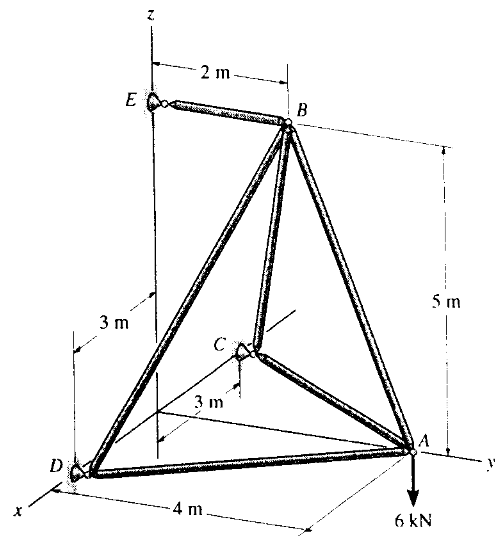
*6-56. Determine the force in each member of the space truss and state if the members are in tension or compression. *Hint:* The support reaction at E acts along member EB. Why?

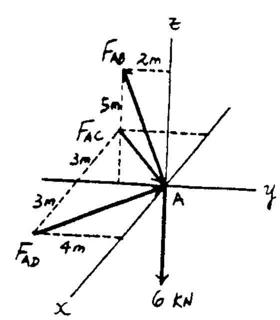


Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *A*

$$\Sigma F_z = 0; \quad F_{AB}\left(\frac{5}{\sqrt{29}}\right) - 6 = 0$$

$$F_{AB} = 6.462 \text{ kN (T)} = 6.46 \text{ kN (T)} \qquad \textbf{Ans}$$



$$\Sigma F_x = 0; \quad F_{AC}\left(\frac{3}{5}\right) - F_{AD}\left(\frac{3}{5}\right) = 0 \qquad F_{AC} = F_{AD} \qquad [1]$$

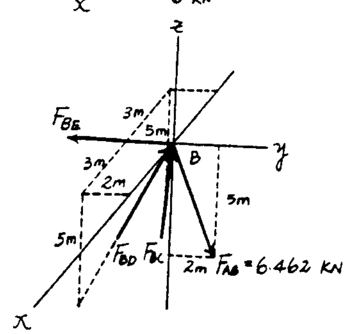
$$\Sigma F_y = 0; \quad F_{AC}\left(\frac{4}{5}\right) + F_{AD}\left(\frac{4}{5}\right) - 6.462\left(\frac{2}{\sqrt{29}}\right) = 0$$

$$F_{AC} + F_{AD} = 3.00 \qquad [2]$$

Solving Eqs.[1] and [2] yields

$$F_{AC} = F_{AD} = 1.50 \text{ kN (C)} \qquad \textbf{Ans}$$

Joint *B*



$$\Sigma F_x = 0; \quad F_{BC}\left(\frac{3}{\sqrt{38}}\right) - F_{BD}\left(\frac{3}{\sqrt{38}}\right) = 0 \qquad F_{BC} = F_{BD} \qquad [1]$$

$$\Sigma F_z = 0; \quad F_{BC}\left(\frac{5}{\sqrt{38}}\right) + F_{BD}\left(\frac{5}{\sqrt{38}}\right) - 6.462\left(\frac{5}{\sqrt{29}}\right) = 0$$

$$F_{BC} + F_{BD} = 7.397 \qquad [2]$$

Solving Eqs.[1] and [2] yields

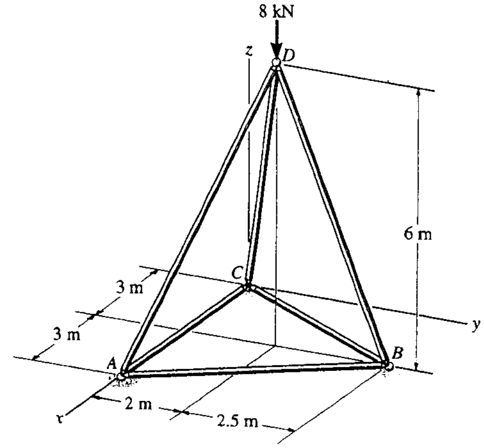
$$F_{BC} = F_{BD} = 3.699 \text{ kN (C)} = 3.70 \text{ kN (C)} \qquad \textbf{Ans}$$

$$\Sigma F_y = 0; \quad 2\left[3.699\left(\frac{2}{\sqrt{38}}\right)\right] + 6.462\left(\frac{2}{\sqrt{29}}\right) - F_{BE} = 0$$

$$F_{BE} = 4.80 \text{ kN (T)} \qquad \textbf{Ans}$$

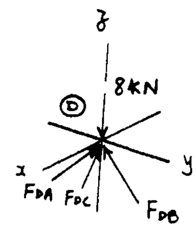
Note : The support reactions at supports C and D can be determined by analyzing joints C and D, respectively using the results obtained above.

