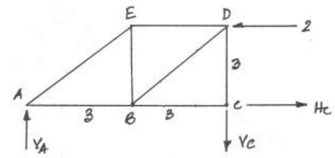
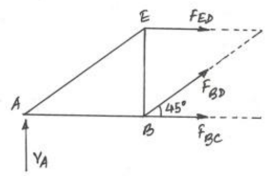
(1) Considering whole truss, taking moment about C (assuming clockwise +ve)

$$\sum M_C = 0; \quad V_A(6) - 2(3) = 0$$

$$V_A = 1$$



A section is considered between E and D



Taking moment about B (assuming clockwise +ve)

$$\sum M_B = 0; \quad V_A(3) + F_{ED}(3) = 0$$

This gives $F_{ED} = -1\ N\ (C)$

Taking moment about D (assuming clockwise +ve)

$$\sum M_D = 0; \quad V_A(6) - F_{BC}(3) = 0$$

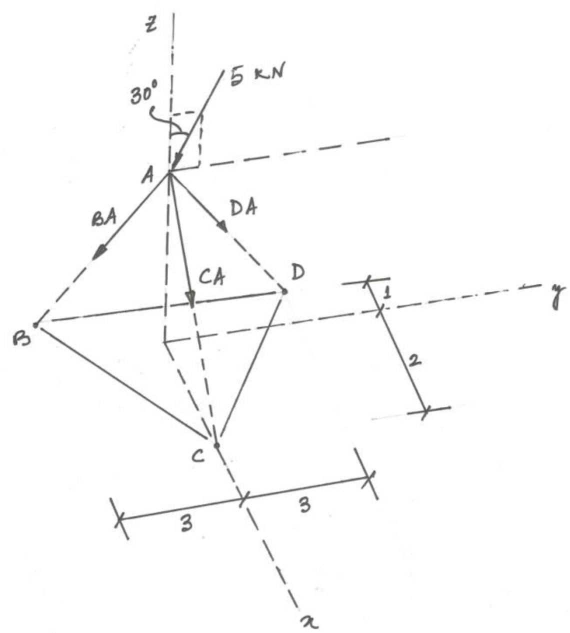
This gives $F_{BC} = 2\ N\ (T)$

For vertical equilibrium

$$\sum F_V = 0; \quad V_A + F_{BD}\sin 45° = 0$$

This gives $F_{BD} = -\sqrt{2}\ N\ (C)$

(2)



$$\overline{BA} = BA\frac{-i-3j-6k}{\sqrt{1^2+3^3+6^2}} = BA\frac{-i-3j-6k}{\sqrt{46}}$$
$$\overline{CA} = CA\frac{2i-6k}{\sqrt{2^2+6^2}} = CA\frac{2i-6k}{\sqrt{40}}$$
$$\overline{DA} = DA\frac{-i+3j-6k}{\sqrt{1^2+3^2 6^2}} = DA\frac{-i+3j-6k}{\sqrt{46}}$$

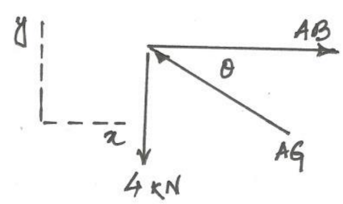
$\sum F_A = 0$ which gives $\overline{BA} + \overline{CA} + \overline{DA} - 5(cos30°i + sin30°j) = 0$

Equating coefficient of i, j and k to the right hand

$$-\frac{1}{\sqrt{46}}BA + \frac{2}{\sqrt{40}}CA - \frac{1}{\sqrt{46}}DA = 0$$
$$-\frac{3}{\sqrt{46}}BA + \frac{3}{\sqrt{46}}DA - \frac{1}{2}5 = 0$$
$$-\frac{6}{\sqrt{46}}BA - \frac{6}{\sqrt{40}}CA - \frac{6}{\sqrt{46}}DA - 5\frac{\sqrt{3}}{2} = 0$$

Solving this three equation
$$BA = -4.46 \text{ kN}$$
$$CA = -1.521 \text{ kN}$$
$$DA = 1.194 \text{ kN}$$

(3)

