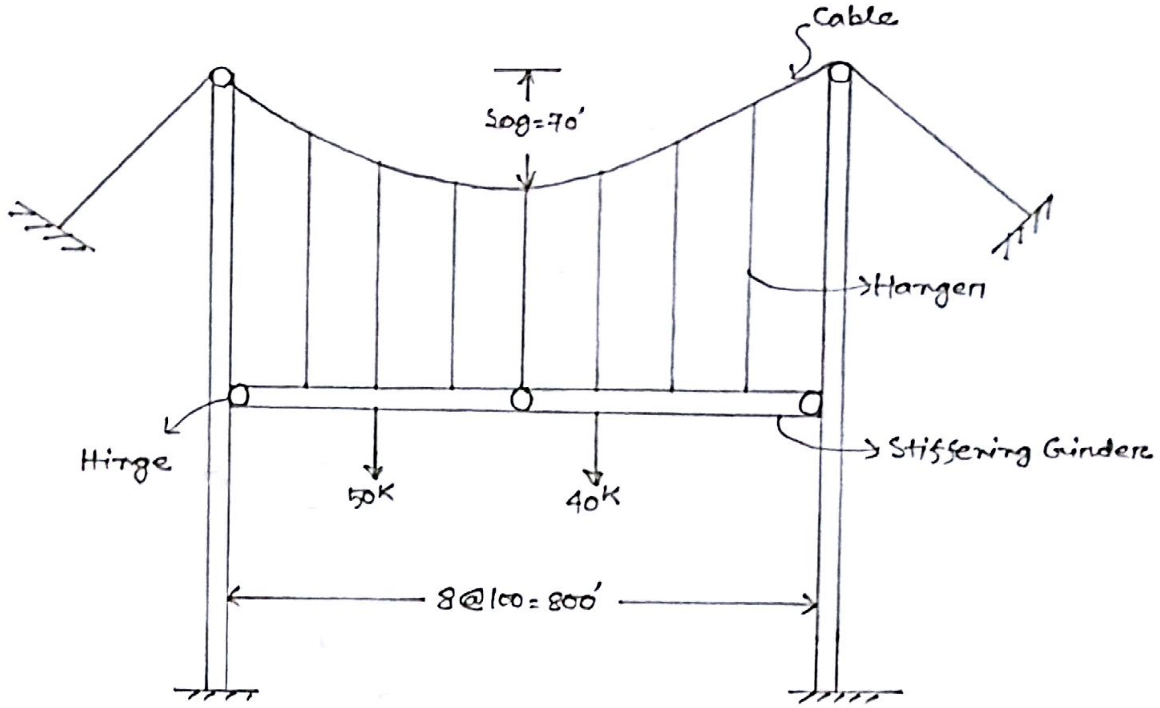
Assignment # 1 :



Find

(1) Hanger force

(2) Draw SFD for Girder

(3) Draw BMD for Girder

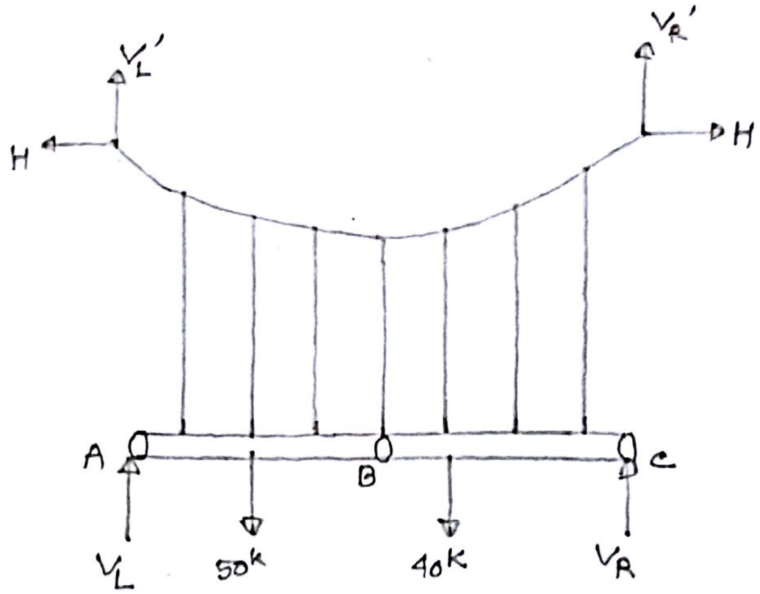
(4) T_{max} of cable

(5) Cable stretch

(6) Unstressed length of cable

Let, $A = 40\ in^2$; $E = 27 \times 10^3$ ksi

Solution:

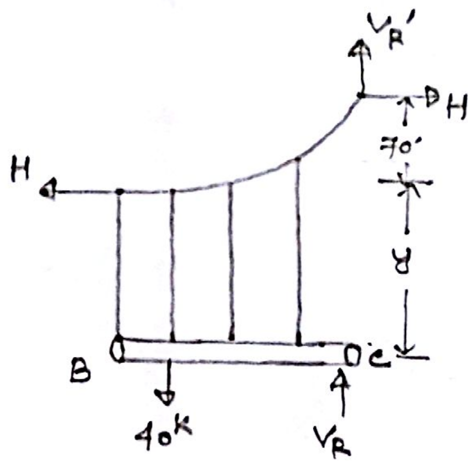


FBD of whole structure

$\Sigma M @ A = 0 \quad +ve \circlearrowright$

$\Rightarrow \quad 50 \times 200 + 40 \times 500 - (V_R + V_R') \times 800 = 0$

$\therefore \quad V_R + V_R' = 37.5^k$



FBD for right segment

$\Sigma M @ B = 0 \quad +ve$

$\Rightarrow 40 \times 100 - H \times y + H(y+70) - (V_R + V_R') \times 400 = 0$

$\Rightarrow 40 \times 100 - Hy + Hy + 70H - 37.5 \times 400 = 0$

$\therefore H = 157.14^k$

Applying General Cable Theorem,

$$\text{Max sag}, h = \frac{WL^2}{8H}$$

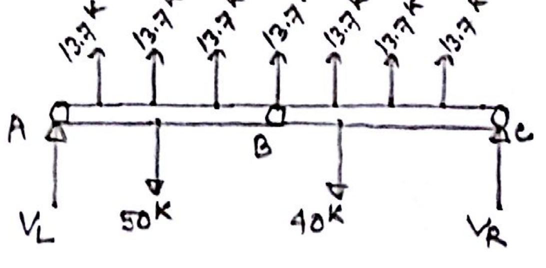
$$\Rightarrow 70 = \frac{W \times 800^2}{8 \times 157.14}$$

$\therefore W = 0.137$ kip/horizontal foot

(1) Hanger force = W × spacing of hanger

$= 0.137 \times 100$

$\boxed{= 13.7 \text{ kip}}$



$\Sigma M @ A = 0 \quad +ve$

$\Rightarrow 50 \times 200 + 40 \times 500 - 13.7(100+200+300+400+500+600+700)$

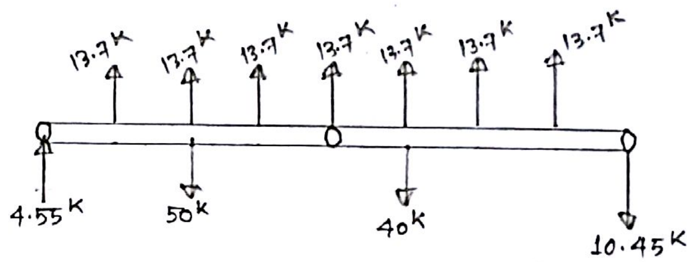
$- V_R \times 800 = 0$

$\therefore V_R = -10.45^K (\downarrow)$

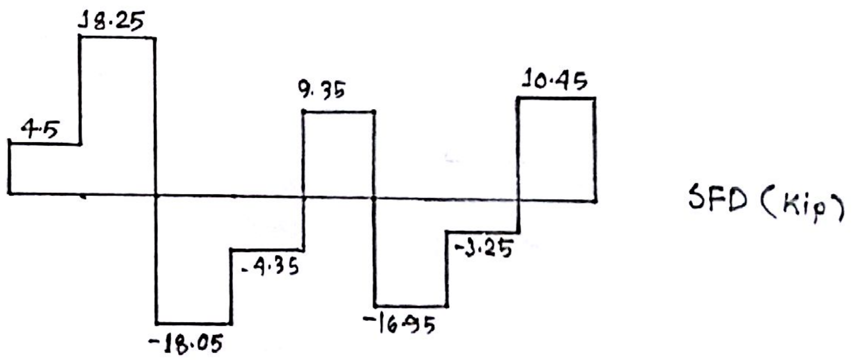
$\Sigma F_y = 0$ +ve ↑,

$\Rightarrow V_L + 13.7 \times 7 - 50 - 40 - 10.45 = 0$

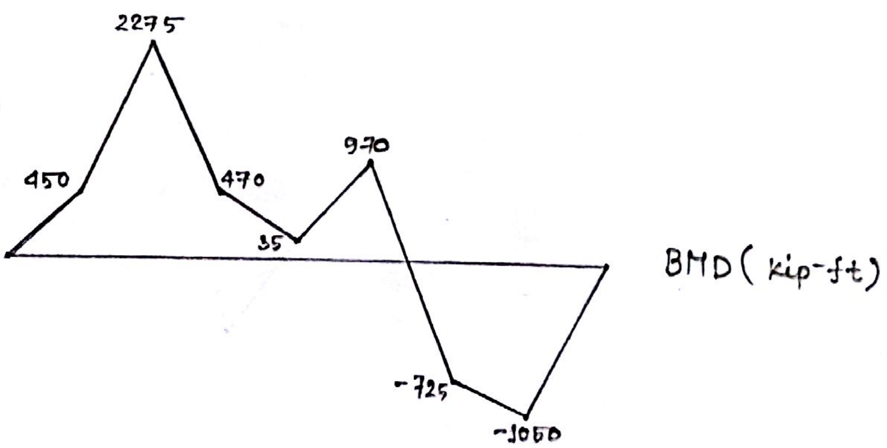
$\therefore V_L = +4.55^k$ (↑)



(2) SFD (Kip)



(3) BMD (K-ft)



T_{max} occurs at ends.

For a horizontal cable chord:

4 $T_{max} = H(1+16\theta^2)^{1/2}$

$= 157.14\left[1+16\left(\frac{70}{800}\right)^2\right]^{1/2}$

$\boxed{= 166.49 \text{ kip}}$

5 Cable stretch, $\Delta s = \frac{HL}{AE}\left[1+\frac{16}{3}\theta^2+\tan^2\gamma\right]$

$= \frac{157.14\times 800}{40\times 27\times 10^3}\left[1+\frac{16}{3}\left(\frac{70}{800}\right)^2+0\right] \quad [\because \gamma = 0]$

$\boxed{= 0.121 \text{ ft}}$

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

$= \frac{800}{2}\left\{1+16\times(0.089)^2\right\}^{1/2} + \frac{800}{8\times .089}\ln\left[4\times .089 + \left\{1+16(.089)^2\right\}^{1/2}\right]$

$= 816.59$ ft

6: Unstressed length of cable $= s - \Delta s$

$= 816.59 - 0.121$

$= 816.47$

$\boxed{\approx 816 \text{ ft}}$

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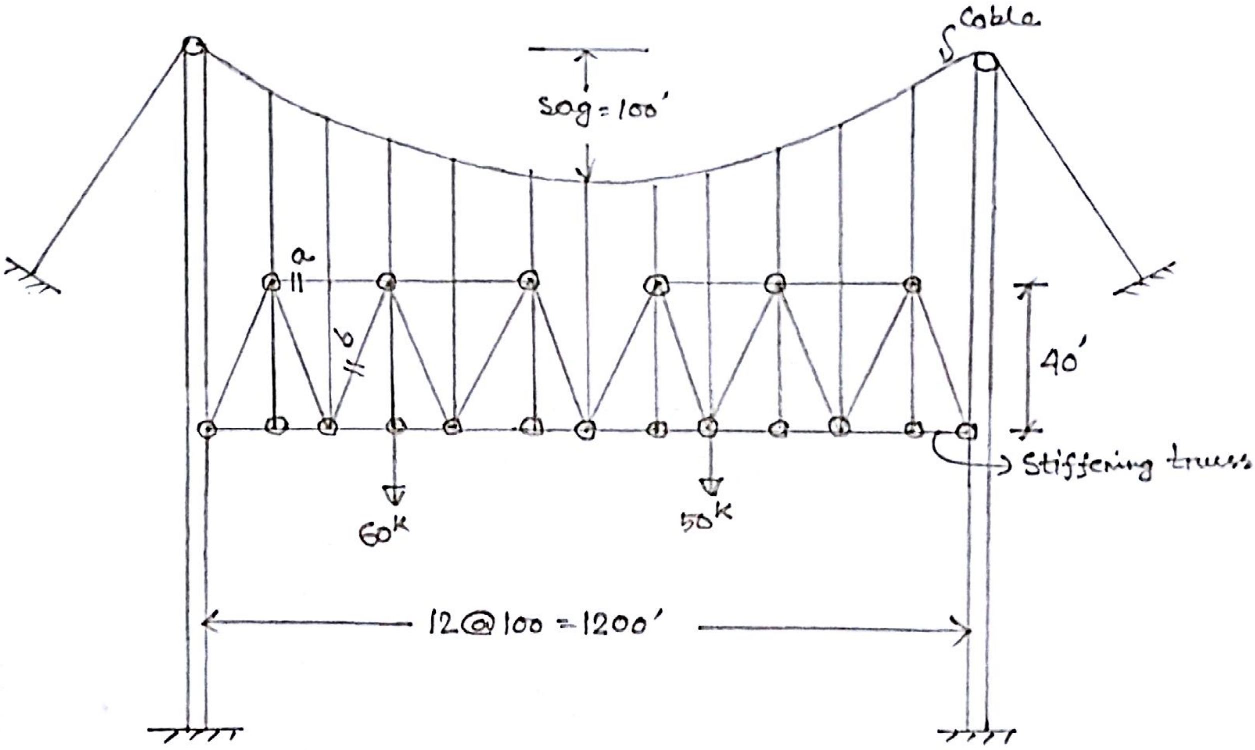
Assignment #2:



Find

(1) Horizontal force

(2) Member force a & b

(3) Tmax

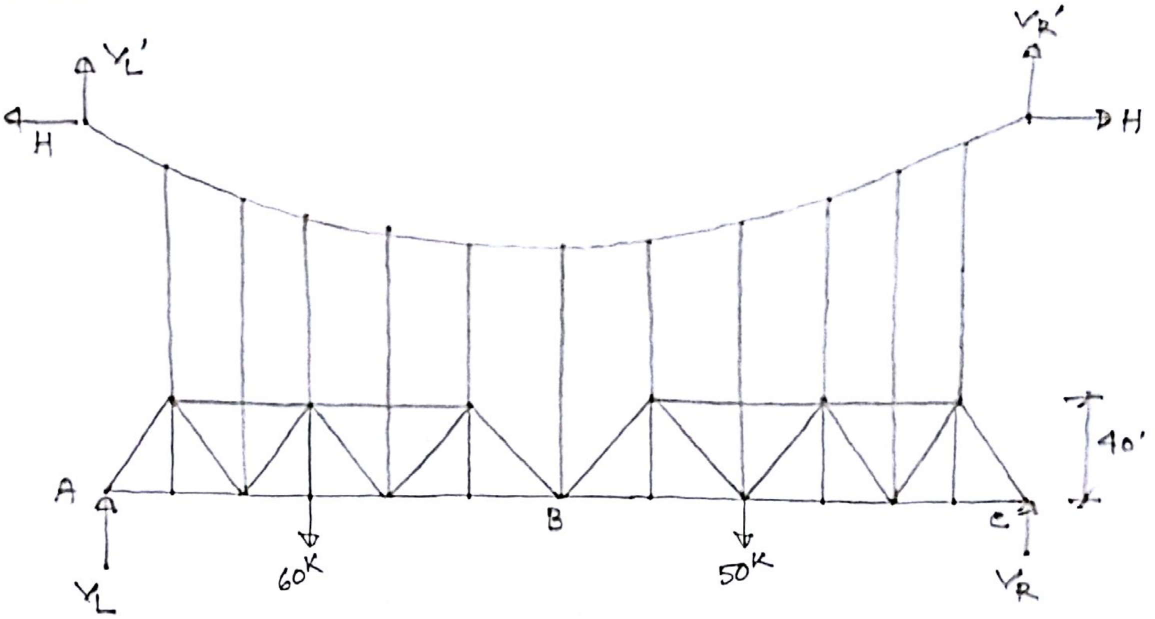
(4) Stretch

(5) Unstressed length

Let, $A = 40\ in^2$; $E = 27 \times 10^3$ ksi

Solution:

1

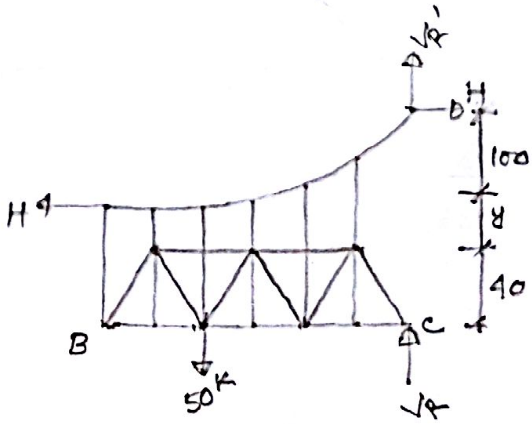


FBD of whole Structure

$\Sigma M @ A = 0$ +ve ↻

$\Rightarrow 60 \times 300 + 50 \times 800 - (V_R + V_R') \times 1200 = 0$

$\therefore V_R + V_R' = 48.33^K$



$\Sigma M @ B = 0$ +ve ↻,

$\Rightarrow 50 \times 200 - H(y+40) + H(100+y+40) - (V_R + V_R') \times 600 = 0$

$\Rightarrow 50 \times 200 - Hy - 40H + 100H + Hy + 40H - 48.33 \times 600 = 0$

$\therefore \boxed{H = 189.98^K}$

Applying General Cable Theorem,

$$\text{Max sag}, h = \frac{WL^2}{8H}$$

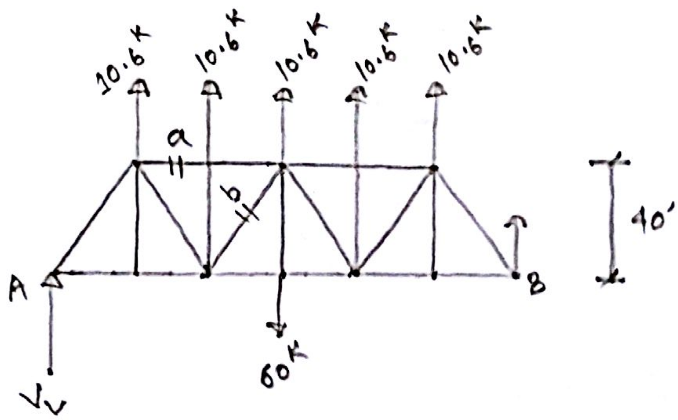
$$\Rightarrow 100 = \frac{W \times 1200^2}{8 \times 189.98}$$

$$\Rightarrow W = 0.1055 \text{ kip/horizontal foot}$$

$\therefore$ Hanger force = W x spacing of hanger

$= 0.1055 \times 100$

$= 10.6$ kip

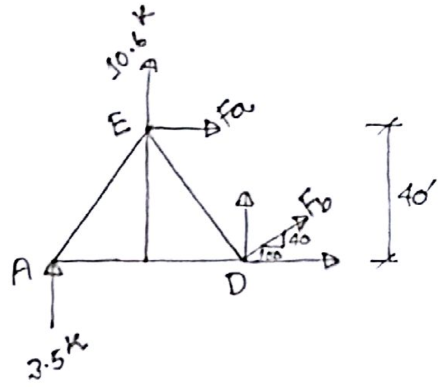


ΣM @ B = 0 +ve

$$\Rightarrow -60 \times 300 + 10.6\,(100+200+300+400+500) + V_L \times 600 = 0$$

$$\therefore V_L = +3.5^k \;(\uparrow)$$

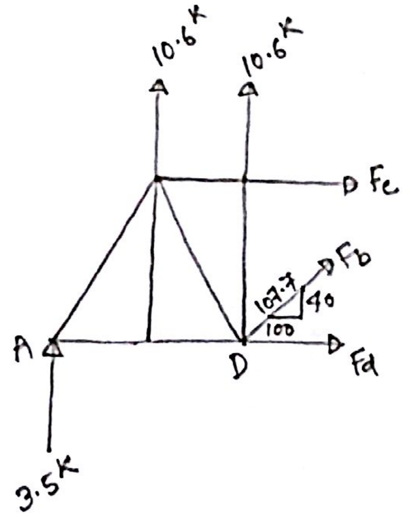
2



ΣM @ $D = 0$ +ve ↻

$\Rightarrow$ $3.5 \times 200 + 10.6 \times 100 + Fa \times 40 = 0$

$\therefore$ $\boxed{Fa = -44 \text{ kip } (\leftarrow)}$



$\Sigma Fy = 0$ +ve ↑,

$\Rightarrow$ $3.5 + 10.6 + 10.6 + F_b \times \frac{40}{107.7} = 0$

$\therefore$ $\boxed{F_b = -66.5 \text{ kip } (\leftarrow)}$

T_{max} occurs at ends

For a horizontal cable chord :

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

$= 189.98\left[1+16\left(\frac{100}{1200}\right)^2\right]^{1/2}$

$= \boxed{200.26 \text{ kip}}$

(4) Cable stretch, $\Delta s = \frac{HL}{AE}\left[1+\frac{16}{3}\theta^2 + \tan^2\gamma\right]$

$= \frac{189.98 \times 1200}{40 \times 27 \times 10^3}\left[1+\frac{16}{3}(.083)^2 + 0\right]$ $[\because \gamma = 0]$

$= \boxed{0.219 \text{ ft}}$

Stressed length, $s = \frac{L}{2}(1+16\theta^2)^{1/2} + \frac{L}{8\theta}\ln\{4\theta + (1+16\theta^2)^{1/2}\}$

$= \frac{1200}{2}\{1+(.083)^2 16\}^{1/2} + \frac{1200}{8 \times .083}\ln\{4 \times .083 + (1+16(.083)^2)^{1/2}\}$

$= 1221.69$ ft

(5). Unstressed length of cable $= s - \Delta s$

$= 1221.69 - 0.219$

$= 1221.47$

$\boxed{\approx 1221 \text{ ft}}$

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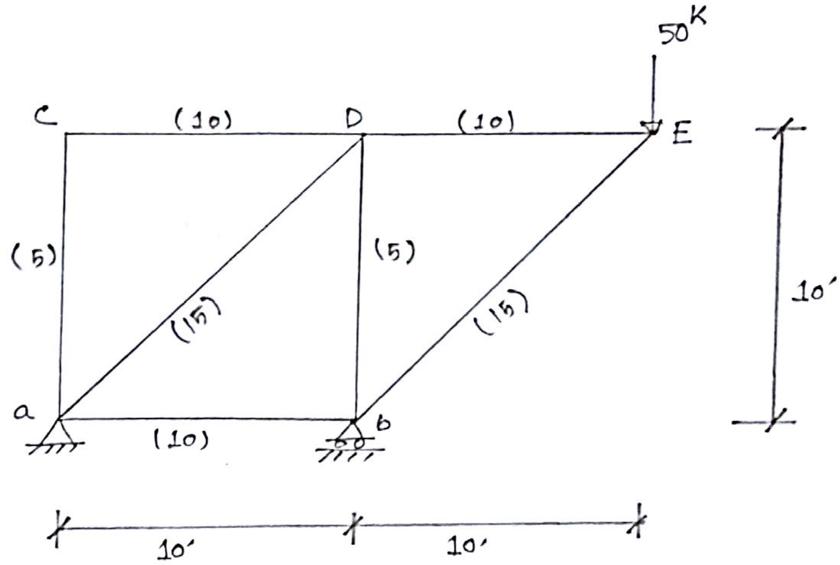
Assignment # 3 :



