6.2.1 What is the method of sections?

5.2.1 The method of sections is a tool used for determining tensions in the bars of a truss system. It involves passing an imaginary line through the truss, cutting it into sections, each of which includes more than one joint. For the truss to be in equilibrium, each sub-section thus formed should also be in equilibrium.

The method of sections is a method through which a certain bar or set of bars tensions can be found through one or more joints and less than the whole structure.

6.2.2 When is the method of sections most useful?

The method of sections is most useful in the case where the tension of only a few bars of the truss has to be found. Additionally it is useful in simple trusses.

6.2.3 With the free-body diagram associated with one section cut how many bar tensions can you hope to find?

With a single section cut, the tensions of upto 3 bars can be found.

6.2.4 Given a truss and a particular bar in that truss

a) Can you always find one section cut with which you can find the desired bar tension?

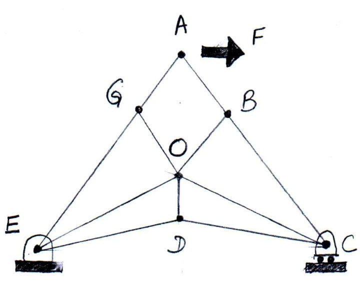
b) If so, how do you find that cut? If not, why not?

c) Whichever your answer above, give an example of a bar in a truss that illustrates your point.

5.2.4 a) No, it is not always possible to find one section cut with which the desired bar tension can be found.

b) It is not always possible to find a section cut because the method of sections has an upper limit of 3 bars through which it can pass. In complex geometries it can often be impossible to find a section cut that passes through 3 bars or less.

c)

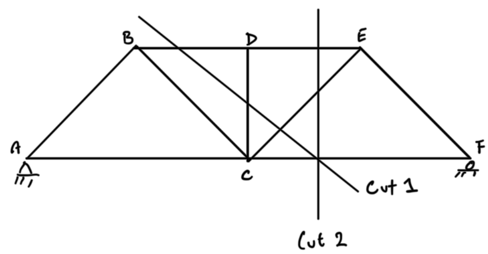


In the given truss system, it is not possible to cut a section which can help us find the tension in member OD.

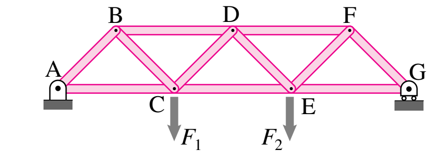
(a) Not necessarily, in certain cases more than one cut may be needed.

(b) The first cut would be such that it cuts the desired bar and the least number of total bars. The next set of cuts then cut one of the bars cut by the first cut, cutting the least number of bars. This process continues until only 3 bars are cut.

(c) Example Truss :



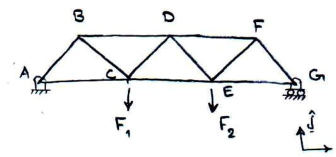
6.2.5 This problem is exactly the same as Sample **??** where it was solved using method of joints. The truss is made up of five horizontal and six inclined rods. All inclined rods are 1 m long and at right angles to each other. The truss carries two vertical loads, $F_1 = 4\,\text{kN}$ and $F_2 = 1\,\text{kN}$ as shown. Find the tensions in rods CE, DE, and DF.



Problem 6.5

5.2.5

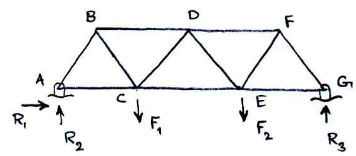
Given that all the inclined rods are 1m long and right angles to each other.



$F_1 = 4\,KN$ and $F_2 = 1\,KN$.

Find the tensions in rods CE, DE & DF.

Consider the FBD of the truss.



Apply force balance for truss, $\sum \underline{F} = \underline{0}$

$\Rightarrow \{R_1\hat{\underline{i}} + R_2\hat{\underline{j}} + R_3\hat{\underline{j}} - F_1\hat{\underline{j}} - F_2\hat{\underline{j}} = \underline{0}\}$

$\{\}\cdot\hat{\underline{i}} \Rightarrow R_1 = 0$

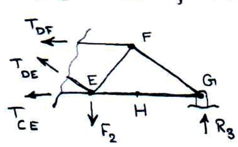
$\{\}\cdot\hat{\underline{j}} \Rightarrow R_2 + R_3 = F_1 + F_2 = 5\,KN$

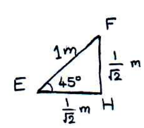
Applying Moment Balance about A, $\sum \underline{M}_{/A} = \underline{0}$

$\Rightarrow \{\sqrt{2}\,m\,\hat{\underline{i}} \times -F_1\hat{\underline{j}} + 2\sqrt{2}\,m\,\hat{\underline{i}} \times -F_2\hat{\underline{j}} + 3\sqrt{2}\,m\,\hat{\underline{i}} \times R_3\hat{\underline{j}} = \underline{0}\}$

$\Rightarrow \{\}\cdot\hat{\underline{k}} \Rightarrow R_3 = \dfrac{F_1 + 2F_2}{3} \Rightarrow R_3 = 2\,KN \Rightarrow R_2 = 3\,KN$

To find the tensions in rods CE, DE and DF, we use method of Sections. The section is cut through CE, DE and DF. Consider the FBD of the cut truss consisting of E, F and G joints as shown.





Applying Moment Balance about E, $\sum \underline{M}_{/E} = \underline{0}$

$\Rightarrow \left\{\frac{1}{\sqrt{2}}m\hat{\underline{j}} \times -T_{DF}\hat{\underline{i}} + \sqrt{2}\,\hat{\underline{i}}\,m \times R_3\hat{\underline{j}} = \underline{0}\right\}$

$\{\}\cdot\hat{\underline{k}} \Rightarrow \boxed{T_{DF} = -4\,KN}$

Applying force balance, $\sum \underline{F} = \underline{0}$

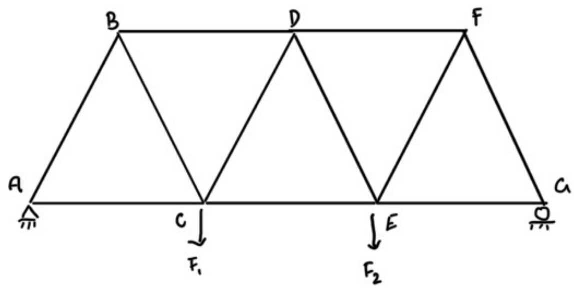
$\Rightarrow \{-T_{CE}\hat{\underline{i}} - T_{DF}\hat{\underline{i}} - T_{DE}\cos 45^\circ\hat{\underline{i}} + T_{DE}\sin 45^\circ\hat{\underline{j}} - F_2\hat{\underline{j}} + R_3\hat{\underline{j}} = \underline{0}\}$

$\{\}\cdot\hat{\underline{j}} \Rightarrow T_{DE} = \dfrac{(F_2 - R_3)}{\sin 45^\circ} \Rightarrow \boxed{T_{DE} = -\sqrt{2}\,KN}$

$\{\}\cdot\hat{\underline{i}} \Rightarrow -T_{CE} - T_{DF} - \dfrac{T_{DE}}{\sqrt{2}} = 0 \Rightarrow \boxed{T_{CE} = 5\,KN}$

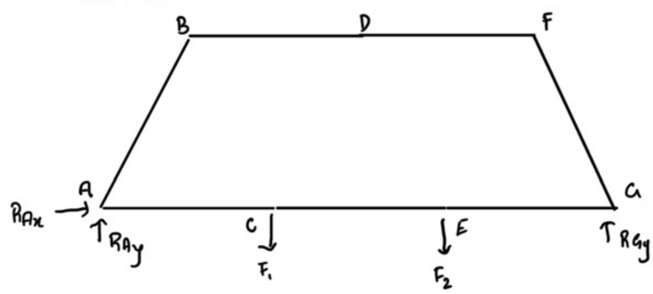
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Sketch:



To Find: T_{CE}, T_{CD}, T_{DF}

FBD (Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

$$\Rightarrow R_{Ax}\hat{i} + (R_{Ay} - 4kN - 1kN + R_{Gy}) = 0$$

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

$$\Sigma F_y = 0$$

$$\Rightarrow R_{Ay} + R_{Gy} = 5kN$$

$$\Sigma \vec{M}_{/A} = (\vec{r}_{AC} \times (-F_1)\hat{j}) + (\vec{r}_{AE} \times (-F_2)\hat{j}) + (\vec{r}_{AG} \times R_{Gy}\hat{j}) = \vec{0}$$

$$\Rightarrow (1m\hat{i} \times -4kN\hat{j}) + (2m\hat{i} \times -1kN\hat{j}) + (3m\hat{i} \times R_{Gy}\hat{j}) = \vec{0}$$

$$\Rightarrow -4m\,kN\hat{k} - 2m\,kN\hat{k} + 3R_{Gy}\,m\hat{k} = \vec{0}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

