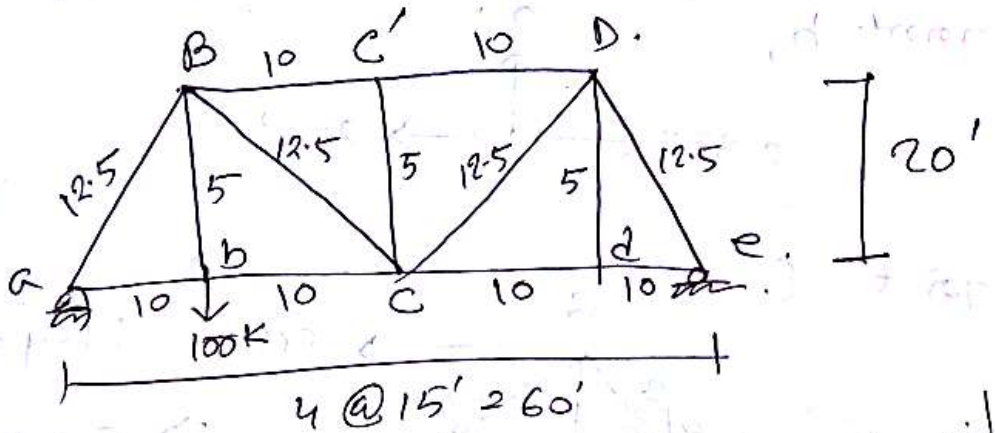
Virtual work:

→ 2-3 to, quest' ones.

For truss structure:

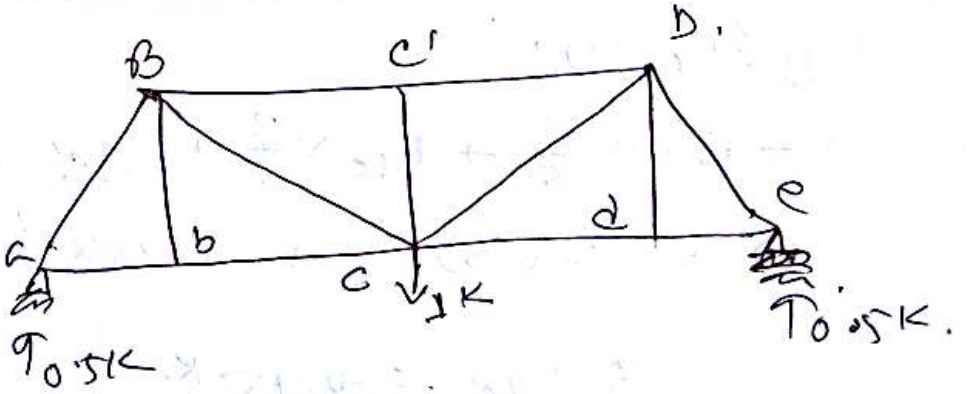
$$\Sigma Q \cdot \delta = \Sigma \frac{F_p \cdot F_Q L}{AE} + \Sigma \alpha_t t \cdot L F_Q.$$

Example-8.1

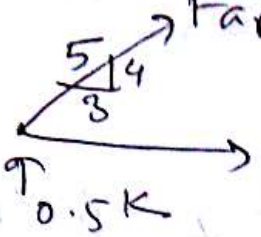


determine deflection at C. $\alpha = \frac{1}{150\,000}$.

Q Force analysis



Joint a,



$\Sigma F_y = 0$.

$\Rightarrow F_{aB} \times \frac{4}{5} + 0.5 = 0$.

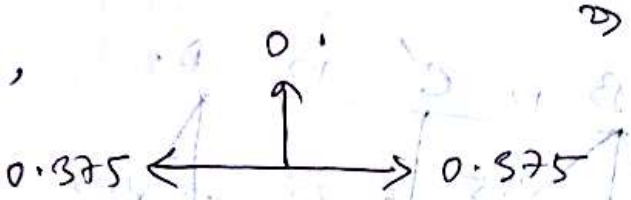
$\Rightarrow F_{aB} = -0.625^K$.

$\Sigma F_x = 0$.

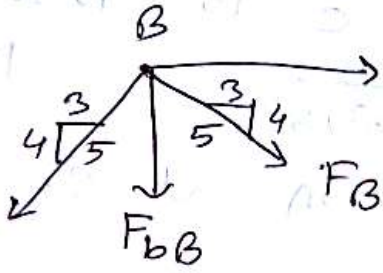
$F_{ab} + F_{aB} \times \frac{3}{5} = 0$.

$\Rightarrow F_{ab} = 0.375^K$.

Joint b,



Joint B,



$\Sigma F_y = 0$. (↓ +ve)

$\Rightarrow F_{aB} \times \frac{4}{5} + F_{Bc} \times \frac{4}{5} + 0 = 0$.

$\Rightarrow F_{Bc} = -F_{aB}$

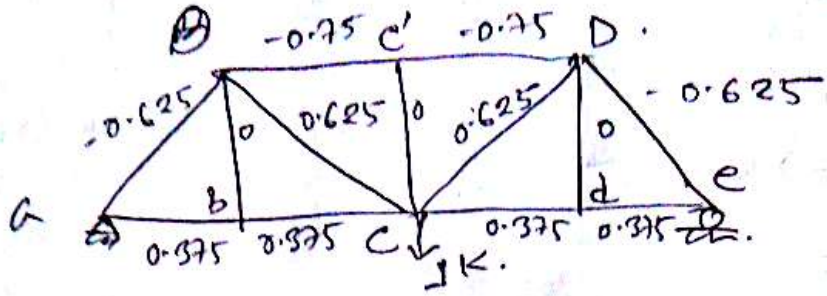
$= 0.625K$.

$\Sigma F_x = 0$.