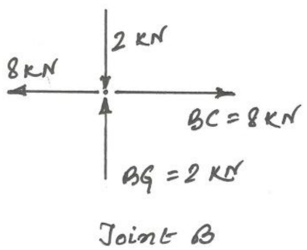


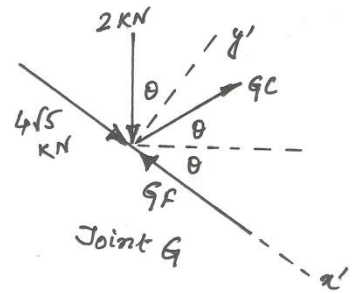
Joint A

$\theta = \tan^{-1}\frac{1}{2} = 26.57°$ $\sin\theta = \frac{1}{\sqrt{5}}$ $\cos\theta = \frac{2}{\sqrt{5}}$

$\sum F_y = 0;$ $\frac{AG}{\sqrt{5}} - 4 = 0;$ $AG = 4\sqrt{5}$ kN (Compression)

$\sum F_x = 0;$ $AB - 4\sqrt{5}\left(\frac{2}{\sqrt{5}}\right) = 0;$ $AB = 8$ kN (Tension)



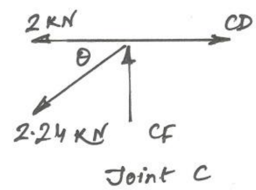


From joint B, $\sum F_x = 0;\quad$ BC = 8 kN (Tension)

$\sum F_y = 0;\quad BG = 2\ kN$ (Compression)

From joint G, $\sum F_y' = 0;\quad 2\left(\frac{2}{\sqrt{5}}\right) - \text{CG}\sin 2\theta = 0;\quad \text{CG} = 2.24$ kN (Tension)

$$\sum F_{x'} = 0;\ \ 2.24\cos 2\theta + \frac{2}{\sqrt{5}} + \frac{4}{\sqrt{5}} - \text{GF} = 0;\quad \text{GF} = 11.18 \text{ kN (Compression)}$$



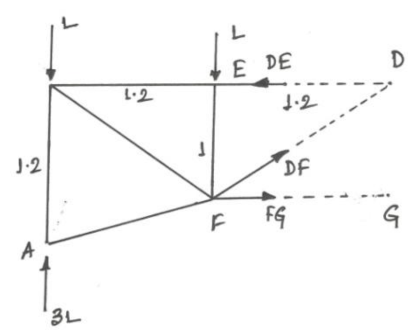
From joint C, $\sum F_y = 0;\quad \text{CF} - 2.24\sin\theta = 0;\quad \text{CF} = 1.0$ kN (Compreesion)

$\sum F_x = 0;\quad CD - 2 - 2.24\cos\theta = 0;\quad CD = 4.0$ kN (Tension)

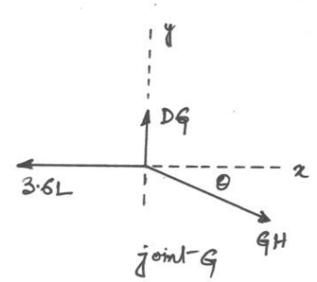
(4) Considering entire truss, reactions at A and B are

$$\text{A} = \text{B} = 3L$$

Considering section between ED, and taking moment about D (assuming anti-clockwise positive)



$\sum M_D = 0;\quad \text{FG}(1) + L(1.2 + 2.4) - 3L(2.4) = 0;\quad \text{FG} = 3.6L$ (Tension)



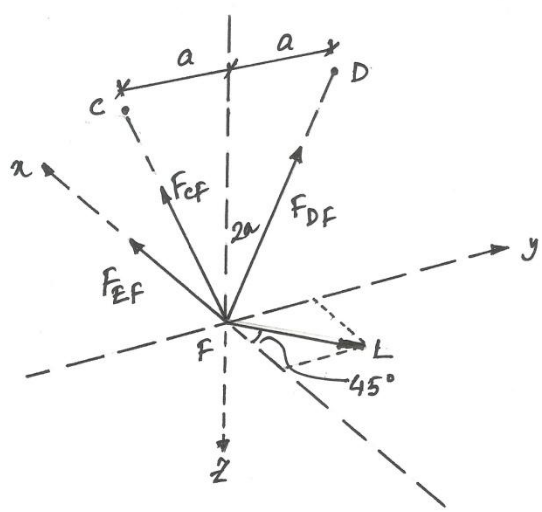
From joint G,

$$\theta = \tan^{-1}\left(\frac{0.2}{1.2}\right) = 9.5°$$

$$\sum F_x = 0;\ \ -3.6L + \mathrm{GH}\cos\theta = 0;\ \ \mathrm{GH} = 3.65L\ \text{(Tension)}$$

$$\sum F_y = 0;\ \ \mathrm{DG} - 3.65L\sin\theta = 0;\ \ \mathrm{DG} = 0.60L\ \text{(Tension)}$$