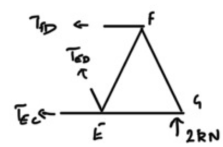
$$\Rightarrow \; 3 R_{Gy}\, m\, \hat{k} = 6\, m\, kN\, \hat{k}$$

$$\Rightarrow \; R_{Gy} = 2\ kN$$

$$\Rightarrow \; R_{Ay} = 3\ kN$$

Find T_{CE}, T_{CD}, T_{DF},

FBD (Section):



$$\sum F_x = 0$$

$$\Rightarrow \; -T_{EC} - T_{ED}\cos 60 - T_{FD} = 0$$

$$\sum F_y = 0$$

$$\Rightarrow \; T_{ED}\sin 60 + 2kN = 0$$

$$\Rightarrow \; T_{ED} = -\frac{4}{\sqrt{3}}\ kN$$

$$\boxed{T_{DE} = \frac{4}{\sqrt{3}}\ kN}$$

$$\sum \vec{M}_{/E} = (\vec{r}_{EG} \times R_{Gy}\hat{j}) + (\vec{r}_{EF} \times \vec{T}_{FD}) = \vec{0}$$

$$\Rightarrow \; (2kN\, m + T_{FD}\, m)\,\hat{k} = \vec{0}$$

$$\Rightarrow \; T_{FD} = -2\ kN$$

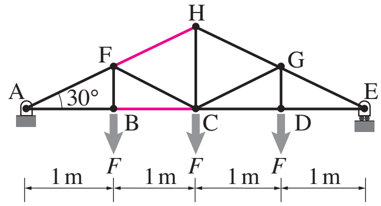
$$\boxed{T_{DF} = 2kN}$$

$$\Rightarrow \; T_{EC} = 2\left(1 + \frac{1}{\sqrt{3}}\right) kN$$

$$\boxed{T_{CE} = -2\left(1 + \frac{1}{\sqrt{3}}\right) kN}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

6.2.6 For the truss shown in the figure, find the tensions in rods BC and FH, assuming $F = 10\,\text{kN}$.



Problem 6.6

5.2.6 To find reactions at A & E

In fig (1)

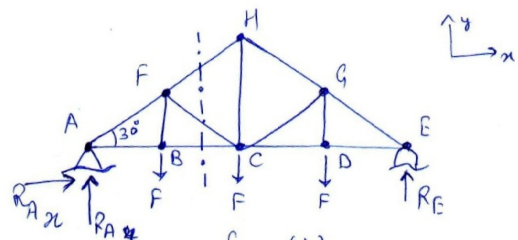


fig.(1)

$[\sum \vec{M}_A = \vec{0}]\cdot\hat{k}$

$\Rightarrow -F - 2F - 3F + R_E \times 4 = 0$

$\Rightarrow \boxed{R_E = \frac{3F}{2}}$

$[\sum \vec{F} = \vec{0}]\cdot\hat{i}$

$\Rightarrow \boxed{R_{Ax} = 0}$

$[\sum \vec{F} = \vec{0}]\cdot\hat{j}$

$\Rightarrow R_{Ay} + R_E - 3F = 0$

$\Rightarrow \boxed{R_{Ay} = \frac{3F}{2}}$

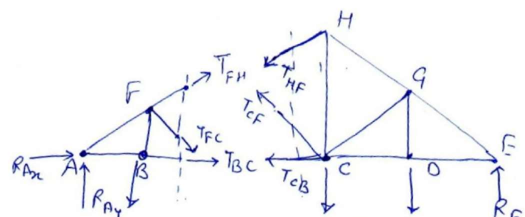


fig (11) fig (111)

Now In figure (11)

$[\sum \vec{M}_F = \vec{0}]\cdot\hat{k}$

$\Rightarrow \left[-\frac{3F}{2} + T_{BC}\tan 30^\circ\right] = 0$

$T_{BC} = \frac{3F}{2\tan 30^\circ} = 25.98\ \text{KN}$

$\boxed{T_{BC} = 25.98\ \text{KN}}$

In figure (111)

$[\sum \vec{M}_C = \vec{0}]\cdot\hat{k}$

$\Rightarrow 2\sin 30^\circ \cdot T_{FH} - F + \frac{3F}{2}\times 2 = 0$

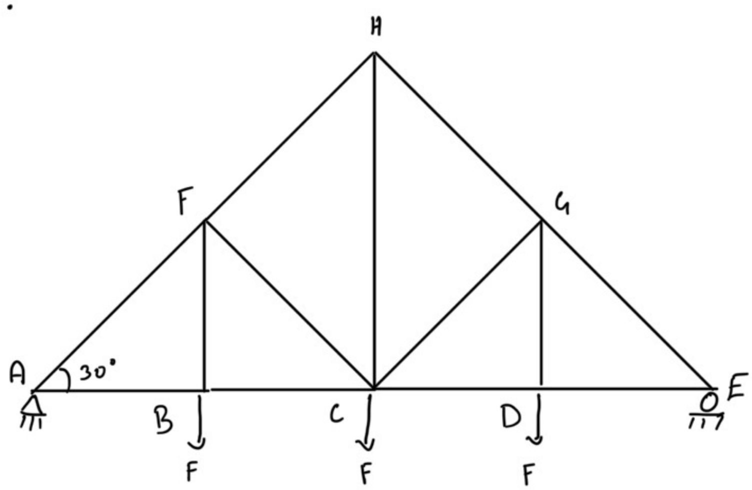
$\Rightarrow T_{FH} = \frac{-F}{\sin 30^\circ}$

$T_{FH} = -2F$

$\boxed{T_{FH} = -20\ \text{KN}}$

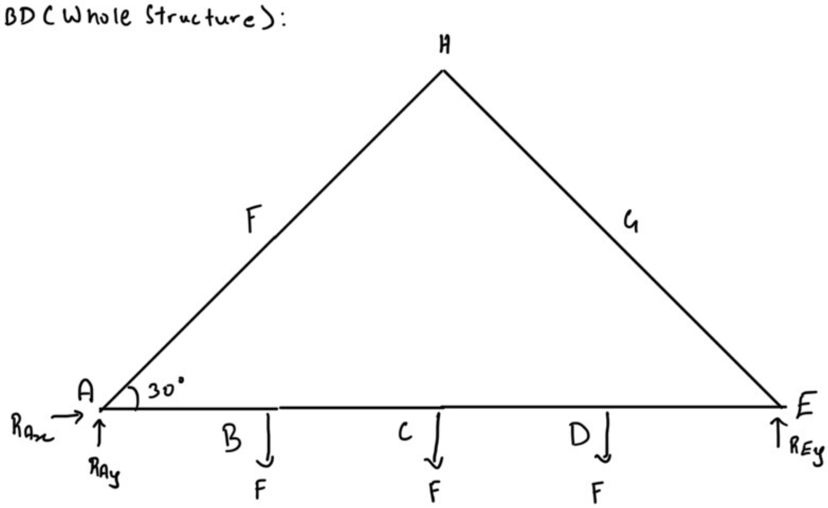
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Sketch :



$\boxed{\text{To Find}: T_{BC}, T_{FH}}$

FBD (Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

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

$$\Sigma F_y = 0$$

$$\Rightarrow R_{Ay} - 10kN - 10kN - 10kN + R_{Ey} = 0$$

$$\Rightarrow R_{Ay} + R_{Ey} = 30\,kN$$

$$\sum \vec{M}_{/A} = (\vec{r}_{AB} \times (-F)\hat{j}) + (\vec{r}_{AC} \times (-F)\hat{j}) + (\vec{r}_{AD} \times (-F)\hat{j}) + (\vec{r}_{AE} \times R_{Ey}\hat{j}) = \vec{0}$$

$$\Rightarrow (-10\,kN - 20\,kN - 30\,kN + 4R_{Ey})\hat{k} = \vec{0}$$

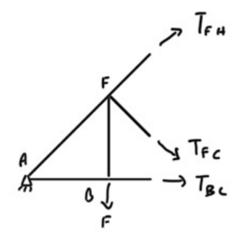
$$\Rightarrow 4R_{Ey} = 60\,kN$$

$$\Rightarrow R_{Ey} = 15\,kN$$

$$\Rightarrow R_{Ay} = 15\,kN$$

Find T_{FH}, T_{BC},

FBD (Section):



$$\sum F_x = 0$$

$$\Rightarrow T_{BC} + T_{FH}\cos 30 + T_{FC}\cos 30 = 0 \quad -(i)$$

$$\sum F_y = 0$$

$$= T_{BC} + T_{FH}\sin 30 - T_{FC}\sin 30 = -30\,kN \quad -(ii)$$

$$\sum \vec{M}_{/F} = (\vec{r}_{FA} \times (R_{Ax}\hat{i} + R_{Ay}\hat{j})) + (\vec{r}_{FB} \times T_{BC}\hat{i}) = \vec{0}$$

$$= ((-\hat{i} - \tan 30\hat{j})m \times R_{Ay}\hat{j}) + (-\tan 30\, m\hat{j} \times T_{BC}\hat{i}) = \vec{0}$$

$$\Rightarrow R_{Ay}\hat{k} - T_{BC}\tan 30\hat{k} = \vec{0}$$

$$\boxed{T_{BC} = 15\sqrt{3}\,kN}$$

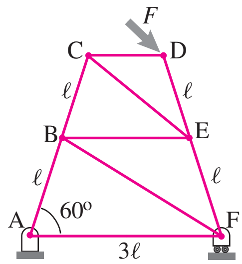
$\sin 30\,(i) + \cos 30\,(ii)$

$$30\sqrt{3}\,kN + 2T_{FH}\cos 30\sin 30 = 30\frac{\sqrt{3}}{2}\,kN$$

$$\boxed{T_{FH} = -30\,kN}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

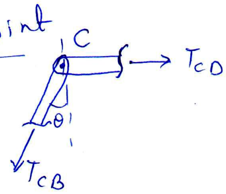
6.2.7 A force $F = 3\,\text{kN}$ acts at 45° with the horizontal at joint D of the truss shown in the figure. Find the tension in rod BE.