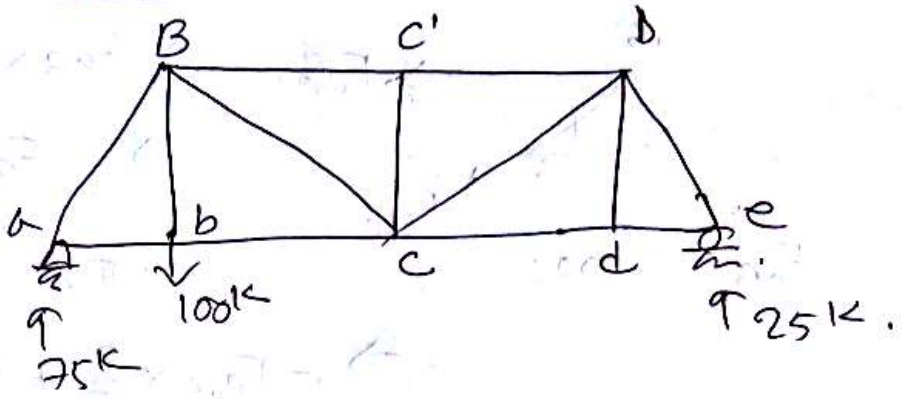
$-F_{aB} \times \frac{3}{5} + F_{Bc} \times \frac{3}{5} + F_{BC'} = 0$

$\Rightarrow -(-0.625) \times \frac{3}{5} + 0.625 \times \frac{3}{5} + F_{BC'} = 0$

$\Rightarrow F_{BC'} = -0.75K$



P Force analysis:



joint A,

$\Sigma F_y = 0$.

$\Rightarrow 75 + F_{AB} \times \frac{4}{5} = 0$.

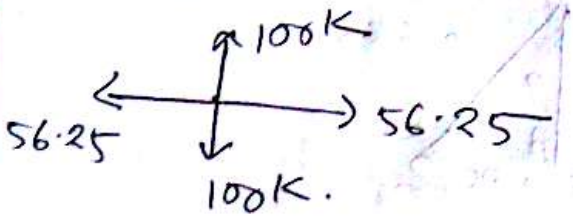
$\Rightarrow F_{AB} = -93.75$K.

$\Sigma F_x = 0$.

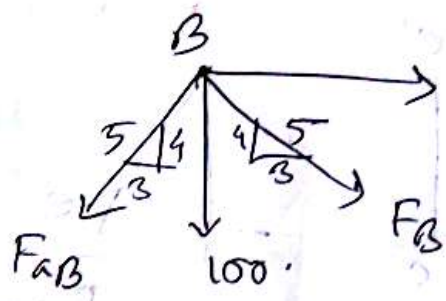
$\Rightarrow F_{Ab} + F_{AB} \times \frac{3}{5} = 0$.

$\Rightarrow F_{Ab} = 56.25$K.

Joint b,



Joint B,



$\Sigma F_y = 0.$ (↓ +ve)

$\Rightarrow F_{AB} \times \frac{4}{5} + 100 + F_{BC} \times \frac{4}{5} = 0$

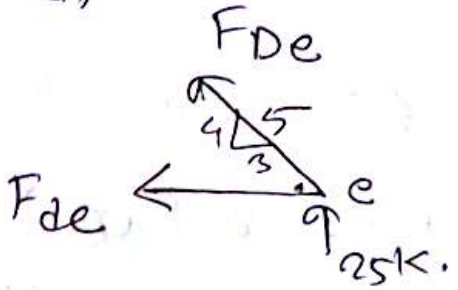
$\Rightarrow F_{BC} = -31.25K.$

$\Sigma F_x = 0.$

$\Rightarrow -F_{AB} \times \frac{3}{5} + F_{BE'} + F_{BC} \times \frac{3}{5} = 0.$

$\Rightarrow F_{BE'} = -37.5K$

Joint e,



$\Sigma F_y = 0.$

$F_{DE} \times \frac{4}{5} + 25 = 0.$

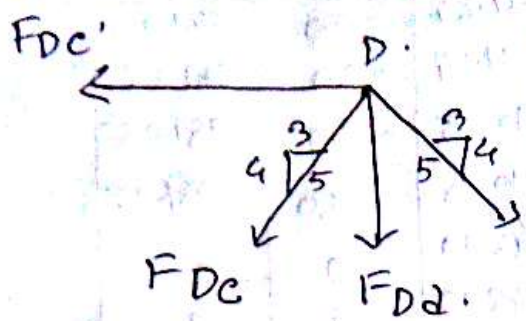
$\Rightarrow F_{DE} = -31.25K$

$\Sigma F_x = 0.$

$\Rightarrow F_{de} + F_{DE} \times \frac{3}{5} = 0$

$\Rightarrow F_{de} = 18.75K$

Joint D.



$\Sigma F_y = 0 \cdot (\downarrow)$

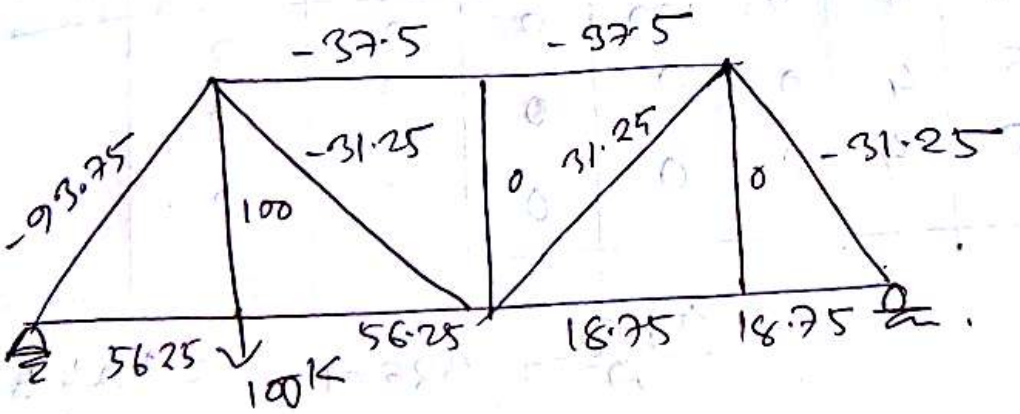
$\Rightarrow F_{De} \times \frac{4}{5} + F_{DC} \times \frac{4}{5} + F_{D2} = 0.$

$\Rightarrow F_{De} = 31.25^{K}.$

$\Sigma F_x = 0.$

$\Rightarrow F_{DC'} + F_{DC} \times \frac{3}{5} - F_{De} \times \frac{3}{5} = 0.$

$\Rightarrow F_{DC'} = -37.5^{K}.$



0.10803.

