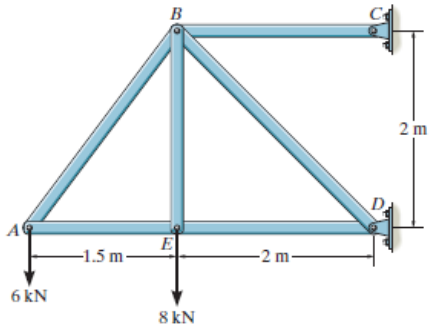
CHAPTER VI

STRUCTURAL ANALYSIS

6–9.

Determine the force in each member of the truss and state if the members are in tension or compression. *Hint:* The vertical component of force at C must equal zero. Why?



SOLUTION

Joint A:

$+\uparrow \Sigma F_y = 0; \quad \frac{4}{5} F_{AB} - 6 = 0$

$F_{AB} = 7.5 \text{ kN (T)}$ **Ans.**

$\pm \Sigma F_x = 0; \quad -F_{AE} + 7.5\left(\frac{3}{5}\right) = 0$

$F_{AE} = 4.5 \text{ kN (C)}$ **Ans.**

Joint E:

$\pm \Sigma F_x = 0; \quad F_{ED} = 4.5 \text{ kN(C)}$ **Ans.**

$+\uparrow \Sigma F_y = 0; \quad F_{EB} = 8 \text{ kN (T)}$ **Ans.**

Joint B:

$+\uparrow \Sigma F_y = 0; \quad \frac{1}{\sqrt{2}}(F_{BD}) - 8 - \frac{4}{5}(7.5) = 0$

$F_{BD} = 19.8 \text{ kN (C)}$ **Ans.**

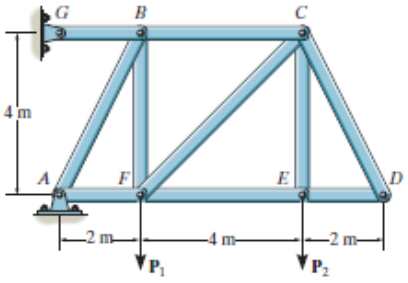
$\pm \Sigma F_x = 0; \quad F_{BC} - \frac{3}{5}(7.5) - \frac{1}{\sqrt{2}}(19.8) = 0$

$F_{BC} = 18.5 \text{ kN (T)}$ **Ans.**

C_y is zero because BC is a two-force member .

6–12.

Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 10$ kN, $P_2 = 15$ kN.



SOLUTION

$\zeta + \Sigma M_A = 0;$ $\quad G_x(4) - 10(2) - 15(6) = 0$

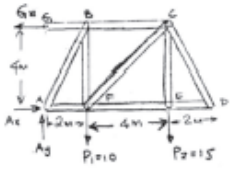
$G_x = 27.5$ kN

$\pm \Sigma F_x = 0;$ $\quad A_x - 27.5 = 0$

$A_x = 27.5$ kN

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 10 - 15 = 0$

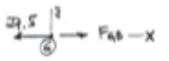
$A_y = 25$ kN



Joint G:

$\pm \Sigma F_x = 0;$ $\quad F_{GB} - 27.5 = 0$

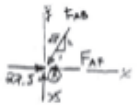
$F_{GB} = 27.5$ kN (T) **Ans.**



Joint A:

$\pm \Sigma F_x = 0;$ $\quad 27.5 - F_{AF} - \frac{1}{\sqrt{5}}(F_{AB}) = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 25 - F_{AB}\left(\frac{2}{\sqrt{5}}\right) = 0$



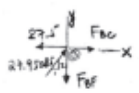
$F_{AF} = 15.0$ kN (C) **Ans.**

$F_{AB} = 27.95 = 28.0$ kN (C) **Ans.**

Joint B:

$\pm \Sigma F_x = 0;$ $\quad 27.95\left(\frac{1}{\sqrt{5}}\right) + F_{BC} - 27.5 = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 27.95\left(\frac{2}{\sqrt{5}}\right) - F_{BF} = 0$



$F_{BF} = 25.0$ kN (T) **Ans.**

$F_{BC} = 15.0$ kN (T) **Ans.**

Joint F:

$\pm \Sigma F_x = 0;$ $\quad 15 + F_{FE} - \frac{1}{\sqrt{2}}(F_{FC}) = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 25 - 10 - F_{FC}\left(\frac{1}{\sqrt{2}}\right) = 0$

$F_{FC} = 21.21 = 21.2$ kN (C) **Ans.**

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

Joint E:

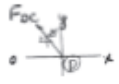
$\pm \Sigma F_x = 0;$ $\quad F_{ED} = 0$ **Ans.**

$+\uparrow \Sigma F_y = 0;$ $\quad F_{EC} - 15 = 0$

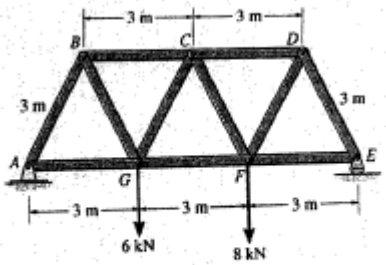
$F_{EC} = 15.0$ kN (T) **Ans.**

Joint D:

$\pm \Sigma F_x = 0;$ $\quad F_{DC} = 0$ **Ans.**



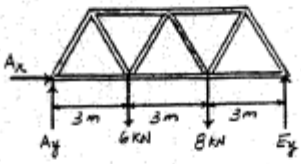
6-27. Determine the force in members *BC*, *CG*, and *GF* of the *Warren truss*. Indicate if the members are in tension or compression.



Support Reactions :

$\zeta + \Sigma M_E = 0;\quad 6(6) + 8(3) - A_y(9) = 0 \quad A_y = 6.667\ \text{kN}$

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad A_x = 0$



Method of Sections :

$\zeta + \Sigma M_C = 0;\quad F_{GF}(3\sin 60°) + 6(1.5) - 6.667(4.5) = 0$

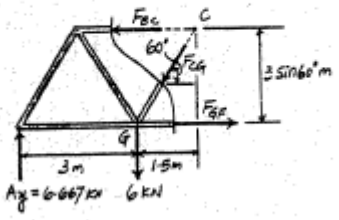
$F_{GF} = 8.08\ \text{kN (T)}$ **Ans.**

$\zeta + \Sigma M_G = 0;\quad F_{BC}(3\sin 60°) - 6.667(3) = 0$

$F_{BC} = 7.70\ \text{kN (C)}$ **Ans.**

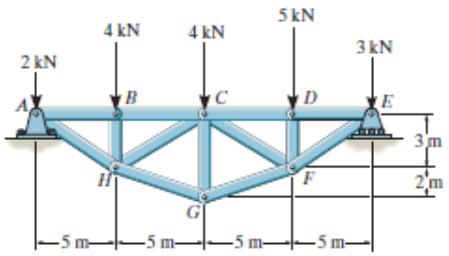
$+\uparrow \Sigma F_y = 0;\quad 6.667 - 6 - F_{CG}\sin 60° = 0$

$F_{CG} = 0.770\ \text{kN (C)}$ **Ans.**



6–35.

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

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

$A_y = 8.25\ \text{kN}$

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

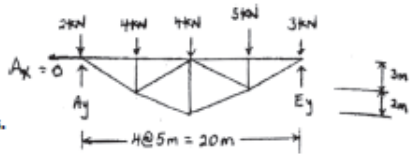
$F_{BC} = 10.4\ \text{kN (C)}$ **Ans.**

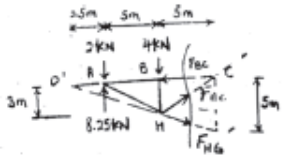
$\zeta + \Sigma M_C = 0;\quad -8.25(10) + 2(10) + 4(5) + \frac{5}{\sqrt{29}}F_{HG}(5) = 0$

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

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

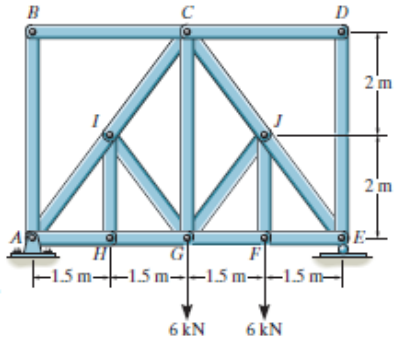
$F_{HC} = 2.24\ \text{kN (T)}$ **Ans.**





6–39.

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.

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

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

Ans.

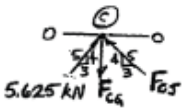
Joint C:

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

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

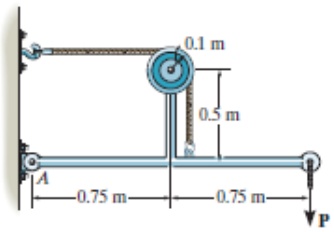
$F_{CG} = 9.00\ \text{kN (T)}$

Ans.