6-57. Determine the force in each member of the space truss and state if the members are in tension or compression. The truss is supported by rollers at A, B, and C.



$\Sigma F_x = 0;\qquad \frac{3}{7}F_{DC} - \frac{3}{7}F_{DA} = 0$

$F_{DC} = F_{DA}$



$\Sigma F_y = 0;\qquad \frac{2}{7}F_{DC} + \frac{2}{7}F_{DA} - \frac{2.5}{6.5}F_{DB} = 0$

$F_{DB} = 1.486\,F_{DC}$

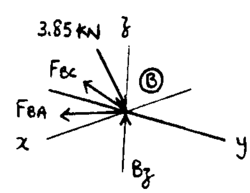
$\Sigma F_z = 0;\qquad -8 + 2(\frac{6}{7})F_{DC} + \frac{6}{6.5}F_{DB} = 0$

$F_{DC} = F_{DA} = 2.59\text{ kN (C)}$ **Ans**

$F_{DB} = 3.85\text{ kN (C)}$ **Ans**

$\Sigma F_x = 0;\qquad F_{BC} = F_{BA}$

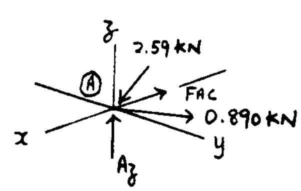
$\Sigma F_y = 0;\qquad 3.85(\frac{2.5}{6.5}) - 2(\frac{4.5}{\sqrt{29.25}})F_{BC} = 0$



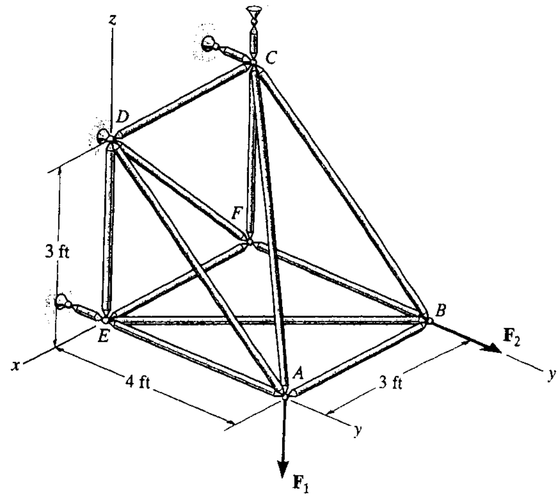
$F_{BC} = F_{BA} = 0.890\text{ kN (T)}$ **Ans**

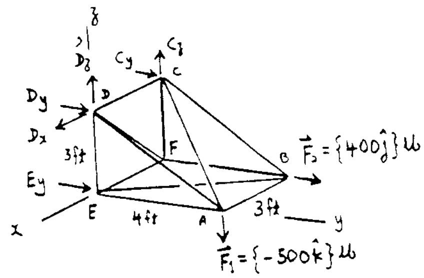
$\Sigma F_x = 0;\qquad 2.59(\frac{3}{7}) - 0.890(\frac{3}{\sqrt{29.25}}) - F_{AC} = 0$

$F_{AC} = 0.616\text{ kN (T)}$ **Ans**



***6-58.** The space truss is supported by a ball-and-socket joint at D and short links at C and E. Determine the force in each member and state if the members are in tension or compression. Take $\mathbf{F}_1 = \{-500\mathbf{k}\}$ lb and $\mathbf{F}_2 = \{400\mathbf{j}\}$ lb.