7.5×10^{-3}

	Bar	L	A	$\frac{L}{A}$	Fa	Fp	$\frac{FpFaL}{A}$	ϵ	FaLe
Hor.	ab	15	10	1.5	0.375	56.25	31.64	-50	-281.25
	bc	15	10	1.5	0.375	56.25	31.64	-50	-281.25
	cd	15	10	1.5	0.375	18.75	10.55	-50	-281.25
	de	15	10	1.5	0.375	18.75	10.55	-50	-281.25
	Bc'	15	10	1.5	-0.75	-37.5	42.19	0	0
	c'D	15	10	1.5	-0.75	-37.5	42.19	0	0
Diag	aB	25	12.5	2	-0.625	-93.75	117.19	0	0
	Bc	25	12.5	2	0.625	-31.25	-39.06	0	0
	CD	25	12.5	2	0.625	31.25	+39.06	0	0
	De	25	12.5	2	-0.625	-31.25	39.06	0	0
vert.	Bb	20	5	4	0	100	0	0	0
	Cc	20	5	4	0	0	0	0	0
	Dd.	20.	5	4	0	0	0	0.	0.

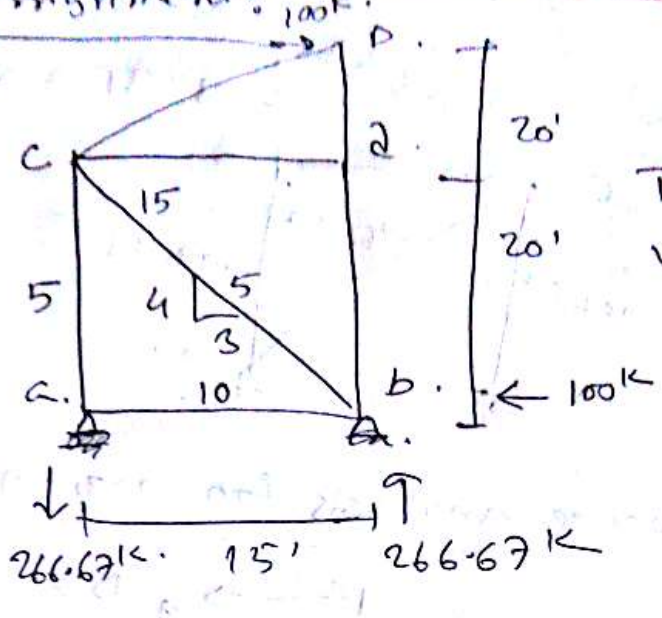
$\Sigma \frac{FpFaL}{A} = 325.01$ $\quad \Sigma FaL\epsilon = -1125.$

$$\therefore \text{Q.S} = \frac{\Sigma FpFaL}{AE} + \Sigma FaL\epsilon.$$

$$= \left(\frac{325.01}{30 \times 10^3} - \frac{1125}{150000} \right)$$

$$= 3.35 \times 10^{-3}. = 0.1008 \text{ ft}.$$

From Assignment:



Support moved:

a vertical
= 0.8" (↑)

b vertical
= 0.9" (↓)

b horizontal
= 0.3" (→)

Temp. change.

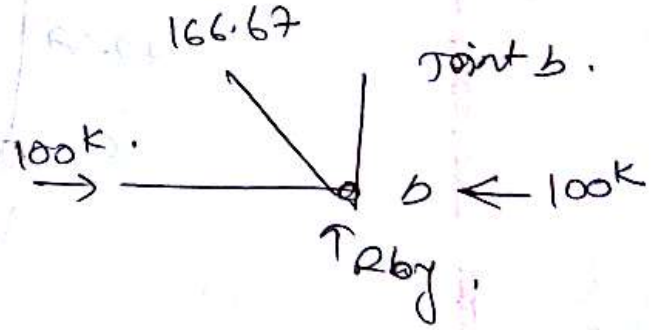
Vertical member
40°F. decrease

Diagonal member.
50°F increase

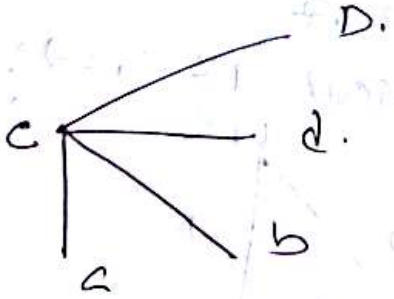
① compute horizontal deflection at D.

② " Vertical " at D.

P force - analysis;



Joint c.



F_{ac} = 266.67 (↑)

F_{ab} = 100 k (→)

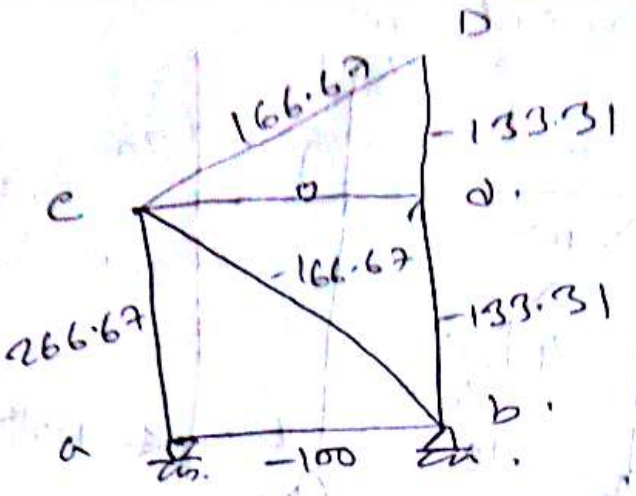
F_{bd} = 133.31 (↓)

F_{bc} = 166.67 (→)

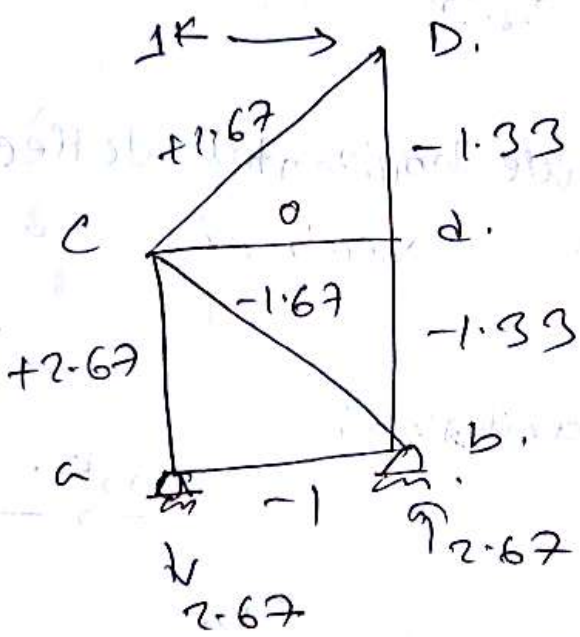
F_{dD} = 133.31 (↑)

F_{cd} = 0.