Given,

$E = 29000$ ksi

$A =$ horizontal ($10 \, in^2$)

Vertical ($5 \, in^2$)

Diagonal ($15 \, in^2$)

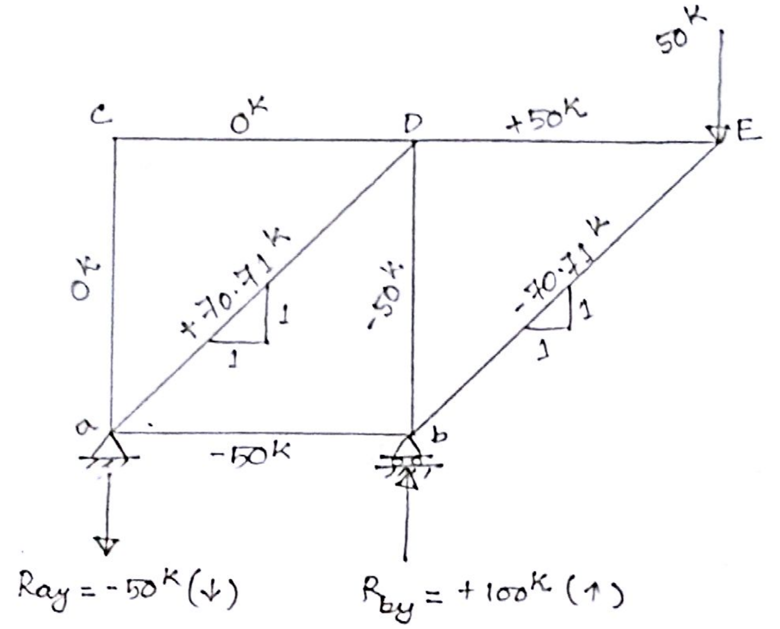
Find (a) Vertical Deflection at 'C'

(b) Horizontal deflection at 'E'

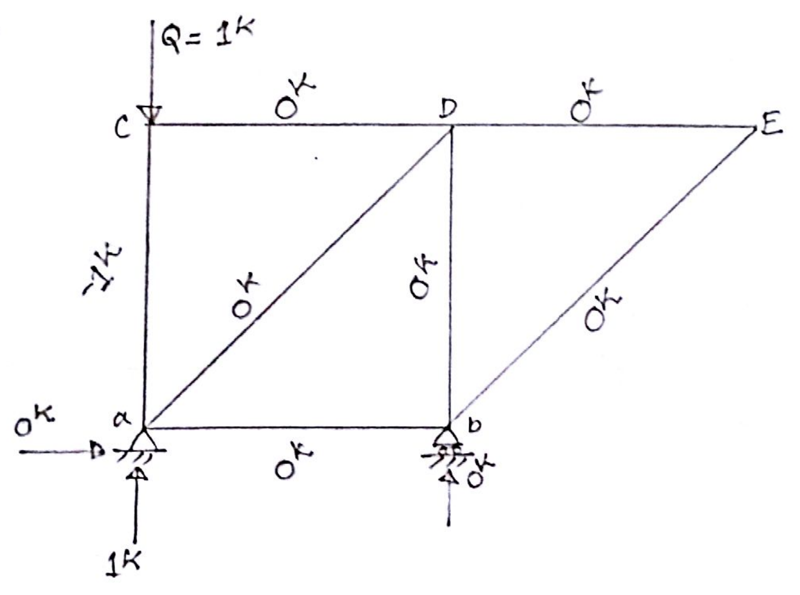
Solution:

(a)

Analysing for real force.



Analysing for virtual force,



Member	Bar	L (ft)	A (in^2)	$\frac{L}{A}$	F_Q (K)	F_P (K)	$F_Q F_P \frac{L}{A}$
Horizontal	ab	10	10	1	0	-50	0
	CD	10	10	1	0	0	0
	DE	10	10	1	0	+50	0
Vertical	aC	10	5	2	-1	0	0
	bD	10	5	2	0	-50	0
Diagonal	aD	14.14	15	0.943	0	70.71	0
	bE	14.14	15	0.943	0	-70.71	0

$\Sigma F_Q F_P \frac{L}{A} = 0$

If Q = unit load,

$$1^{K} \cdot \delta = \Sigma \frac{F_Q F_P L}{AE}$$

$$\Rightarrow 1 \cdot \delta_e = \frac{0}{E}$$

$$\therefore \boxed{\delta_e = 0}$$

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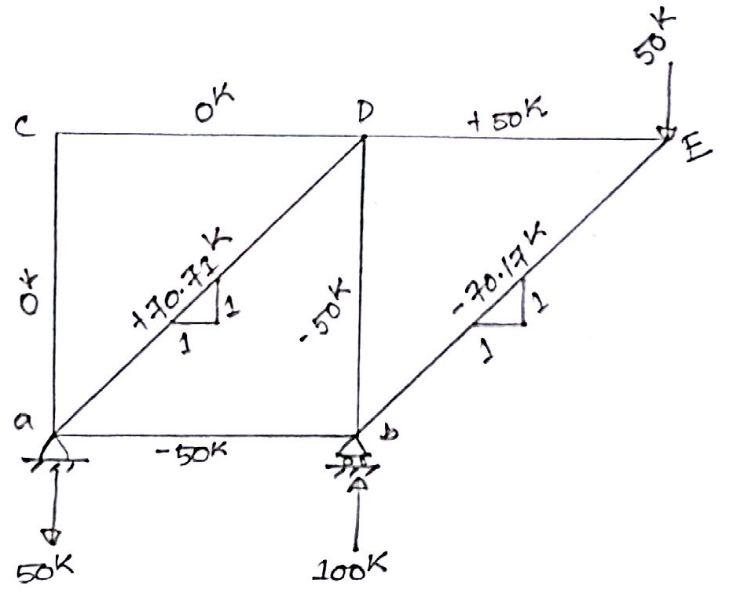
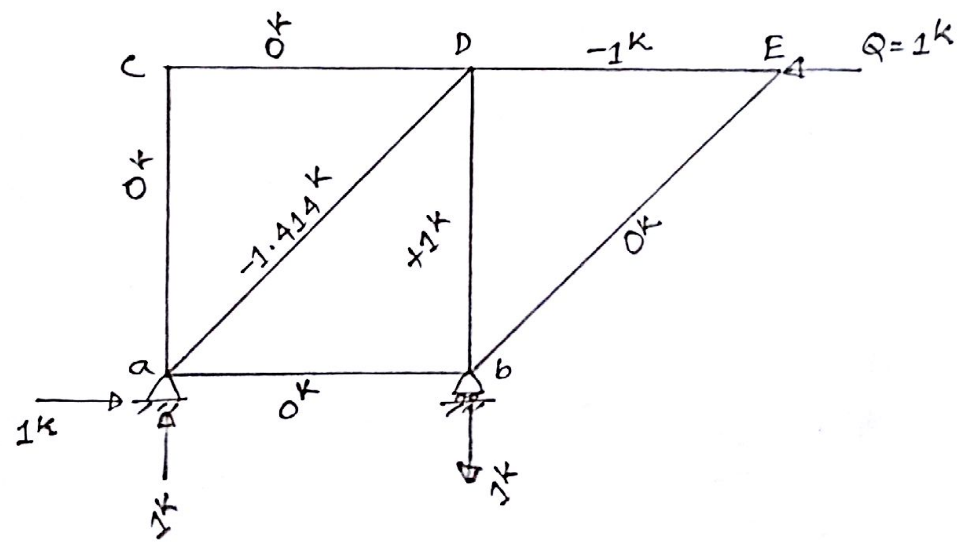
(b)

Analysing for real force,



Analysing for virtual force,



Member	Bar	L (ft)	A (in^2)	$\frac{L}{A}$	F_Q (K)	F_P (K)	$F_Q F_P \frac{L}{A}$
Horizontal	ab	10	10	1	0	-50	0
	CD	10	10	1	0	0	0
	DE	10	10	1	-1	+50	-50
Vertical	aC	10	5	2	0	0	0
	bD	10	5	2	+1	-50	-100
Diagonal	aD	14.14	15	0.943	-1.414	70.71	-94.25
	bE	14.14	15	0.943	0	-70.71	0

$$\Sigma F_Q F_P \frac{L}{A} = -244.25$$

If Q = unit load.

$$1^K . \delta = \Sigma \frac{F_Q F_P L}{AE}$$

$$\Rightarrow \; 1.\ \delta_E = \frac{-244.25}{29000}$$

$$\therefore \boxed{\delta_E = -8.42 \times 10^{-3} \text{ ft (rightward)}}$$

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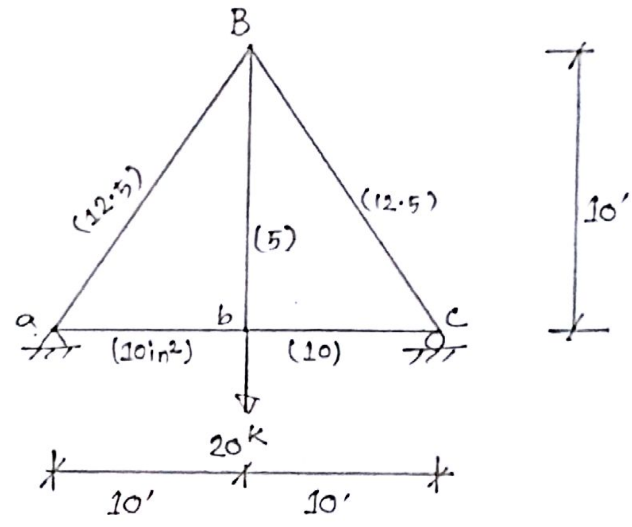
Assignment # 4 :



Compute vertical deflection of joint B if 50°F temp. decreases is observed in bottom chord member only + P = 20K

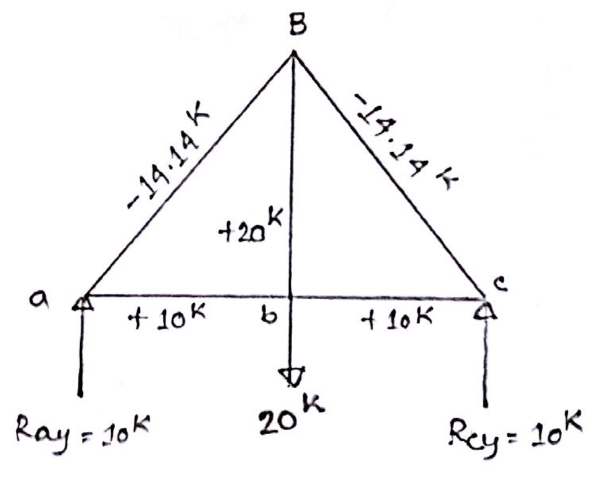
Given, $a_t = \frac{1}{1,50,000}$ per °F

$E = 29000$ ksi

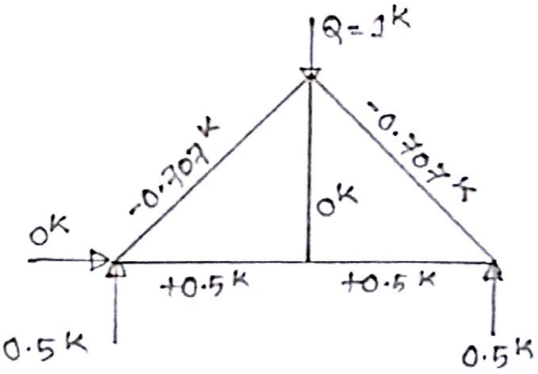
A = in in² in parentheses

Solution:

Analysis for real force,



Analysing for virtual force,



Member	Bar	L (ft)	A (in²)	$\frac{L}{A}$	F_Q (K)	F_P (K)	$F_Q F_P \frac{L}{A}$	t	$F_Q t L$
Horizontal	ab	10	10	1	+0.5	+10	5	-50	-250
	bc	10	10	1	+0.5	+10	5	-50	-250
Vertical	bB	10	5	2	0	+20	0	0	0
Diagonal	aB	14.14	12.5	1.13	-0.707	-14.14	11.29	0	0
	cB	14.14	12.5	1.13	-0.707	-14.14	11.29	0	0

$\Sigma F_Q F_P \frac{L}{A} = +32.6$ $\Sigma F_Q t L = -500$

If Q = unit load,

$$1^K . \delta = \Sigma \frac{F_Q F_P L}{AE} + \Sigma F_Q \alpha_t t L$$

$$\Rightarrow 1 . \delta_B = \frac{32.6}{29000} + \frac{-500}{1,50,000}$$

$$\boxed{\therefore \delta_B = -2.21 \times 10^{-3} \text{ ft (upward)}}$$

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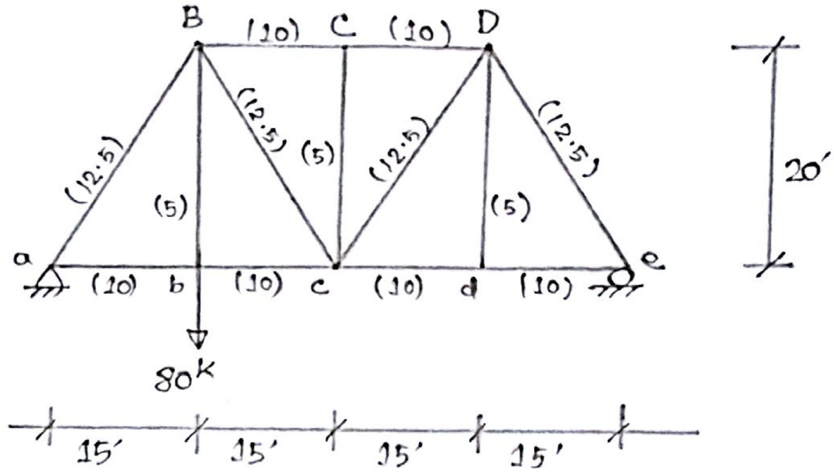
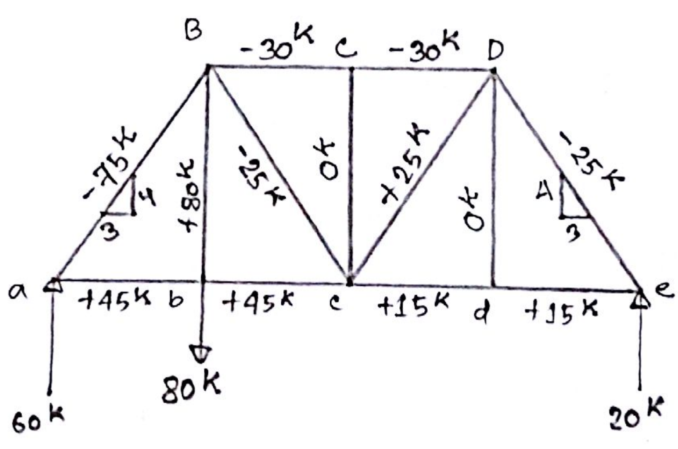
Assignment #5 :



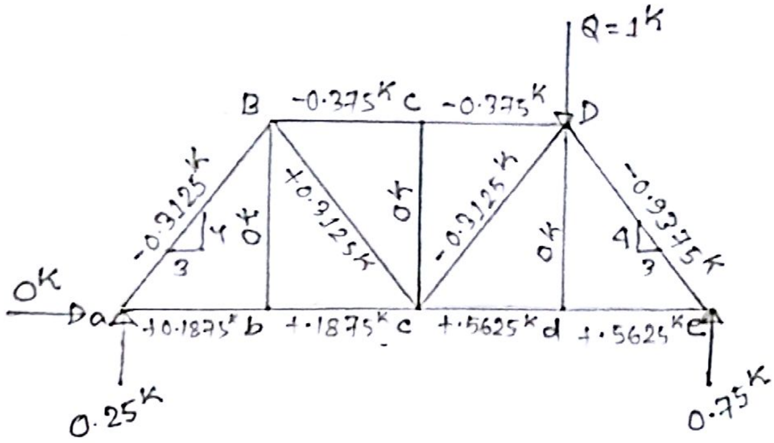
Compute vertical deflection at joint D, due to a decrease of temparature of 50° F in the bottom chord only. Given, $\alpha_t = \frac{1}{150000}$ per °F , $E = 30 \times 10^3$ ksi and due to the 80 kip load shown.

Solution:

Analysing for real force,



Analysing for virtual force,



Member	Bar	L (ft)	A (in²)	L/A	FQ (K)	FP (K)	FQ FP L/A	t	FQ t L
Horizontal	ab	15	10	1.5	+.1875	+45	+12.66	-50	-140.63
	bc	15	10	1.5	+.1875	+45	+12.66	-50	-140.63
	cd	15	10	1.5	+.5625	+15	+12.66	-50	-421.88
	de	15	10	1.5	+.5625	+15	12.66	-50	-421.88
	BC	15	10	1.5	-.375	-30	+16.88	0	0
	CD	15	10	1.5	-.375	-30	16.88	0	0
Vertical	bB	20	5	4	0	+80	0	0	0
	cC	20	5	4	0	0	0	0	0
	dD	20	5	4	0	0	0	0	0
Diagonal	aB	25	12.5	2	-.3125	-75	46.88	0	0
	cB	25	12.5	2	+.3125	-25	-15.63	0	0
	cD	25	12.5	2	-.3125	+25	-15.63	0	0
	eD	25	12.5	2	-.9375	-25	46.88	0	0

$\Sigma F_Q F_P \frac{L}{A} = 178.16$ $\quad \Sigma F_Q t L = -1125.02$

If Q = unit load,

$$1^K \cdot \delta = \frac{\Sigma F_Q F_P L}{AE} + \Sigma F_Q \alpha_t \, t L$$

$$\Rightarrow 1 \cdot \delta_D = \frac{178 \cdot 16}{30000} + \frac{-1125 \cdot 02}{150000}$$

$$\therefore \quad \boxed{\delta_D = -1.56 \times 10^{-3} \text{ ft (upward)}}$$

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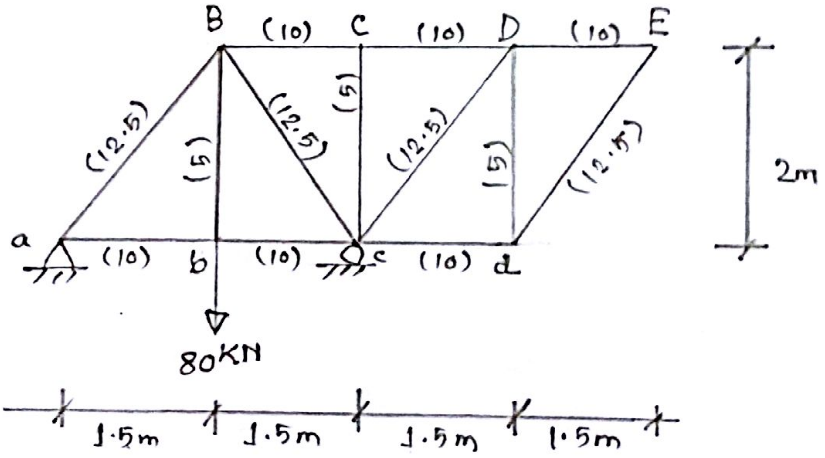
Assignment # 6 :



Calculate vertical component of deflection at E

Given, $P = 80^{KN}$

Temp. Change = $+50^\circ F$ in bottom chord member

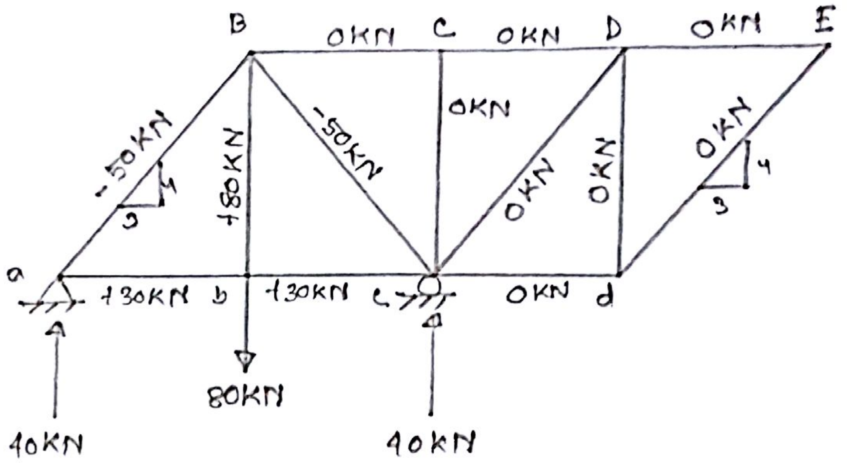
$= -30^\circ F$ in vertical member

$E = 20.7 \times 10^3 \ KN/cm^2$

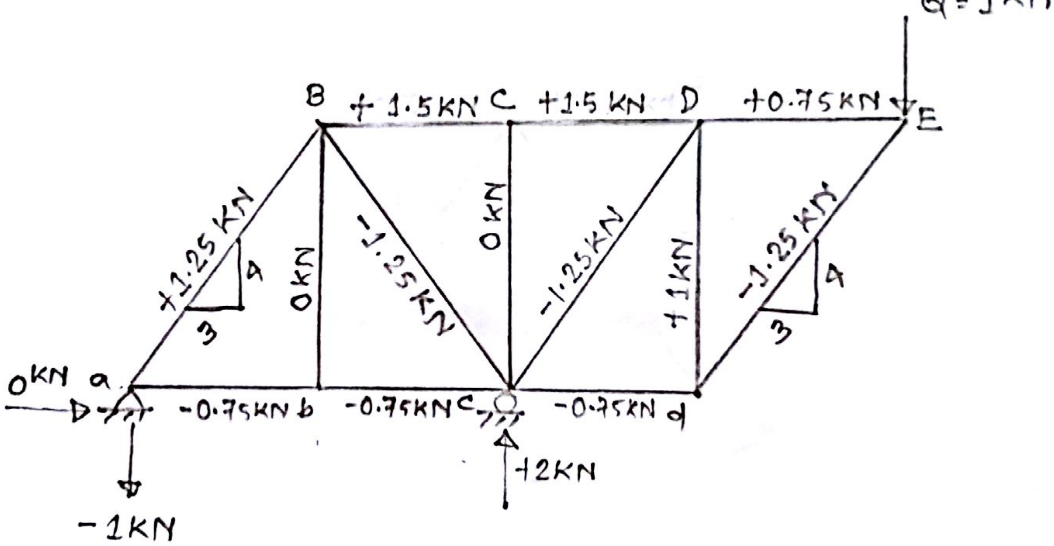
A = in cm^2 in parontheses

$\alpha_t = \frac{1}{150000}$ per $^\circ F$

Analysis for real force,



Analysis for virtual force,



Member	Bar	L (m)	A (cm²)	$\frac{L}{A}$	Fq (KN)	Fp (KN)	$F_q F_p \frac{L}{A}$	t (°F)	FqtL
Horizontal	ab	1.5	10	0.15	-0.75	+30	-3.375	50	-56.25
	bc	1.5	10	0.15	-0.75	+30	-3.375	50	-56.25
	cd	1.5	10	0.15	-0.75	0	0	50	-56.25
	BC	1.5	10	0.15	+1.5	0	0	0	0
	CD	1.5	10	0.15	+1.5	0	0	0	0
	DE	1.5	10	0.15	+0.75	0	0	0	0
Vertical	bB	2	5	0.4	0	+80	0	-30	0
	cC	2	5	0.4	0	0	0	-30	0
	dD	2	5	0.4	+1	0	0	-30	-60
Diagonal	aB	2.5	12.5	0.2	+1.25	-50	-12.5	0	0
	cB	2.5	12.5	0.2	-1.25	-50	12.5	0	0
	cD	2.5	12.5	0.2	-1.25	0	0	0	0
	dE	2.5	12.5	0.2	-1.25	0	0	0	0

$\Sigma F_q F_p \frac{L}{A} = -6.75$ $\quad\quad \Sigma F_q t L = -228.75$

If Q = unit load,

$$1\,\text{KN} \cdot \delta = \Sigma \frac{F_q F_p L}{AE} + \Sigma F_q \alpha_t t L$$

$$\Rightarrow 1 \cdot \delta_E = \frac{-6.75}{20.7 \times 10^3} + \frac{-228.75}{150000}$$

$$\boxed{\therefore \delta_E = -1.85 \times 10^{-3} \text{ m (upward)}}$$

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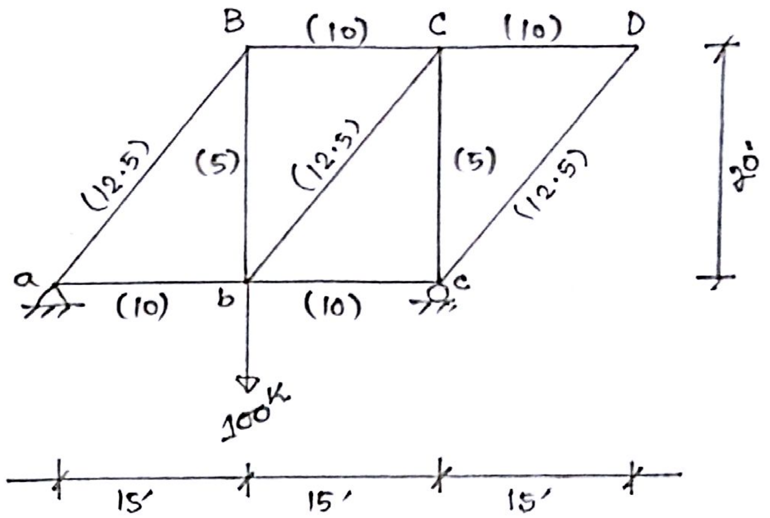
Assignment #7:



Calculate horizontal deflection at joint at point D.