(5)



$\bar{L} = \frac{L}{\sqrt{2}}(-i + j)$; $\bar{F}_{EF} = F_{EF}\, i$; $\bar{F}_{CF} = \frac{F_{CF}}{\sqrt{5}}(-j - 2k)$;

$$\bar{F}_{DF} = \frac{F_{DF}}{\sqrt{5}}(j - 2k)$$

At joint F, $\sum F = \bar{L} + \bar{F}_{EF} + \bar{F}_{CF} + \bar{F}_{DF} = 0$
and equating the coefficient of i, j and k

$$-\frac{L}{\sqrt{2}} + F_{EF} = 0$$

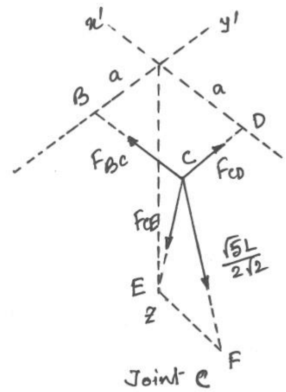
$$\frac{L}{\sqrt{2}} - \frac{F_{CF}}{\sqrt{5}} + \frac{F_{DF}}{\sqrt{5}} = 0$$

$$-\frac{2}{\sqrt{5}}F_{CF} - \frac{2}{\sqrt{5}}F_{DF} = 0$$

$$F_{EF} = \frac{L}{\sqrt{2}}$$

From above three equation $F_{CF} = \frac{\sqrt{5}L}{2\sqrt{2}}$

$$F_{DF} = -\frac{\sqrt{5}L}{2\sqrt{2}}$$



At joint C, $\bar{F}_{CD} = F_{CD}j$; $\bar{F}_{BC} = F_{BC}i$; $\bar{F}_{CE} = \frac{F_{CE}}{\sqrt{6}}(i + j + 2k)$;

$$\bar{F}_{CF} = \frac{F_{CF}}{\sqrt{5}}(j + 2k) = \frac{L}{2\sqrt{2}}(j + 2k)$$

For equilibrium $\sum F = \bar{F}_{CD} + \bar{F}_{BC} + \bar{F}_{CE} + \bar{F}_{CF} = 0$

And equating coefficient of i, j and k

$$F_{BC} + \frac{F_{CE}}{\sqrt{6}} = 0$$

$$F_{CD} + \frac{F_{CE}}{\sqrt{6}} + \frac{L}{2\sqrt{2}} = 0$$

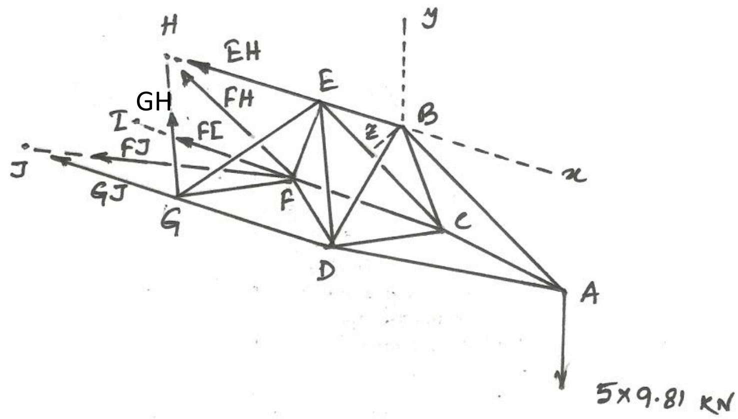
$$\frac{2F_{CE}}{\sqrt{6}} + \frac{L}{\sqrt{2}} = 0$$

$$F_{BC} = \frac{L\sqrt{2}}{4}$$

Solving the above three equation $F_{CD} = 0$

$$F_{CE} = -\frac{L\sqrt{3}}{2}$$

(6)



$$\overline{GJ} = -GJi; \quad \overline{FI} = -FIi; \quad \overline{FJ} = \frac{FJ}{\sqrt{2}}(-i+k)$$

