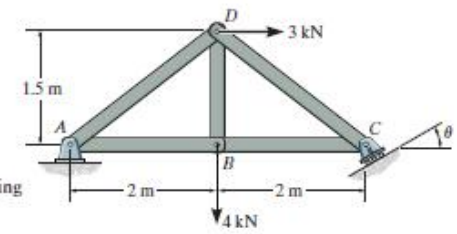
# CHAPTER VI (SELECTED PROBLEMS)

Determine the force in each member of the truss, and state if the members are in tension or compression. Set $\theta = 30°$.




## SOLUTION

***Support Reactions:*** From the free-body diagram of the truss, Fig. *a*, and applying the equations of equilibrium, we have

$\zeta + \Sigma M_A = 0;$ $\quad N_C \cos 30°(2 + 2) - 3(1.5) - 4(2) = 0$

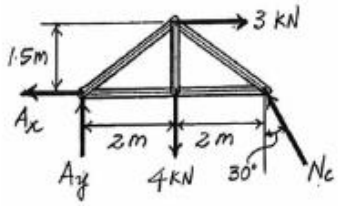
$N_C = 3.608$ kN

$\pm \Sigma F_x = 0;$ $\quad 3 - 3.608 \sin 30° - A_x = 0$

$A_x = 1.196$ kN

$+\uparrow \Sigma F_y = 0;$ $\quad A_y + 3.608 \cos 30° - 4 = 0$

$A_y = 0.875$ kN




(a)

***Method of Joints:*** We will use the above result to analyze the equilibrium of joints *C* and *A*, and then proceed to analyze of joint *B*.

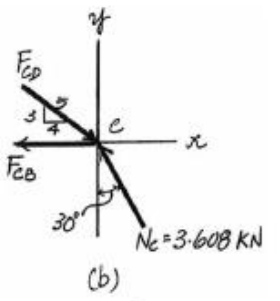
Joint *C*: From the free-body diagram in Fig. *b*, we can write

$+\uparrow \Sigma F_y = 0;$ $\quad 3.608 \cos 30° - F_{CD}\left(\frac{3}{5}\right) = 0$

$F_{CD} = 5.208$ kN $= 5.21$ kN (C) **Ans.**

$\pm \Sigma F_x = 0;$ $\quad 5.208\left(\frac{4}{5}\right) - 3.608 \sin 30° - F_{CB} = 0$

$F_{CB} = 2.362$ kN $= 2.36$ kN (T) **Ans.**




(b)

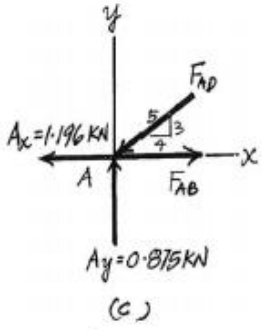
Joint *A*: From the free-body diagram in Fig. *c*, we can write

$+\uparrow \Sigma F_y = 0;$ $\quad 0.875 - F_{AD}\left(\frac{3}{5}\right) = 0$

$F_{AD} = 1.458$ kN $= 1.46$ kN (C) **Ans.**

$\pm \Sigma F_x = 0;$ $\quad F_{AB} - 1.458\left(\frac{4}{5}\right) - 1.196 = 0$

$F_{AB} = 2.362$ kN $= 2.36$ kN (T) **Ans.**




(c)

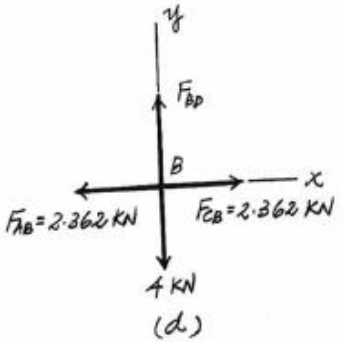
Joint *B*: From the free-body diagram in Fig. *d*, we can write

$+\uparrow \Sigma F_y = 0;$ $\quad F_{BD} - 4 = 0$

$F_{BD} = 4$ kN (T) **Ans.**

$\pm \Sigma F_x = 0;$ $\quad 2.362 - 2.362 = 0$ (check!)

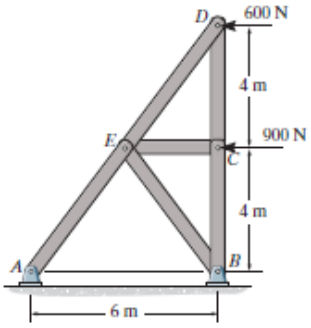
***Note:*** The equilibrium analysis of joint *D* can be used to check the accuracy of the solution obtained above.