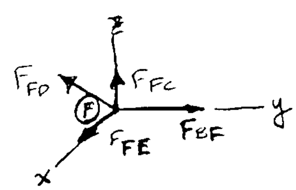
$\Sigma M_z = 0; \quad -C_y(3) - 400(3) = 0$

$C_y = -400$ lb

$\Sigma F_x = 0; \quad D_x = 0$

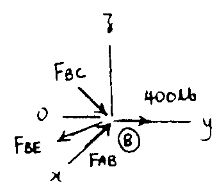
$\Sigma M_y = 0; \quad C_z = 0$

Joint F: $\quad \Sigma F_y = 0; \quad F_{BF} = 0$ **Ans**



Joint B:

$\Sigma F_z = 0; \quad F_{BC} = 0$ **Ans**



$\Sigma F_y = 0; \quad 400 - \frac{4}{5}F_{BE} = 0$

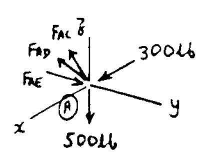
$F_{BE} = 500$ lb (T) **Ans**

$\Sigma F_x = 0; \quad F_{AB} - \frac{3}{5}(500) = 0$

$F_{AB} = 300$ lb (C) **Ans**

Joint A:

$\Sigma F_x = 0; \quad 300 - \frac{3}{\sqrt{34}}F_{AC} = 0$



$F_{AC} = 583.1 = 583$ lb (T) **Ans**

6-58 Cont'd

$\Sigma F_z = 0; \quad \frac{3}{\sqrt{34}}(583.1) - 500 + \frac{3}{5}F_{AD} = 0$

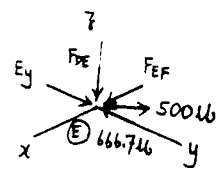
$F_{AD} = 333$ lb (T) **Ans**

$\Sigma F_y = 0; \quad F_{AE} - \frac{4}{5}(333.3) - \frac{4}{\sqrt{34}}(583.1) = 0$

$F_{AE} = 667$ lb (C) **Ans**

Joint E :

$\Sigma F_z = 0; \quad F_{DE} = 0$ **Ans**



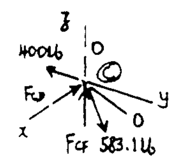
$\Sigma F_x = 0; \quad F_{EF} - \frac{3}{5}(500) = 0$

$F_{EF} = 300$ lb (C) **Ans**

Joint C :

$\Sigma F_x = 0; \quad \frac{3}{\sqrt{34}}(583.1) - F_{CD} = 0$

$F_{CD} = 300$ lb (C) **Ans**



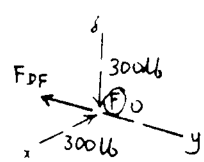
$\Sigma F_z = 0; \quad F_{CF} - \frac{3}{\sqrt{34}}(583.1) = 0$

$F_{CF} = 300$ lb (C) **Ans**

$\Sigma F_y = 0; \quad \frac{4}{\sqrt{34}}(583.1) - 400 = 0$ Check!

Joint F :

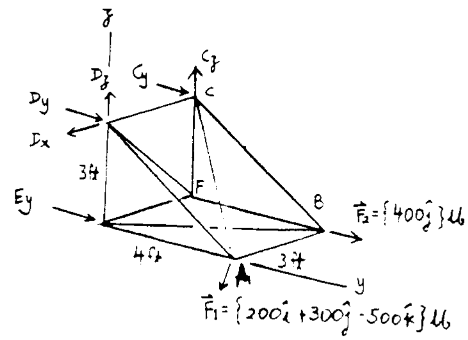
$\Sigma F_x = 0; \quad \frac{3}{\sqrt{18}}F_{DF} - 300 = 0$



$F_{DF} = 424$ lb (T) **Ans**

$\Sigma F_z = 0; \quad \frac{3}{\sqrt{18}}(424.3) - 300 = 0$ Check!

6-59. The space truss is supported by a ball-and-socket joint at D and short links at C and E. Determine the force in each member and state if the members are in tension or compression. Take $\mathbf{F}_1 = \{200\mathbf{i} + 300\mathbf{j} - 500\mathbf{k}\}$ lb and $\mathbf{F}_2 = \{400\mathbf{j}\}$ lb.