Taking moment around joint H

$$\sum M_H = 0$$

$$-49.05(5)k + (-2\cos 30°\, j + 2\sin 30°\, k)(-GJi)$$
$$+ (-2\cos 30°\, j - 2\sin 30°\, k)(-FIi)$$
$$+ (i - 2\cos 30°\, j - k)\left\{\frac{FJ}{\sqrt{2}}(-i+k)\right\} = 0$$

Equating coefficient of i, j and k

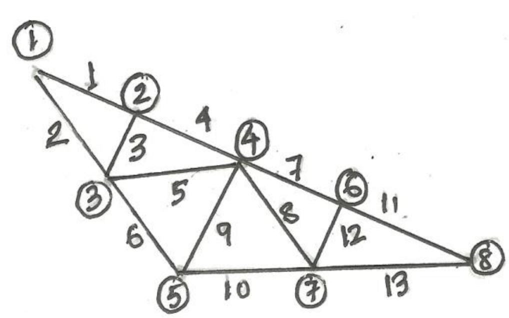
$$-1.225FJ = 0$$
$$-GJ + FI = 0$$
$$-1.732GJ - 1.732FI = 245$$

$$FJ = 0$$

Solving these three equation $FI = -70.8$ kN (Compression)

$GJ = -70.8$ kN (Compression)

(7)



In above figure elements numbers are given

Considering the whole truss, Vertical reaction at A (R_2) and reaction at H (R_3) would be

$$R_2 + R_3 = 3200$$

Taking moment about A, considering anti-clock wise as positive

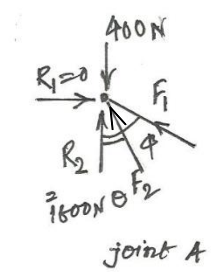
$$\sum M_A = 0$$

$$-1.7(800) - 3.4(800) - 5.1(800) + 6.8(R_3 - 400) = 0; \quad R_3 = 1600\ N$$

$$R_2 = 1600\ N$$

Force in member +ve is compression and –ve is tension.

Note: At each joint, angles are marked as new and have no continuation from other joints.



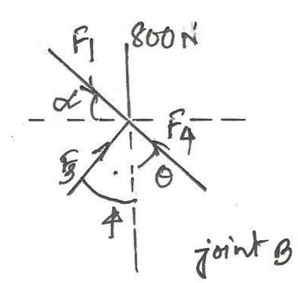
From joint A, $\theta = \tan^{-1}\left(\frac{3.2}{2}\right) = 57.99°$; $\phi = \tan^{-1}\left(\frac{3.2+3.6}{2}\right) = 73.61°$

$$\sum F_H = 0; \quad F_1 \sin\phi + F_2 \sin\theta = 0$$

$$\sum F_V = 0; \quad -400 + R_2 + F_1 \cos\phi + F_2 \cos\theta = 0$$

$$F_1 cos\phi + F_2 \cos\theta = -1200$$

This gives $F_1 = 3780.27\ N$; $F_2 = -4276.74\ N$

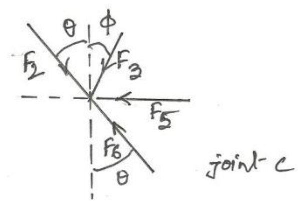


From joint B, $\alpha = 16.3895°$; $\phi = \alpha$; $\theta = 73.61°$

$$\sum F_H = 0; \quad F_1 \cos\alpha + F_3 \sin\phi - F_4 \sin\theta = 0\,; \; F_3 \sin\phi - F_4 \sin\theta = -3626.66$$

$$\sum F_V = 0; \;\; -800 - F_1 \sin\alpha + F_3 \cos\phi + F_4 \cos\theta = 0; \quad F_3 \cos\phi + F_4 \cos\theta = 1866.66$$

This gives, $F_3 = 767.49\ N$; $F_4 = 4006.00\ N$

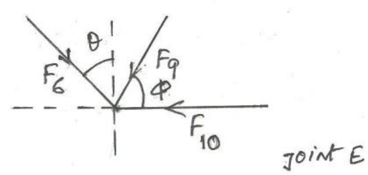


From joint C, $\theta = 57.9946°$; $\phi = 16.3895°$

$$\sum F_H = 0; \;\; F_2 \sin\theta - F_5 - F_6 \sin\theta - F_3 \sin\phi = 0; \quad F_5 + F_6 \sin\theta = -3843.23$$

$$\sum F_V = 0; \;\; F_6 \cos\theta - F_2 \cos\theta - F_3 \cos\phi = 0$$

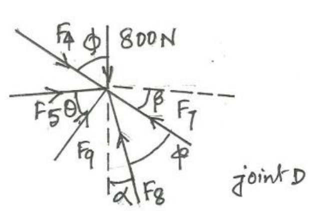
This gives $F_6 = -2887.49\ N$; $F_5 = -1394.65\ N$