(d)

**6–6.**

Determine the force in each member of the truss, and state if the members are in tension or compression.




## SOLUTION

***Method of Joints:*** We will begin by analyzing the equilibrium of joint $D$, and then proceed to analyze joints $C$ and $E$.

Joint $D$: From the free-body diagram in Fig. *a*,

$\stackrel{+}{\rightarrow}\Sigma F_x = 0;$ $\quad F_{DE}\left(\frac{3}{5}\right) - 600 = 0$

$F_{DE} = 1000\ \text{N} = 1.00\ \text{kN (C)}$ **Ans.**

$+\uparrow\Sigma F_y = 0;$ $\quad 1000\left(\frac{4}{5}\right) - F_{DC} = 0$

$F_{DC} = 800\ \text{N (T)}$ **Ans.**

Joint $C$: From the free-body diagram in Fig. *b*,

$\stackrel{+}{\rightarrow}\Sigma F_x = 0;$ $\quad F_{CE} - 900 = 0$

$F_{CE} = 900\ \text{N (C)}$ **Ans.**

$+\uparrow\Sigma F_y = 0;$ $\quad 800 - F_{CB} = 0$

$F_{CB} = 800\ \text{N (T)}$ **Ans.**

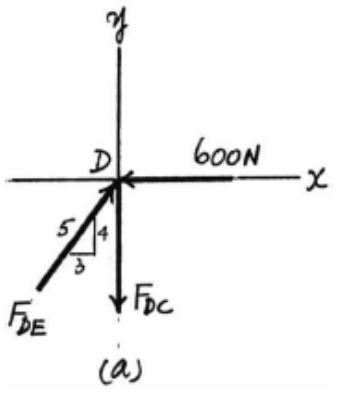
Joint $E$: From the free-body diagram in Fig. *c*,

$\searrow+\Sigma F_{x'} = 0;$ $\quad -900\cos 36.87° + F_{EB}\sin 73.74° = 0$

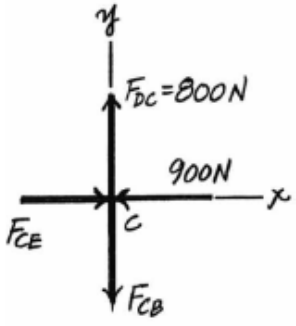
$F_{EB} = 750\ \text{N (T)}$ **Ans.**

$\nearrow+\Sigma F_{y'} = 0;$ $\quad F_{EA} - 1000 - 900\sin 36.87° - 750\cos 73.74° = 0$

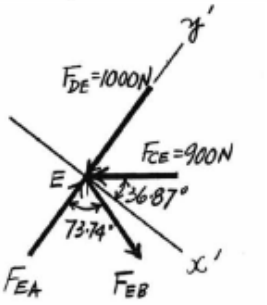
$F_{EA} = 1750\ \text{N} = 1.75\ \text{kN (C)}$ **Ans.**




(a)

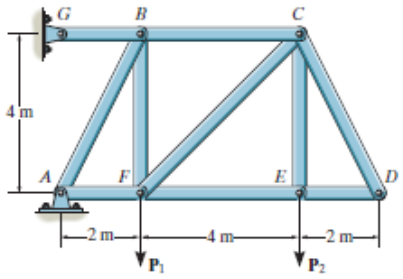



(b)




(c)

Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 0$, $P_2 = 20$ kN.




## SOLUTION

$\zeta + \Sigma M_A = 0;$ $\quad -F_{GB}(4) + 20(6) = 0$

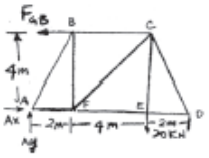
$F_{GB} = 30$ kN (T) **Ans.**

$\stackrel{+}{\rightarrow} \Sigma F_x = 0;$ $\quad A_x - 30 = 0$

$A_x = 30$ kN

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 20 = 0$

$A_y = 20$ kN




Joint $A$:

$\stackrel{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 30 - F_{AF} - \frac{1}{\sqrt{5}}(F_{AB}) = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 20 - F_{AB}\left(\frac{2}{\sqrt{5}}\right) = 0$

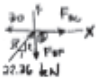
$F_{AF} = 20$ kN (C) **Ans.**

$F_{AB} = 22.36 = 22.4$ kN (C) **Ans.**


Joint $B$:

$\stackrel{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 22.36\left(\frac{1}{\sqrt{5}}\right) + F_{BC} - 30 = 0$

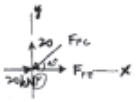
$+\uparrow \Sigma F_y = 0;$ $\quad 22.36\left(\frac{2}{\sqrt{5}}\right) - F_{BF} = 0$




$F_{BF} = 20$ kN (T) **Ans.**

$F_{BC} = 20$ kN (T) **Ans.**

Joint $F$:

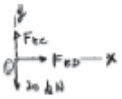



$\stackrel{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 20 + F_{FE} - \frac{1}{\sqrt{2}}(F_{FC}) = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 20 - F_{FC}\left(\frac{1}{\sqrt{2}}\right) = 0$

$F_{FC} = 28.28 = 28.3$ kN (C) **Ans.**

$F_{FE} = 0$ **Ans.**



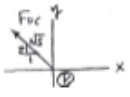

Joint $E$:

$\stackrel{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F_{ED} - 0 = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad F_{EC} - 20 = 0$

$F_{ED} = 0$ **Ans.**

$F_{EC} = 20.0$ kN (T) **Ans.**

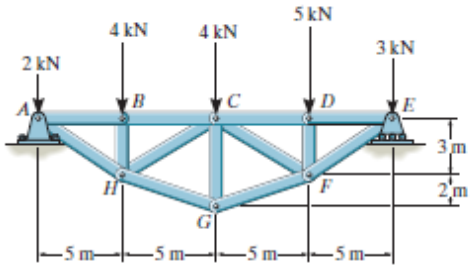



Joint $D$:

$\stackrel{+}{\rightarrow} \Sigma F_x = 0;$ $\quad \frac{1}{\sqrt{5}}(F_{DC}) - 0 = 0$

$F_{DC} = 0$ **Ans.**

Determine the force in members *BC*, *HC*, and *HG*. After the truss is sectioned use a single equation of equilibrium for the calculation of each force. State if these members are in tension or compression.



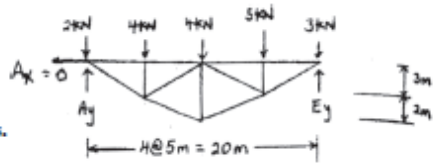

## SOLUTION

$\zeta + \Sigma M_E = 0;$ $\quad -A_y(20) + 2(20) + 4(15) + 4(10) + 5(5) = 0$

$A_y = 8.25\ \text{kN}$

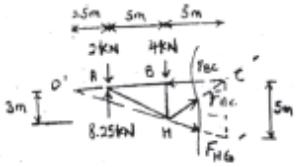
$\zeta + \Sigma M_H = 0;$ $\quad -8.25(5) + 2(5) + F_{BC}(3) = 0$

$F_{BC} = 10.4\ \text{kN (C)}$ **Ans.**




$\zeta + \Sigma M_C = 0;$ $\quad -8.25(10) + 2(10) + 4(5) + \frac{5}{\sqrt{29}} F_{HG}(5) = 0$

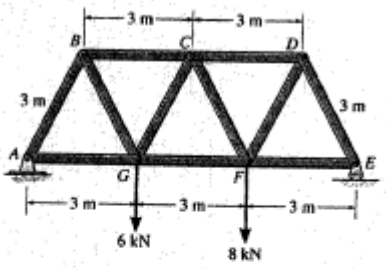
$F_{HG} = 9.1548 = 9.15\ \text{kN (T)}$ **Ans.**




$\zeta + \Sigma M_O = 0;$ $\quad -2(2.5) + 8.25(2.5) - 4(7.5) + \frac{3}{\sqrt{34}} F_{HC}(12.5) = 0$

$F_{HC} = 2.24\ \text{kN (T)}$ **Ans.**

**6-28.** Determine the force in members *CD*, *CF*, and *FG* of the *Warren truss*. Indicate if the members are in tension or compression.