Temp change = +50°F in bottom chord member

= −30°F in vertical " "

Given, $\alpha_t = \frac{1}{150000}$ per °F

at 'a' horizontal movement = 0.75" (to right)

at 'a' vertical " = 0.5" (down)

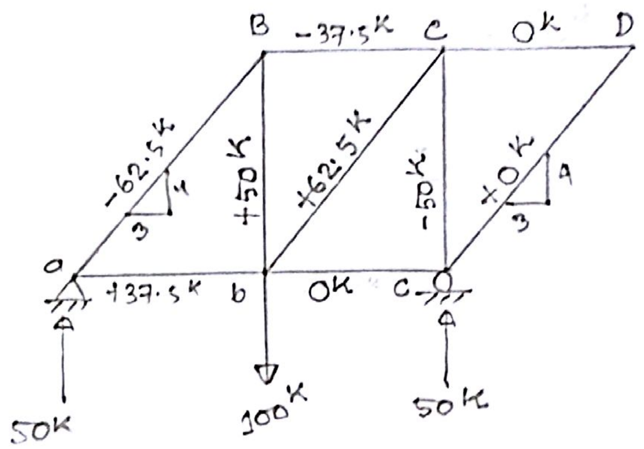
at 'c' vertical " = 0.4" (down)

E = 29000 ksi

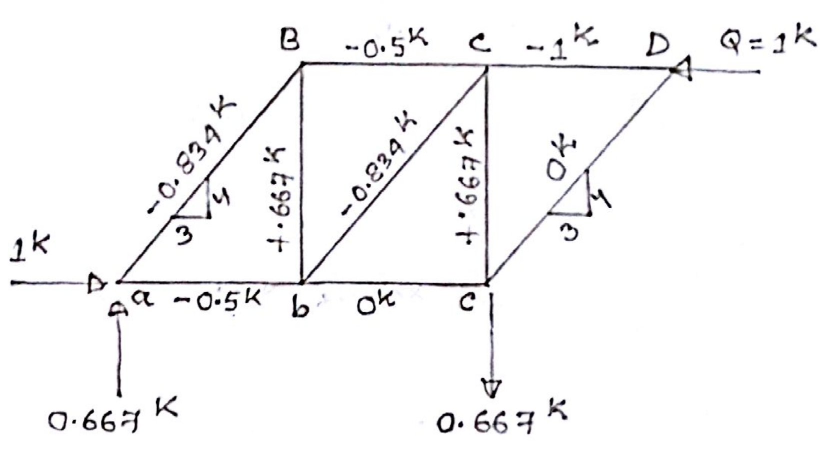
A = in in^2 in paranthesces

Solution:

Analysing for real force,



Analysing for virtual force,



Member	Bar	L (ft)	A (in²)	$\frac{L}{A}$	Fq (K)	Fp (K)	$F_Q F_P \frac{L}{A}$	t (°F)	$F_Q t L$
Horizontal	ab	15	10	1.5	-0.5	+37.5	-28.13	50	-375
	bc	15	10	1.5	0	0	0	50	0
	BC	15	10	1.5	-0.5	-37.5	28.13	0	0
	CD	15	10	1.5	-1	0	0	0	0
Vertical	bB	20	5	4	+.667	+50	133.4	-30	-400.2
	cC	20	5	4	+.667	-50	-133.4	-30	-400.2
Diagonal	aB	25	12.5	2	-0.834	-62.5	104.25	0	0
	bC	25	12.5	2	-0.834	+62.5	-104.25	0	0
	cD	25	12.5	2	0	0	0	0	0

$\Sigma F_Q F_P \frac{L}{A} = 0$ $\qquad$ $\Sigma F_Q t L = -1175.4$

Applying principle of virtual work,

$$W_s + W_R = W_d$$

$$\Rightarrow Q \cdot \delta_{Dh} + (R_{ay} \times \Delta_{ay} + R_{ax} \times \Delta_{ax} + R_{cy} \times \Delta_{ay}) = \Sigma \frac{F_Q F_P L}{AE} + \Sigma F_Q \alpha_t t L$$

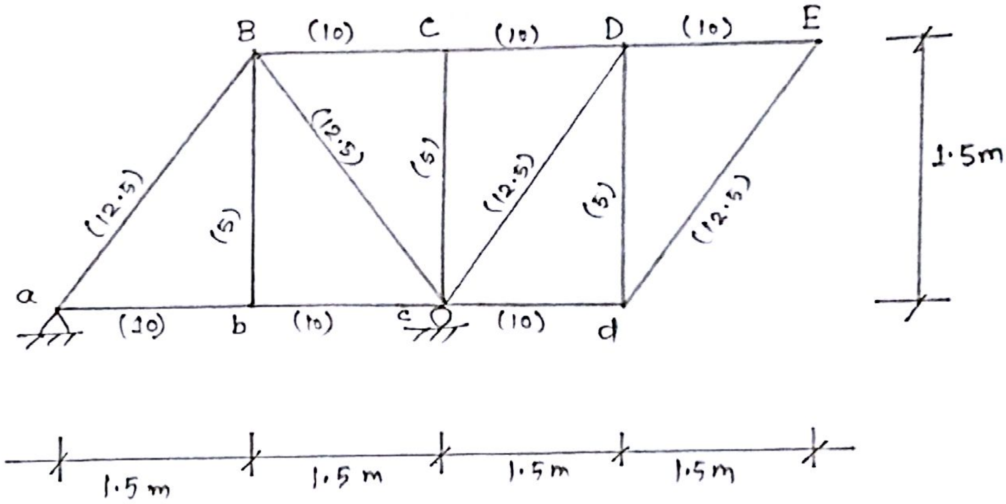
$$\Rightarrow 1^K \cdot \delta_{Dh} + \left(0.667 \times \frac{-0.5}{12} + 1 \times \frac{.75}{12} + .667 \times \frac{.4}{12}\right) = \frac{0}{29000} + \frac{-1175.4}{150000}$$

$$\Rightarrow \delta_{Dh} + 0.0569 = -7.84 \times 10^{-3}$$

$$\boxed{\therefore \delta_{Dh} = 0.0491 \text{ ft (leftward)}}$$

— o —

Assignment # 8 :



Compute the horizontal component of the deflection of joint E due to the following movements of the supports :

At a, horizontal = 7.5×10^{-3} m to left

At a, vertical = 11.25×10^{-3} m down

At c, vertical = 3.75×10^{-3} m down

$E = 20.7 \times 10^{3}$ kN/cm^2

A = in cm^2 in parentheses

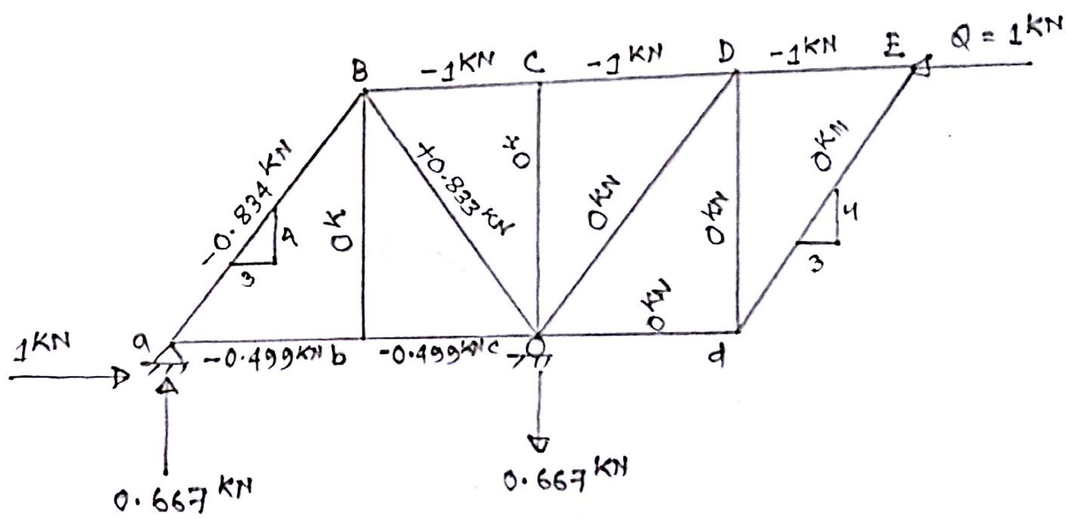
No temparature change

Solution:

Here, there is no real force and no temparature change. The deflection is caused simply by support movements. There are no changes in length of members.

That is, $\Sigma \frac{F_Q F_P L}{AE} = 0$ and $\Sigma F_Q \alpha_t t L = 0$

Analysing for virtual force,



Applying principle of virtual work;

$$W_s + W_R = W_d$$

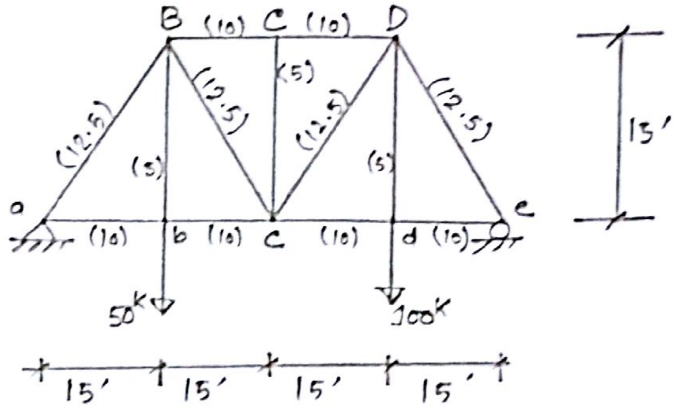
$$\Rightarrow 1^{kN} \cdot \delta_{Eh} + (R_{ay} \times \Delta_{ay} + R_{ax} \times \Delta_{ax} + R_{ey} \times \Delta_{ey}) = \Sigma \frac{F_Q F_P L}{AE} + \Sigma F_Q \alpha_t t L$$

$$\Rightarrow 1 \cdot \delta_{Eh} + (\cdot 667 \times -11.25 \times 10^{-3} + 1 \times -7.5 \times 10^{-3} + \cdot 667 \times 3.75 \times 10^{-3}) = 0$$

$$\boxed{\therefore \quad \delta_{Eh} = +0.0125 \ m \ (\text{leftward})}$$

— o —

Assignment # 9:



Compute the relative deflections of joint d and B along the line joining them

Given, $E = 30 \times 10^3$ ksi

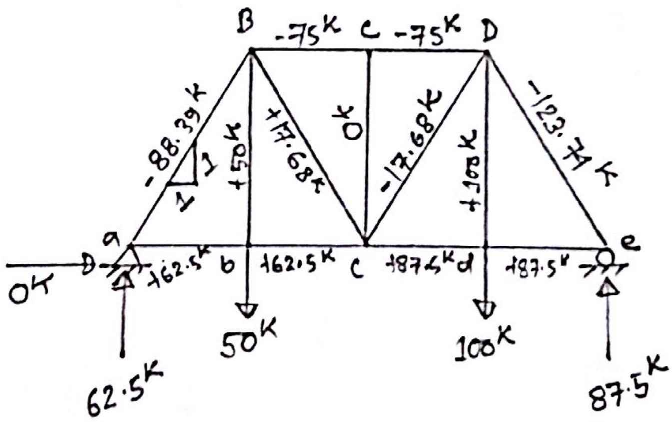
$A =$ in in^2 in parantheses

An increase in temparature of 40°c in the top chord ; a decrease of 10°c in the bottom chord.

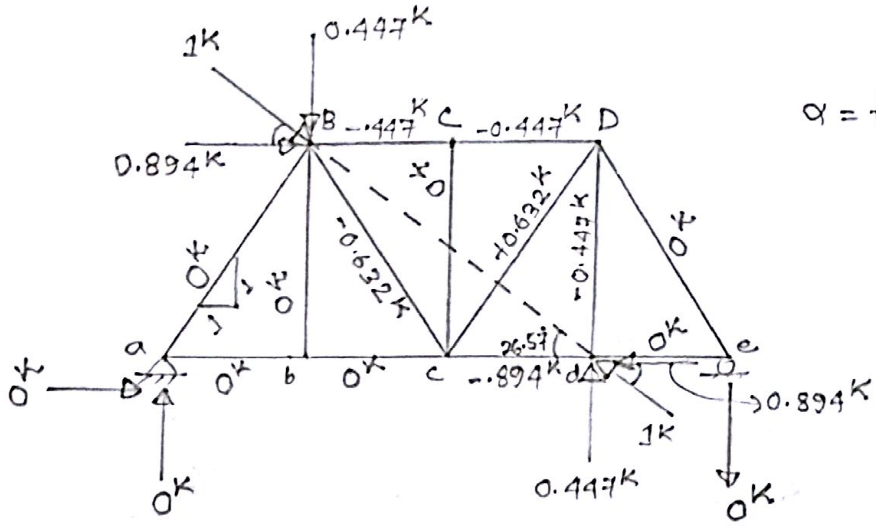
$a_t = \frac{1}{75000}$ per °c

Solution :

Analysing for real force,



Analysing for virtual force,



$\alpha = \tan^{-1}(\frac{15}{30}) = 26.57°$

Member	Bar	L (ft)	A (in²)	$\frac{L}{A}$	F_Q (K)	F_P (K)	$F_Q F_P \frac{L}{A}$	t (°C)	$F_Q t L$
Horizontal	ab	15	10	1.5	0	+62.5	0	-10	0
	bc	15	10	1.5	0	+62.5	0	-10	0
	cd	15	10	1.5	-0.894	+87.5	-117.34	-10	134.1
	de	15	10	1.5	0	+87.5	0	-10	0
	BC	15	10	1.5	-0.447	-75	50.29	40	-536.4
	CD	15	10	1.5	-0.447	-75	50.29	40	-536.4
Vertical	bB	15	5	3	0	+50	0	0	0
	cC	15	5	3	0	0	0	0	0
	dD	15	5	3	-.447	+100	-134.1	0	0
Diagonal	aB	21.2	12.5	1.69	0	-88.39	0	0	0
	cB	21.2	12.5	1.69	-0.632	+17.68	-18.88	0	0
	cD	21.2	12.5	1.69	+0.632	-17.68	-18.88	0	0
	eD	21.2	12.5	1.69	0	-123.74	0	0	0

$\Sigma F_Q F_P \frac{L}{A} = -188.62$ $\Sigma F_Q t L = -938.7$

If Q = unit load,

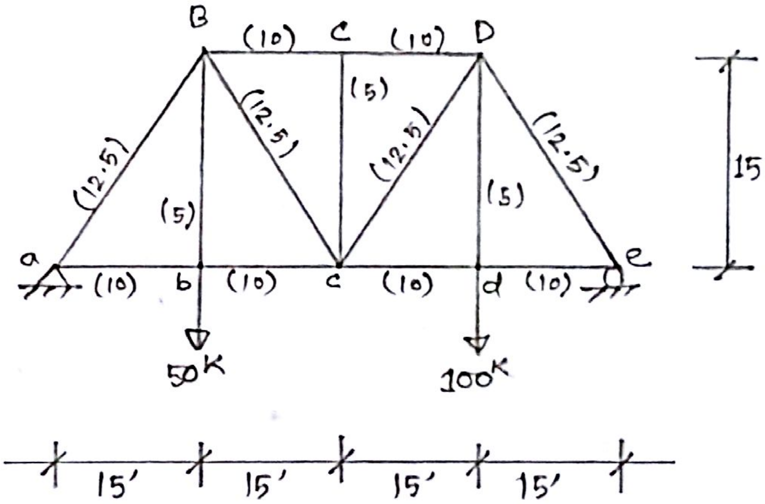
$$1^k . \delta_d^{\nwarrow} + 1^k . \delta_B^{\searrow} = \Sigma \frac{F_Q F_P L}{AE} + \Sigma F_Q \alpha_t t L$$

$$\Rightarrow 1^k . \delta_{d-B}^{\searrow\nwarrow} = \frac{-188.62}{30000} + \frac{-998.7}{75000}$$

$$\therefore \boxed{\delta_{d-B}^{\searrow\nwarrow} = -0.0188 \text{ ft (apart)}}$$

— o —

Assignment 10:



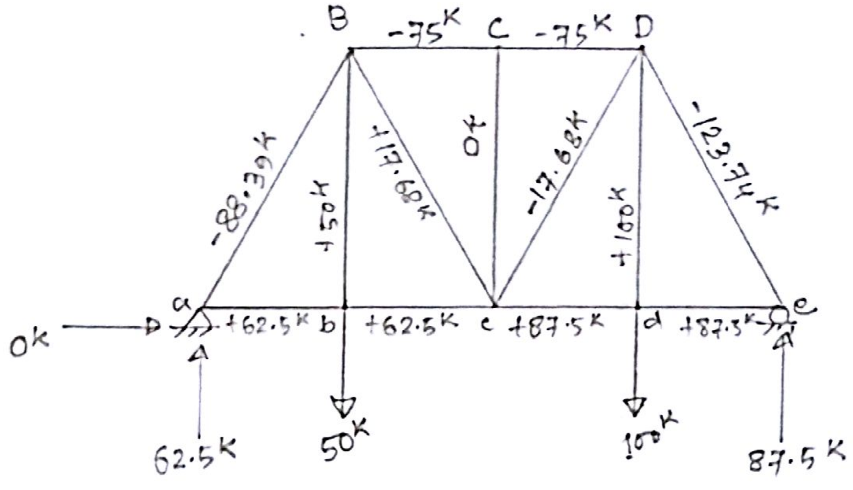
Find rotation of bar BC.

Given, $E = 30 \times 10^3$ ksi, A = in in^2 in parantheses

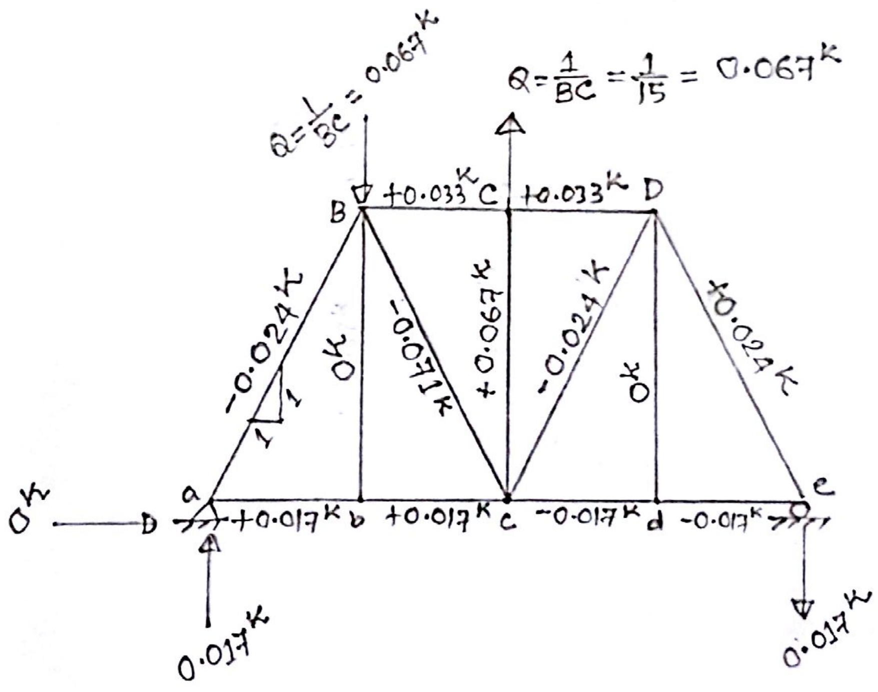
An increase of the temparature of 40°c in the top chord, a decrease of 10°c in the bottom chord, $\alpha_t = \frac{1}{75000}$ per °c.

Solution:

Analysing for real force,



Analysing for virtual force,



Member	Bar	L (ft)	A (in²)	$\frac{L}{A}$	F_Q (K)	F_P (K)	$F_Q F_P \frac{L}{A}$	t (°c)	$F_Q tL$
Horizontal	ab	15	10	1.5	+0.017	+62.5	+1.594	-10	-2.55
	bc	15	10	1.5	+0.017	+62.5	+1.594	-10	-2.55
	cd	15	10	1.5	-0.017	+87.5	-2.23	-10	2.55
	de	15	10	1.5	-0.017	+87.5	-2.23	-10	2.55
	BC	15	10	1.5	+0.033	-75	-3.71	40	19.8
	CD	15	10	1.5	+0.033	-75	-3.71	40	19.8
Vertical	bB	15	5	3	0	+50	0	0	0
	cC	15	5	3	+0.067	0	0	0	0
	dD	15	5	3	0	+100	0	0	0
Diagonal	aB	21.2	12.5	1.69	-0.024	-88.39	+3.59	0	0
	cB	21.2	12.5	1.69	-0.071	+17.68	-2.12	0	0
	cD	21.2	12.5	1.69	-0.024	-17.68	0.717	0	0
	eD	21.2	12.5	1.69	+0.024	-123.74	-5.019	0	0

$\Sigma F_Q F_P \frac{L}{A} = -11.524$ $\quad \Sigma F_Q tL = 39.6$

If Q = unit load,

$$\frac{1}{BC} \cdot \delta_B^{\downarrow} + \frac{1}{BC} \delta_C^{\uparrow} = \Sigma \frac{F_Q F_P L}{AE} + \Sigma F_Q \alpha_t tL$$

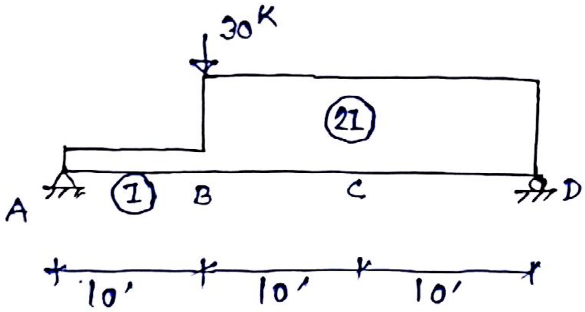
$$\Rightarrow \frac{1}{BC} (\delta_B^{\downarrow} + \delta_C^{\uparrow}) = \frac{-11.524}{30000} + \frac{39.6}{75000}$$

$$\Rightarrow 1. \; a_{B-C}^{\curvearrowleft} = 1.44 \times 10^{-4} \text{ radian}$$

$$\boxed{\therefore \; a_{B-C}^{\curvearrowleft} = 1.44 \times 10^{-4} \text{ radian (counterclockwise)}}$$

— o —

Assignment # 11:

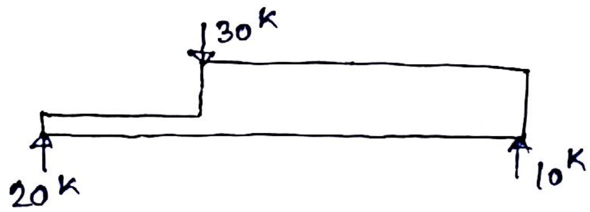


Given, $E = 30000$ ksi, $I = 200$ in^4

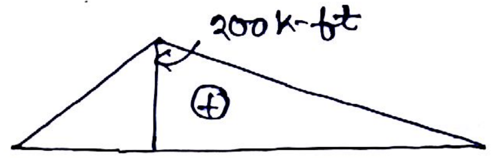
Compute rotation / change in slope at joint A.