From joint E, $\theta = 57.99°$; $\phi = 78.69°$

$$\sum F_V = 0; \;\; F_6 \cos\theta + F_9 \sin\phi = 0; \quad F_9 = 1560.67\ N$$

$$\sum F_V = 0; \;\; F_6 \sin\theta - F_9 \cos\phi - F_{10} = 0; \quad F_{10} = -2754.66\ N$$

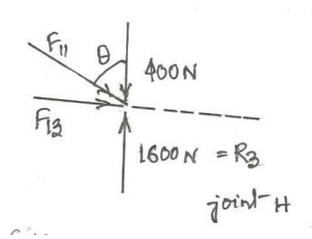


From joint D, $\phi = 73.61°; \theta = 78.69°$; $\beta = 16.39°$; $\alpha = 57.22°$

$$\sum F_H = 0; \quad F_5 + F_4 \sin\phi + F_9 \cos\theta - F_8 \sin\alpha - F_7 \sin\phi = 0; \;\; F_8 \sin\alpha + F_7 \sin\phi = 2754.64$$

$$\sum F_V = 0; \;\; -F_4 \cos\phi + F_8 \cos\alpha + F_7 \cos\phi + F_9 \sin\theta - 800 = 0; \;\; F_8 \cos\alpha + F_7 \cos\phi = 400$$

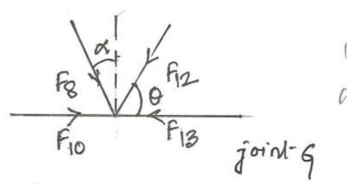
This gives $F_7 = 4093.54\ N$; $F_8 = -1394.64\ N$



From joint H, $\theta = 73.61°$

$$\sum F_V = 0;\ \ F_{11}\cos\theta = 1200;\ \ F_{11} = 4252.82\ N$$

$$\sum F_H = 0;\ \ F_{13} + F_{11}\sin\theta = 0;\ \ F_{13} = -4080.01\ N$$



From joint G, $\theta = 73.61°$; $\alpha = 57.22°$

$$\sum F_H = 0;\ \ F_{10} + F_8\sin\alpha - F_{13} - F_{12}\cos\theta = 0;\ \ F_8\sin\alpha - F_{12}\cos\theta = -1325.35$$

$$\sum F_V = 0; F_8\cos\alpha + F_{12}\sin\theta = 0$$

This gives $F_8 = -1325.35$; $F_{12} = 747.94\ N$

+ve: Compression, –ve: Tension

Member	Force (N)
F_1	3780.27
F_2	-4276.74
F_3	767.49
F_4	4006.00
F_5	-1394.65
F_6	-2887.49
F_7	4093.54
F_8	-1325.35
F_9	1560.67
F_{10}	-2754.66
F_{11}	4252.82
F_{12}	747.94
F_{13}	-4080.01

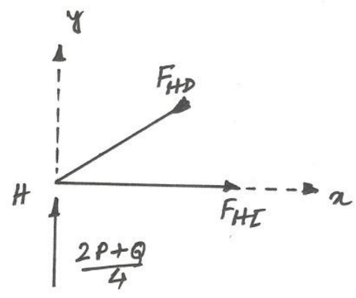
Note: One set of solution is provided. Method of sections is left as home task for the students to compare the above results.