***Support Reactions :***

$\zeta + \Sigma M_A = 0;$ $\quad E_y(9) - 8(6) - 6(3) = 0$ $\quad E_y = 7.333\ \text{kN}$

***Method of Sections :***

$\zeta + \Sigma M_C = 0;$ $\quad 7.333(4.5) - 8(1.5) - F_{FG}(3\sin 60°) = 0$

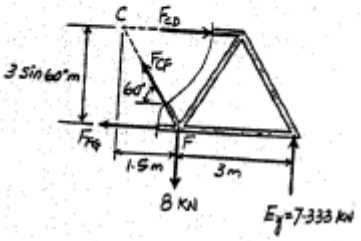
$F_{FG} = 8.08\ \text{kN (T)}$ **Ans.**

$\zeta + \Sigma M_F = 0;$ $\quad 7.333(3) - F_{CD}(3\sin 60°) = 0$

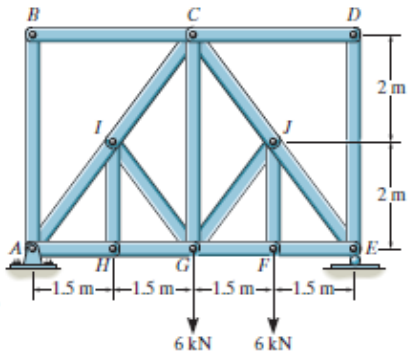
$F_{CD} = 8.47\ \text{kN (C)}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad F_{CF}\sin 60° + 7.333 - 8 = 0$

$F_{CF} = 0.770\ \text{kN (T)}$ **Ans.**



Determine the force in members $IC$ and $CG$ of the truss and state if these members are in tension or compression. Also, indicate all zero-force members.




## SOLUTION

By inspection of joints $B$, $D$, $H$ and $I$,

*AB*, *BC*, *CD*, *DE*, *HI*, and *GI* are all zero-force members.

Ans.

$\zeta + \Sigma M_G = 0; \quad -4.5(3) + F_{IC}\left(\frac{3}{5}\right)(4) = 0$

$F_{IC} = 5.625 = 5.62 \text{ kN (C)}$ Ans.

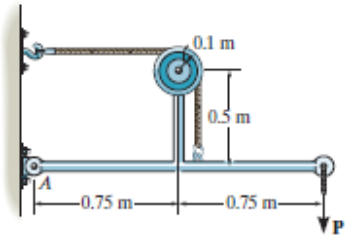
Joint $C$:

$\stackrel{+}{\rightarrow} \Sigma F_x = 0; \quad F_{CJ} = 5.625 \text{ kN}$

$+\uparrow \Sigma F_y = 0; \quad \frac{4}{5}(5.625) + \frac{4}{5}(5.625) - F_{CG} = 0$

$F_{CG} = 9.00 \text{ kN (T)}$ Ans.

Determine the greatest force $P$ that can be applied to the frame if the largest force resultant acting at $A$ can have a magnitude of 2 kN.




## SOLUTION

$\zeta + \Sigma M_A = 0; \quad T(0.6) - P(1.5) = 0$

$\stackrel{+}{\rightarrow} \Sigma F_x = 0; \quad A_x - T = 0$

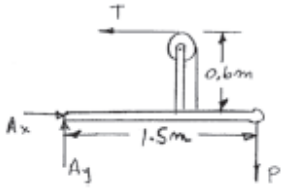
$+\uparrow \Sigma F_y = 0; \quad A_y - P = 0$

Thus, $A_x = 2.5\,P$, $A_y = P$

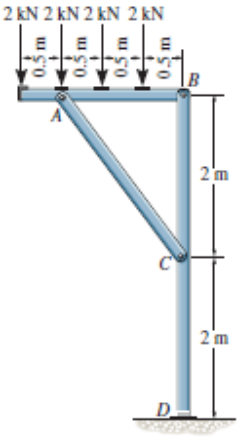
Require,

$2 = \sqrt{(2.5P)^2 + (P)^2}$

$P = 0.743 \text{ kN} = 743 \text{ N}$ Ans.



Determine the horizontal and vertical components of force at pins $A$,$B$, and $C$,and the reactions at the fixed support $D$ of the three-member frame.




## SOLUTION

***Free Body Diagram:*** The solution for this problem will be simplified if one realizes that member $AC$ is a two force member.

***Equations of Equilibrium:*** For FBD(a),

$$\zeta + \Sigma M_B = 0; \qquad 2(0.5) + 2(1) + 2(1.5) + 2(2) - F_{AC}\left(\frac{4}{5}\right)(1.5) = 0$$