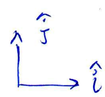


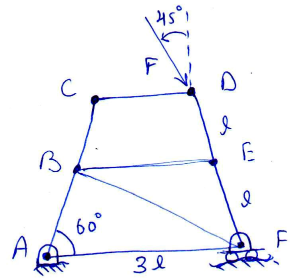
Problem 6.7

5.2.7

At point C







$\sum \vec{F} = \vec{0}$

$\Rightarrow \{ T_{CD}\,\hat{i} + T_{BC}\cos\theta\,(-\hat{j}) + T_{BC}\sin\theta\,(-\hat{i}) = \vec{0} \}$

$\Rightarrow \left[\sum \vec{F} = \vec{0}\right]\cdot\hat{j} \Rightarrow -T_{BC}\sin\theta = 0$

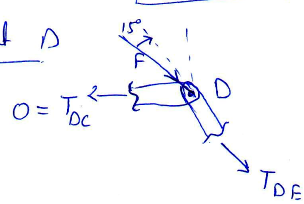
$\therefore \boxed{T_{BC} = 0}$

$\Rightarrow \left[\sum \vec{F} = \vec{0}\right]\cdot\hat{i}$

$\Rightarrow T_{CD} - \cancel{T_{BC}}^{\,0}\sin\theta = 0$

$\Rightarrow \boxed{T_{CD} = 0}$

At point D

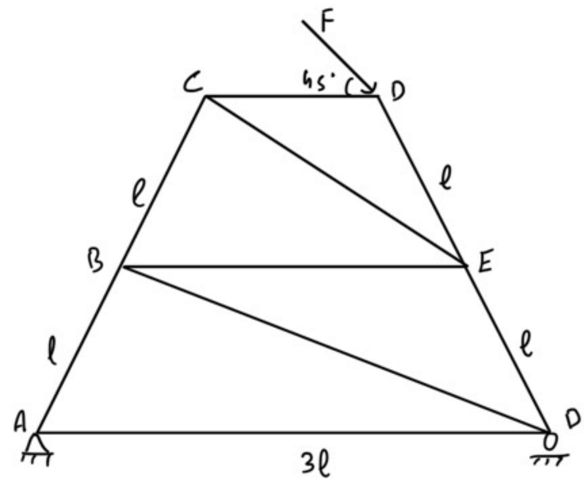


There is no bar tension to balance the part of F that is perpendicular to DE.

So problem is indeterminate, can't be solved.

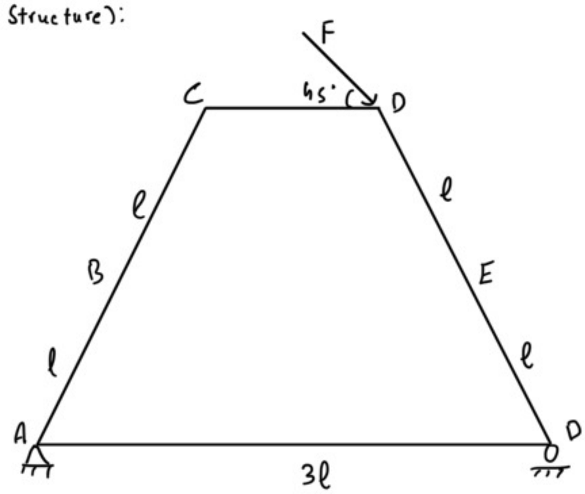
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Sketch:



$\boxed{\text{To Find : } T_{BE}}$

FBD (Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

$$\Rightarrow \quad 3\,\text{kN} \cos 45 + R_{Ax} = 0$$

$$\Rightarrow \quad R_{Ax} = -\frac{3}{\sqrt{2}}\ \text{kN}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

$$\sum F_y = 0$$

$$\Rightarrow 3\,kN \sin 45 + R_{Ay} + R_{Fy} = 0$$

$$\Rightarrow R_{Ay} + R_{Fy} = -\frac{3}{\sqrt{2}}\,kN$$

$$\sum \vec{M}_{/A} = \left(\vec{r}_{AD} \times \left(\frac{1}{\sqrt{2}}\hat{i} - \frac{1}{\sqrt{2}}\hat{j}\right) F\right) + \left(\vec{r}_{AO} \times R_{Dy}\hat{j}\right) = \vec{0}$$

$$= \left(\left((2\ell\cos 60 + \ell)\hat{i} + (2\ell \sin 60)\hat{j}\right) \times \left(-\frac{3}{\sqrt{2}}kN\,\hat{i} - \frac{3}{\sqrt{2}}kN\,\hat{j}\right)\right)$$

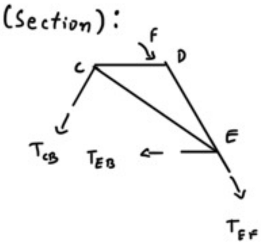
$$+ \left(3\ell\hat{i} \times R_{Ey}\hat{j}\right) = \vec{0}$$

$$\Rightarrow 3\left(3\sqrt{1.5} - \sqrt{2}\right)\ell\,kN\,\hat{k} + 3R_{Ey}\hat{k} = \vec{0}$$

$$\Rightarrow R_{Ey} = \left(3\sqrt{\frac{3}{2}} - \sqrt{2}\right)\ell\,kN$$

Find T_{EB},

FBD(Section):



$$\sum F_x = 0$$

$$\Rightarrow F\cos 45 - T_{EB} - T_{CB}\cos 75$$

$$+ T_{EF}\cos 75 = 0 \qquad -(i)$$

$$\sum F_y = 0$$

$$\Rightarrow -F\sin 45 - T_{CB}\sin 75 - T_{EF}\sin 75 = 0 \qquad -(ii)$$

$$\sum \vec{M}_{/E} = \left(\vec{r}_{EC} \times \vec{T}_{CB}\right) + \left(\vec{r}_{ED} \times \vec{F}\right) = \vec{0}$$

$$= \left((-\ell\cos 75 - \ell)\hat{i} + (\ell \sin 75)\hat{j}\right) \times \vec{T}_{CB}$$

$$+ \left(-\ell\cos 75\,\hat{i} + \ell\sin 75\,\hat{j}\right) \times \left(F\cos 45\hat{i} - F\sin 45\hat{j}\right) = \vec{0}$$

$$\Rightarrow [\ell\, T_{CB}\sin 75 + F\ell\left(\sin 45\cos 75 - \sin 75 \cos 45\right)\hat{k} = \vec{0}$$

$$\Rightarrow T_{CB} = -F(\sin 45 \cot 75 - \cos 45)$$

$\sin 75$ (i) + $\cos 75$ (ii)

$$F(\cos 45 \sin 75 - \sin 45 \cos 75) - T_{EB}\sin 75 - T_{CB}(\cos 75 + \sin 75) = 0$$

$$\Rightarrow F(\cos 45 \sin 75 - \sin 45 \cos 75 + \sin 45 \cot 75 - \cos 45)(\cos 75 + \sin 75) - T_{EB}\sin 75 = 0$$

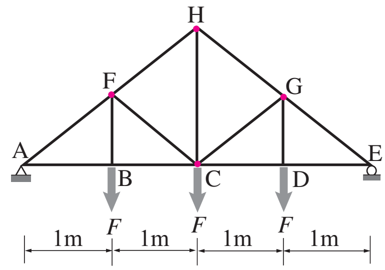
$$\Rightarrow T_{EB} = F\left(\cos 45 - \sin 45 \cot 75 + \frac{\sin 45 \cot 75}{\sin 75} - \frac{\cos 45}{\sin 75}\right)(\cot 75 + 1)$$

$$T_{BE} = -F\left(\cos 45 - \sin 45 \cot 75 + \frac{\sin 45 \cot 75}{\sin 75} - \frac{\cos 45}{\sin 75}\right)(\cot 75 + 1)$$

$$= -0.023F$$

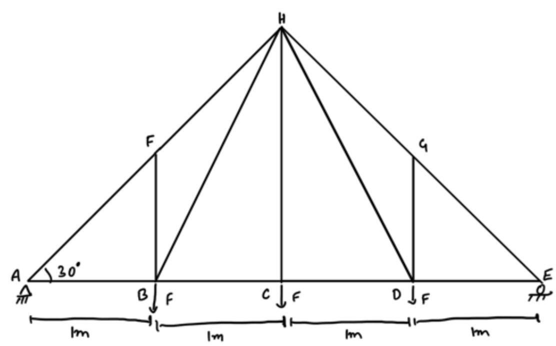
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

6.2.8 For the 2m high truss shown, find the forces in bars FH, FB, and BC. Use $F = 10\,\text{kN}$. Now pretend that bars FC and CG are removed and two new bars BH and HD are put in. Find the forces in bars FH, FB, and BC again. Are the forces different now? Why?