(8) For equilibrium of entire truss, $V_H + V_L = P + Q$

Taking moment about joint L, (considering clockwise +ve)

$$\sum M_L = 0; \qquad V_H(4a) - P(2a) - Q(a) = 0; \quad V_H = \frac{2P+Q}{4}$$

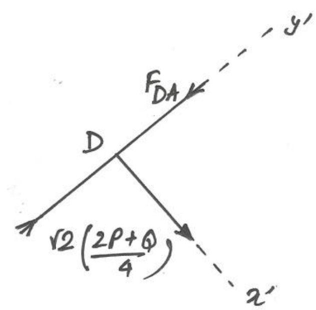
$$V_L = \frac{2P+Q}{4}$$



Joint H

From joint H, $\sum F_y = 0;\ \frac{F_{HD}}{\sqrt{2}} = \frac{2P+Q}{4};\quad F_{HD} = \sqrt{2}\frac{(2P+Q)}{4}\ \ (C)$

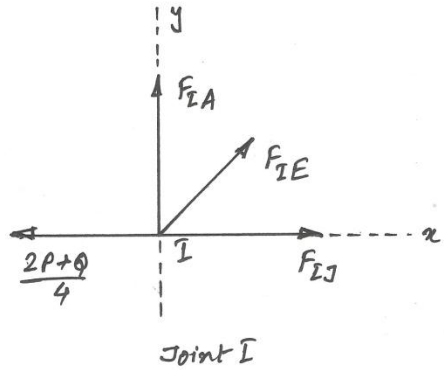
$$\sum F_x = 0; \quad F_{HI} = F_{HD}\frac{1}{\sqrt{2}} = \frac{2P+Q}{4}\ \ (T)$$



Joint D

From joint D, $\sum F_{y'} = 0; \quad F_{DA} = F_{DH} = \sqrt{2}\frac{2P+Q}{4}\ (C)$

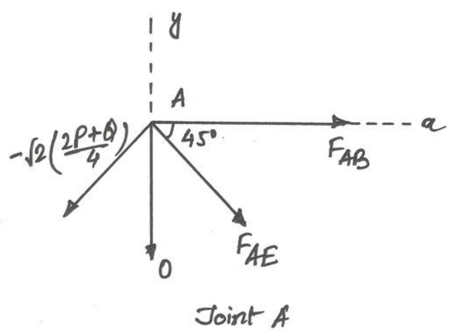
$$\sum F_{x'} = 0; \quad F_{DI} = 0$$



From joint I, $\sum F_y = 0;\quad F_{IA} + F_{IE}\frac{1}{\sqrt{2}} = 0$

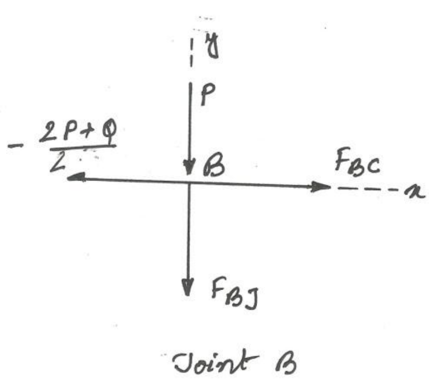
$$\sum F_x = 0;\quad F_{IJ} + F_{IE}\frac{1}{\sqrt{2}} = F_{IH}$$

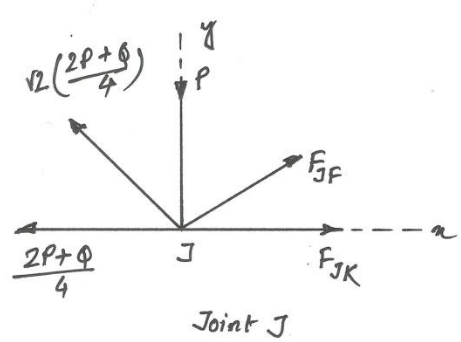
From above two equation $F_{IH} = F_{IJ} = \frac{2P+Q}{4}$ (T) and $F_{IA} = F_{IE} = 0$



From joint A, $\sum F_y = 0;\quad F_{AE}\frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}}\sqrt{2}\frac{2P+Q}{4} = 0;\quad F_{AE} = \sqrt{2}\left(\frac{2P+Q}{4}\right)$ (T)

$$\sum F_y = 0;\quad F_{AB} + F_{AE}\frac{1}{\sqrt{2}} = -\sqrt{2}\left(\frac{2P+Q}{4}\right)\frac{1}{\sqrt{2}};\quad F_{AB} = -\frac{2P+Q}{2}\ (C)$$