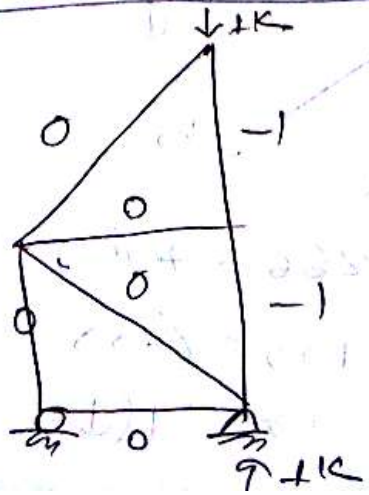
F_{eD} = 166.67 (→)



Q Force analysis for horizontal 1K load:



Q Force for vertical 1K load.



→ horizontal. → temperature change. → vertical.

Bar	L	A	L/A	Fp.	FQ (→)	FpFqL/A	t	Fqαt L (→)	FQ (↓)	FqFpL/A	Fqαt L t.
ab	15	10	1.5	-100	-1	150	0	0	0	0	0
ac	20	5	4	266.67	2.67	2668.04	-40	14.24×10^{-3}	0	0	0
bc	25	15	5/3	-166.67	-1.67	463.9	+50	13.92×10^{-3}	0	0	0
bd	20	5	4	-133.31	-1.33	709.2	-40	7.09×10^{-3}	-1	533.2	5.33×10^{-3}
CD	25	15	5/3	166.67	+1.67	4639	+50	13.92×10^{-3}	0	0	0
cd	15	10	1.5	0	0	0	0	0	0	0	0
Dd	20	5	4	-133.33	-1.33	709.2	-40	7.09×10^{-3}	-1	533.2	5.33×10^{-3}

$\Sigma \frac{FpFqL}{A} = 5344.24$

$\Sigma Fq\alpha t L t = -6\times10^{-5}$

$\Sigma \frac{FpFqL}{A} = 1066.4$

$\Sigma Fq\alpha t L t = 10.66\times10^{-3}$

For Q (→)

$W_S + W_R = W_Q$.

$\Rightarrow 1.8 + \left(2.67 \times \frac{-0.8}{12}\right) + \left(2.67 \times -\frac{0.9}{12}\right) + \left(1 \times \frac{-0.3}{12}\right)$

$= \frac{5344.24}{30000.} + (-6\times10^{-5})$

$\Rightarrow \delta = 0.58 ft = 6.96''$

For Q (↓)

$W_S + W_R = W_Q$.

$1.8 + \left(1 \times \frac{-0.9}{12}\right) = \frac{1066.4}{30000} + 10.66\times10^{-3}$

$\Rightarrow \delta = 0.12 ft = 1.44''$

Q: focus.

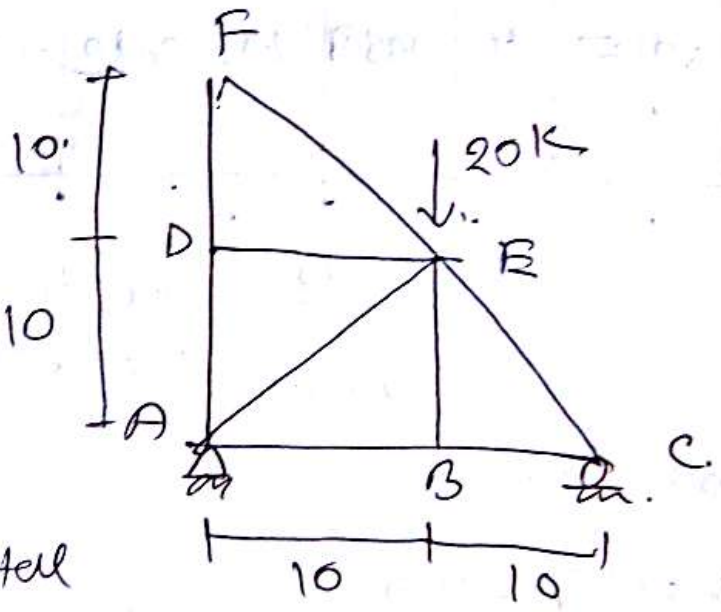
2015-16 → Na.
2014-15 → 9
2013-14 → 5
2012-13 → 10.
2011-12 → 4
2010-11 → Na.
2009-10 → Na.

2008-09 → Na.

16-17 → must

28 marks.

2011-12 (4)

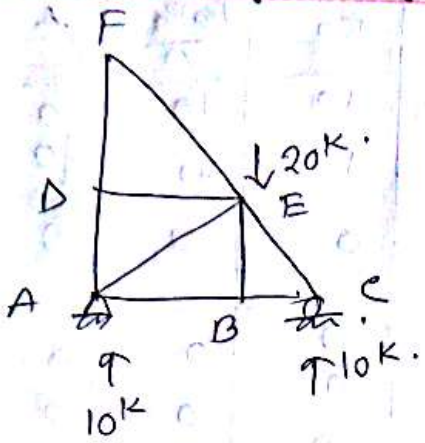


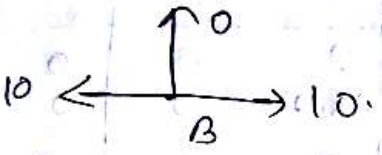
horizontal deflection at F

$E = 30000 \text{ Ksi}$

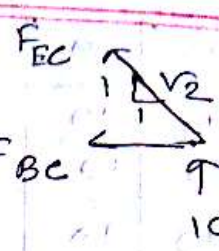
$A_1 = 10 \text{ in}^2$ → horizontal

$A_2 = 15 \text{ in}^2$ vertical and diagonal.





Joint B.



Joint C

$\Sigma F_y = 0$.