Solⁿ:

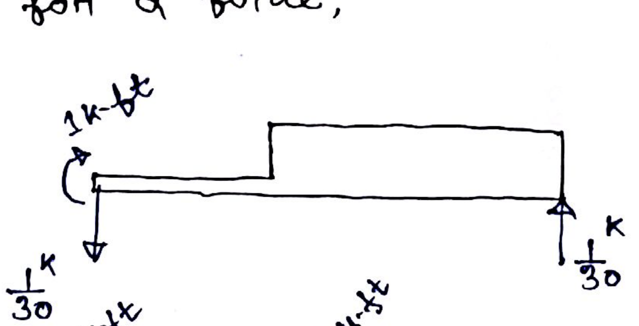
Analysis for P force;



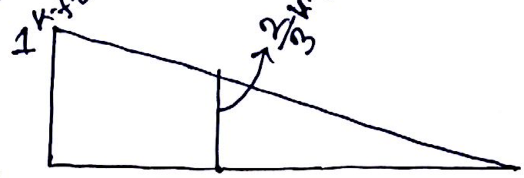
BMD



Analysis for Q force;



BMD



Principle of V.W. ;

$$Q.\,\alpha_A = \int_A^B \frac{M_Q M_P}{EI}\,dx + \int_B^D \frac{M_Q M_P}{EI}\,dx$$

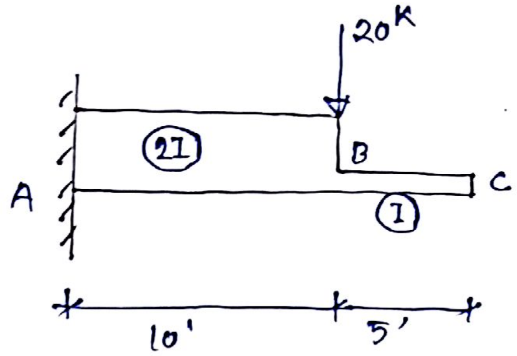
$$\Rightarrow 1^K.\,\alpha_A = \int_A^B \frac{(20x)\left(1-\frac{x}{30}\right)}{EI_1}\,dx + \int_B^D \frac{(200-10x)\left(\frac{2}{3}-\frac{x}{30}\right)}{EI_2}\,dx$$

$$\Rightarrow 1^K.\,\alpha_A = \frac{7000}{9EI_1} + \frac{8000}{9EI_2}$$

$$\therefore \boxed{\alpha_A = 0.04 \text{ radian (clockwise)}}$$

— o —

Assignment #12:



Given, $E = 29000$ ksi, $I = 100$ in^4

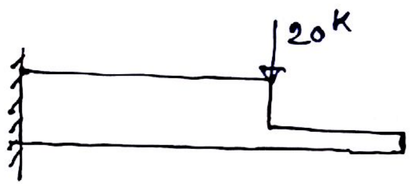
Compute (1) Vertical deflection at 'c'.

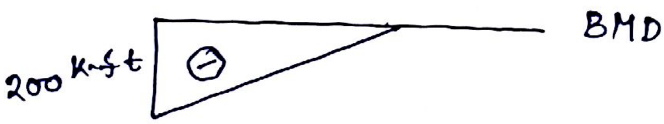
(2) Change in slope at 'c'.

(3) Change in slope at 'B'.

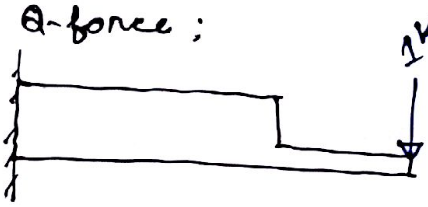
Soln:

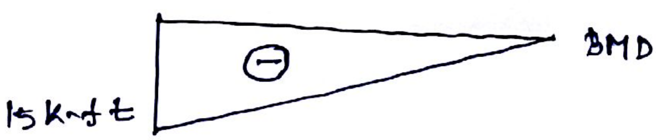
(1) Analysis for P force;





Analysis for Q-force;





Principle of V.W. ;

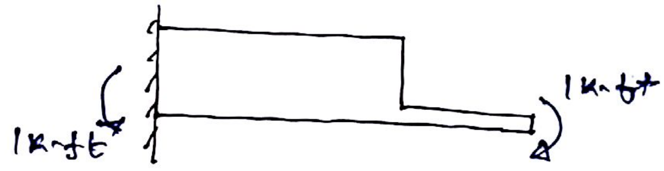
$$Q.\,\delta_{cv} = \int_A^B \frac{M_Q M_P}{EI}\,dx$$

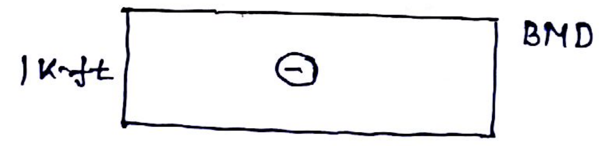
$$\Rightarrow 1^K.\,\delta_{cv} = \frac{1}{3EI}\left[\int_0^{10}(-200+20x)(-15+x)\,dx\right]$$

$$\Rightarrow \delta_{cv} = \frac{35000/3}{3EI}$$

$$\therefore \boxed{\delta_{cv} = +\,0.1931 \text{ ft (downward)}}$$

(2) Analysis for Q force ;





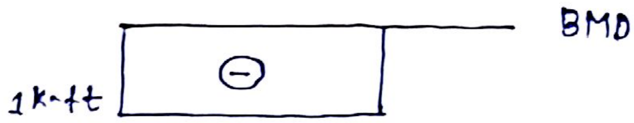
Principle of V.W. ;

$$Q.\,\alpha_c = \int_A^B \frac{M_Q M_P}{EI}\,dx$$

$$\Rightarrow 1^K.\,\alpha_c = \frac{1}{3EI}\int_0^{10}(20x-200)(-1)\,dx$$

$$\therefore \boxed{\alpha_c = 0.01655 \text{ radian (anticlockwise)}}$$

(3) Analysis for Q force ;



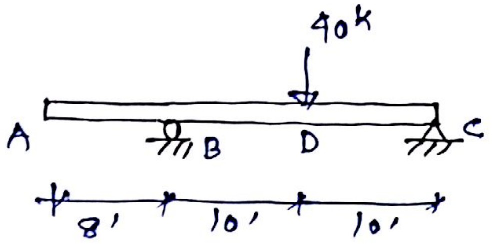
Principle of V.W. ;

$$Q \cdot \alpha_B = \int_A^B \frac{M_Q M_P}{EI} \, dx$$

$$\Rightarrow 1^K \cdot \alpha_B = \frac{1}{3EI} \int_0^{10} (20x - 200)(-1)$$

$$\therefore \boxed{\alpha_B = 0.01655 \text{ radian (clockwise)}}$$

Assignment # 13:



Given, $E = 30000$ ksi, $I = 300$ in^4

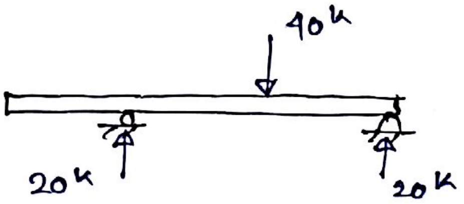
Find (1) Deflection at A

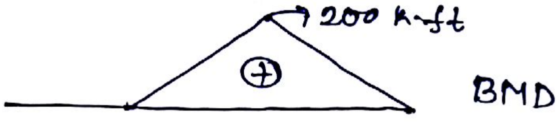
(2) Change in slope at 'A'.

(3) Change in slope at 'B'.

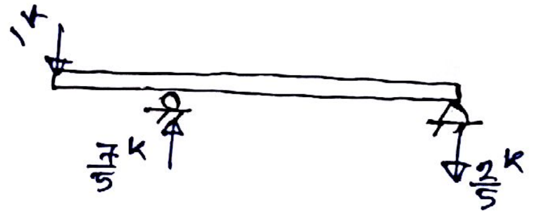
Soln:

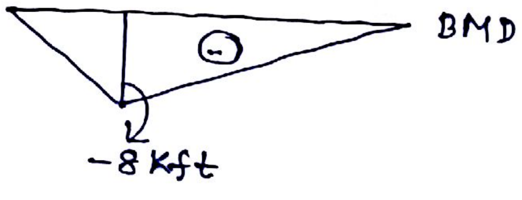
(1) Analysis for P force;





Analysis for Q force;





Principle of V.W.;

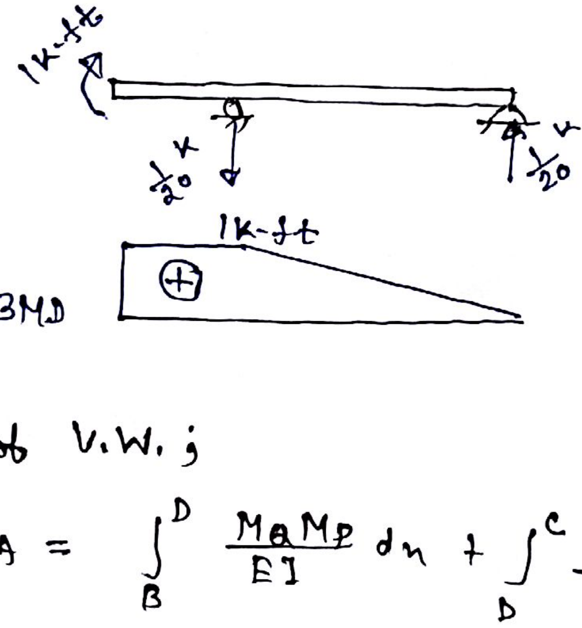
$$Q.\,\delta_A = \int_B^D \frac{M_Q M_P}{EI}\,dx + \int_D^C \frac{M_Q M_P}{EI}\,dx$$

$$\Rightarrow 1^K \cdot \delta_A = \frac{1}{EI}\left[\int_0^{10} (20x)\left(-8+\frac{2x}{5}\right)dx + \int_0^{10} (200-20x)\left(-4+\frac{2x}{5}\right)dx\right]$$

$$\Rightarrow \delta_A = -\frac{8000}{EI}$$

$$\therefore \boxed{\delta_A = -0.128 \text{ ft (upward)}}$$

(2) Analysis for Q force;



BMD

Principle of V.W.;

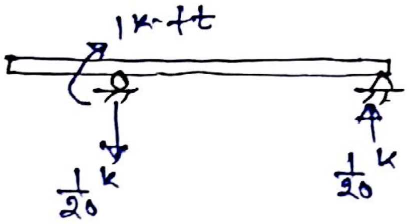
$$Q.\,\alpha_A = \int_B^D \frac{M_Q M_P}{EI}\,dx + \int_D^C \frac{M_Q M_P}{EI}\,dx$$

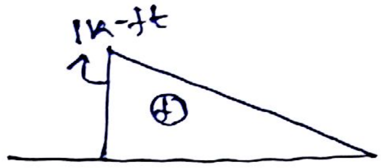
$$\Rightarrow 1^K \cdot \alpha_A = \frac{1}{EI}\left[\int_0^{10} (20x)\left(1-\frac{x}{20}\right)dx + \int_0^{10} (20x)\left(\frac{x}{20}\right)dx\right]$$

$$\Rightarrow \alpha_A = \frac{1000}{EI}$$

$$\therefore \boxed{\alpha_A = 0.016 \text{ radian (clockwise)}}$$

(3) Analysis for Q-force ;





Principle of V.W. ;

$$Q \cdot \alpha_B = \int_B^D \frac{M_Q M_P}{EI} dx + \int_D^C \frac{M_Q M_P}{EI} dx$$

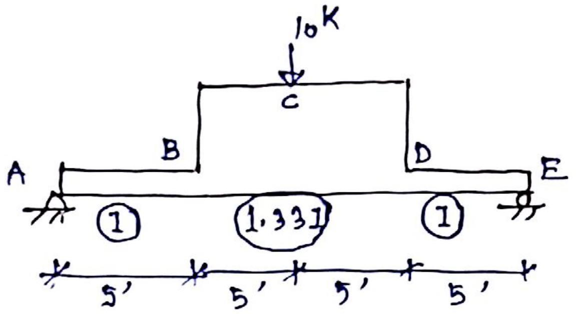
$$\Rightarrow 1^k \cdot \alpha_B = \frac{1}{EI} \left[\int_0^{10} (20x)\left(1 - \frac{x}{20}\right) dx + \int_0^{10} (20x)\left(\frac{x}{20}\right) dx \right]$$

$$\Rightarrow \alpha_B = \frac{1000}{EI}$$

$$\therefore \boxed{\alpha_B = 0.016 \text{ radian (clockwise)}}$$

— o —

Assignment # 14:



Given,

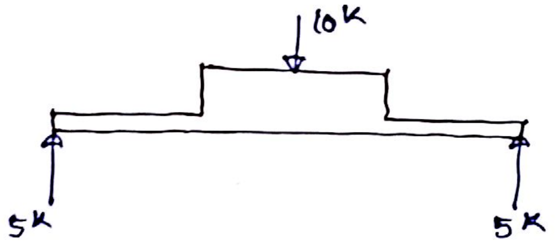
$E = 30 \times 10^3$ kips/in^2, $I = 150$ in^4

Compute ① Deflection at 'B'.

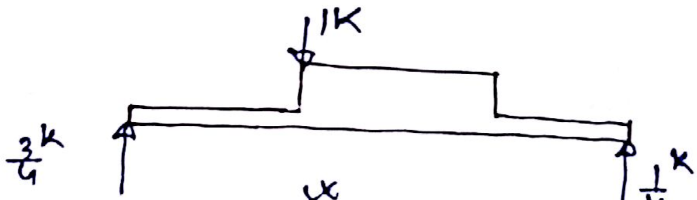
② Change in slope at 'D'.

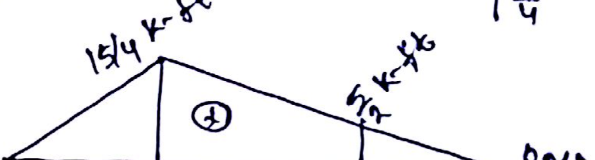
Soln :

① Analysis for P force ;



Analysis for Q force .





Principle of V.W.;

$$Q . \delta_B = \int_A^B \frac{M_Q M_P}{EI} dx + \int_B^C \frac{M_Q M_P}{EI} dx + \int_C^D \frac{M_Q M_P}{EI} dx + \int_D^E \frac{M_Q M_P}{EI} dx$$

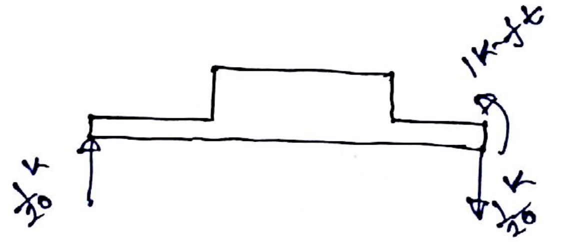
$$\Rightarrow 1K . \delta_B = \frac{1}{EI} \left[\int_0^5 (5x)\left(\frac{3x}{4}\right) dx + \int_0^5 \frac{(25+5x)}{1.33}\left(\frac{15}{4} - \frac{x}{4}\right) dx \right.$$

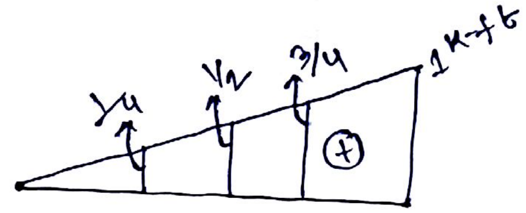
$$\left. + \int_0^5 \frac{(50-5x)\left(\frac{5}{2} - \frac{x}{4}\right)}{1.33} dx + \int_0^5 (5x)\left(\frac{x}{4}\right) dx \right]$$

$$\Rightarrow \delta_B = \frac{913.22}{EI}$$

$$\therefore \boxed{\delta_B = 0.029 \text{ ft (downward)}}$$

(2) Analysis for Q force;





Principle of V.W.;

$$Q.\,\alpha_D = \int_A^B \frac{M_Q M_P}{EI}\,dx + \int_B^C \frac{M_Q M_P}{EI}\,dx + \int_C^D \frac{M_Q M_P}{EI}\,dx + \int_D^E \frac{M_Q M_P}{EI}\,dx$$

$$\Rightarrow 1K.\,\alpha_D = \frac{1}{E}\Big[\frac{1}{150}\Big\{\int_0^5 \frac{x}{20}(5x)\,dx + \int_0^5 (5x)\left(1-\frac{x}{20}\right)dx\Big\}$$

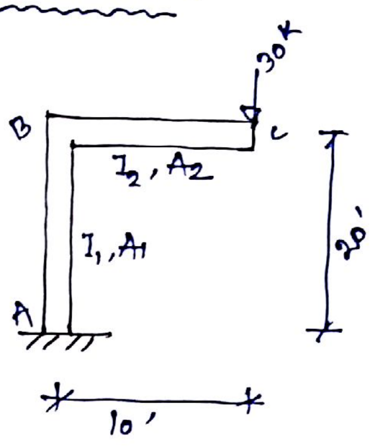
$$+ \frac{1}{200}\Big\{\int_0^5 (25+5x)\left(\frac{1}{4}+\frac{x}{20}\right)dx + \int_0^5 (50-5x)\left(\frac{1}{2}+\frac{x}{20}\right)dx\Big\}\Big]$$

$$\Rightarrow \alpha_D = \frac{5/12 + 15/16}{E}$$

$$\therefore \boxed{\alpha_D = 0.0065 \text{ radian (anticlockwise)}}$$

— o —

Assignment #15:



Compute horizontal deflection at B

Given, $I_1 = 300 \text{ in}^4$

$I_2 = 200 \text{ in}^4$

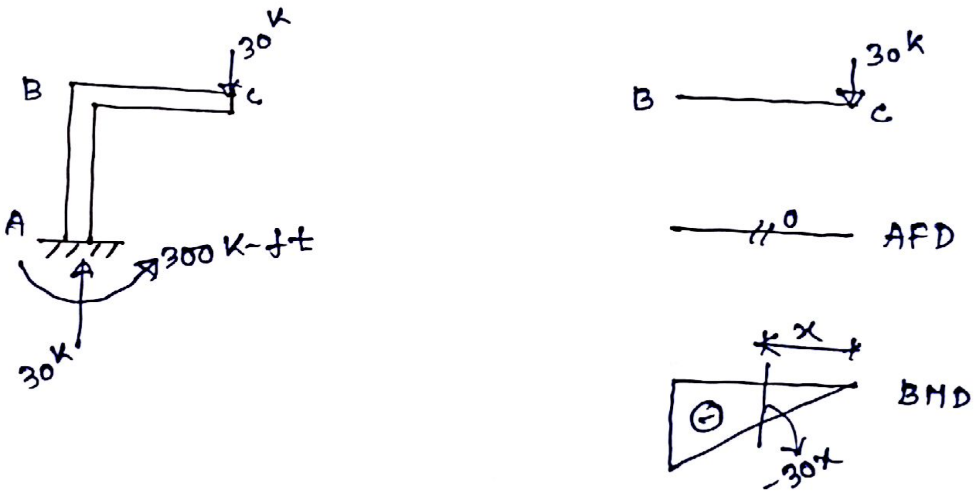
$A_1 = 15 \text{ in}^2$

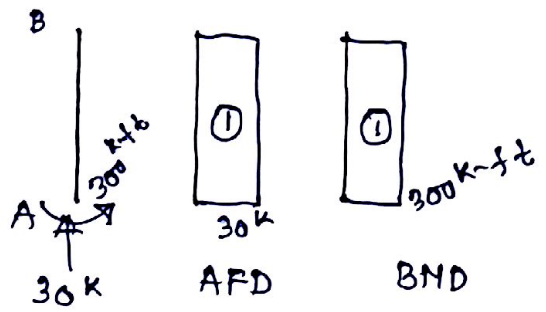
$A_2 = 10 \text{ in}^2$

$E = 30000$ ksi

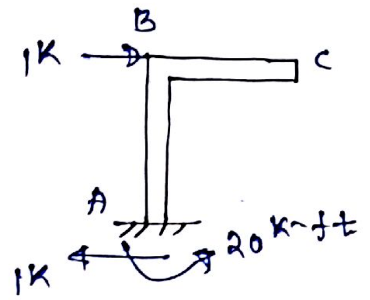
Soln:

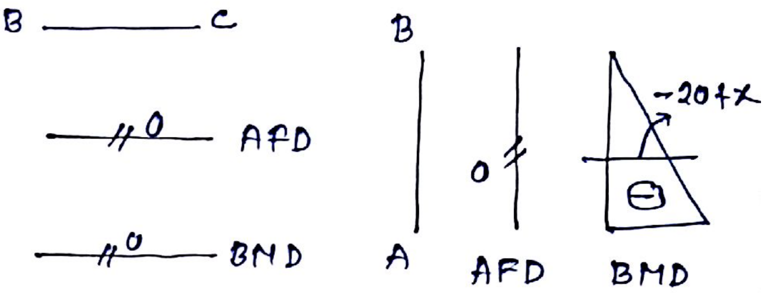
P-force analysis :





Q-force analysis :





Segment AB	Segment BC
$M_Q = (x-20)$	$M_Q = -30x$
$M_P = -300$	$M_P = 0$
$F_Q = 0$	$F_Q = 0$
$F_P = -30$	$F_P = 0$

Principle of V.W. ;

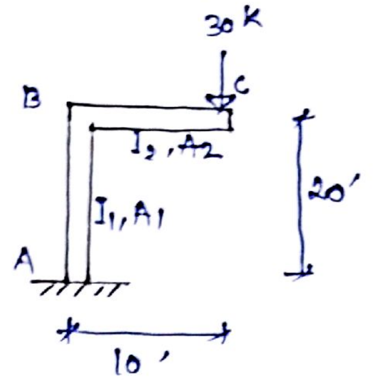
$$Q \cdot \delta_{Bh} = \int_A^B \frac{M_Q M_P}{EI} dx + 0$$

$$\Rightarrow 1K \cdot \delta_{Bh} = \int_0^{20} \frac{-300(x-20)}{I_1 E} dx$$

$$\therefore \boxed{\delta_{Bh} = 0.96 \text{ ft } (\rightarrow)}$$

— o —

Assignment #16 :



Compute change in slope at C.