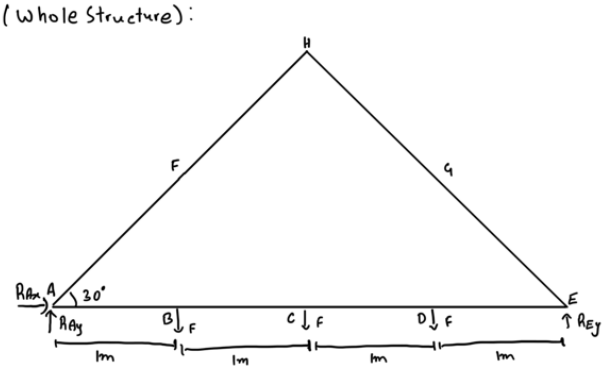
Problem 6.8

Sketch:



$\boxed{\text{To Find}: T_{FH}, T_{FB}, T_{BC}}$

FBD (Whole Structure):



Finding Reaction Forces,

$$\Sigma F_x = 0$$

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

$$\Sigma F_y = 0$$

$$\Rightarrow R_{Ay} - 30\,\text{kN} + R_{Ey} = 0$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

$$\Rightarrow \quad R_{Ay} + R_{Ey} = 30 kN$$

$$\sum \vec{M}_{/A} = (\vec{r}_{AB} \times (-F)\hat{j}) + (\vec{r}_{AC} \times (-F)\hat{j}) + (\vec{r}_{AD} \times (-F)\hat{j}) + (\vec{r}_{AE} \times R_{Ey}\hat{j}) = \vec{0}$$

$$\Rightarrow (10 m kN + 20 m kN + 30 kN + 4m R_{Ey})\hat{k} = \vec{0}$$

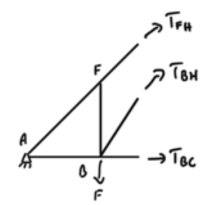
$$\{\ \}\cdot\hat{k} \Rightarrow R_{Ey} = -15 kN$$

$$\Rightarrow R_{Ay} = 45 kN$$

Find T_{BC} and T_{FH},

$$\sum F_x = 0$$

FBD (Section):



$$T_{BC} + \frac{T_{BH}}{\sqrt{3}} + \frac{T_{FH}}{\sqrt{2}} = 0 \qquad -(i)$$

$$\sum F_y = 0$$

$$\frac{2T_{BH}}{\sqrt{3}} + \frac{T_{FH}}{\sqrt{2}} + 45 kN = 0 \qquad -(ii)$$

$$\sum \vec{M}_{/A} = (\vec{r}_{AB} \times (-F)\hat{j}) + \left(\vec{r}_{AB} \times \left(\frac{1}{\sqrt{3}}\hat{i} + \frac{2}{\sqrt{3}}\hat{j}\right)T_{BH}\right)$$

$$= (1m\hat{i} \times -10kN\hat{j}) + \left(1m\hat{i} \times \left(\frac{1}{\sqrt{3}}T_{BH}\hat{i} + \frac{2}{\sqrt{3}}T_{BH}\hat{j}\right)\right)$$

$$\Rightarrow -10 kN m\hat{k} + \frac{2}{\sqrt{3}}T_{BH}\hat{k} = \vec{0}$$

$$\Rightarrow \quad T_{BH} = 5\sqrt{3} kN$$

(i) - (ii)

$$T_{BC} - T_{BH}\left(\frac{-1}{\sqrt{3}}\right) = 45 kN$$

$$\boxed{T_{BC} = 40 kN}$$

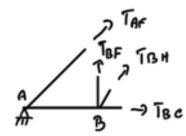
Substituting in (ii)

$$\boxed{T_{FH} = -55\sqrt{2} kN}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Find T_{BF}.

FBD (Section):



$$\sum F_x = 0$$

$$\Rightarrow T_{BC} + \frac{T_{BH}}{\sqrt{3}} + \frac{T_{AH}}{\sqrt{2}} = 0$$

$$\Rightarrow \qquad T_{AH} = -55\sqrt{2}\ kN$$

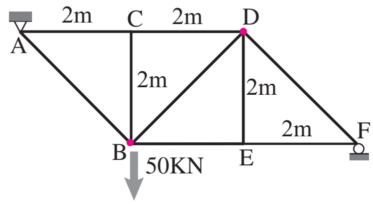
$$\sum F_y = 0$$

$$\Rightarrow \frac{2T_{BH}}{\sqrt{3}} + \frac{T_{AH}}{\sqrt{2}} + T_{BF} = 0$$

$$\Rightarrow \qquad T_{BF} = 45\ kN$$

$$\boxed{T_{FB} = -45\ kN}$$

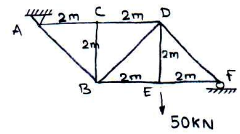
6.2.9 Find the forces in bars BC and BD in the truss shown in the figure. How does the force change in each of these bars if the load is moved to joint B from joint E?



Problem 6.9

5.2.9

Case 1: Find tension in bars BC & BD when the load is at E.

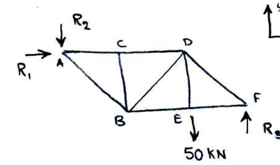


Applying force balance to the truss,

$\Sigma \underline{F} = \underline{0} \Rightarrow \{ R_1 \hat{\underline{i}} - R_2 \hat{\underline{j}} - 50\text{KN}\,\hat{\underline{j}} + R_3 \hat{\underline{j}} = \underline{0} \}$

$\{\}\cdot\hat{\underline{i}} \Rightarrow R_1 = 0$ —(1)

$\{\}\cdot\hat{\underline{j}} \Rightarrow R_3 - R_2 = 50\,\text{KN}$ —(2)



Applying Moment balance about A, $\Sigma \underline{M}_{/A} = \underline{0}$

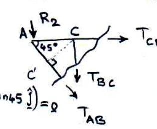
$\Rightarrow \{ 4\text{m}\,\hat{\underline{i}} \times -50\text{KN}\,\hat{\underline{j}} + 6\text{m}\,\hat{\underline{i}} \times R_3 \hat{\underline{j}} = \underline{0} \}$

$\{\}\cdot\hat{\underline{k}} \Rightarrow R_3 = 33.33\,\text{KN}$ —(3)

From (2) and (3), $R_2 = -16.67\,\text{KN}$ —(4)

Consider the FBD with the section cut through AB, BC and CD.

Moment balance about C, $\Sigma \underline{M}_{/C} = \underline{0}$



$CC' = AC \sin 45°$

$CC' = \sqrt{2}\,\text{m}$

$\Rightarrow -2\text{m}\,\hat{\underline{i}} \times -R_2 \hat{\underline{j}} + [\sqrt{2}\,\text{m} \cos 45 (-\hat{\underline{i}}) + \sqrt{2}\,\text{m} \sin 45 (-\hat{\underline{j}})] \times (T_{AB} \cos 45 \hat{\underline{i}} - T_{AB} \sin 45 \hat{\underline{j}}) = \underline{0}$

$\Rightarrow 2\text{m}\, R_2 \hat{\underline{k}} + \sqrt{2}\,\text{m} \frac{1}{2} T_{AB} \hat{\underline{k}} + \sqrt{2}\,\text{m} \frac{1}{2} T_{AB} \hat{\underline{k}} = \underline{0}$

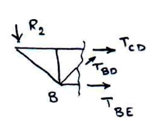
$\Rightarrow T_{AB} = -\sqrt{2} R_2 \Rightarrow T_{AB} = 23.57\,\text{KN}$ —(5)

Force balance, $\Sigma \underline{F} = \underline{0} \Rightarrow \{ T_{AB} \cos 45 \hat{\underline{i}} - T_{AB} \sin 45 \hat{\underline{j}} - T_{BC} \hat{\underline{j}} + T_{CD} \hat{\underline{i}} - R_2 \hat{\underline{j}} = \underline{0} \}$

$\{\}\cdot\hat{\underline{i}} \Rightarrow T_{CD} = -\frac{T_{AB}}{\sqrt{2}} = R_2 \Rightarrow T_{CD} = -16.67\,\text{KN}$

$\{\}\cdot\hat{\underline{j}} \Rightarrow T_{BC} = -\frac{T_{AB}}{\sqrt{2}} - R_2 \Rightarrow \boxed{T_{BC} = 0\text{N}}$

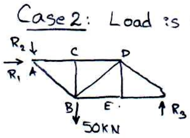
To find T_{BD}, Consider the FBD with the section cut through CD, BD and BE.



Applying Force balance in $\hat{\underline{j}}$ direction, $T_{BD} \sin 45 - R_2 = 0$

$\Rightarrow \boxed{T_{BD} = -23.57\,\text{KN}}$

Case 2: Load is moved to 'B'



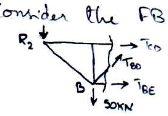
Apply Moment balance about A, $\Sigma \underline{M}_{/A} = \underline{0} \Rightarrow \{ 2\text{m}\,\hat{\underline{i}} \times -50\text{KN}\,\hat{\underline{j}} + 6\text{m}\, R_3 \hat{\underline{k}} = \underline{0} \}\cdot\hat{\underline{k}}$

$\Rightarrow R_3 = 16.67\,\text{KN}$

Using LMB (2) $R_2 = -33.33\,\text{KN}$.

As the analysis of the section cut through AB, BC & CD done in case 1 is still applicable, $T_{AB} = -\sqrt{2} R_2 = 47.13\,\text{KN}$ and $\boxed{T_{BC} = 0\text{N}}$

Consider the FBD, applying force balance in $\hat{\underline{j}}$ direction, $T_{BD} \sin 45 - R_2 - 50\,\text{KN} = 0$

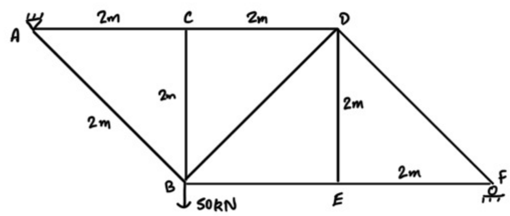


$\Rightarrow \boxed{T_{BD} = 23.57\,\text{KN}}$

When load is moved to B, compression in BD changes to tension of same magnitude.