From joint B, $\sum F_x = 0;\quad F_{BC} = -\frac{2P+Q}{2}\quad (C)$

$$\sum F_y = 0; \quad F_{BJ} = -P \quad (C)$$

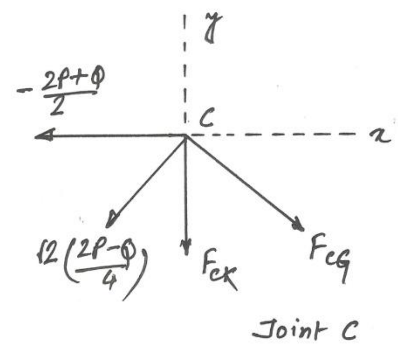
From joint J, $\sum F_y = 0; \quad F_{JF}\frac{1}{\sqrt{2}} - P + \sqrt{2}\left(\frac{2P+Q}{4}\right)\frac{1}{\sqrt{2}} = 0; \quad F_{JF} = \sqrt{2}\left(\frac{2P-Q}{4}\right) \ (T)$

$$\sum F_x = 0; \quad F_{JK} + F_{JF}\frac{1}{\sqrt{2}} = \sqrt{2}\left(\frac{2P+Q}{4}\right)\frac{1}{\sqrt{2}} + \frac{2P+Q}{4}$$

$$F_{JK} = \frac{2P+3Q}{4} \ (T)$$

Same as joint D, at joint F

$$F_{JF} = F_{FC}; \quad F_{FK} = 0$$

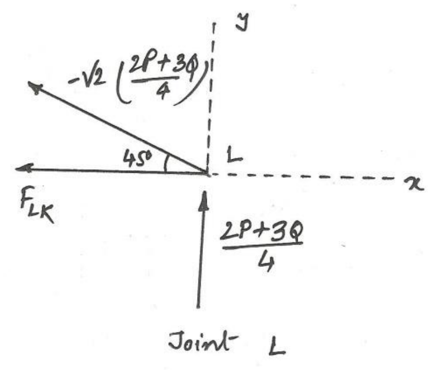


From joint C, $\sum F_x = 0; \quad F_{CG}\frac{1}{\sqrt{2}} = -\frac{2P+Q}{2} + \sqrt{2}\left(\frac{2P-Q}{4}\right)\frac{1}{\sqrt{2}}; \quad F_{CG} = -\sqrt{2}\left(\frac{2P+3Q}{4}\right) \ (C)$

$$\sum F_y = 0; \quad F_{CK} + F_{CG}\frac{1}{\sqrt{2}} + \sqrt{2}\left(\frac{2P-Q}{4}\right)\frac{1}{\sqrt{2}} = 0; \quad F_{CK} = Q \ (T)$$

Same as joint D, at joint G

$$F_{CG} = F_{GL}; \quad F_{GK} = 0$$

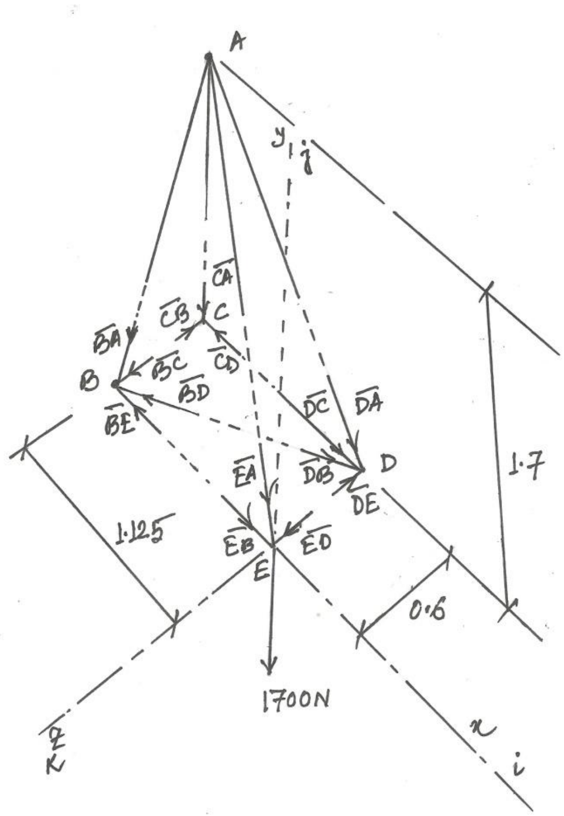


From joint L, $\sum F_x = 0; \; F_{LK} - \sqrt{2}\left(\frac{2P+Q}{4}\right)\frac{1}{\sqrt{2}} = 0; \quad F_{LK} = \frac{2P+3Q}{4} \ (T)$