Given, $I_1 = 300\ in^4$

$I_2 = 200\ in^4$

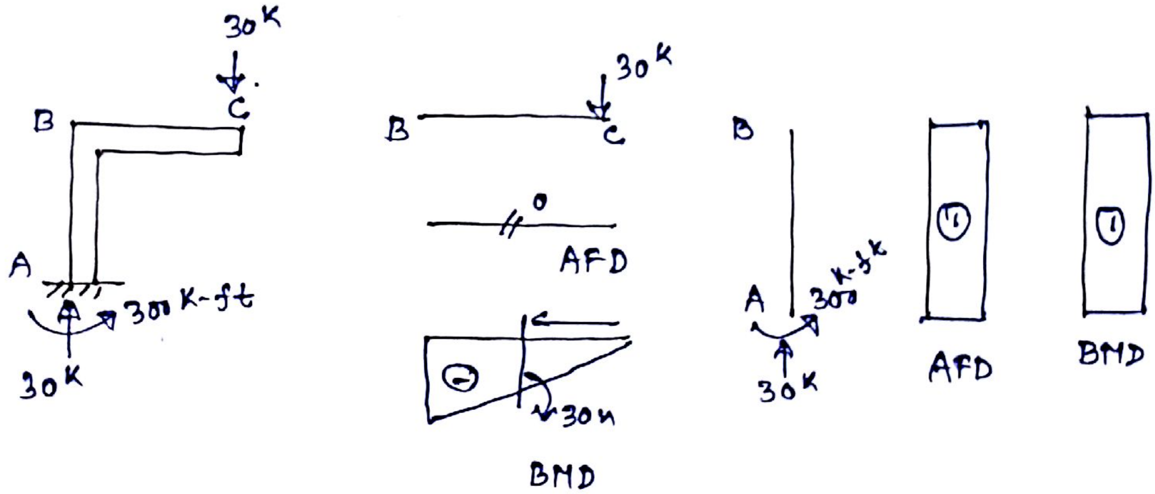
$A_1 = 15\ in^2$

$A_2 = 10\ in^2$

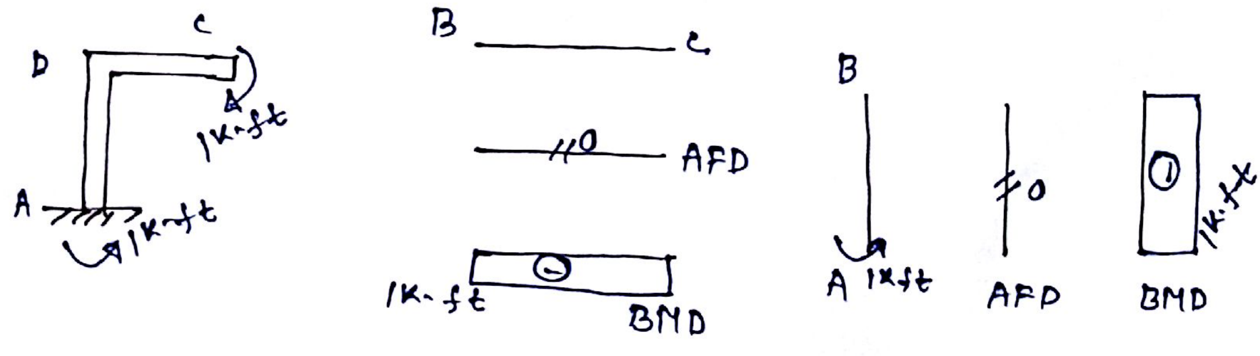
$E = 30000\ ksi$

Soln :

P- force analysis :



Q-force analysis :



Principle of V.W. ;

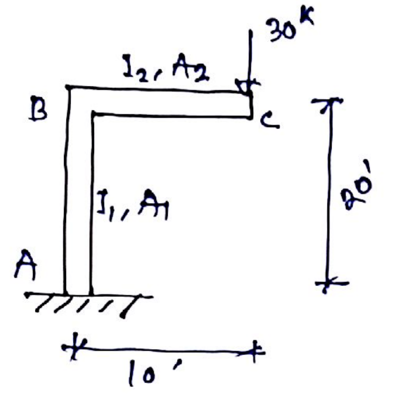
$$Q \cdot \alpha_c = \int_A^B \frac{M_Q M_P}{EI} \, dx$$

$$\Rightarrow 1^k \cdot \alpha_c = \int_0^{20} \frac{(-1)(-30x)}{I_1 E} \, dx$$

$$\therefore \boxed{\alpha_c = 0.096 \text{ radian (clock wise)}}$$

— o —

Assignment # 17 :



Compute vertical deflection at mid-point of BC

Given, $I_1 = 300 \text{ in}^4$

$I_2 = 200 \text{ in}^4$

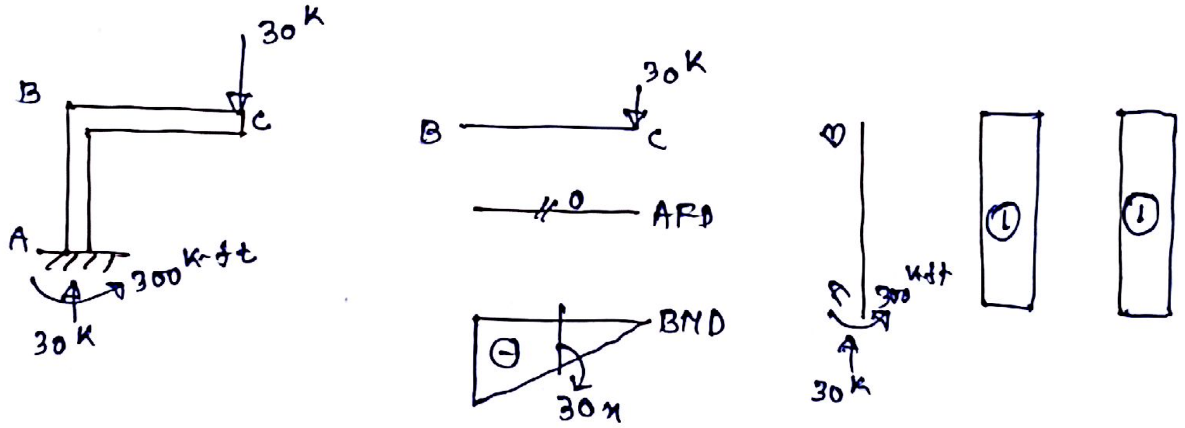
$A_1 = 15 \text{ in}^2$

$A_2 = 10 \text{ in}^2$

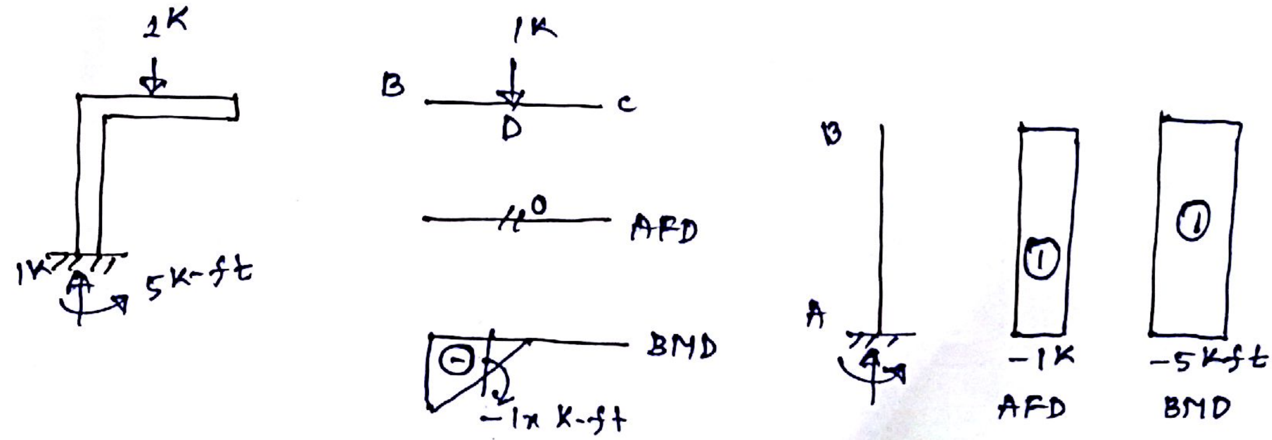
$E = 30000 \text{ Ksi}$

Soln :

P-force analysis :



Q-force analysis :



Principle of V.W.;

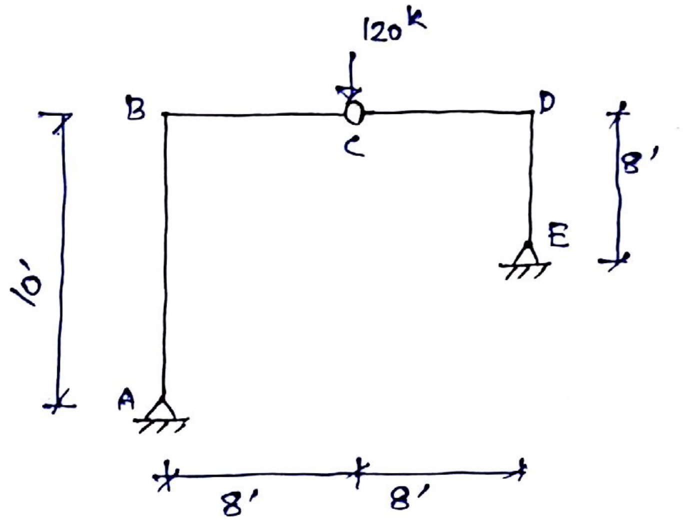
$$Q \cdot \delta_v = \int \frac{M_Q M_P}{EI} dx$$

$$\Rightarrow 1K \cdot \delta_v = \int_0^{20} \frac{-300x - 5}{EI} dx + 0 + \int_5^{10} \frac{(-30x)(-x)}{EI} dx$$

$$\therefore \boxed{\delta_v = 3.52 \times 10^{-3} \text{ ft (downward)}}$$

— o —

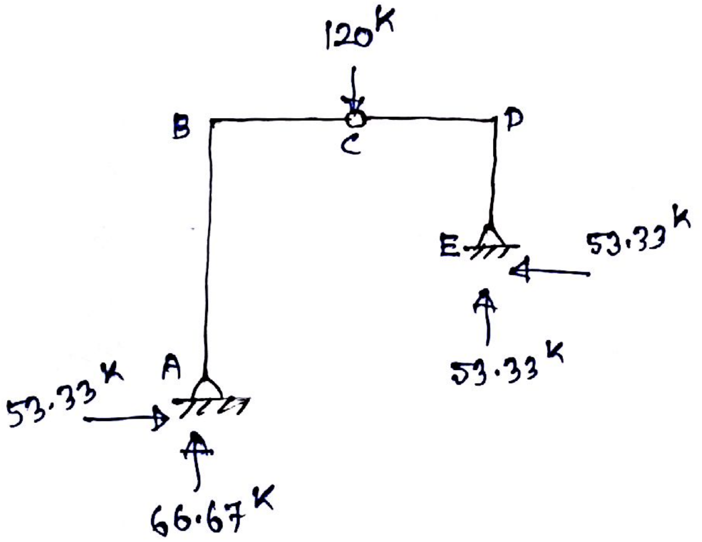
Assignment #18:



Compute change in slope at the cross section on the left of hinge.

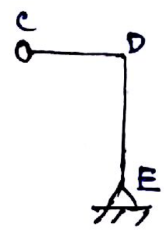
Soln:

P-force analysis:



$\Sigma M_A = 0$

$\Rightarrow R_{Ex} + 8R_{Ey} = 480$ — (1)



$\Sigma M_C = 0$

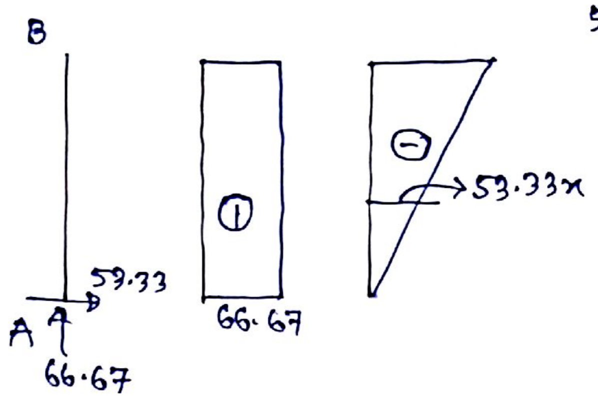
$\Rightarrow R_{Ex} * 8 = R_{Ey} * 8$

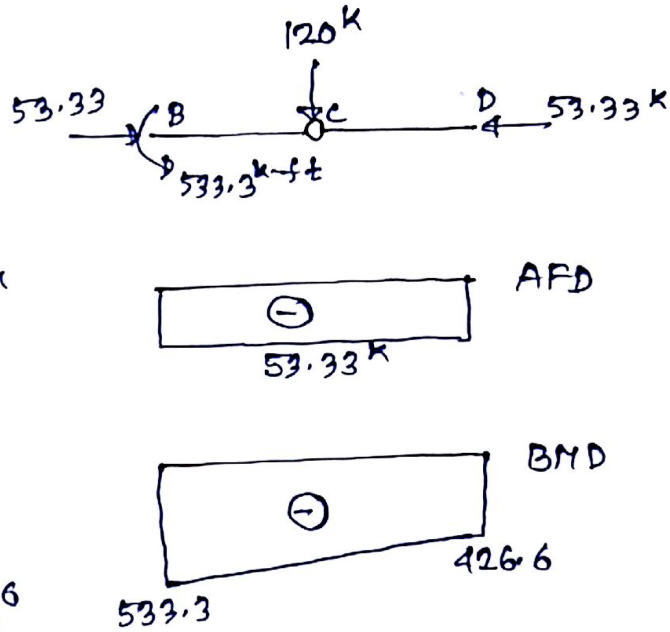
$\therefore R_{Ex} = R_{Ey}$ — (2)

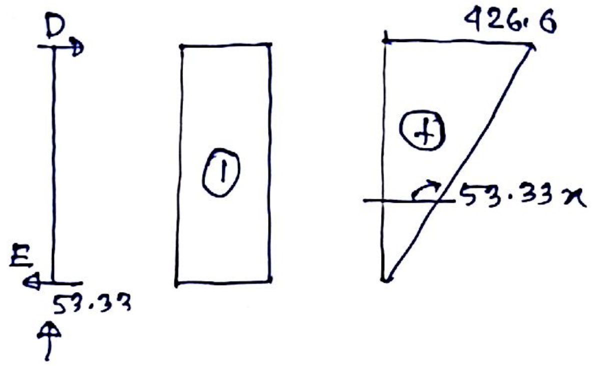
From (1) & (2);

$R_{Ex} = R_{Ax} = 53.33^k$

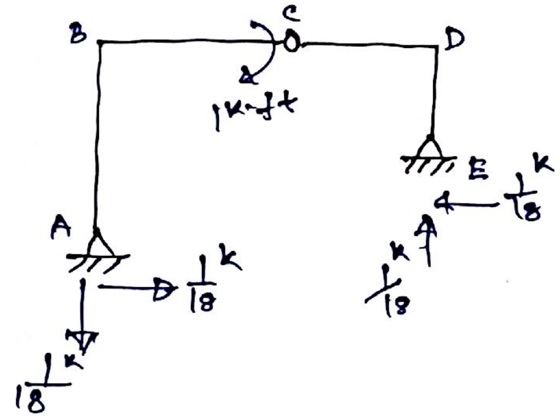
$R_{Ay} = 66.67^K$

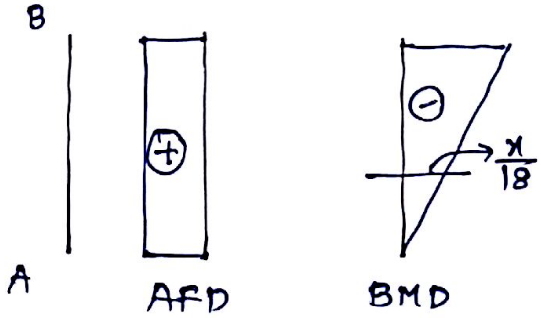


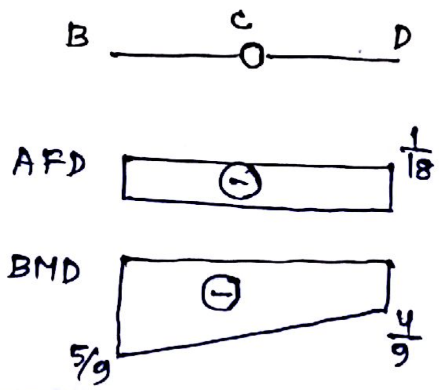


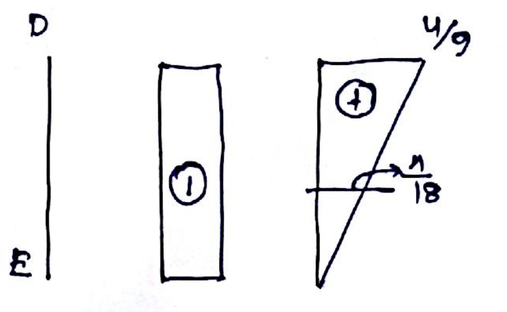


Q-force analysis:









Principle of V.W. ;

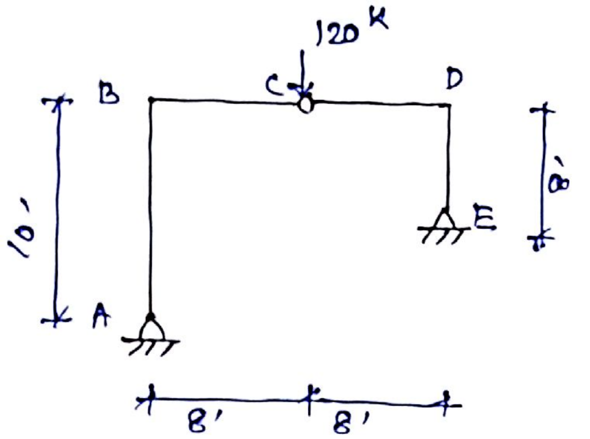
$$Q \cdot \theta_c = \int \frac{M_a M_p}{EI} \, dx$$

$$\Rightarrow 1K \cdot \theta_c = \frac{1}{EI} \left[\int_0^{10} \left(53.33x + \frac{x}{18}\right) dx + \int_0^{16} \left\{\left(\frac{-5}{9} + -\frac{x}{18}\right) + 1\right\} \left\{-533.3 + 66.7x - 120(x-8)\right\} \right]$$

$$\therefore \boxed{\theta_c = 24.57 \times 10^{-4} \text{ radian (clockwise)}}$$

— o —

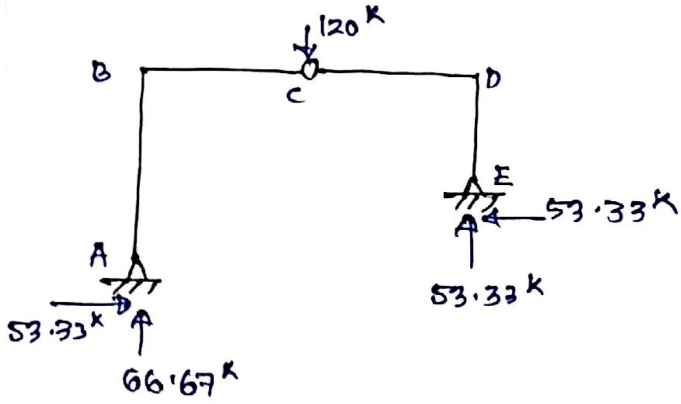
Assignment #19:

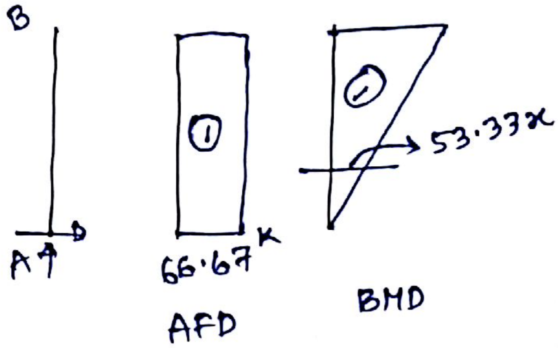


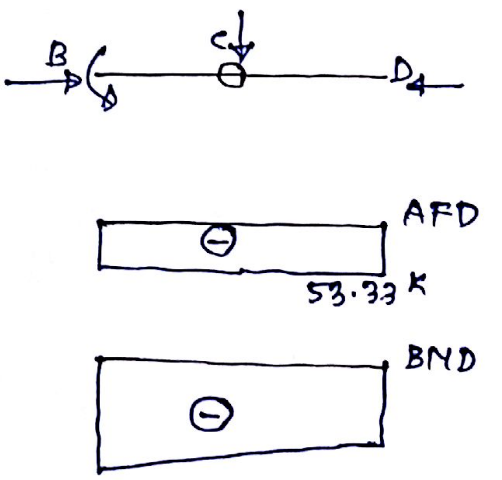
Find horizontal deflection at B.

