Problem 6.138  Consider the truss in Problem 6.136. Which members have the largest tensile and compressive forces, and what are their values?

Solution: The axial forces for all members have been obtained in Problems 6.136 and 6.137 except for members $EG$ and $GH$. These are:

**Joint E:**
\[ \sum F_x = -CE + EG + EH \cos \alpha_{EH} = 0, \]
from which $EG = 0$

**Joint G:**
\[ \sum F_y = -GH - 400 = 0, \]
from which $GH = -400 \text{ N (C)}$.

This completes the determination for all members. A comparison of tensile forces shows that $[AC = 480 \text{ N (T)}]$ is the largest value, and a comparison of compressive forces shows that $[BD = -632.5 \text{ N (C)}]$ is the largest value.
Problem 6.140  For the roof truss in Problem 6.139, use the method of sections to determine the axial forces in members $CD$, $CJ$, and $IJ$.

Solution:  The free body diagram of the section is shown at the right. The support force at $A$ is already known from the solution to Problem 6.139. The equations of equilibrium for the section are

$$\sum F_x = T_{CD} + T_{CJ} + T_{IJ} = 0,$$

$$\sum F_y = T_{CD} + T_{CJ} + A_y = 0,$$

and $$\sum M_C = y_C T_{IJ} - 4A_y = 0.$$  

Solving, we get

$$T_{IJ} = 12.0 \text{ kN},$$

$$T_{CJ} = -4.17 \text{ kN},$$

and $$T_{CD} = -11.4 \text{ kN}.$$  

Note that these values check with the values obtained in Problem 6.139.
Problem 6.143  Determine the forces on member \(ABC\), presenting your answers as shown in Fig. 6.35. Obtain the answer in two ways:

(a) When you draw the free-body diagrams of the individual members, place the 400-lb load on the free-body diagram of member \(ABC\).

(b) When you draw the free-body diagrams of the individual members, place the 400-lb load on the free-body diagram of member \(CD\).

**Solution:** The angle of element \(BE\) relative to the horizontal is
\[ \alpha = \tan^{-1} \left( \frac{1}{2} \right) = 26.57^\circ. \]

The complete structure as a free body: The sum of the moments about \(A\):
\[ \sum M_A = -3(400) - 1(200) + 2F_y = 0 \]
from which \(F_y = 700\) lb. The sum of forces:
\[ \sum F_y = A_y + F_y - 200 = 0, \]
from which \(A_y = -500\) lb.

\[ \sum F_x = A_x + F_x + 400 = 0. \]

(a) Element \(CD\): The sum of the moments about \(D\):
\[ \sum M_D = 200 + 2C_y = 0, \]
from which \(C_y = -100\) lb.

\[ \sum F_y = -D_y - C_y - 200 = 0, \]
from which \(D_y = -100\).

\[ \sum F_x = -C_x - D_x = 0, \]
from which \(D_x = -C_x\).

Element \(DEF\): The sum of the moments about \(F\):
\[ \sum M_F = -3D_x + B \cos \alpha = 0, \]
from which \(D_x = B \left( \frac{\cos \alpha}{3} \right) \)
\[ \sum F_y = F_y + B \sin \alpha + D_y = 0, \]
from which \(B = \frac{-700 + 100}{\sin \alpha} = -1341.6\) lb. and \(D_y = -400\) lb.

Element \(ABC\):
\[ \sum M_A = -2B \cos \alpha - 3(400) - 3C_x = 0. \]
The sum of the forces
\[ \sum F_y = C_y - B \sin \alpha + A_y = 0. \]

from which Check:
\[ B = \frac{500 + 100}{\sin \alpha} = -1341.6\) lb.

check. From above \(C_y = -D_y = 400\) lb
\[ \sum F_y = 400 + C_y + B \cos \alpha + A_y = 0, \]
from which \(A_y = 400\) lb.

(b) When the 400 lb load is applied to element \(CD\) instead, the following changes to the equilibrium equations occur: Element \(CD\):
\[ \sum F_y = -C_y - D_y + 400 = 0. \]
from which \(C_y + D_y = 400\). Element \(ABC\):
\[ \sum F_y = C_y + A_y - B \cos \alpha = 0. \]

Element \(DEF\): No changes. The changes in the solution for \(\text{Element} \ ABC\) \(C_y = 800\) lb when the external load is removed, instead of \(C_y = 400\) lb when the external load is applied, so that the total load applied to point \(C\) is the same in both cases.
Problem 6.148  This structure supports a conveyor belt used in a lignite mining operation. The cables connected to the belt exert the force \( F \) at \( J \). As a result of the counterweight \( W = 8 \text{ kip} \), the reaction at \( E \) and the vertical reaction at \( D \) are equal. Determine \( F \) and the axial forces in members \( BG \) and \( EF \).

Solution:  The complete structure as a free body: The moments about point \( J \): using the fact that the vertical reactions at \( E \) and \( D \) are equal:

\[
\sum M_J = -54W + 66D_y = 0
\]

from which \( E = D_y = 6.545 \text{ kip} \). The sum of forces:

\[
\sum F_y = -F \cos(50^\circ) + 2D_y - W = 0,
\]

from which \( F = 7.920 \text{ kip} \).

The method of sections: Make a cut through \( BG, BF, \) and \( EF \). Consider the section to the left of the cut. The angle of member \( BG \) from the horizontal is

\[
\alpha = \tan^{-1} \left( \frac{9}{33} \right) = 15.26^\circ.
\]

The angle of member \( BF \) from the horizontal is

\[
\beta = \tan^{-1} \left( \frac{9}{13} \right) = 34.7^\circ.
\]

The length of member \( FG \) is \( L_{FG} = 20 \tan \alpha \).

The section as a free body: The sum of the moments about the point \( F \):

\[
\sum M_F = 20F \cos(50^\circ) - L_{FG}BG \cos \alpha = 0,
\]

from which \( BG = 19.35 \text{ kip (T)} \).

The sum of the forces:

\[
\sum F_y = BF \sin \beta + BG \sin \alpha - F \cos(50^\circ) = 0,
\]

from which \( BF = 0 \)

\[
\sum F_x = EF + BF \cos \beta + BG \cos \alpha - F \sin(50^\circ) = 0,
\]

from which \( EF = -12.6 \text{ kip (C)} \).