$\Sigma F_x = 0;\qquad D_x + 200 = 0$

$D_x = -200$ lb

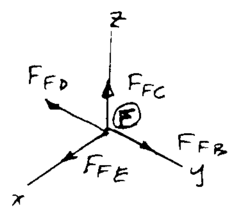
$\Sigma M_z = 0;\qquad -C_y(3) - 400(3) - 200(4) = 0$

$C_y = -666.7$ lb

$\Sigma M_y = 0;\qquad C_z(3) - 200(3) = 0$

$C_z = 200$ lb

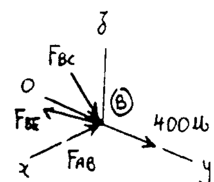
Joint F: $\qquad F_{BF} = 0\qquad$ **Ans**



Joint B :

$\Sigma F_z = 0;\qquad F_{BC} = 0\qquad$ **Ans**

$\Sigma F_y = 0;\qquad 400 - \frac{4}{5}F_{BE} = 0$



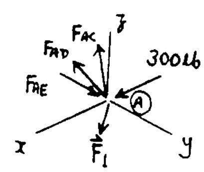
$F_{BE} = 500$ lb (T) $\qquad$ **Ans**

$\Sigma F_x = 0;\qquad F_{AB} - \frac{3}{5}(500) = 0$

$F_{AB} = 300$ lb (C) $\qquad$ **Ans**

Joint A :

$\Sigma F_x = 0;\qquad 300 + 200 - \frac{3}{\sqrt{34}}F_{AC} = 0$



$F_{AC} = 971.8 = 972$ lb (T) $\qquad$ **Ans**

$\Sigma F_z = 0;\qquad \frac{3}{\sqrt{34}}(971.8) - 500 + \frac{3}{5}F_{AD} = 0$

$F_{AD} = 0\qquad$ **Ans**

$\Sigma F_y = 0;\qquad F_{AE} + 300 - \frac{4}{\sqrt{34}}(971.8) = 0$

$F_{AE} = 367$ lb (C) $\qquad$ **Ans**

Cor

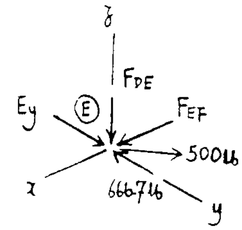
6-59 cont'd

Joint E:

$\Sigma F_z = 0;$ $F_{DE} = 0$ **Ans**

$\Sigma F_x = 0;$ $F_{EF} - \frac{3}{5}(500) = 0$

$F_{EF} = 300 \text{ lb (C)}$ **Ans**

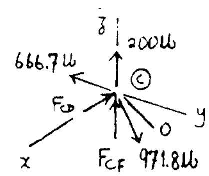


Joint C:

$\Sigma F_x = 0;$ $\frac{3}{\sqrt{34}}(971.8) - F_{CD} = 0$

$F_{CD} = 500 \text{ lb (C)}$ **Ans**

$\Sigma F_z = 0;$ $F_{CF} - \frac{3}{\sqrt{34}}(971.8) + 200 = 0$

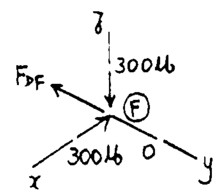


$F_{CF} = 300 \text{ lb (C)}$ **Ans**

$\Sigma F_y = 0;$ $\frac{4}{\sqrt{34}}(971.8) - 666.7 = 0$ Check!

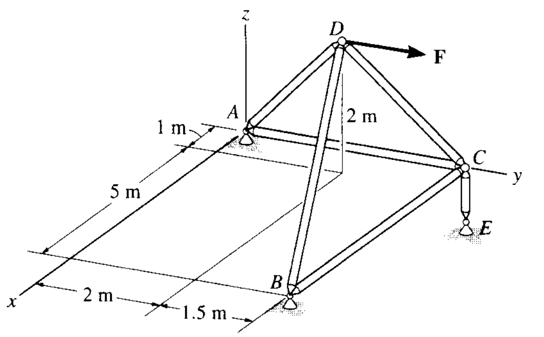
Joint F:

$\Sigma F_x = 0;$ $\frac{3}{\sqrt{18}}F_{DF} - 300 = 0$



$F_{DF} = 424 \text{ lb (T)}$ **Ans**

***6–60** Determine the force in each member of the space truss and state if the members are in tension or compression. The truss is supported by ball-and-socket joints at A, B, and E. Set $\mathbf{F} = \{-200\mathbf{i} + 400\mathbf{j}\}$ N. *Hint:* The support reaction at E acts along member EC. Why?