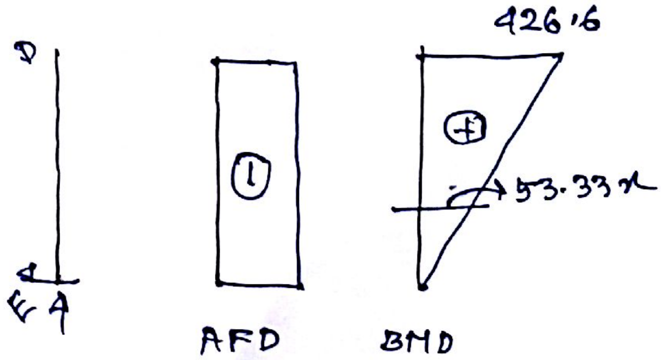
Sol^n :

P-force analysis :

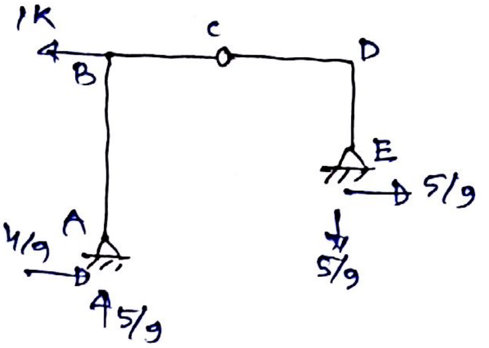


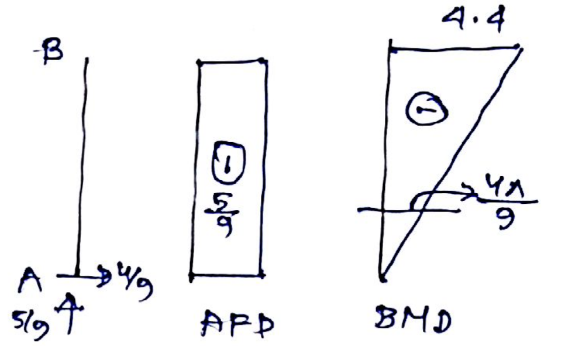


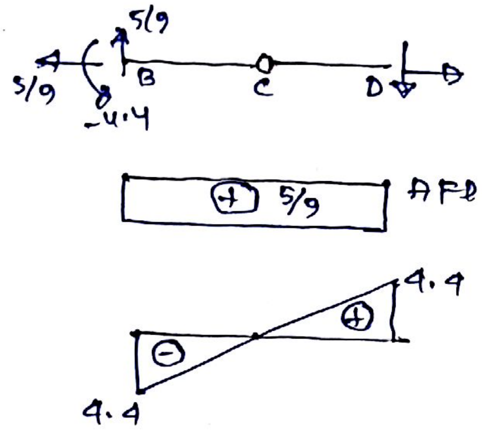


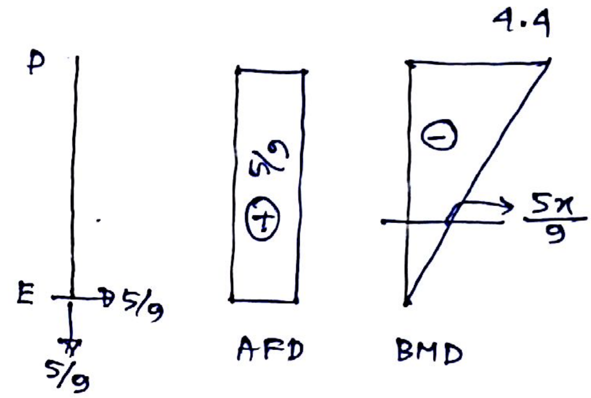


Q- force analysis :









Principle of V.W. ;

$$Q \cdot \delta_{Bh} = \int_0^{10} \frac{\left(\frac{-4x}{9}\right)(-53.33x)}{EI}\,dx + \int_0^{8} \frac{-5x(53.33x)}{9EI}\,dx$$

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

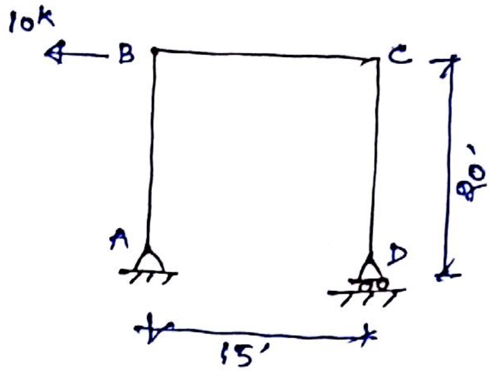
$$+ \frac{(-5/9)(-66.67)\,10}{AE} + \frac{5/9(-53.33)\,16}{AE} + \frac{5/9(-53.33)\,8}{AE}$$

$$\Rightarrow 1K \cdot \delta_{Bh} = -5.18 \times 10^{-3} - 0.0194$$

$$\therefore \boxed{\delta_{Bh} = -0.0246' \text{ (right)}}$$

— o —

Assignment # 20 :



Given, $E = 30000$ ksi

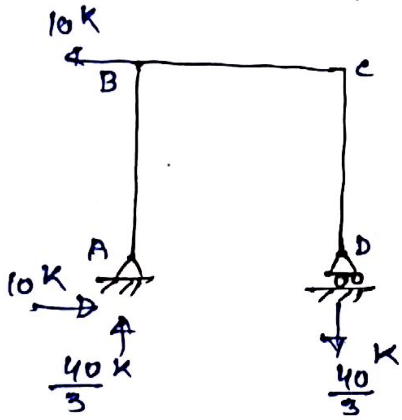
$I = 800 \ in^4$

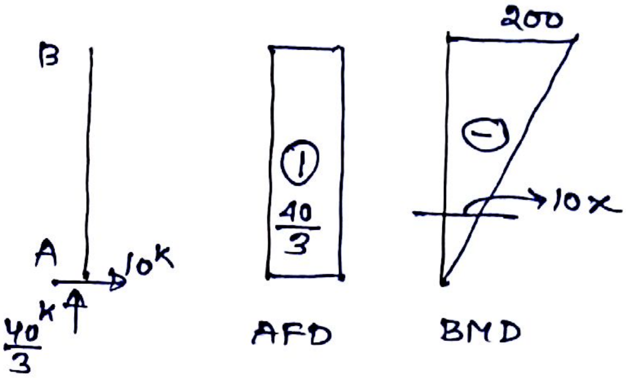
$A = 20 \ in^2$

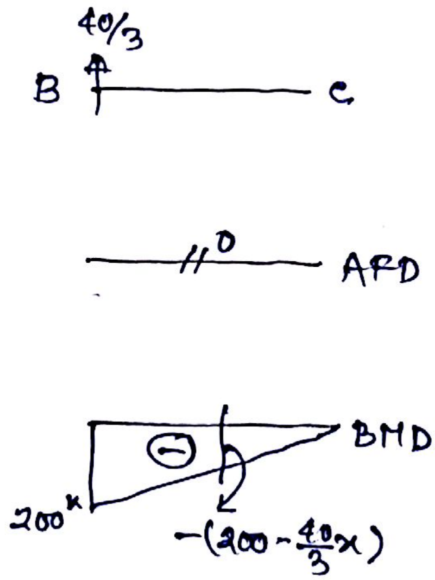
Find $\delta_{ch} = ?$

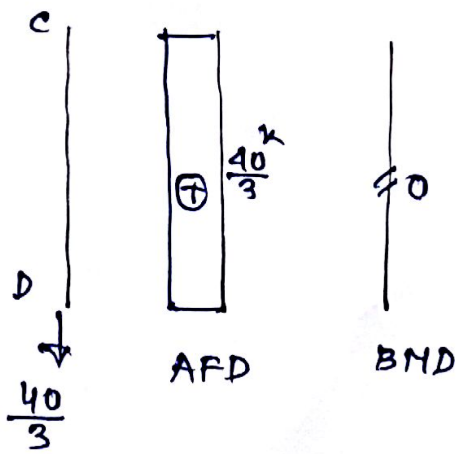
Soln :

P-force analysis :

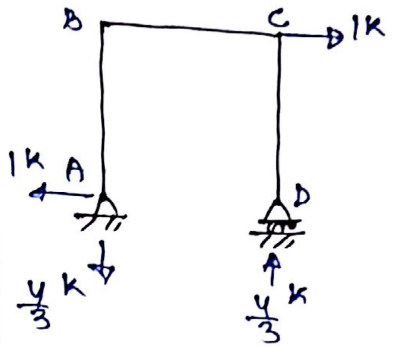


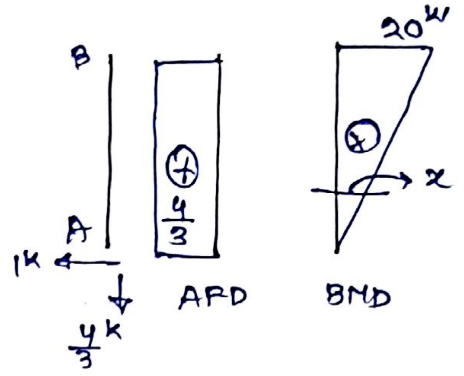


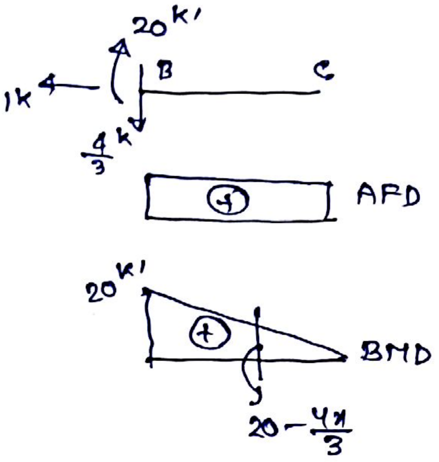


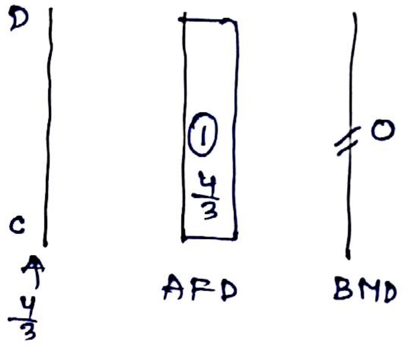


Q-force analysis:









Principle of V.W.;

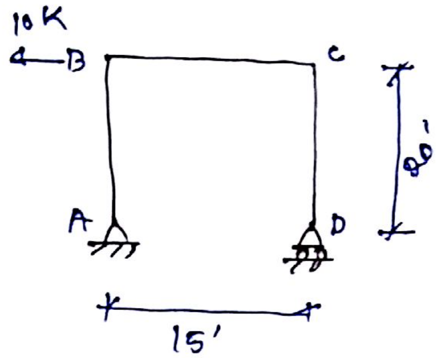
$$Q\cdot\delta_{ch} = \int_0^{20} \frac{x(-10x)}{EI}\,dx + \int_0^{15} \frac{\left(20-\frac{4}{3}x\right)\left(\frac{40x}{3}-200\right)}{EI}\,dx$$

$$+ \frac{\left(-\frac{4}{3}\right)\left(\frac{40}{3}\right)20}{AE} + \frac{\frac{4}{3}\left(-\frac{40}{3}\right)20}{AE}$$

$$\therefore \boxed{\delta_{ch} = -0.0292' \text{ (leftward)}}$$

— o —

Assignment # 21 :



Given,

$E = 30000$ ksi

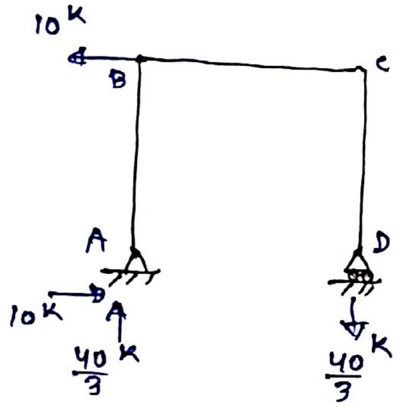
$I = 800$ in^4

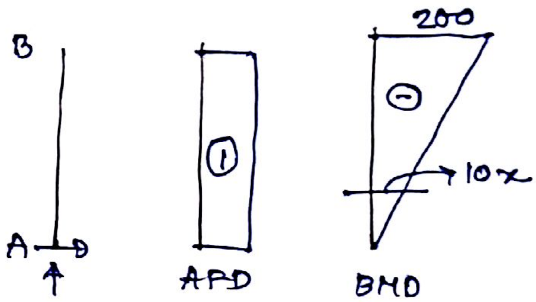
$A = 20$ in^2

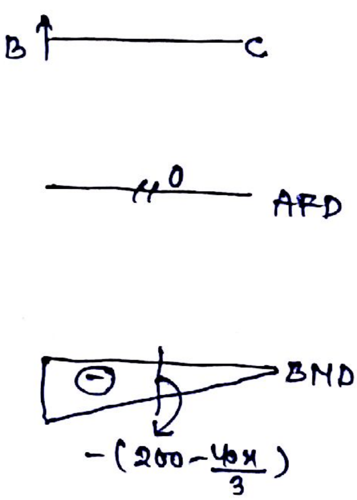
Find θ_B

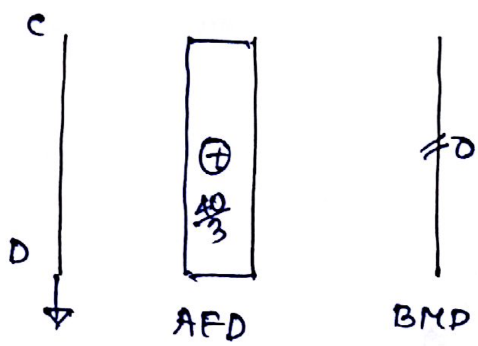
Soln :

P-force analysis :

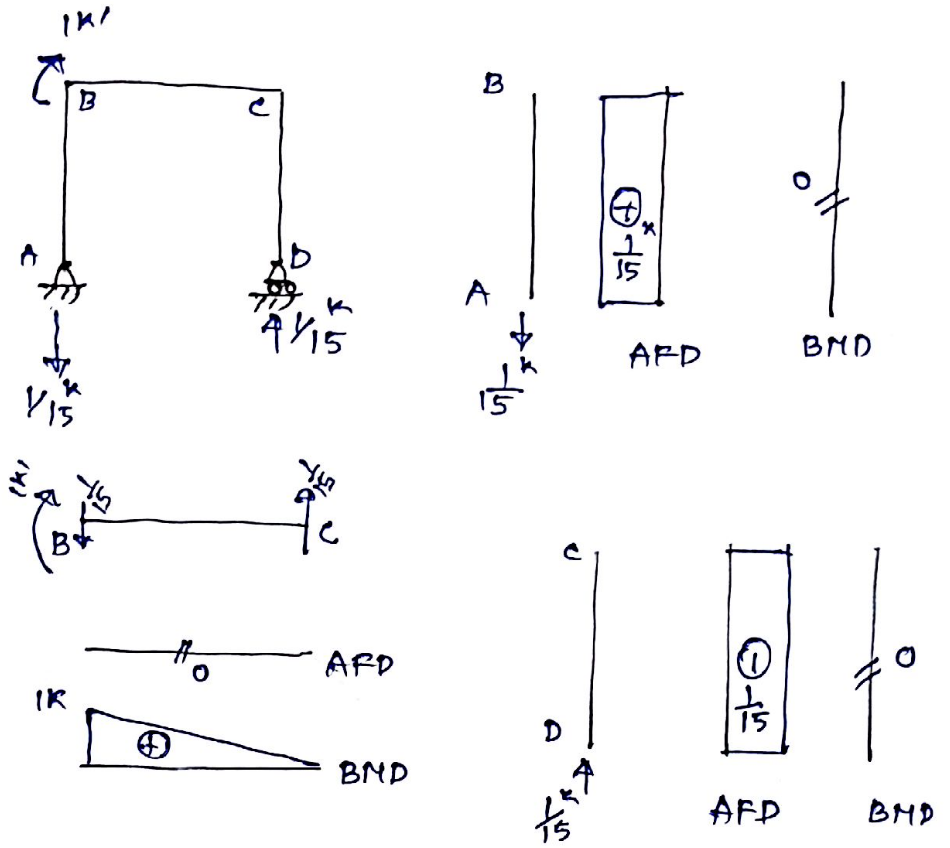








Q-force analysis :



Principle of V.W. ;

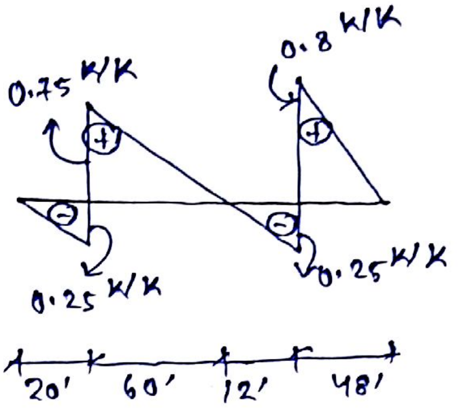
$$Q \cdot \theta_B = \frac{\left(-\frac{40}{3}\right)\left(\frac{1}{15}\right)\times 20}{AE} + \frac{\left(\frac{-1}{15}\right)\left(\frac{40}{3}\right)\times 20}{AE}$$

$$+ \int_0^{15} \frac{\frac{x}{15}\times\left(-\frac{40x}{3}\right)}{EI}\,dx$$

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

— o —

Assignment # 22:



Find ① Max^m shear

② Max^m (+)ve shear

③ Max^m (-)ve shear

For uniform load of $6^{K/ft}$ and a concentrated load of 120^K.

Sol^n:

Max^m (+)ve shear $= \frac{1}{2} \times 0.75 \times 60 \times 6 + \frac{1}{2} \times 0.8 \times 48 \times 6 + 0.8 \times 120$

$= \boxed{346.2^K}$

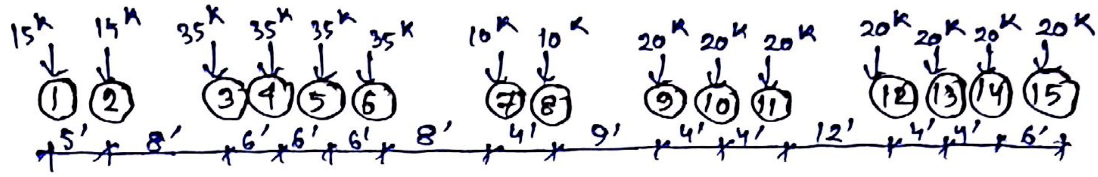
Max^m (-)ve shear $= \frac{1}{2} \times 20 \times 0.25 \times 6 + \frac{1}{2} \times 12 \times 0.25 \times 6 + 0.25 \times 120$

$= \boxed{54^K}$

Max^m shear $= \boxed{346.2^K \text{ (+ve)}}$

— o —

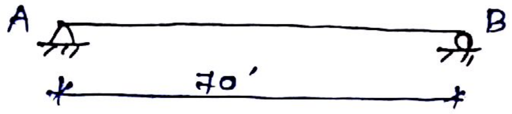
Assignment # 23 :

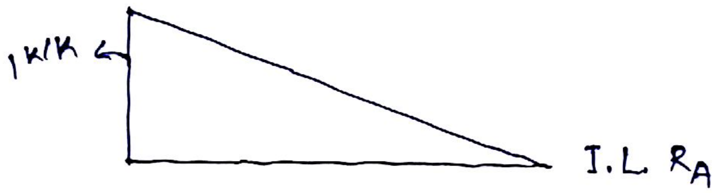


Span = 70'

Find Maximum R_A.

Soln :





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

Trial ① : Wheel ① at A to ② at A

Here, ΣP = wheel ② to ⑪ = 235^k

P_1 = wheel ① = 15^k

P' = wheel ⑫ = 20^k

$e' = 3'$

$d = 5'$

$\therefore \Delta R = 2.64$ (+ve, increasing)

Trial (2) : Wheel (2) at A to (3) at A

Here, ΣP = (3) to (12) = 240^k

P_1 = (1) = 15^k

P' = (12) & (13) = $20^k + 20^k = 40^k$

e = 11' for (12) and 7' for (13)

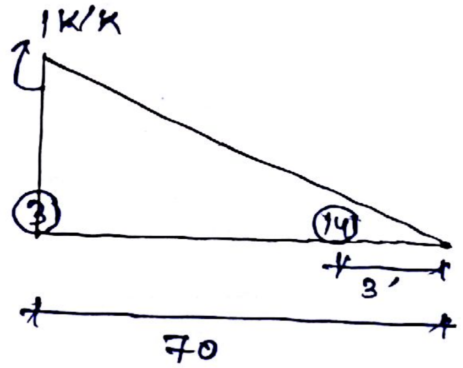
$d = 8'$

$\therefore$ $\Delta R = +17.57$ (increasing)

Trial (3) : Wheel (3) at A to (4) at (A)

$\Delta R = -13.57$ (decreasing)

Hence wheel (3) at A will give max^m reaction at A.

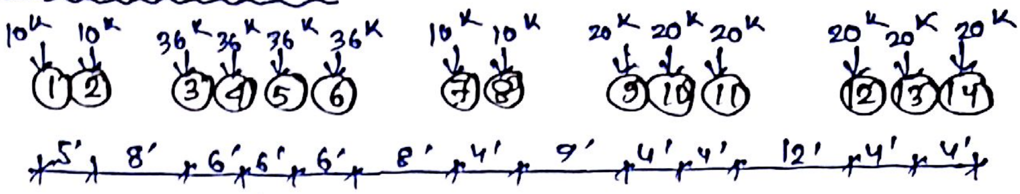


$\therefore$ Max^m Reaction, $R_A = \frac{1}{70}\left[(3\times20)+(7\times20)+(11\times20)+(23\times20)+(27\times20)+(31\times20)+(40\times10)+(44\times10)+(52\times35)+(58\times35)+(64\times35)+(70\times35)\right]$

$\therefore$ $\boxed{R_{A\,max} = 163.143^k}$

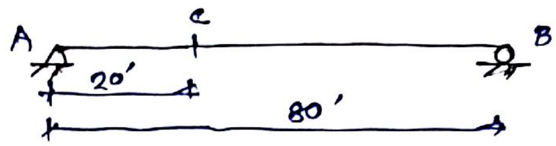
— o —

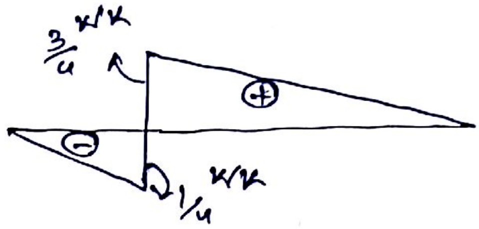
Assignment #24 :



Find mom^n shear at quarter point of a simply supported beam having 80' span for the load shown.

Sol^n :





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

Trial ①: wheel ① at c to wheel ② at c

Here,

ΣP = ② to ⑪ = 234^K

$d_1 = 5'$

P_1 = ① = 10^K

$P' = e = P_2 = 0$

$\therefore \Delta V = +\ 4.625$ (increasing)

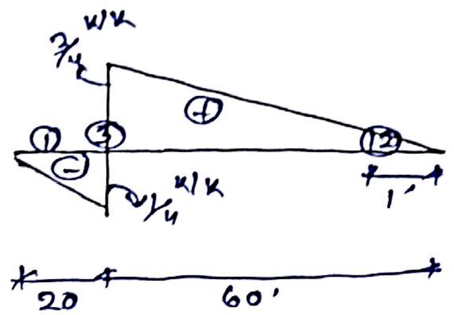
Trial ②: wheel ② at c to ③ at c

$\Delta V = +12.65^k$ (increasing)

Trial ③: wheel ③ at c to ④ at c

$\Delta V = -21.15^k$ (decreasing)

Hence wheel ③ at c will give max^m shear force



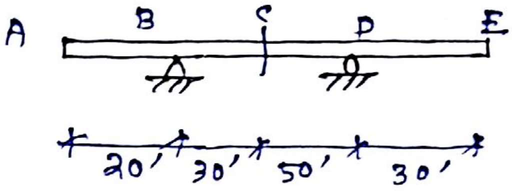
$\therefore$ Max^m shear at c $= \frac{1}{60}\left[20\times1 + 20(13+17+21) + 10(30+34) + 36(38+44+50+50)\right]$

$- \frac{1}{60}\{10\times68 + 10\times73\}$

$\therefore$ $\boxed{V_{max} = 117.3^k \text{ (+ve)}}$

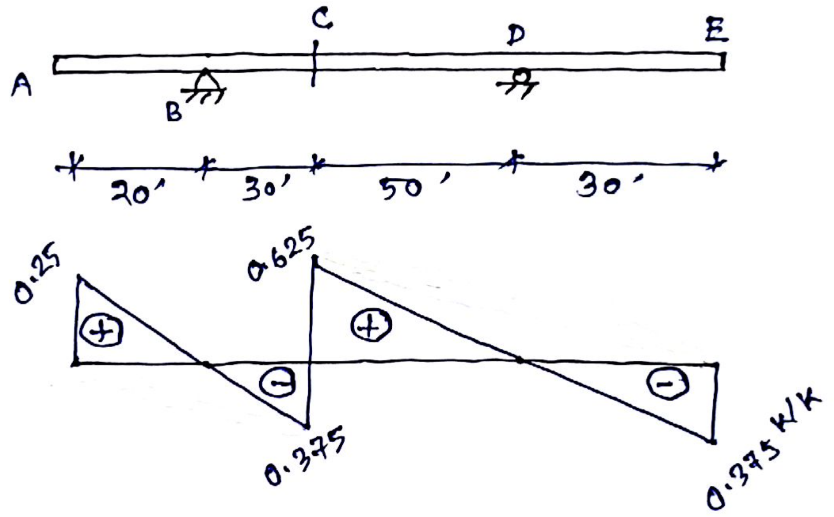
——— o ———

Assignment # 25:



Find max^m shear and moment at section C for the beam shown. Consider an uniform moving load of 7 K/ft combined with a moving concentration of 90^K.