Member	Force	Type (C: Compression, T: Tension)
HI	$\frac{2P+Q}{4}$	T
HD	$\frac{\sqrt{2}(2P+Q)}{4}$	C
DA	$\frac{\sqrt{2}(2P+Q)}{4}$	C
AI	0	
IE	0	
AE	$\frac{\sqrt{2}(2P+Q)}{4}$	T
EJ	$\frac{\sqrt{2}(2P+Q)}{4}$	T
AB	$\frac{2P+Q}{2}$	C
BJ	P	C
JK	$\frac{2P+3Q}{4}$	T
JF	$\sqrt{2}\left(\frac{2P-Q}{4}\right)$	T
FC	$\sqrt{2}\left(\frac{2P-Q}{4}\right)$	T
BC	$\frac{2P+Q}{2}$	C
CK	Q	T
KG	0	
KL	$\frac{2P+3Q}{4}$	T
FK	0	
CG	$\sqrt{2}\left(\frac{2P+3Q}{4}\right)$	C
GL	$\sqrt{2}\left(\frac{2P+3Q}{4}\right)$	C
IJ	$\frac{2P+Q}{4}$	T

Note: One set of solution is provided. Method of sections is left as home task for the students to compare the above results.

(9)



Co-ordinate of the joints are A(-1.125,1.7,-0.6), B(-1.125,0,0), C(-1.125, 0,-0.6), D(0,0,-0.6) and E(0,0,0)

$$\overline{EB} = EB\left(\frac{1.125i}{\sqrt{1.125^2}}\right)$$

$$\overline{ED} = ED\left(\frac{0.6k}{\sqrt{0.6^2}}\right)$$

$$\overline{EA} = EA\left(\frac{1.125i - 1.7j + 0.6k}{\sqrt{1.125^2 + 1.7^2 + 0.6^2}}\right) = EA(0.53i - 0.8j + 0.3k)$$

$$\bar{P} = -1700j$$

For equilibrium of joint E

$$\overline{EB} + \overline{ED} + \overline{EA} + \bar{P} = 0$$

Replacing the vector value in above equation and equating the coefficients of unit vector i, j and k

$$EB + 0.53EA = 0; \quad -0.8EA - 1700 = 0; \quad ED + 0.3EA = 0$$

This will give $EB = 1126.25\ N\ (C); \quad EA = -2125\ N\ (T); \quad ED = 637.5\ N\ (C)$

$$\overline{DB} = DB\left(\frac{1.125i - 0.6k}{\sqrt{1.125^2 + 0.6^2}}\right) = DB(0.9i - 0.5k)$$

$$\overline{DC} = DC\frac{1.125i}{\sqrt{1.125^2}} = DCi$$

$$\overline{DA} = DA\left(\frac{1.125i - 1.7j}{\sqrt{1.125^2 + 1.7^2}}\right) = DA(0.55i - 0.83j)$$

For equilibrium of joint D

$$\overline{DE} + \overline{DB} + \overline{DC} + \overline{DA} = 0$$

Replacing the vector value in above equation and collecting the coefficient of unit vector

$$0.9DB + DC + 0.55DA = 0; \; -0.83DA = 0; \; -0.5DB - ED = 0$$

This will give $DC = 1147.5\ N\ (C); \quad DA = 0; \quad DB = -1275\ N\ (T)$

$$\overline{BC} = BC\frac{0.6k}{\sqrt{0.6^2}} = BCk$$

$$\overline{BA} = BA\left(\frac{-1.7j + 0.6k}{\sqrt{1.7^2 + 0.6^2}}\right) = BA(-0.94j + 0.33k)$$

For equilibrium of joint B

$$\overline{BE} + \overline{BD} + \overline{BC} + \overline{BA} = 0$$

Replacing the vector value in above equation and collection the coefficient of unit vector

$$0.94BA = 0; \; -0.5(-1275) + BC + 0.33(BA) = 0$$

This will give $BA = 0; \quad BC = -637.5\ N\ (T)$

For joint equilibrium of joint C

$$\overline{CA} + \overline{CB} + \overline{CD} = 0$$

Replacing the vector value in above equation and collection the coefficient of unit vector

$$CA = 0$$

(10)

In the given truss, number of member is $m = 28$, number of joint is $j = 15$

Therefore,

$$m + 3 = 31 > 2j$$

Hence, it is an indeterminate truss and can not be solved by method of sections. However, zero force members may be identified this case. Students are advised to identify those members.