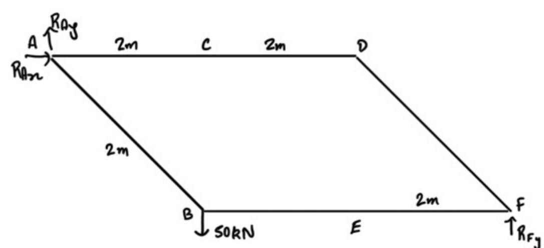
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Sketch:



$\boxed{\text{To Find : } T_{BC}, T_{BD}}$

FBD (Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

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

$$\Sigma F_y = 0$$

$$\Rightarrow R_{Ay} + R_{Fy} = 50kN$$

$$\Sigma \vec{M}_{/A} = \vec{0}$$

$$= (2m\hat{i} - 2m\hat{j}) \times (-50kN\hat{j}) + (6m\hat{i} - 2m\hat{j}) \times R_{Fy}$$

$$= (-100kNm + 6mR_{Fy})\hat{k} = \vec{0}$$

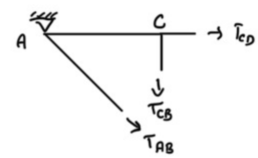
$$\Rightarrow R_{Fy} = \frac{50}{3} kN$$

$$\Rightarrow R_{Ay} = \frac{100}{3} kN$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Find T_{CB},

FBD (Section):



$\Sigma F_x = 0$

$\Rightarrow T_{CD} + \frac{T_{AB}}{\sqrt{2}} = 0$

$\Sigma F_y = 0$

$\Rightarrow -T_{CB} - \frac{T_{AB}}{\sqrt{2}} + \frac{100}{\sqrt{3}} \text{ kN} = 0$

$\Sigma \vec{M}_{/A} = \vec{r}_{AC} \times T_{CB}\,\hat{j}$

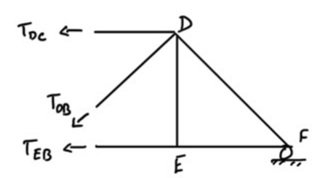
$= 2m\hat{i} \times T_{CB}\,\hat{j} = 0$

$\Rightarrow T_{CB} = 0$

$\boxed{T_{BC} = 0\text{N}}$

Find T_{DB},

FBD (Section):



$\Sigma F_x = 0$

$\Rightarrow -T_{EB} - \frac{T_{DB}}{\sqrt{2}} - T_{DC} = 0$

$\Sigma F_y = 0$

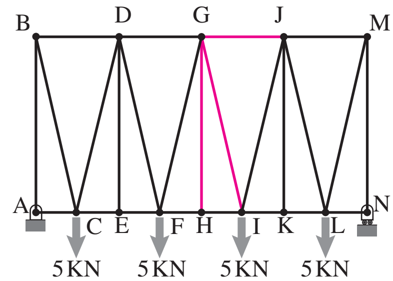
$\Rightarrow -\frac{T_{DB}}{\sqrt{2}} + R_{Fy} = 0$

$\Rightarrow T_{DB} = \frac{50}{3}\sqrt{2} \text{ kN}$

$\boxed{T_{BD} = -\frac{50}{3}\sqrt{3} \text{ kN}}$

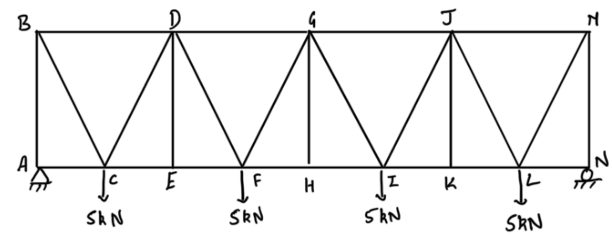
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

6.2.10 For the truss shown in the figure, assume that AC=CE=1 m, and AB=BD=2 m. The rest of the bays are identical to bay ABDE. For the given loads, find the tensions in rods GH, GI, and GJ. [Hint: you can use information about zero-force members.]



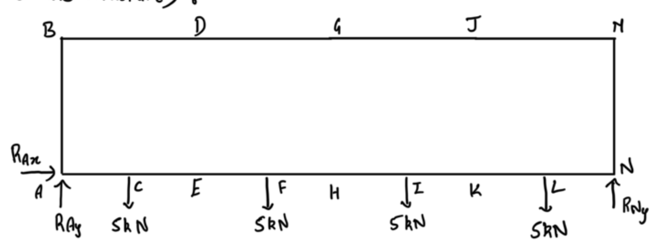
Problem 6.10

Sketch:



$\boxed{\text{To Find : } T_{GH}, T_{GI}, T_{GJ}}$

FBD (Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

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

$$\Sigma F_y = 0$$

$$\Rightarrow R_{Ay} - 20kN + R_{Ny} = 0$$

$$\Rightarrow R_{Ay} + R_{Ny} = 20kN$$

$$\Sigma \vec{M}_{/A} = (\vec{r}_{AC} \times (-5kN)\hat{j}) + (\vec{r}_{AF} \times (-5kN)\hat{j}) + (\vec{r}_{AI} \times (-5kN)\hat{j})$$

$$+ (\vec{r}_{AL} \times (-5kN)\hat{j}) + (\vec{r}_{AN} \times R_{Ny}\hat{j}) = \vec{0}$$

$$= (1m\hat{i} \times (-5kN)\hat{j}) + (3m\hat{i} \times (-5kN\hat{j})) + (5m\hat{i} \times (-5kN\hat{j}))$$

$$+ (7m\hat{i} \times (-5kN)\hat{j}) + (8m\hat{i} \times R_{Ny}\hat{j}) = \vec{0}$$

$$= ((-5 - 15 - 25 - 35)\ kN + 8\ R_{Ny})\,m\,\hat{k} = \vec{0}$$

$$\Rightarrow R_{Ny} = 10\ kN$$

$$\Rightarrow R_{Ay} = 10kN$$

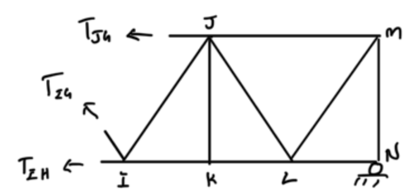
Find T_{GH},

Since vertical bars are zero force members,

$$\boxed{T_{GH} = 0N}$$

Finding T_{IG}, T_{JG}

FBD (Section):



$$\sum f_x = 0$$

$$\Rightarrow -T_{IH} - \frac{T_{IG}}{\sqrt{3}} - T_{JG} = 0$$

$$\sum F_y = 0$$

$$\Rightarrow \frac{2T_{IG}}{\sqrt{3}} + R_{Ny} = 0$$

$$\boxed{T_{IG} = -5\sqrt{3}\ kN}$$

$$\sum \vec{M}_{/I} = (\vec{r}_{IN} \times R_{Ny}\hat{j}) + (\vec{r}_{IJ} \times (-T_{JG})\hat{i})$$

$$= (3m\hat{i} \times 10\ kN\,\hat{j}) + ((1m\,\hat{i} + 2m\,\hat{j}) \times (-T_{JG}\,\hat{i}))$$

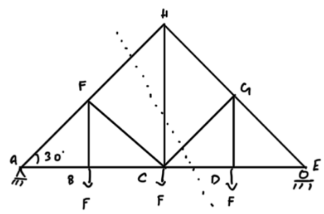
$$\Rightarrow (30kN + 2T_{JG})\,m\,\hat{k} = \vec{0}$$

$$\Rightarrow T_{JG} = -15\ kN$$

$$\boxed{T_{GJ} = 15kN}$$

6.2.11 Consider the truss shown in Problem 6.2.6. Find the tension in rod CH. [Hint: you may have to use multiple sections or solve Problem 6.2.6 first.]

Sketch:



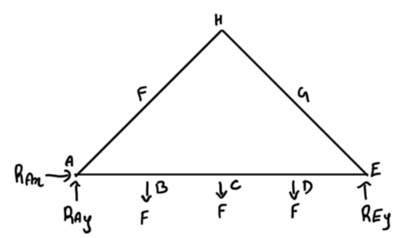
$\boxed{\text{To Find}: T_{CH}}$

From 6.2.6,

$R_{Ey} = 15\text{ kN}$

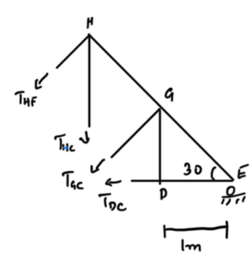
$T_{HF} = 30\text{ kN}$

FBD (Whole Structure):



Finding T_{HC},

FBD (Section):