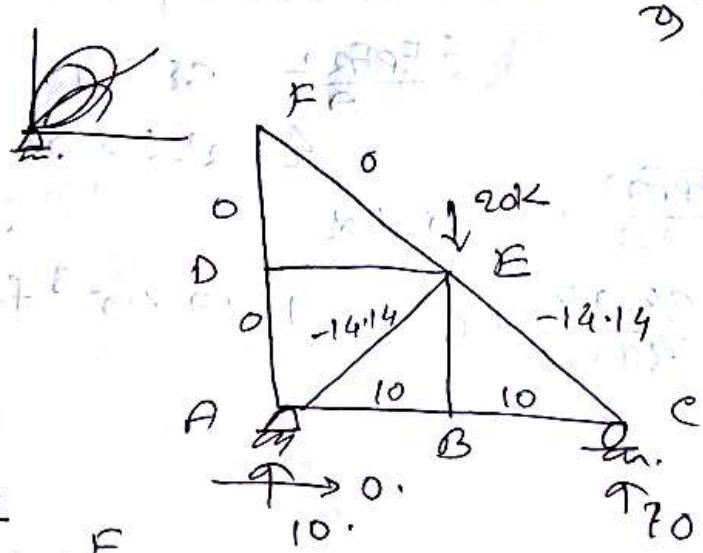
$\Rightarrow 10 + \frac{F_{EC}}{\sqrt{2}} = 0$.

$\Rightarrow F_{EC} = -14.14K$

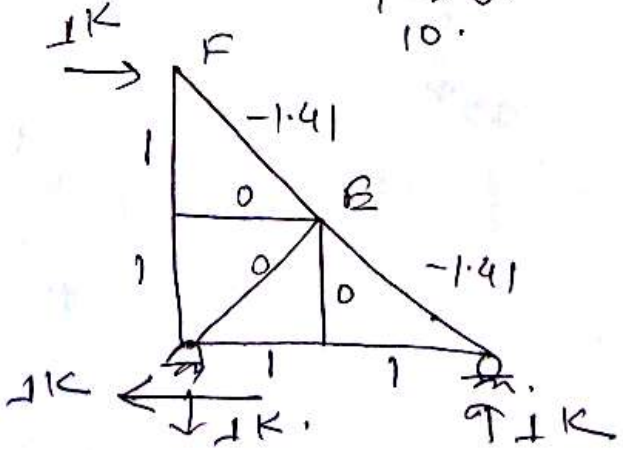
$\Sigma F_x = 0$.

$\Rightarrow F_{BC} + F_{EC} \times \frac{1}{\sqrt{2}} = 0$.

$\Rightarrow F_{BC} = 10K$.



P FORCE.



Q FORCE.

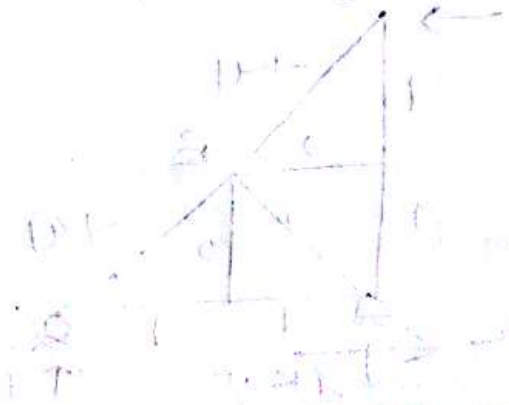
Bar	L	A	L/A	FQ	FP	FPFQL/A	t	FQLt.
AB	10	10	1	1	10	10	0	0
BC	10	10	1	1	10	10	0	0
DE	10	10	1	0	0	0	0	0
AD	10	15	0.67	0	0	0	0	0
BE	10	15	0.67	0	0	0	0	0
DF	10	15	0.67	0	0	0	0	0
AE	14.14	15	0.94	-1.41	-14.14	0	0	0
CE	14.14	15	0.94	-1.41	-14.14	18.74	0	0
EF	14.14	15	0.94	-1.41	0	0	0	0

$$\Sigma \frac{FPFQL}{A} = 38.74$$

$$\Sigma FQLt = 0$$

$$Q.\delta = \frac{\Sigma FPFQL}{AE} + \Sigma FQLt\alpha$$

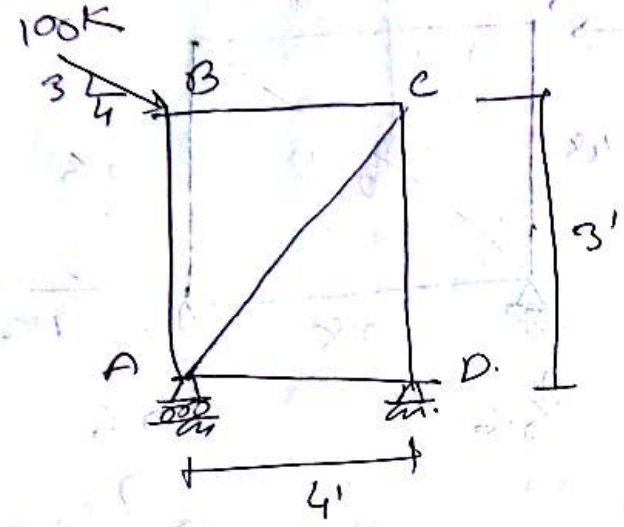
$$\therefore 1.\delta = \frac{38.74}{30000} + 0 = 1.29 \times 10^{-3} \text{ ft.}$$



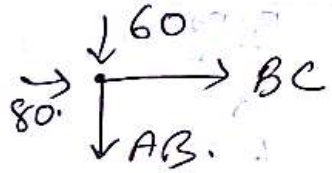
2012-13 (10)

$A_{AC} = 0.5 in^2$.
Other $A = 1 in^2$
$E = 30000$ ksi

deflection alone BD (↓)