6–68.

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

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

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

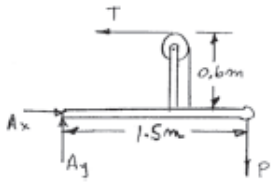
$+\uparrow \Sigma F_y = 0; \qquad A_y - P = 0$

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.

6–69.

Determine the horizontal and vertical components of force that pins A and C exert on the frame.

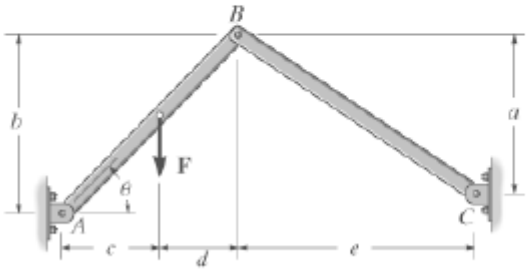
Given:

$F = 500$ N

$a = 0.8$ m $\quad d = 0.4$ m

$b = 0.9$ m $\quad e = 1.2$ m

$c = 0.5$ m $\quad \theta = 45$deg



Solution:

BC is a two-force member

Member AB :

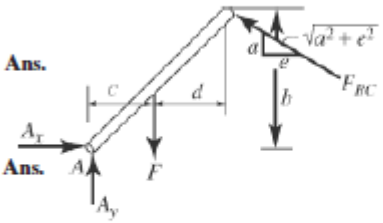
$$\Sigma M_A = 0; \quad -F c + F_{BC}\frac{e}{\sqrt{a^2+e^2}} b + F_{BC}\frac{a}{\sqrt{a^2+e^2}}(c+d) = 0$$

$$F_{BC} = F c \frac{\sqrt{a^2+e^2}}{e\,b + a\,c + a\,d} \qquad F_{BC} = 200.3 \text{ N}$$

Thus,

$$C_x = F_{BC}\frac{e}{\sqrt{a^2+e^2}} \qquad C_x = 167 \text{ N} \quad \textbf{Ans.}$$

$$C_y = F_{BC}\frac{a}{\sqrt{a^2+e^2}} \qquad C_y = 111 \text{ N} \quad \textbf{Ans.}$$

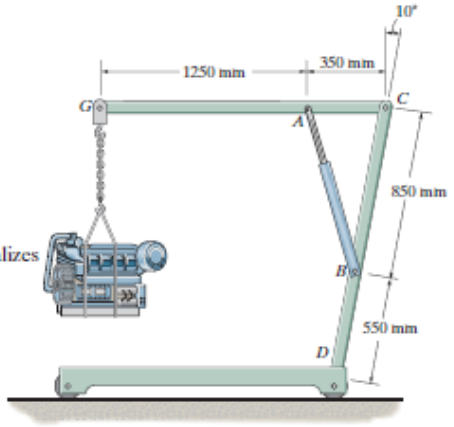


$$\Sigma F_x = 0; \quad A_x - F_{BC}\frac{e}{\sqrt{a^2+e^2}} = 0 \qquad A_x = F_{BC}\frac{e}{\sqrt{a^2+e^2}} \qquad A_x = 167 \text{ N} \quad \textbf{Ans.}$$

$$\Sigma F_y = 0; \quad A_y - F + F_{BC}\frac{a}{\sqrt{a^2+e^2}} = 0 \qquad A_y = F - F_{BC}\frac{a}{\sqrt{a^2+e^2}} \qquad A_y = 389 \text{ N} \quad \textbf{Ans.}$$

6–81.

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),

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

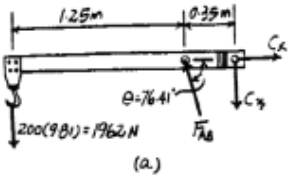
$F_{AB} = 9227.60 \text{ N} = 9.23 \text{ kN}$ **Ans.**

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

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



(a)

From FBD (b),

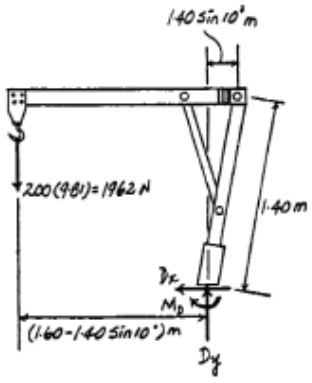
$\pm\rightarrow \Sigma F_x = 0;$ $\quad D_x = 0$ **Ans.**

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

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



(b)