$\Sigma F_x = 0$

$$T_{HF}\cos 60 - T_{GC}\cos 60 - T_{DC} = 0$$

$$\frac{T_{GC}}{2} + T_{DC} = -15\text{ kN} \quad -(i)$$

$\Sigma F_y = 0$

$$-T_{HC} - T_{HF}\sin 60 - T_{GC}\sin 60 + 30\text{ kN} = 0$$

$$-T_{HC} - 15\sqrt{3}\text{ kN} - \frac{\sqrt{3}\,T_{GC}}{2} + 30\text{ kN} = 0$$

$$T_{HC} + \frac{\sqrt{3}}{2}T_{GC} = 15(\sqrt{3}-2)\text{ kN}$$

$$\Sigma \vec{M}_{/H} = \vec{0}$$

$$= (\vec{r}_{HG} \times \vec{T}_{GC}) + (\vec{r}_{HD} \times \vec{T}_{DC}) + (\vec{r}_{HE} \times R_{Ey}\hat{j}) = \vec{0}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

$$= (1m\cos 60\,\hat{\imath} - 1m\sin 60\,\hat{\jmath}) \times T_{GC} + (\cos 60\,\hat{\imath} - (1m\sin 60 + \tfrac{1}{2}m)\,\hat{\jmath}) \times T_{DC}$$

$$+ (2m\cos 60\,\hat{\imath} - 2m\sin 60\,\hat{\jmath}) \times R_{Ey}\,\hat{\jmath} = \vec{0}$$

$$= \left(-\cos 60 \sin 60\, m\, T_{GC} - \sin 60 \cos 60\, m\, T_{GC} - \sin 60\, m\, T_{DC} + \frac{T_{DC}}{2} + 15\, m\, kN\right)\hat{k} = \vec{0}$$

$$\Rightarrow -2\sin 60\cos 60\, m\, T_{GC} - T_{DC}\left(\sin 60 + \frac{1}{2}\right) = -15\ kNm$$

$$\Rightarrow \qquad -\frac{\sqrt{3}}{2}T_{GC} - \frac{1+\sqrt{3}}{2}T_{DC} = -15\ kNm \qquad -\ (ii)$$

$\sqrt{3}\,(i) + (ii)$

$$T_{DC}\left(\sqrt{3} - \frac{1+\sqrt{3}}{2}\right) = -15\sqrt{3}\ kNm - 15\ kNm$$

$$\Rightarrow \qquad T_{DC}\,(1+\sqrt{3}) = -15(1+\sqrt{3})\ kNm$$

$$\Rightarrow \qquad T_{DC} = -15\ kNm$$

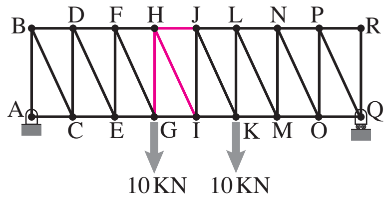
$$\Rightarrow \qquad T_{GC} = -60\ kNm$$

$$\Rightarrow \qquad T_{HC} = (15(\sqrt{3}-2) - 30\sqrt{3})\ kN$$

$$= 15(\sqrt{3} - 2 - 2\sqrt{3})\ kN$$

$$\boxed{T_{CH} = -15(2+\sqrt{3})\ kN}$$

6.2.12 The truss shown in the figure consists of 8 'N' bays. In each bay, the vertical rod is 2 m long and the horizontal rod is 1 m long. For the given loads, find the tensions in rods HJ, HI, and GH.

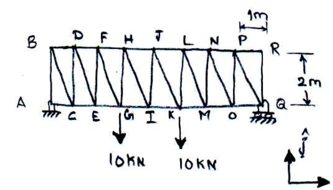


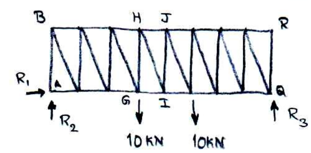
Problem 6.12

5.2.12

Find the tensions in rods HJ, HI & GH.

Consider the FBD of the truss shown in the figure.





Applying force balance, $\sum \underline{F} = \underline{0}$

$\Rightarrow \{R_1\,\hat{\imath} + R_2\,\hat{\jmath} - 10\,\text{kN}\,\hat{\jmath} - 10\,\text{kN}\,\hat{\jmath} + R_3\,\hat{\jmath} = \underline{0}\}$

$\{\}\cdot\hat{\imath} \Rightarrow R_1 = 0$ —(1)

$\{\}\cdot\hat{\jmath} \Rightarrow R_2 + R_3 = 20\,\text{kN}$. —(2)

Applying Moment balance, $\sum \underline{M}_{/A} = \underline{0}$

$\Rightarrow \{3\text{m}\,\hat{\imath} \times -10\,\text{kN}\,\hat{\jmath} + 5\text{m}\,\hat{\imath} \times -10\,\text{kN}\,\hat{\jmath} + 8\text{m}\,\hat{\imath} \times R_3\,\hat{\jmath} = \underline{0}\}$

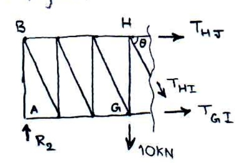
$\{\}\cdot\hat{k} \Rightarrow -30\,\text{kNm} - 50\,\text{kNm} + 8\text{m}\,R_3 = 0 \Rightarrow R_3 = 10\,\text{kN}$ —(3)

From (2) and (3), $R_2 = 10\,\text{kN}$.

As the loading is symmetric, a quick verification reveals that the vertical reactions at A and Q are 10kN each.

Consider the FBD of a portion of the truss with the section cut through HJ, HI, and GI as shown in the figure.

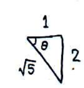
Applying Moment balance about H, $\sum \underline{M}_{/H} = \underline{0}$



$\Rightarrow \{-2\text{m}\,\hat{\jmath} \times T_{GI}\,\hat{\imath} - 3\text{m}\,\hat{\imath} \times R_2\,\hat{\jmath} = \underline{0}\}$

$\Rightarrow T_{GI} = \frac{3}{2} R_2 = 15\,\text{kN}$. —(4)

Applying force balance, $\sum \underline{F} = \underline{0}$



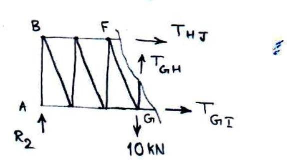
$\Rightarrow \{R_2\,\hat{\jmath} - 10\,\text{kN}\,\hat{\jmath} + T_{GI}\,\hat{\imath} + T_{HI}\cos\theta\,\hat{\imath} - T_{HI}\sin\theta\,\hat{\jmath} + T_{HJ}\,\hat{\imath} = \underline{0}\}$

$\{\}\cdot\hat{\jmath} \Rightarrow R_2 - 10\,\text{kN} - T_{HI}\sin\theta = 0 \Rightarrow \boxed{T_{HI} = 0}$ —(5)

$\{\}\cdot\hat{\imath} \Rightarrow T_{GI} + T_{HI}\cos\theta + T_{HJ} = 0 \Rightarrow \boxed{T_{HJ} = -15\,\text{kN}}$ —(6) [From (4) & (5)]

To find the force in GH, Consider the following FBD,

Applying force balance in $\hat{\jmath}$ direction,

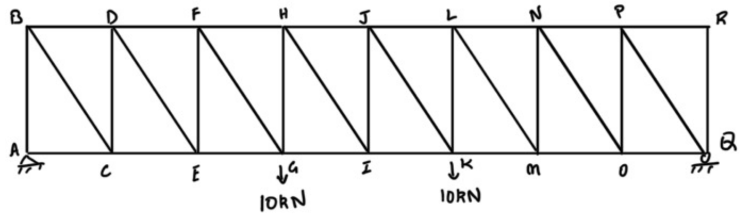


$\Rightarrow \{R_2\,\hat{\jmath} - 10\,\text{kN}\,\hat{\jmath} + T_{GH}\,\hat{\jmath} = \underline{0}\}$

$\{\}\cdot\hat{\jmath} \Rightarrow 10\,\text{kN} - 10\,\text{kN} + T_{GH} = 0$

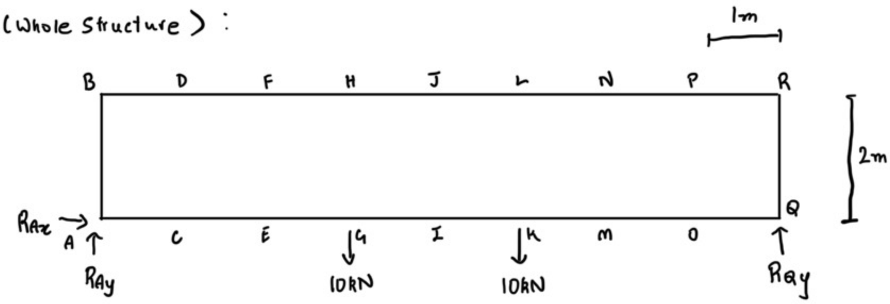
$\Rightarrow \boxed{T_{GH} = 0}$

Sketch:



$\boxed{\text{To Find}: T_{HI}, T_{HJ}, T_{GH}}$

FBD (Whole Structure):



Find Reaction Forces.

$$\Sigma F_x = 0 \qquad \Rightarrow R_{Ax} = 0$$

$$\Sigma F_y = 0$$

$$R_{Ay} + R_{Qy} - 20\,kN = 0$$

$$R_{Ay} + R_{Qy} = 20\,kN$$

$$\Sigma \vec{M}_{/A} = \vec{0}$$

$$\Sigma \vec{M}_{/A} = \left(\vec{r}_{AG} \times (-10\,kN\,\hat{j})\right) + \left(\vec{r}_{AK} \times (-10\,kN\,\hat{j})\right) + \left(\vec{r}_{AQ} \times R_{Qy}\,\hat{j}\right) = \vec{0}$$

$$= (3m\,\hat{i} \times -10\,kN\,\hat{j}) + (5m\,\hat{i} \times -10\,kN\,\hat{j}) + (8m\,\hat{i} \times R_{Qy}\,\hat{j}) = \vec{0}$$