Sol^n:



$\therefore$ Max^m shear at C $= 90 \times 0.625 + \frac{1}{2} \times 0.625 \times 50 \times 7$

$+ \frac{1}{2} \times 0.25 \times 20 \times 7$

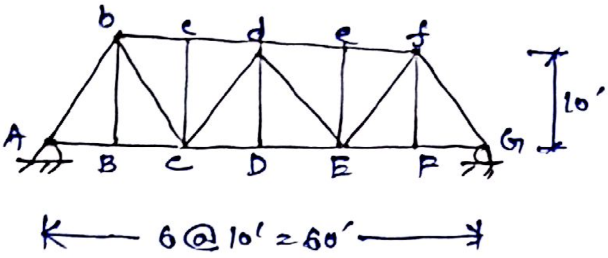
$$\boxed{\therefore V_{c\,max} = 183.125^K}$$

— o —

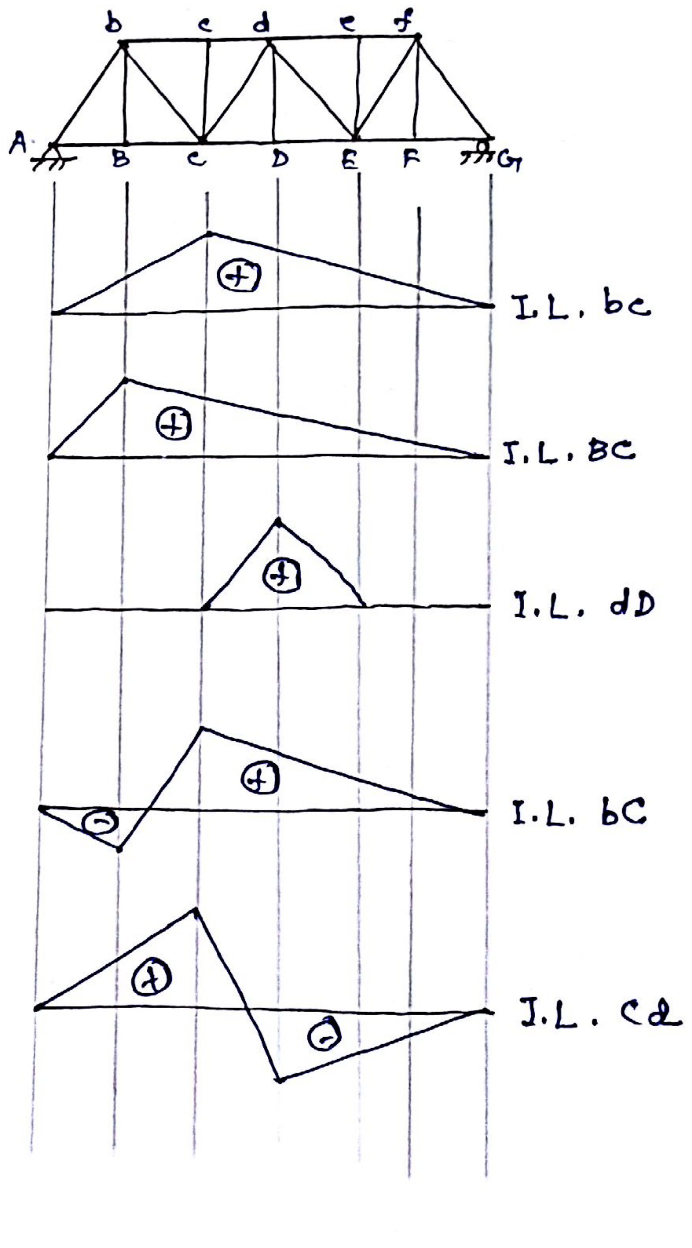
Assignment #26:

Draw IL diagram for

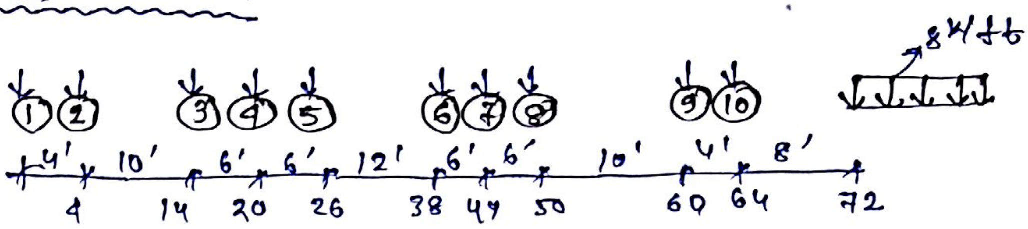
1. Top chord member
2. Bottom " "
3. Diagonal "
4. Vertical "



Solⁿ:

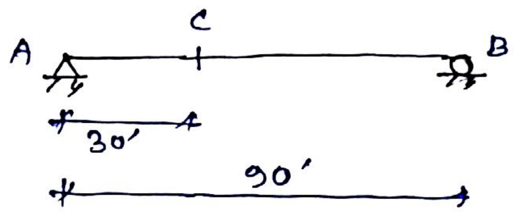


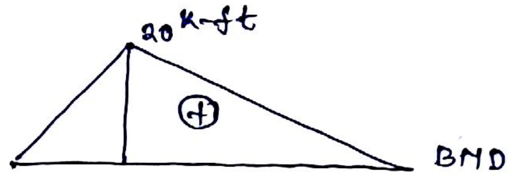
Assignment #27:



Find max^m moment at one third point of simple span of 90'.

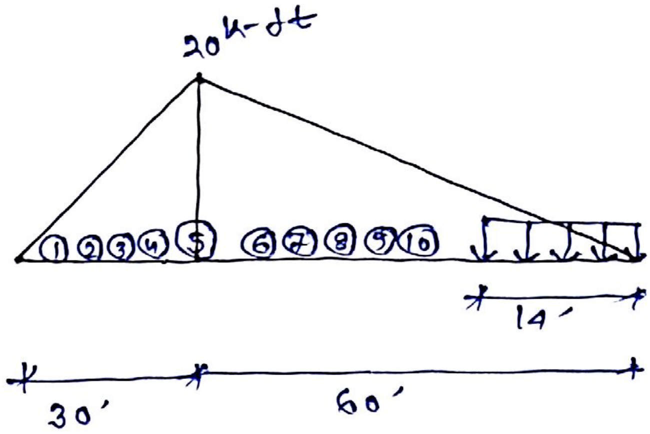
Soln:





Trial No.	Position of wheel	$\frac{W}{L}$		$\frac{W_1}{a}$	Remarks
1	Wheel 5 at C → just right	$\frac{672}{90}$	>	$\frac{200}{30}$	Criterion satisfied
	→ just left	$\frac{672}{90}$	<	$\frac{280}{30}$	
2	Wheel 4 at C → just right	$\frac{624}{90}$	>	$\frac{120}{30}$	Criterion not satisfied
	→ just left	$\frac{624}{90}$	>	$\frac{200}{30}$	

Hence wheel 5 at C gives max^m moment at C.



$\therefore$ Max^m moment at C $= \frac{2}{3}\left[20(4+8)+30(18+24+30)\right]$

$+\frac{1}{3}\left[20(22+26)+30(36+42+48)\right]$

$+\frac{1}{2}\times 14\times\frac{1}{3}\times\frac{1}{4}\times 8$

$\therefore$ $\boxed{M_{max} = 7941.33^k}$

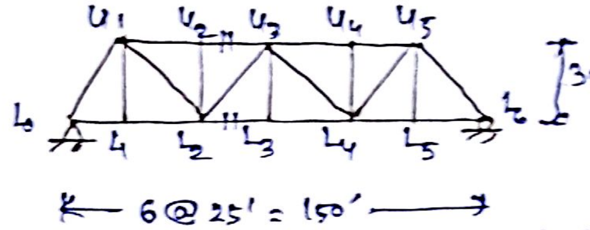
— o —

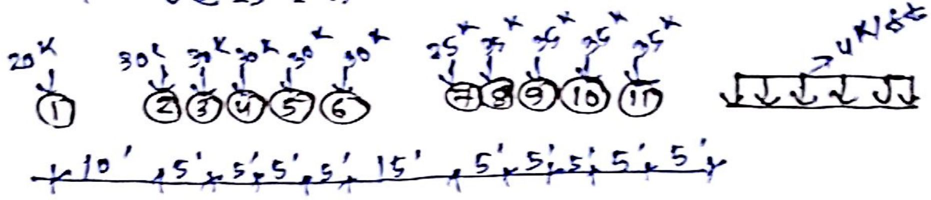
Assignment # 28 :

Find max^m stress

(a) in member U_2U_3

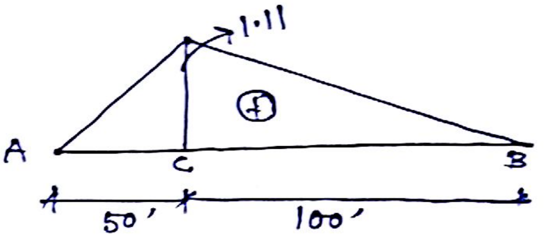
(b) in member L_2L_3





Soln :

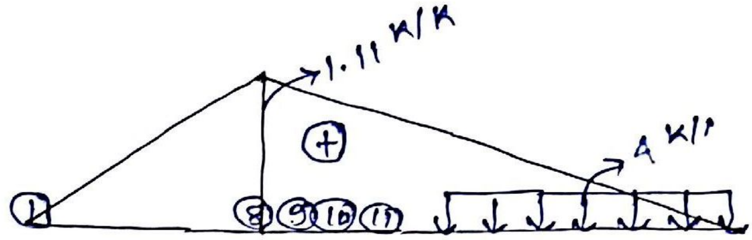
(a)



I.L. $F_{U_2U_3}$

Trial No.	Position of wheel		$\frac{W}{L}$		$\frac{W_1}{a}$	Remarks
1	Wheel ⑥ at C	just right	3.9	>	2.8	Criterion not satisfied
		just left	3.9	>	3.4	
2	Wheel ⑦ at C	just right	4.3	>	3.4	Criterion not satisfied
		just left	4.3	>	4.1	
3	Wheel ⑧ at C	just right	4.43	>	4.1	Criterion satisfied
		just left	4.3	<	4.4	

Hence wheel 8 will give max^m stress



$\therefore$ Max^m stress in member U_2U_3 of truss =

$$\frac{1.11}{50}\left[30(10+15+20+25+30+35+45+50)\right]$$

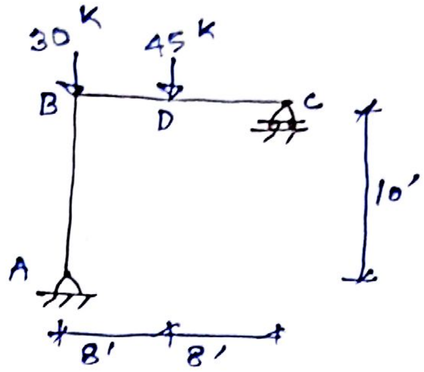
$$+\frac{1.11}{100}\left[35(35+40+45)\right]$$

$$+\frac{1}{2}\times\frac{1.11}{100}\times 80\times 80\times 4$$

$$\boxed{= 387.49^k \text{ (Compression)}}$$

—— o ——

Assignment # 29:



Compute rotation at C

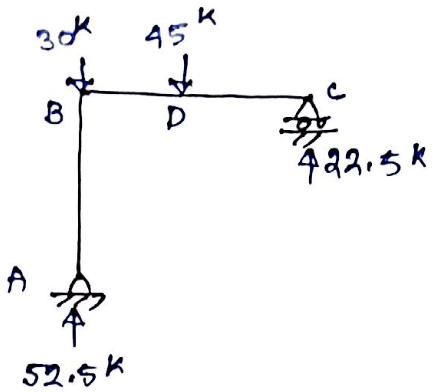
$E = 30000$ ksi

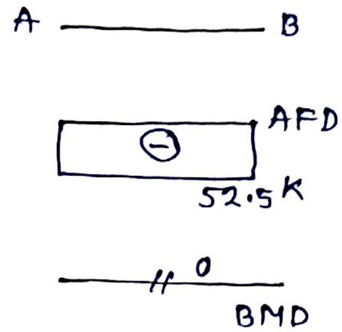
$I = 480$ in^4

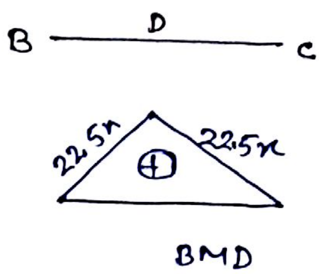
$A = 20$ in^2

Soln:

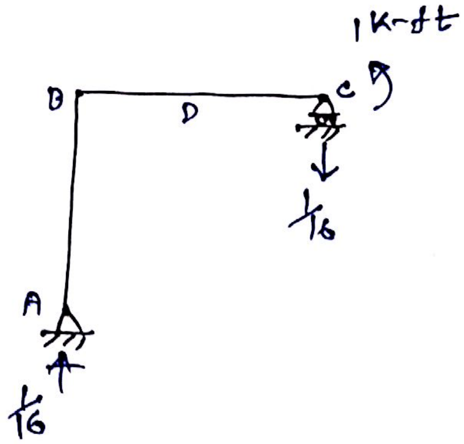
P-force analysis:

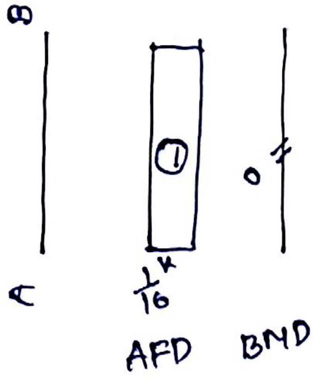


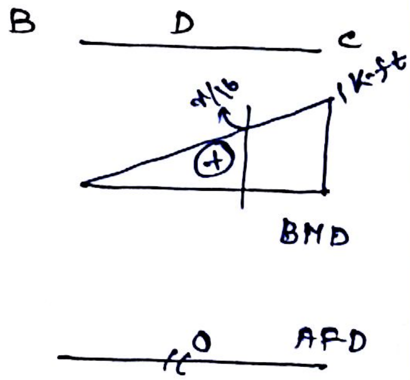




Q-force analysis:







Principle of V.W.;

$$Q.\,\alpha_c = \int \frac{M_Q M_P}{EI}\,dx + \Sigma \frac{F_Q F_P L}{AE}$$

$$\Rightarrow 1^k.\,\alpha_c = \int_0^{16} \frac{(22.5x)\cdot\frac{x}{16}}{EI}\,dx + \int_0^{10} \frac{(1-\frac{x}{10})(22.5x)}{EI}\,dx$$

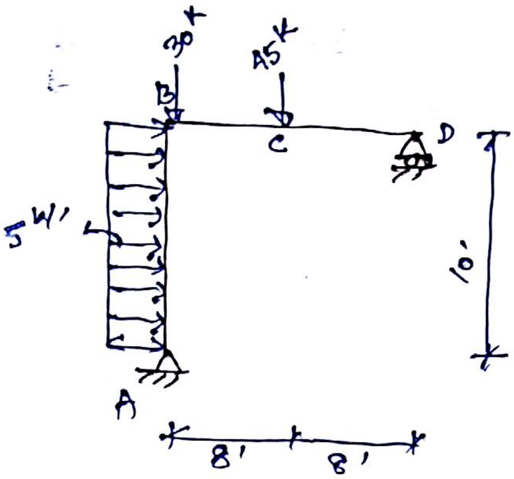
$$+ \int_0^{10} \frac{(\frac{1}{16})(-52.5)}{AE}$$

$$\Rightarrow \alpha_c = 7.2\times10^{-3} + 4.375\times10^{-5}$$

$$\therefore \boxed{\alpha_c = 7.2438\times10^{-3} \text{ radion (anticlockwise)}}$$

— o —

Assignment # 30 :



Compute horizontal deflection at D.

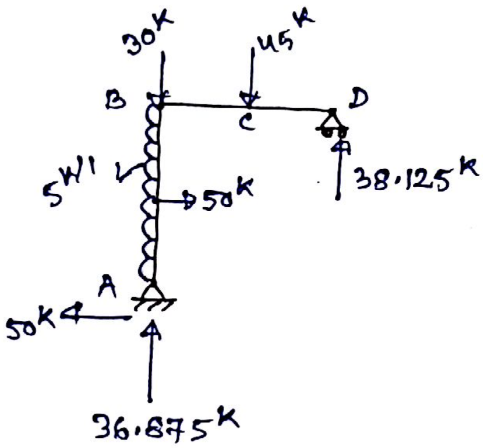
$E = 30000$ Ksi

$I = 480$ in^4

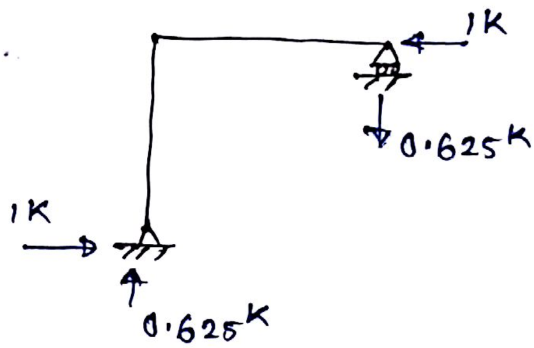
$A = 20$ in^2

Soln :

P-force analysis :



Q-force analysis :



AB	BC	DC
$M_P = 50x - \frac{5x^2}{2}$	$M_P = 6.675x + 250$	$M_P = 38.125x$
$M_Q = -x$	$M_Q = -10 + 0.625x$	$M_Q = -0.625x$
$F_P = -36.875$	$F_P = 0$	$F_P = 0$
$F_Q = -0.625$	$F_Q = -1$	$F_Q = -1$

Principle of V.W.;

$$Q.\,\delta_{Dh} = \frac{\Sigma P_a P_p L}{AE} + \int \frac{M_a M_p}{EI}\,ds$$

$$\Rightarrow 1^K.\,\delta_{Dh} = \frac{-36.875 \times -0.625 \times 10}{20 \times 30000} + \int_0^{10} \frac{(50x - \frac{5x^2}{2})(-x)}{EI}\,dx$$

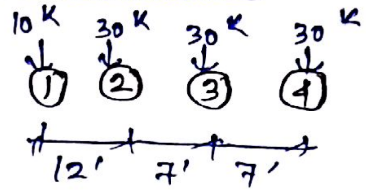
$$+ \int_0^{8} \frac{(-10 + 0.625x)(6.875x + 250)}{EI}\,dx$$

$$+ \int_0^{8} \frac{(38.125x)(-0.625x)}{EI}\,dx$$

$$\therefore \boxed{\delta_{Dh} = -0.1819 \text{ ft } (\rightarrow)}$$

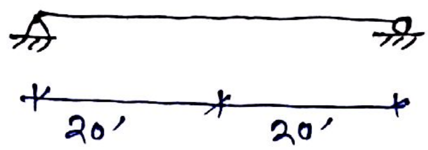
——— o ———

Assignment #31:



Span = 40'. Find Greatest moment.

Solⁿ:

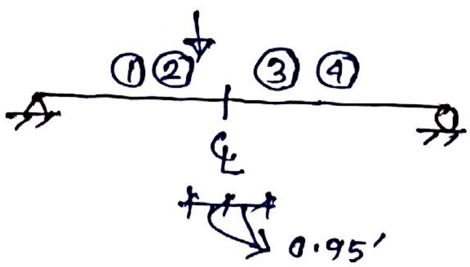


Trial No.	Position of wheel		$\frac{W}{L}$		$\frac{W_1}{a}$	Remarks
1	Wheel ③ at center of beam	→ just right	$\frac{100}{40}$	>	$\frac{40}{20}$	Criterion Satisfied
		→ just left	$\frac{100}{40}$	<	$\frac{70}{20}$	

∴ Wheel ③ gives maxᵐ moment at center

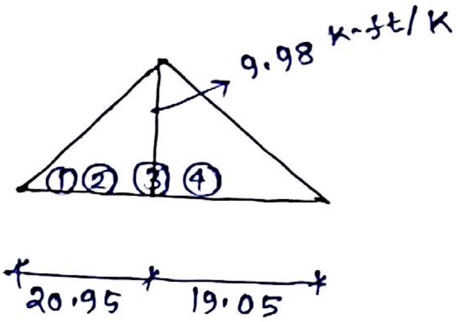
$x = 8.9'$

$\therefore a = 1.9'$



∴ Absolute moment may occur at 20.95' from left support.

Trial no.	Position of wheel		$\frac{W}{L}$		$\frac{W_l}{a}$	Remarks
1	Wheel 3 at 20.95' from left support	→ just right	$\frac{100}{40}$	>	$\frac{40}{20.95}$	Criterion satisfied
		→ just left	$\frac{100}{40}$	<	$\frac{70}{20.95}$	



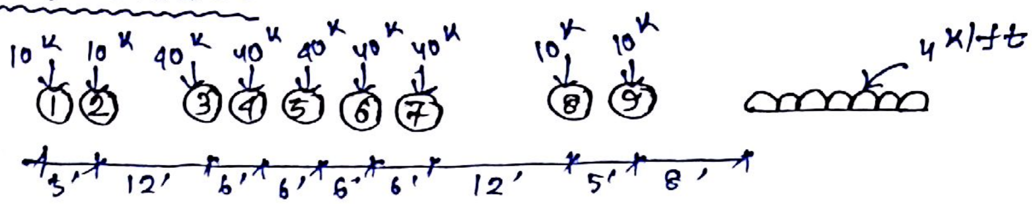
$$\therefore \text{Greatest moment} = \frac{9.98}{19.05}(19.05 \times 30 + 12.05 \times 30)$$

$$+ \frac{9.98}{20.95}(30 \times 13.95 + 1.95 \times 10)$$

$$= \boxed{697.44 \text{ K-ft}}$$

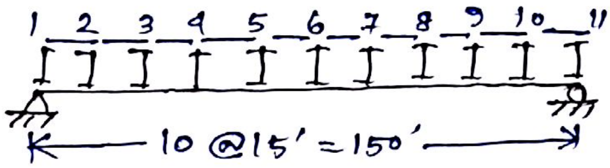
— o —

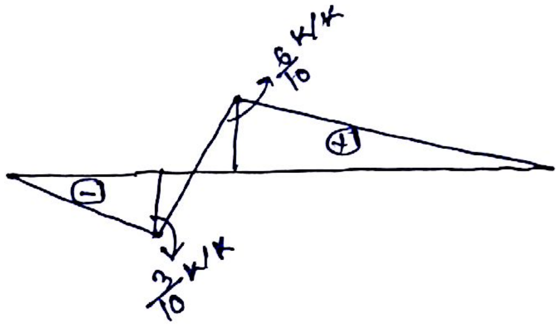
Assignment # 32 :



Find max^m shear in 4th panel of 10 panel @ 15'.