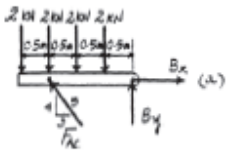
$$F_{AC} = 8.333\ \text{kN}$$

$$+\uparrow \Sigma F_y = 0; \qquad B_y + 8.333\left(\frac{4}{5}\right) - 2 - 2 - 2 - 2 = 0$$

$$B_y = 1.333\ \text{kN} = 1.33\ \text{kN} \qquad \textbf{Ans.}$$

$$\pm \Sigma F_x = 0; \qquad B_x - 8.333\left(\frac{3}{5}\right) = 0$$

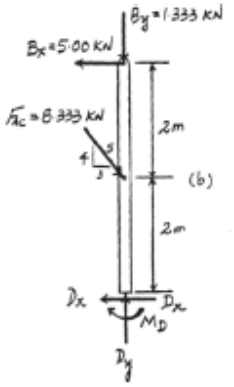
$$B_x = 5.00\ \text{kN} \qquad \textbf{Ans.}$$




For pin $A$ and $C$,

$$A_x = C_x = F_{AC}\left(\frac{3}{5}\right) = 8.333\left(\frac{3}{5}\right) = 5.00\ \text{kN} \qquad \textbf{Ans.}$$

$$A_y = C_y = F_{AC}\left(\frac{4}{5}\right) = 8.333\left(\frac{4}{5}\right) = 6.67\ \text{kN} \qquad \textbf{Ans.}$$




From FBD (b),

$$\zeta + \Sigma M_D = 0; \qquad 5.00(4) - 8.333\left(\frac{3}{5}\right)(2) - M_D = 0$$

$$M_D = 10.0\ \text{kN}\cdot\text{m} \qquad \textbf{Ans.}$$

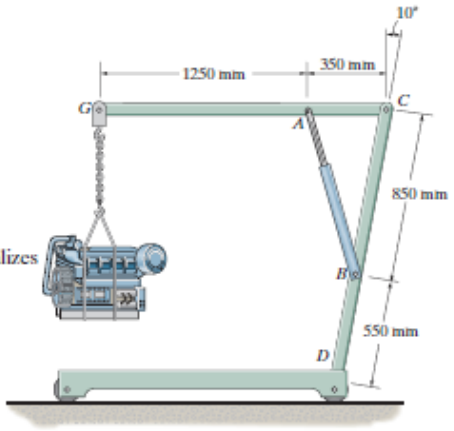
$$+\uparrow \Sigma F_y = 0; \qquad D_y - 1.333 - 8.333\left(\frac{4}{5}\right) = 0$$

$$D_y = 8.00\ \text{kN} \qquad \textbf{Ans.}$$

$$\pm \Sigma F_x = 0; \qquad 8.333\left(\frac{3}{5}\right) - 5.00 - D_x = 0$$

$$D_x = 0 \qquad \textbf{Ans.}$$

The engine hoist is used to support the 200-kg engine. Determine the force acting in the hydraulic cylinder $AB$, the horizontal and vertical components of force at the pin $C$, and the reactions at the fixed connection $D$.




## SOLUTION

***Free-Body Diagram:*** The solution for this problem will be simplified if one realizes that member $AB$ is a two force member. From the geometry,

$$l_{AB} = \sqrt{350^2 + 850^2 - 2(350)(850)\cos 80^\circ} = 861.21 \text{ mm}$$

$$\frac{\sin\theta}{850} = \frac{\sin 80^\circ}{861.24} \qquad \theta = 76.41^\circ$$

***Equations of Equilibrium:*** From FBD (a),

$\zeta + \Sigma M_C = 0;$ $\quad 1962(1.60) - F_{AB}\sin 76.41^\circ(0.35) = 0$

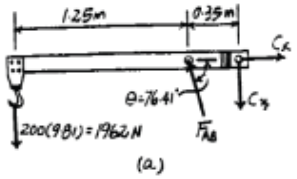
$F_{AB} = 9227.60 \text{ N} = 9.23 \text{ kN}$ **Ans.**

$\pm\rightarrow \Sigma F_x = 0;$ $\quad C_x - 9227.60\cos 76.41^\circ = 0$

$C_x = 2168.65 \text{ N} = 2.17 \text{ kN}$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad 9227.60\sin 76.41^\circ - 1962 - C_y = 0$

$C_y = 7007.14 \text{ N} = 7.01 \text{ kN}$ **Ans.**




From FBD (b),

$\pm\rightarrow \Sigma F_x = 0;$ $\quad D_x = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad D_y - 1962 = 0$

$D_y = 1962 \text{ N} = 1.96 \text{ kN}$ **Ans.**

$\zeta + \Sigma M_D = 0;$ $\quad 1962(1.60 - 1.40\sin 10^\circ) - M_D = 0$

$M_D = 2662.22 \text{ N}\cdot\text{m} = 2.66 \text{ kN}\cdot\text{m}$ **Ans.**