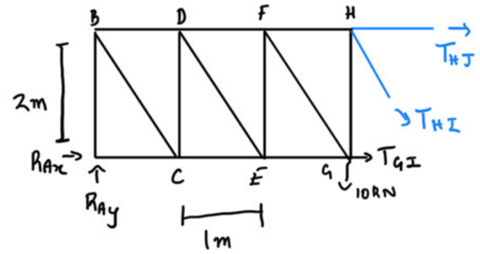
$$= (-30\,m\,kN - 50\,m\,kN + 8\,R_{Qy}\,m)\,\hat{k} = \vec{0}$$

$$\Rightarrow R_{Qy} = 10\,kN \qquad R_{Ay} = 10\,kN$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Find T_{HJ} and T_{HI},

FBD (Section):



$$\sum F_x = 0$$

$$T_{HJ} + \frac{T_{HI}}{\sqrt{3}} + T_{GI} = 0$$

$$\sum F_y = 0$$

$$-\frac{2T_{HI}}{\sqrt{3}} - 10\,kN + 10\,kN = 0$$

$$\boxed{T_{HI} = 0\,kN}$$

$$\sum \vec{M}_{/H} = \vec{0}$$

$$\sum \vec{M}_{/H} = (\vec{r}_{HG} \times T_{GI}\hat{i}) + (\vec{r}_{HA} \times (R_{Ax}\hat{i} + R_{Ay}\hat{j}))$$

$$= (-2m\hat{j} \times T_{GI}\hat{i}) + (-3m\hat{i} - 2m\hat{j}) \times 10\,kN\hat{j}$$

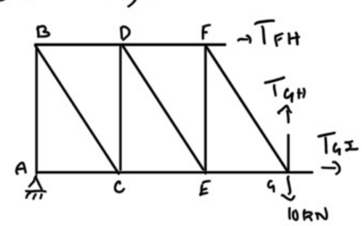
$$= (-2m\,T_{GI} - 30\,m\,kN)\hat{k} = \vec{0}$$

$$\Rightarrow \quad T_{GI} = -15\,kN$$

$$\boxed{T_{HJ} = 15\,kN}$$

Find T_{GH},

FBD (Section):



$$\sum F_y = 0$$

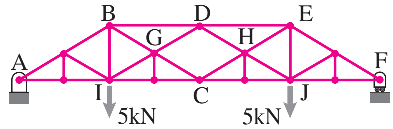
$$T_{GH} - 10\,kN + R_{Ay} = 0$$

$$T_{GH} - 10\,kN + 10\,kN = 0$$

$$\boxed{T_{GH} = 0\,kN}$$

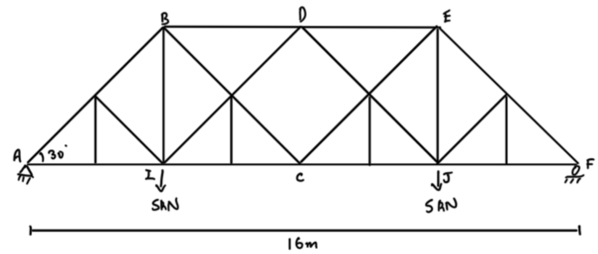
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

6.2.13 A complex symmetric truss spanning a length of 16 m is shown in the figure. The outermost inclined rods make an angle of 30° with the horizontal. Find the tension in rod BD. [Note: you may have to use more than one section to get the answer.]



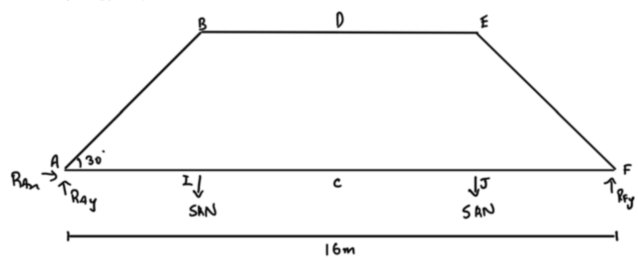
Problem 6.13

Sketch:



$\boxed{\text{To Find : } T_{BD}}$

FBD (Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

$$= R_{Ax} = 0$$

$$\Sigma F_y = 0$$

$$= R_{Ay} + R_{Fy} = 10\,kN$$

$$\Sigma \vec{M}_{/A} = (\vec{r}_{AI} \times -5kN\hat{j}) + (\vec{r}_{AJ} \times -5kN\hat{j}) + (\vec{r}_{AF} \times R_{Fy}\hat{j}) = \vec{0}$$

$$= (4m\hat{i} \times -5kN\hat{j}) + (12m\hat{i} \times -5kN\hat{j}) + (16\,m\hat{i} \times R_{Fy}\hat{j}) = \vec{0}$$

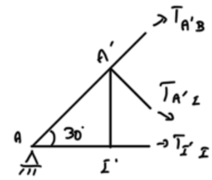
$$= (-20\,m\,kN - 60\,m\,kN + 16\,m\,R_{Fy})\hat{k} = \vec{0}$$

$$\Rightarrow \quad R_{Fy} = 5\,kN$$

$$\Rightarrow R_{Ay} = 5kN$$

Find $T_{I'I}$,

FBD (Section):



$$\Sigma F_x = 0$$

$$= T_{I'I} + T_{A'B}\cos 30 + T_{A'I}\cos 30 + T_{BD} = 0$$

$$\Sigma F_y = 0$$

$$= T_{A'B}\sin 30 + T_{A'I}\sin 30 + 5kN = 0$$

$$\Sigma \vec{M}_{/A'} : (\vec{r}_{A'A} \times R_{Ay}) + (\vec{r}_{A'I'} \times T_{I'I}) = \vec{0}$$

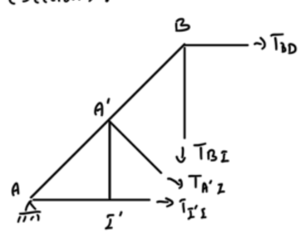
$$= (-2m\hat{i} - 2/\sqrt{3}\,\hat{j}) \times (5kN\,\hat{j}) + (2/\sqrt{3}\,\hat{j} \times T_{I'I}) = \vec{0}$$

$$= (-10m\,kN - \frac{2T_{I'I}}{\sqrt{3}})\hat{k} = \vec{0}$$

$$\Rightarrow T_{I'I} = -5\sqrt{3}\ m\,kN$$

Find T_{BD},

FBD (Section):



$$\Sigma F_x = 0$$

$$\Rightarrow T_{A'I}\cos 30 + T_{BD} = 5\sqrt{3}\ kN$$

$$\Sigma F_y = 0$$

$$\Rightarrow -T_{BI} - T_{A'I}\sin 30 + 5kN = 0$$

$$\Sigma \vec{M}_{/B} = (\vec{r}_{BA'} \times (\cos 30\hat{i} - \sin 30\hat{j})T_{A'I}) + (\vec{r}_{BA} \times (R_{Ax}\hat{i} + R_{Ay}\hat{j})) + (\vec{r}_{BI'} \times T_{I'I'}\hat{i})$$

$$= (-2m\hat{i} - 2m\tan 30) \times (\cos 30\hat{i} - \sin 30\hat{j})T_{A'I}$$

$$+ ((-4m\hat{i} - 4m\tan 30\hat{j}) \times (5kN\hat{j})$$

$$+ (-2m(\hat{i} + 2\tan 30\hat{j}) \times (T_{I'I}\hat{i}) = \vec{0}$$

$$= \left(\frac{5T_{A'I}}{4} - 20\text{ kN} - \frac{4}{\sqrt{3}} T_{ii} \right) \hat{k} = \vec{0}$$

$$\Rightarrow T_{A'I} = 0\text{ kN}$$

$$\boxed{T_{BD} = -5\sqrt{3}\text{ kN}}$$

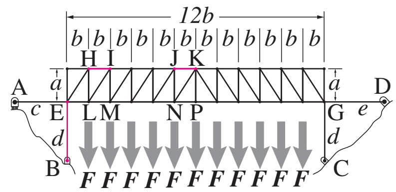
6.2.14 The 2D truss shown consists of 12 diagonally braced rectangles (each a high and b wide). Thus the slope of the diagonal elements is a/b. The whole structure is supported by 4 bars (with lengths c, d, and e as marked). The loading is idealized as 11 identical loads F shown. Give your answers in terms of some or all of a, b, c, d, e and F.

a) On a sketch of the figure below clearly mark all the zero-force members (put a '0' on the middle of each bar that has a 'bar force' of zero).

b) Find the 'bar-force' in bar EB.

c) Find the 'bar-force' in bar HI.

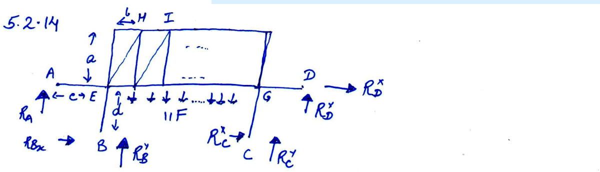
d) Find the 'bar-force' in bar JK. [Hint: Use the method of sections and, to reduce calculations, replace a group of the F forces with a single equivalent force.]