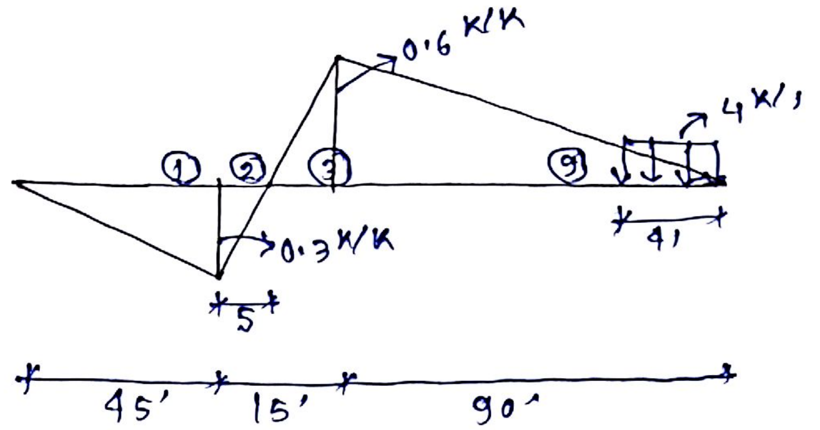
Sol^n :





Trial No.	Position of wheel	$\frac{W}{L}$	$\frac{W_1}{P}$	Remarks
1	Wheel ② at panel pt. → just right	2.373 >	0.67	Criterion not satisfied
	→ just left	2.373 >	1.33	
2	Wheel ③ at panel pt. → just right	2.7 >	0.67	Criterion satisfied
	→ just left	2.7 <	3.33	

Hence wheel ③ at panel point 5 will give max^m panel shear.



$$\therefore \text{Max}^m \text{ panel shear} = \frac{0.6}{90}\Big[\tfrac{1}{2}\times 4\times 41\times 41 + 49\times 10 + 54\times 10 + 66\times 40 + 72\times 40 + 78\times 40 + 84\times 40 + 90\times 40\Big]$$

$$- \frac{0.3}{45}(10\times 43) - \frac{0.3}{15}(2\times 10)$$

$$= \boxed{131.03^K}$$

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Civil Engineering

ASSIGNMENT

CE 311

Structural Analysis and Design I

- Submitted to: Dr. Md. Zakaria Ahmed

- Submitted By: Mohammad Irfan Hossain
- Level: 3
- Term: 1
- Sec: B
- Roll: 1204092

Submission Date: 21/12/2015

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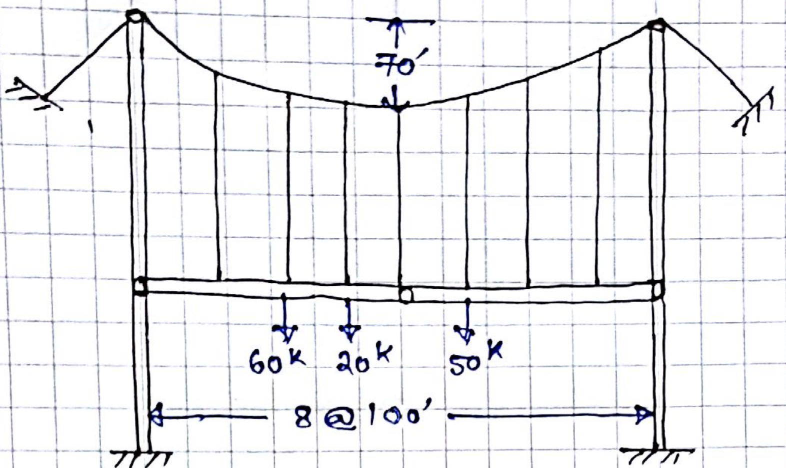
Assignment # 1:

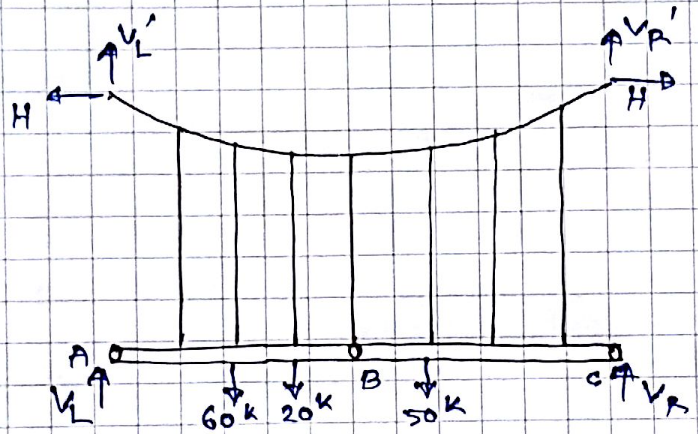


① Find Hanger force

② Draw SFD & BMD

③ Max^m Tension in Hanger

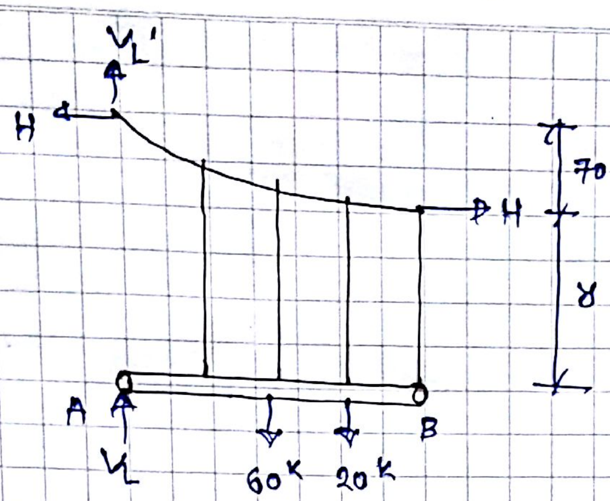
Solution:



$\Sigma M @ C = 0$

$\Rightarrow (V_L + V_L') \times 800 - 60 \times 600 - 20 \times 500 - 50 \times 300 = 0$

$\therefore V_L + V_L' = 76.25^K$



$\Sigma M @ B = 0$

$\Rightarrow (V_L + V_L') \times 400 - H(y+70) - 60 \times 200 - 20 \times 100 + Hy = 0$

$\therefore \; H = 235.714^k$

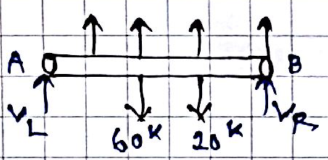
Applying GCT;

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

$\therefore \; w = 0.2063^{k}$/horizontal ft.

$$\text{spacing} = \frac{\text{force}}{w}$$

(a) $\therefore$ Hanger force $= w \times \text{spacing} = \boxed{20.625^k}$

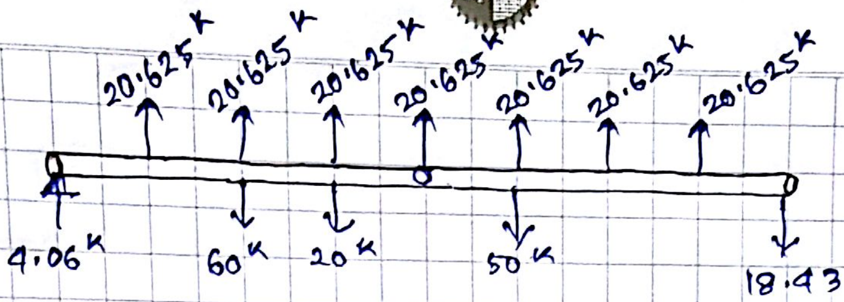


$\Sigma M @ B = 0$

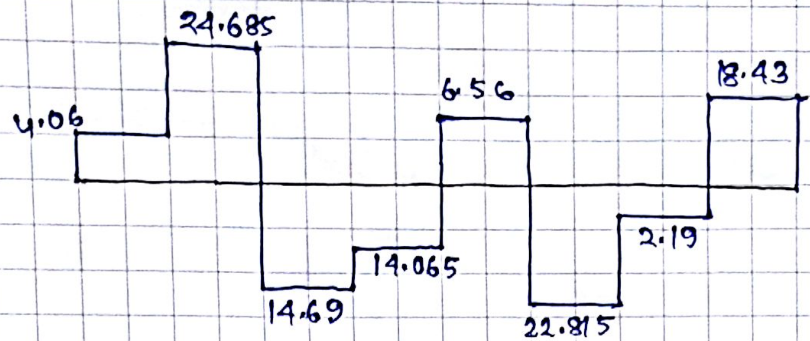
$\Rightarrow V_L \times 400 + 20.615(300+200+100) - 60 \times 200 - 20 \times 100 = 0$

$\therefore \; V_L = 4.06^k \; (\uparrow)$

$\therefore \; V_R = 18.4375^k \; (\downarrow)$

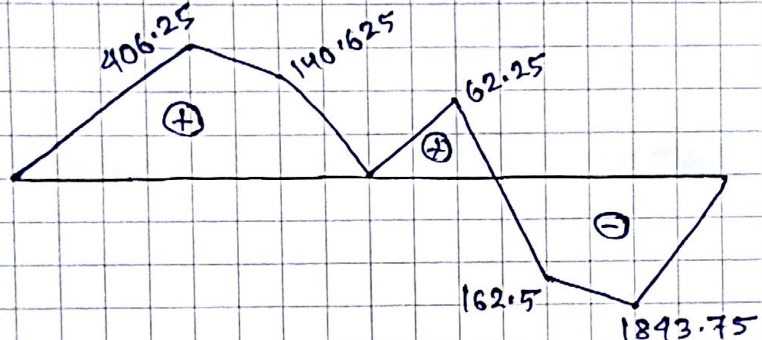


(b)



SFD

(c)



BMD

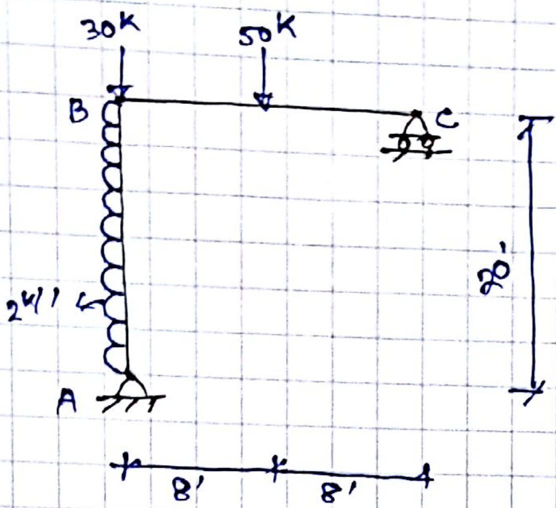
(d) Here, $\theta = \frac{h}{L} = \frac{70}{800} = 0.0875$

$$T_{max} = H\left[1+16\theta^2\right]^{1/2}$$

$$\boxed{= 249.73^k}$$

— o —

Assignment # 2:



Find horizontal deflection at B

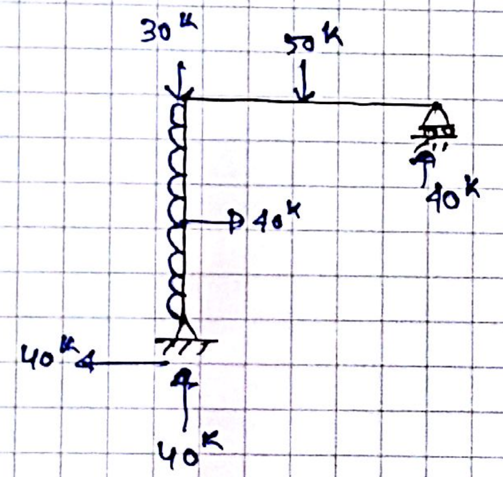
Given, $E = 29000$ ksi

$I = 400$ in^4

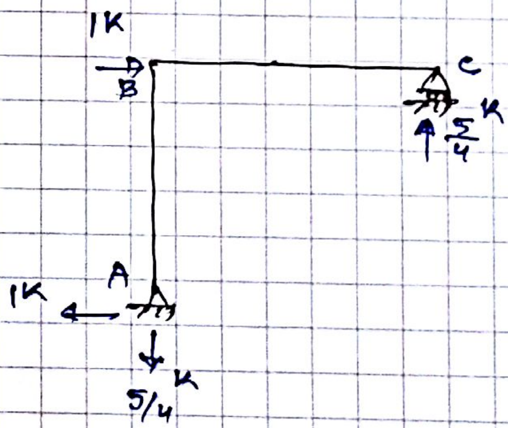
$A = 20$ in^2

Solution:

P-force analysis:



Q-force analysis:



AB

$M_P = 40x - x^2$

$M_Q = x$

$F_P = -40$

$F_Q = \frac{5}{4}$

BC

$M_P = 50(8+x) - 50$

$M_Q = (8+x)\frac{5}{4}$

$F_P = 0$

$F_Q = 0$

DC

$M_P = 50$

$M_Q = \frac{5}{4}$

$F_P = 0$

$F_Q = 0$

Using principle of virtual work;

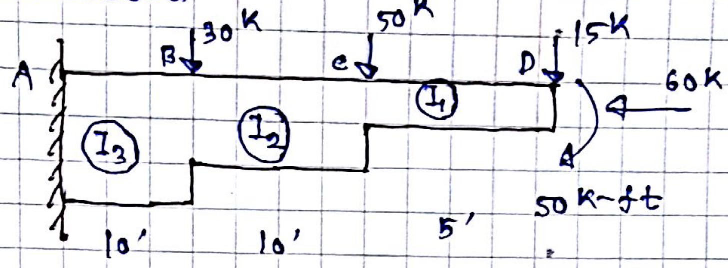
$$Q.\ \delta_{Bh} = \int \frac{M_a M_p}{EI} dx + \Sigma \frac{F_a F_p L}{AE}$$

$$\Rightarrow 1^k .\ \delta_{Bh} = \frac{125333.33}{29000 \times 12^2 \times \frac{400}{12^4}} + \frac{100}{\frac{20}{12^2} \times 29000}$$

$$\therefore \boxed{\delta_{Bh} = 1.56\ ft\ (\rightarrow)}$$

——— o ———

Assignment # 3 :



Given,

$E = 29 \times 10^3$ ksi

$I_1 = 200 \text{ in}^4$, $I_2 = 300 \text{ in}^4$, $I_3 = 400 \text{ in}^4$

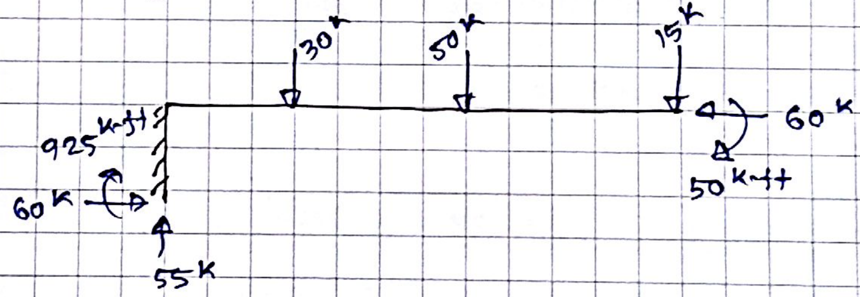
$A_1 = 10 \text{ in}^2$, $A_2 = 15 \text{ in}^2$, $A_3 = 20 \text{ in}^2$

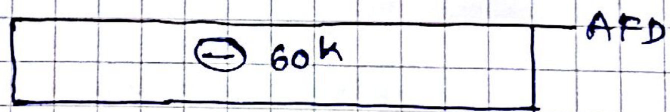
Find

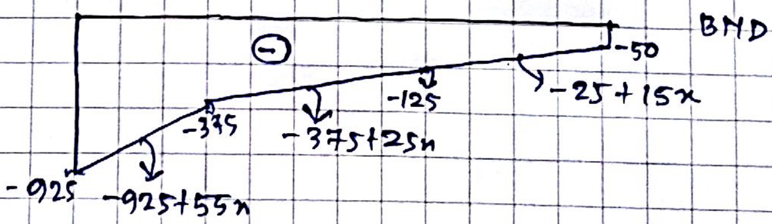
(a) Vertical deflection @ C & (b) Rotation at D

Solution:

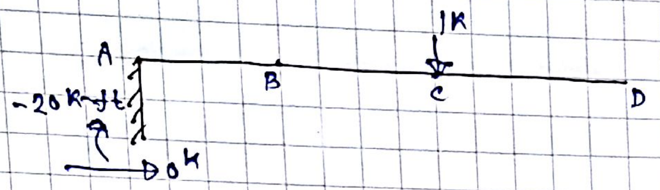
P-force analysis:

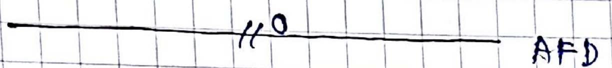


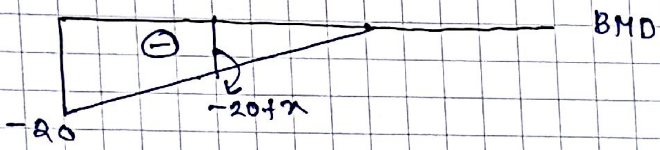




(9) Q-force analysis :







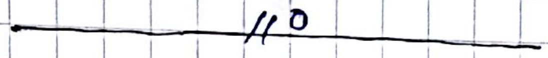
Using principle of V.W.;

$$Q.\ \delta_{cv} = \int \frac{M_Q M_P}{EI}\,dx + \frac{\Sigma F_Q F_P L}{AE}$$

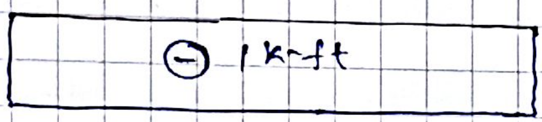
$$\Rightarrow 1^K \cdot \delta_{cv} = \int_A^B \frac{(-20+x)(-925+55x)}{EI}\,dx + \int_B^C \frac{(-10+x)(-375+25x)}{EI}\,dx$$

$$\therefore \boxed{\delta_{cv} = 1.15\,ft\ (\text{downward})}$$

(b) Q-force analysis:



AFD



BMD

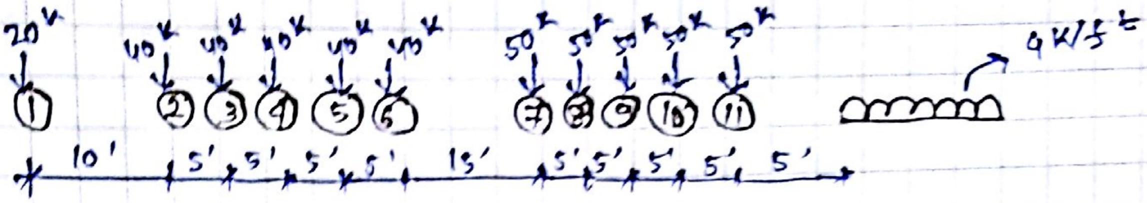
Using principle of V.W:

$$Q \cdot \theta_B = \int \frac{M_Q M_P}{EI} dx + \frac{\Sigma F_Q F_P L}{AE}$$

$$\Rightarrow 1K \cdot \theta_B = \int_A^B \frac{(-925+55x)(-1)}{4EI_1} dx + \int_B^C \frac{(-1)(-375+25x)}{1.5EI_1} dx + \int_C^D \frac{(-1)(-125+15x)}{EI_1} dx$$

$$\therefore \boxed{\theta_B = 17.9 \text{ radian (clockwise)}}$$

Assignment # 4:



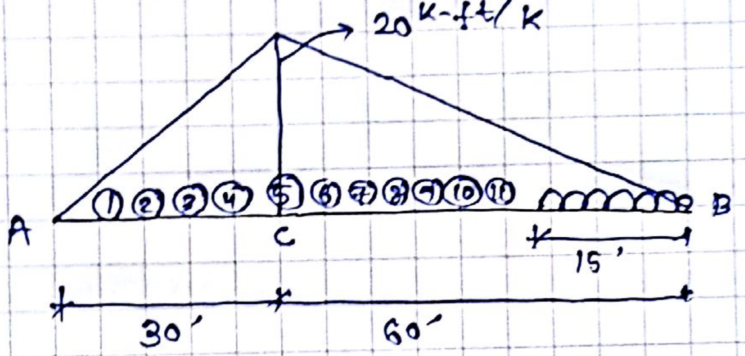
Find (a) Maxm moment at $\frac{1}{3}$ of 90'

(b) Maxm shear at quarter point of 100' span

(c) Maxm reaction for 90' span

Solution:

(a)



Trial No.	Position of Wheel		$\frac{W}{L}$		$\frac{W_1}{a}$	Remarks
1	Wheel 4 at c	just right	$\frac{510}{90}$	>	$\frac{100}{30}$	Criterion not satisfied
		just left	$\frac{510}{90}$	>	$\frac{140}{30}$	
2	Wheel 5 at C	just right	$\frac{530}{90}$	>	$\frac{140}{30}$	Criterion satisfied
		just left	$\frac{530}{90}$	<	$\frac{180}{30}$	

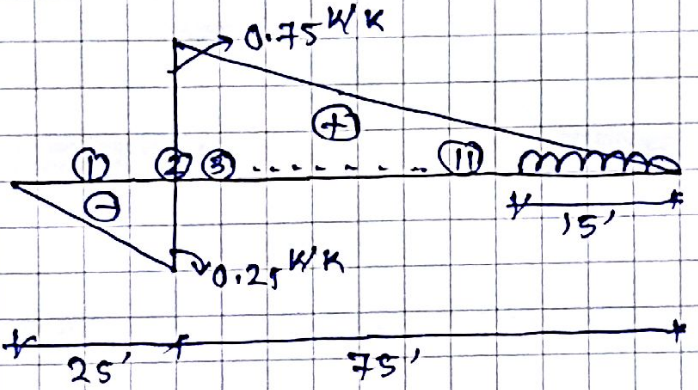
Hence wheel 5 at C gives max^m moment.

$$\therefore\ M_{max} = \frac{20}{60}\left[40(60+55)+50\,(40+35+30+25+20)\right] + \frac{20}{60}\times 15\times 0.5\times 15\times 4$$

$$+\frac{20}{30}\times\left[20\times 5 + 40(15+20+25)\right]$$

$$\boxed{= 5735.5^{\text{k-ft}}}$$

(b)



Trial 1: Wheel 2 at C

Here, ΣP = 1 to 11 + 5' of UDL = 490^k

$d_1 = 10'$

P_1 = 1 = 20^k

P' = 10' of UDL = 40^k

$e = 5'$

$P_2 = 0$

$$\therefore\ \Delta V = \frac{\Sigma P d_1}{L} - P_1 + \frac{P'e}{L} + \frac{P_2 e'}{L} = +31^k \text{ (increasing)}$$

Trial 2: wheel 3 at C

Here, $\Sigma P = 530^k$

$d_1 = 5'$

$P_1 = 60^k$

$P' = 20^k$

$e = 2.5'$

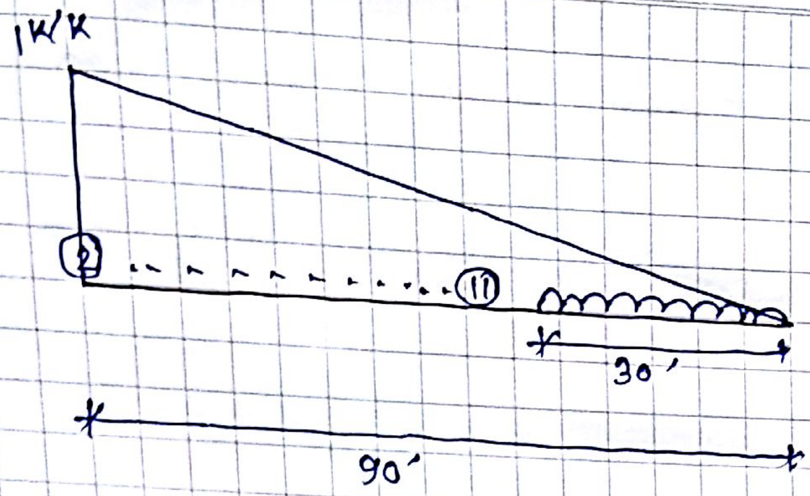
$\therefore \Delta V = -33^k$ (decreasing)

$\therefore$ wheel 2 at C gives max^m shear.

$$\therefore V_{max} = \frac{0.75}{75}\left[40(75+70+65+60+55) + 50\times(40+35+30+25+20) + 7.5\times4\right] - \frac{0.25}{25}(20\times15)$$

$$= \boxed{202.3^k}$$

c)



<u>Trial 1:</u> Wheel ② at c

Here, ΣP = ② to ⑪ + 20' UDL = 530^k

$d_1 = 10'$

P_1 = ① = 20^k

$e = 5'$

P' = 10' UDL = 40^k

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

$= +41.02$ (increasing)

<u>Trial 2:</u> Wheel ③ at c

Here, ΣP = 410 + 30' UDL = 530^k

$d_1 = 5'$

P_1 = ② = 40^k

P' = 5' UDL = 20^k

$e = 2.5'$

$\therefore \Delta R = -10^k$ (decreasing)

Hence wheel 2 at C gives max^m reaction

$\therefore$ Max^m $R_A = \frac{1}{90}$ [40 × (90+85+80+75+70) + 50(55+50+45+40+35)
+ 4 × 15]

$= \boxed{303.44}$ kN

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