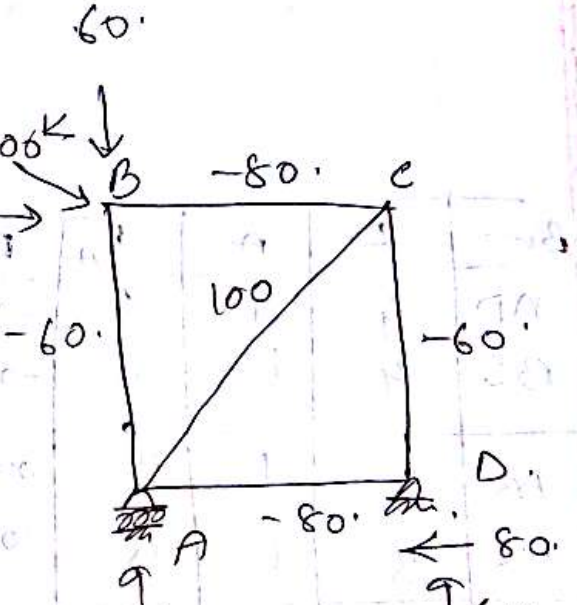


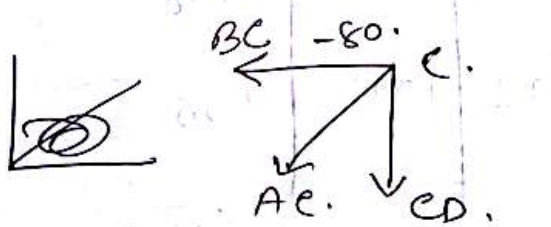
P-force analysis:



$\Sigma F_x = 0 \Rightarrow BC = -80.$

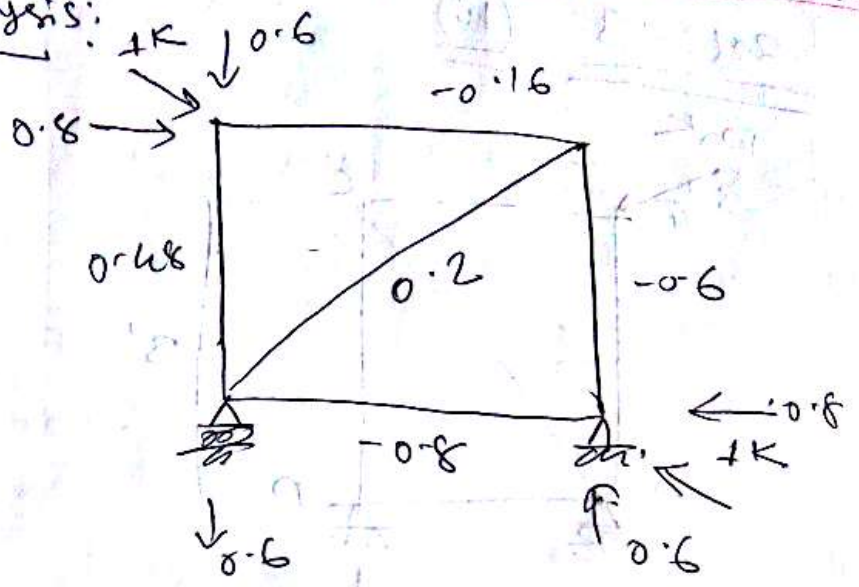
$\Sigma F_y = 0 \Rightarrow AB = -60.$





$\Sigma F_y = -80 + AC \times \frac{4}{5} = 0 \Rightarrow AC = 100.$

Q Force analysis:



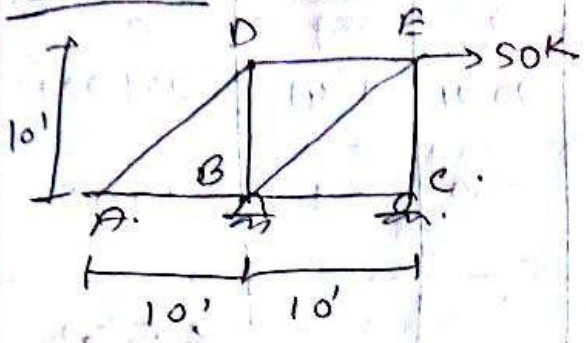
Bw.	L	A	1/A	FQ	Fp.	FpFQL/A
AD	4	1	4	-0.8	-80	256
BC	4	1	4	-0.16	-80	51.2
AB	3	1	3	0.48	-60	-86.4
DC	3	1	3	-0.6	-60	108
AC	5	05	10	0.2	100	206

$\frac{\Sigma FpFQL}{A} = 328.8$

$1.8_{BD} = \frac{\Sigma FpFQ2}{AE}$

$= \frac{528.8}{30\,000} \Rightarrow 0.0176$ ft. (→←)

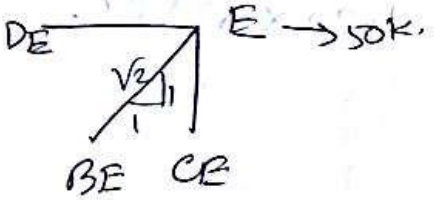
2013-14 (5)



horizontal deflection at D.

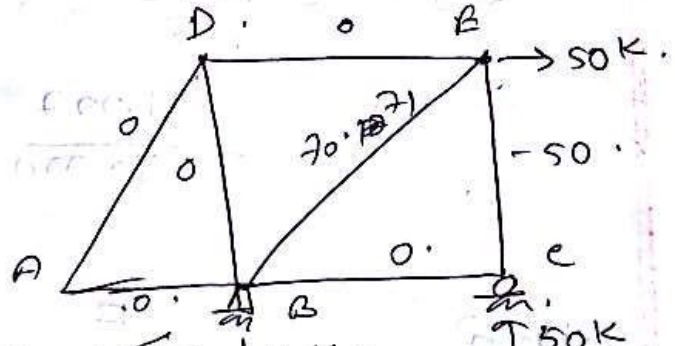
A = 5 in².
E = 30 000 ksi

D force analysis:

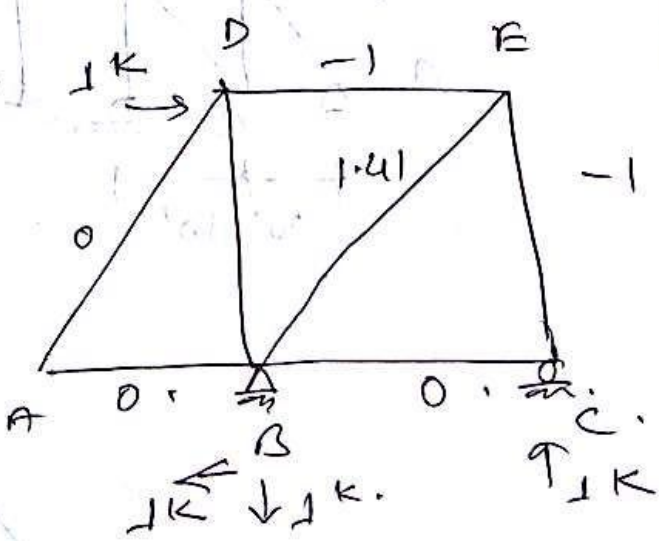


$\Sigma F_y = -50 + BE \times \frac{1}{\sqrt{2}} = 0$

$\Rightarrow BE = 70.71$



Q force analysis:



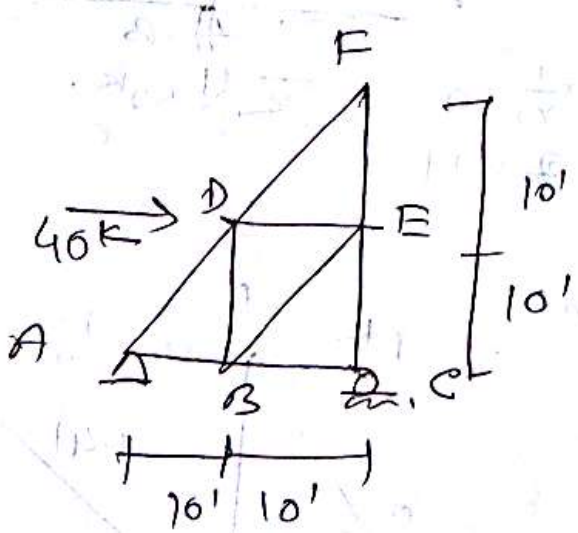
Bar.	L	A	L/A	F_P	F_Q	$\frac{F_P F_Q L}{A}$
DE	10	5	2	0	−1	0.
BE	$10\sqrt{2}$	5	$2\sqrt{2}$	70.71	1.41	281.997
CE	10.	5	2	−50	−1	100.

$$Q.\delta = \frac{\Sigma F_P F_Q L}{AE}$$

$$\frac{\Sigma F_P F_Q L}{A} = 381.997$$

$$\therefore \delta = \frac{381.997}{30\,000} = 1.27 \times 10^{-3} \text{ ft.}$$

2014-15



Horizontal deflection at F.

$A = 10 \text{ in}^2$ (horiz).

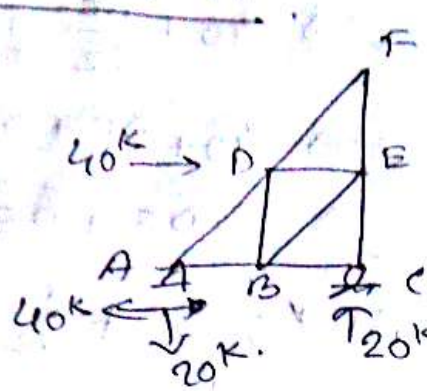
$A = 5 \text{ in}^2$ (other).

$E = 30\,000 \text{ ksi}$

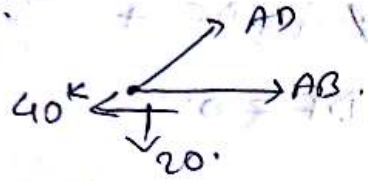
Not Sure :)

AD =

P force analysis:



Joint A.



$\sum F_y = \frac{1}{\sqrt{2}} AD - 20.$

$\Rightarrow AD = 20\sqrt{2}$

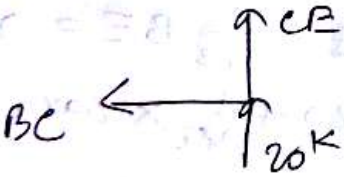
$= 28.28K$

$\sum F_x = 0.$

$\Rightarrow -40 + \frac{1}{\sqrt{2}} AD + AB = 0.$

$\Rightarrow AB = 20K.$

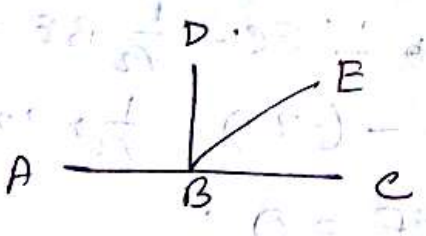
Joint C.



$BC = 0.$

$CE = -20K$

Joint B.



$\sum F_x = 0.$

$\Rightarrow -AB + BC + BE \times \frac{1}{\sqrt{2}} = 0.$

$\Rightarrow -20 + 0 + BE \times \frac{1}{\sqrt{2}} = 0$

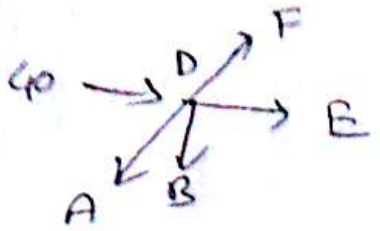
$\Rightarrow BE = 20\sqrt{2}K$

$\sum F_y = 0.$

$BE \times \frac{1}{\sqrt{2}} + BD = 0.$

$\Rightarrow BD = -20K$

Joint D.



$\Sigma F_x = 0.$

$\Rightarrow 40 + \frac{DF}{\sqrt{2}} + DE - \frac{AD}{\sqrt{2}} = 0.$

$\Rightarrow 40 + DF + DE - \frac{20\sqrt{2}}{\sqrt{2}} = 0$

$\Rightarrow DF + DE = -20.$

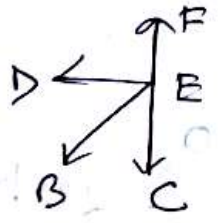
$\Sigma F_y = 0. \rightarrow BD + \frac{1}{\sqrt{2}} DF + \frac{1}{\sqrt{2}} AD = 0.$

$\Rightarrow -20 + \frac{1}{\sqrt{2}} DF + \frac{20\sqrt{2}}{\sqrt{2}} = 0.$

$\Rightarrow DF = 0.$

$\therefore DE = -20.$

Joint E



$\Sigma F_x = 0$

$\Rightarrow DE + \frac{1}{\sqrt{2}} BE = 0.$

$\Rightarrow -20 + \frac{1}{\sqrt{2}} \times 20\sqrt{2} = 0.$

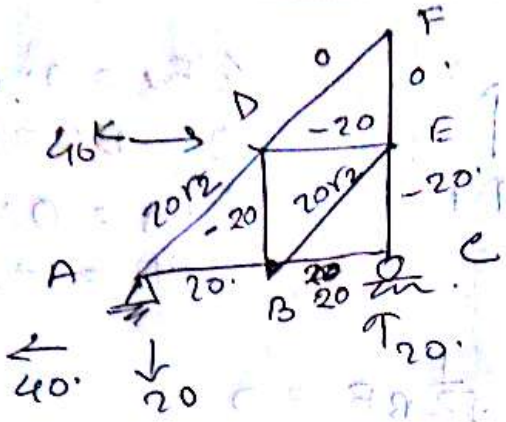
OK.