Problem 6.14

Answer:
$T_{EB} = -11F/2$
$T_{HI} = -11bF/2a$
$T_{JK} = -35bF/2a$, (more than 3 times the compression of HI)

5.2.14



$\Sigma \vec{F}_x = \vec{0} \Rightarrow \vec{R}^x_B + \vec{R}^x_C + \vec{R}^x_D = \vec{0}$; $R^x_C = 0$ & $R^x_B = 0 \Rightarrow R^x_D = 0$

$\Sigma \vec{F}_y = \vec{0} \Rightarrow -11F + \vec{R}_A + \vec{R}^y_B + \vec{R}^y_C + \vec{R}^y_D = \vec{0}$; $R^y_A = 0$ & $R^y_D = 0 \Rightarrow +11F = R^y_B + R^y_C$

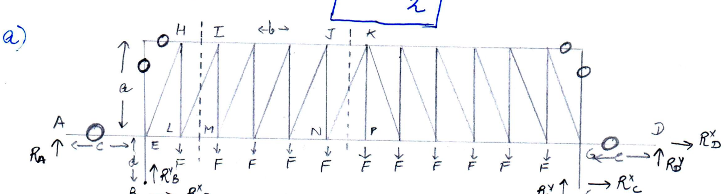
$\Sigma \vec{M}_B = \vec{0} \Rightarrow -\cancel{R_A c} + 12b R^y_C + (12b+e)\cancel{R^y_D} - \cancel{R^x_B}(d) = (\Sigma(i))bF$

$\Rightarrow 12b R^y_C = 66Fb \quad \therefore \boxed{R^y_C = \frac{11F}{2}}$

$\Sigma \vec{M}_C = \vec{0} \Rightarrow (12b+c)\cancel{(-R_A)} + 12b(-R^y_B) + e\cancel{R^y_D} + d\cancel{(-R^x_B)} + b(\Sigma(i))F = \vec{0}$

$\Rightarrow 12b R^y_B = 66bF \quad \therefore \boxed{R^y_B = \frac{11F}{2}}$

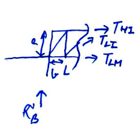
a)



b) For bar EB,

$T_{EB} + R^y_B = 0 \Rightarrow \boxed{T_{EB} = -R^y_B = -\frac{11F}{2}}$

c) For bar HI, we cut a section as shown on the figure

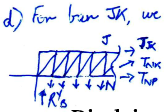


$\Sigma \vec{F}_x = \vec{0} \Rightarrow T_{HI} + T_{LM} + T_{LI}\cos\theta = \vec{0}$

$\Sigma \vec{M}_L = \vec{0} \Rightarrow T_{HI}\, a + R^y_B\, b = \vec{0}$

$\Rightarrow T_{HI} = -\frac{b}{a} R^y_B \quad \therefore \boxed{T_{HI} = -\frac{11b}{2a}F}$

d) For bar JK, we use the method of sections again



$\Sigma \vec{M}_N = \vec{0}$

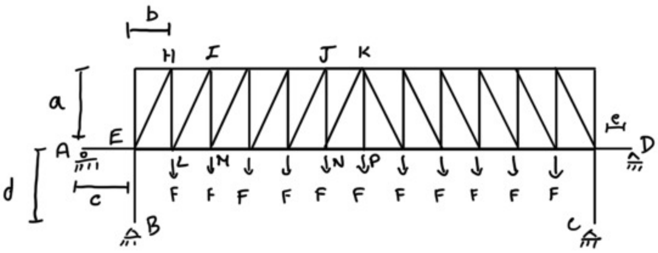
$\Rightarrow -T_{JK}(a) - R^y_B(5b) + F(4+3+2+1)b = 0$

Solving and substituting the value of R^y_B, we get

$\boxed{T_{JK} = -\frac{35b}{2a}F}$

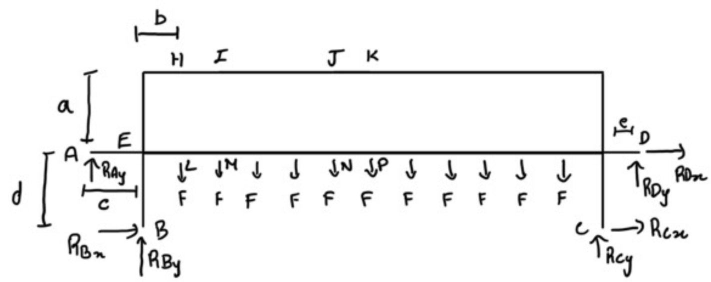
Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

Sketch:



$\boxed{\text{To Find: } T_{EB}, T_{HI}, T_{JK}}$

FBD(Whole Structure):



Find Reaction Forces,

$$\Sigma F_x = 0$$

$$R_{Bx} + R_{Cx} + R_{Dx} = 0$$

$$R_{Bx} = R_{Cx} = 0\,\text{N} \quad (\Sigma F \text{ at } B \text{ and } C)$$

$$\Rightarrow R_{Dx} = 0$$

$$R_{Bx} = R_{Cx} = R_{Dx} = 0$$

$$\Sigma F_y = 0$$

$$R_{Ay} + R_{By} + R_{Cy} + R_{Dy} = 11F$$

$$\Sigma \vec{M}_{/D} = \vec{0}$$

$$= (-e\hat{\imath} - d\hat{\jmath}) \times R_{Cy}\hat{\jmath} + (-e-b)\hat{\imath} \times (-F)\hat{\jmath} + (-e-2b)\hat{\imath} \times (-F)\hat{\jmath} + (-e-3b)\hat{\imath} \times (-F)\hat{\jmath}$$

$$+ (-e-4b)\hat{\imath} \times (-F)\hat{\jmath} + (-e-5b)\hat{\imath} \times (-F)\hat{\jmath} + (-e-6b)\hat{\imath} \times (-F)\hat{\jmath} + (-e-7b)\hat{\imath} \times (-F)\hat{\jmath}$$

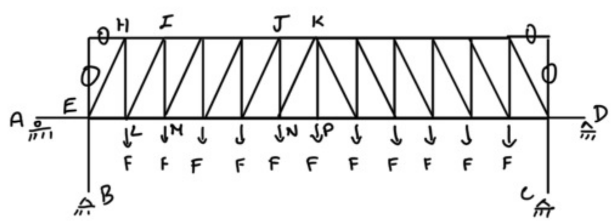
$$+ (-e-8b)\hat{i} \times (-F)\hat{j} + (-e-9b)\hat{i} \times (-F)\hat{j} + (-e-10b)\hat{i} \times (-F)\hat{j} + (-e-11b)\hat{i} \times (-F)\hat{j}$$

$$+ ((-e-12b)\hat{i} + (-d)\hat{j}) \times R_{By}\hat{j}) + (-e-12b-c)\hat{i} \times R_{Ay}\hat{j} = \vec{0}$$

$$= (-e(R_{Ay}+R_{By}+R_{Cy}) - 12b(R_{Ay}+R_{By}) - cR_{Ay} - F(11e+65b))\hat{k} = \vec{0}$$

$$= (-e(R_{Ay}+R_{By}+R_{Cy}+11F) - b(12R_{Ay}+12R_{By}+65F) - cR_{Ay})\hat{k} = \vec{0}$$

a)

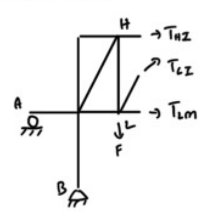


b) Since EB is a vertical bar,

$$\boxed{T_{EB} = 0N}$$

c) Find T_{HI},

FBD (Section):



$$\sum F_x = 0$$

$$T_{HI} + T_{Lm} + T_{LI}\cos(\tan^{-1}(a/b)) = 0$$

$$\sum F_y = 0$$

$$T_{LI}\sin(\tan^{-1}(a/b)) - F + R_{Ay} + R_{By} = 0$$

$$T_{LI} = \operatorname{cosec}(\tan^{-1}(a/b))\,[F - R_{Ay} - R_{By}]$$

$$\sum \vec{M}_{/L} = (\vec{r}_{LH} \times T_{HI}\hat{i}) + (\vec{r}_{LA} \times R_{Ay}\hat{j}) + (\vec{r}_{LB} \times R_{By}\hat{j})$$

$$= a\hat{j} \times T_{HI}\hat{i} + (-b-c)\hat{i} \times R_{Ay}\hat{j} + (-b\hat{i} - d\hat{j}) \times R_{By}\hat{j}$$

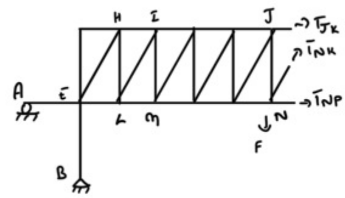
$$= (aT_{HI} - bR_{Ay} - cR_{Ay} - bR_{By})\hat{k} = \vec{0}$$

$$\boxed{T_{HI} = \frac{b}{a}(R_{Ay} + R_{By}) + \frac{c}{a}R_{Ay}}$$

Disclaimer: *We have lost track of the many people who wrote these solutions. They are not official and have not been reviewed by the authors for correctness.*

d) Find T_{JK},

FBD (Section):



$$\sum \vec{M}_{/N} = (\vec{r}_{NJ} \times T_{JK}\hat{i}) + (\vec{r}_{NA} \times R_{Ay}\hat{j})$$

$$= a\hat{j} \times T_{JK}\hat{i} + (-5b-c)\hat{i} \times R_{Ay}\hat{j} + (-5b\hat{i} - d\hat{j}) \times R_{By}\hat{j}$$

$$= (aT_{JK} - 5bR_{Ay} - cR_{Ay} - 5bR_{By})\hat{k} = \vec{0}$$

$$\boxed{T_{JK} = \frac{1}{a}\left[-5b(R_{Ay} + R_{By}) - cR_{Ay}\right]}$$