$\Sigma F_y = 0.$

$EF + EC - \frac{1}{\sqrt{2}} BE = 0.$

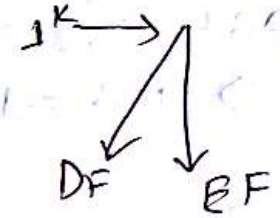
$\Rightarrow EF - (-20) - \frac{1}{\sqrt{2}} \times 20\sqrt{2} = 0$

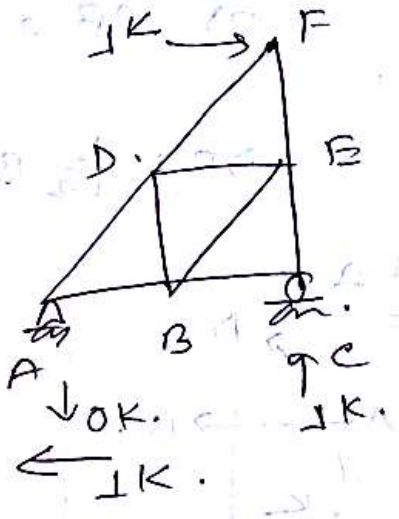
$\Rightarrow EF = 0.$



Q Force analysis:

Joint F.





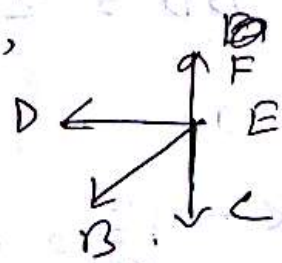
$\Sigma F_x = 0$

$\Rightarrow DF \times \frac{1}{\sqrt{2}} = 1.$

$\Rightarrow DF = \sqrt{2}$

$\Sigma F_y = 0 \Rightarrow DF \times \frac{1}{\sqrt{2}} + EF = 0 \Rightarrow EF = -1.$

Joint E,



$\Sigma F_x = 0.$

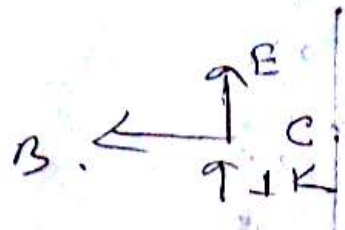
$\Rightarrow DE + \frac{1}{\sqrt{2}} BE = 0.$ — (i)

$\Sigma F_y = 0.$

$\Rightarrow EF - CE - \frac{1}{\sqrt{2}} BE = 0.$

$\Rightarrow -1 - CE - \frac{1}{\sqrt{2}} BE = 0.$ — (ii)

Joint C



$\Sigma F_x = 0$.

② $BC = 0$

$\Sigma F_y = 0$.

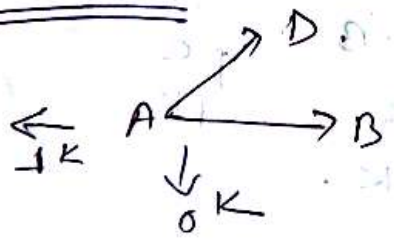
$CE = -1$.

(II) ⇒ $-1 - 1 - \frac{1}{\sqrt{2}} BE = 0$

⇒ $BE = -2\sqrt{2}$

(I) ⇒ $DE + \frac{1}{\sqrt{2}} BE = 0$ ⇒ $DE = 2$

Joint A



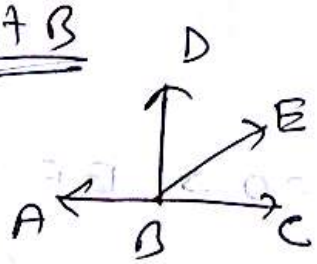
$\Sigma F_x = 0$. $AB + AD/\sqrt{2} = 1$.

~~$AB = 1$~~. ⇒ $AB = 1$.

$\Sigma F_y = 0$.

$AD = 0$.

Joint B



$\Sigma F_y = 0$.

⇒ $BD + \frac{BE}{\sqrt{2}} = 0$.

⇒ $BD = 2$.

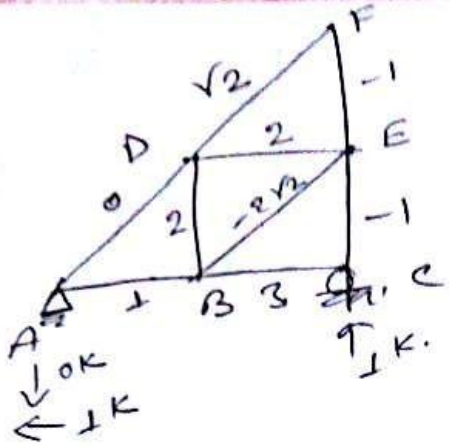
$\Sigma F_x = 0$.

$AB - BC - \frac{BE}{\sqrt{2}} = 0$.

⇒ ~~AB~~ $1 - BC - \frac{(-2\sqrt{2})}{2} = 0$

⇒ $BC = 3$ (T)

Not sure 😕



	Bar	L	A	1/A.	FP	Fa.	FpFaL/A.
Hor	AB	10	10	1	20	1	20.
	BC	10	10	1	20	3	60
	DE	10	10	1	-20	2	-40
Diag	AD	10√2	5	2√2	20√2	0	0
	DF	10√2	5	2√2	0	√2	0
	BE	10√2	5	2√2	20√2	-2√2	-226.27
Ver.	BD	10	5	2	-20	2	-80
	CE	10	5	2	-20	-1	+40.
	EF	10	5	2	0.	-1	0.

$\Sigma \frac{FpFaL}{A} = -226.27$

$\therefore \delta = \frac{-226.27}{30000}$

$= -7.54 \times 10^{-3}$ ft

Need more practice.