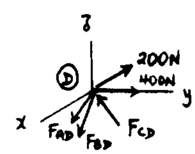


Joint D:

$$\Sigma F_x = 0; \qquad -\frac{1}{3}F_{AD} + \frac{5}{\sqrt{31.25}}F_{BD} + \frac{1}{\sqrt{7.25}}F_{CD} - 200 = 0$$

$$\Sigma F_y = 0; \qquad -\frac{2}{3}F_{AD} + \frac{1.5}{\sqrt{31.25}}F_{BD} - \frac{1.5}{\sqrt{7.25}}F_{CD} + 400 = 0$$

$$\Sigma F_z = 0; \qquad -\frac{2}{3}F_{AD} - \frac{2}{\sqrt{31.25}}F_{BD} + \frac{2}{\sqrt{7.25}}F_{CD} = 0$$



$F_{AD} = 343$ N (T) **Ans**

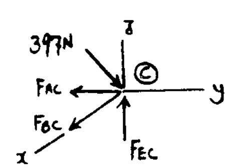
$F_{BD} = 186$ N (T) **Ans**

$F_{CD} = 397$ N (C) **Ans**

Joint C:

$$\Sigma F_x = 0; \qquad F_{BC} - \frac{1}{\sqrt{7.25}}(397) = 0$$

$F_{BC} = 148$ N (T) **Ans**



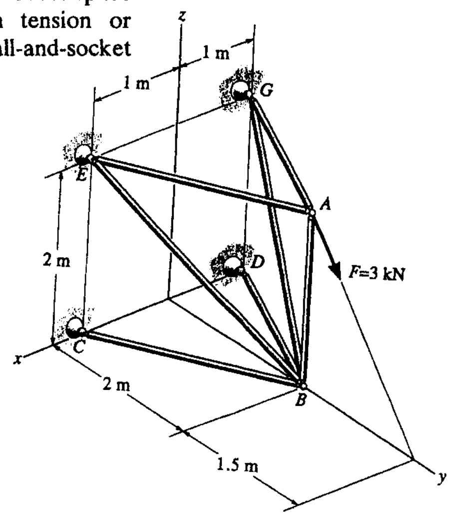
$$\Sigma F_z = 0; \qquad F_{EC} - \frac{2}{\sqrt{7.25}}(397) = 0$$

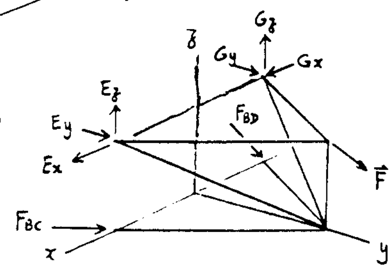
$F_{EC} = 295$ N (C) **Ans**

$$\Sigma F_y = 0; \qquad \frac{1.5}{\sqrt{7.25}}(397) - F_{AC} = 0$$

$F_{AC} = 221$ N (T) **Ans**

6-61. Determine the force in each member of the space truss and state if the members are in tension or compression. The truss is supported by ball-and-socket joints at *C*, *D*, *E*, and *G*.



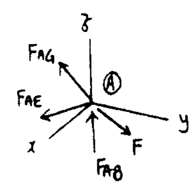


$\Sigma(M_{EG})_x = 0;\qquad \frac{2}{\sqrt{5}}F_{BC}(2) + \frac{2}{\sqrt{5}}F_{BD}(2) - \frac{4}{5}(3)(2) = 0$

$F_{BC} + F_{BD} = 2.683\text{ kN}$

Due to symmetry: $\quad F_{BC} = F_{BD} = 1.342 = 1.34\text{ kN (C)}$ **Ans**

Joint *A* :



$\Sigma F_z = 0;\qquad F_{AB} - \frac{4}{5}(3) = 0$

$F_{AB} = 2.4\text{ kN (C)}$ **Ans**

$\Sigma F_x = 0;\qquad F_{AG} = F_{AE}$

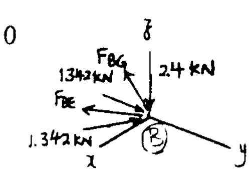
$\Sigma F_y = 0;\qquad \frac{3}{5}(3) - \frac{2}{\sqrt{5}}F_{AE} - \frac{2}{\sqrt{5}}F_{AG} = 0$

$F_{AG} = F_{AE} = 1.01\text{ kN (T)}$ **Ans**

Joint *B* :

$\Sigma F_x = 0;\qquad \frac{1}{\sqrt{5}}(1.342) + \frac{1}{3}F_{BE} - \frac{1}{\sqrt{5}}(1.342) - \frac{1}{3}F_{BG} = 0$

$\Sigma F_y = 0;\qquad \frac{2}{\sqrt{5}}(1.342) - \frac{2}{3}F_{BE} + \frac{2}{\sqrt{5}}(1.342) - \frac{2}{3}F_{BG} = 0$

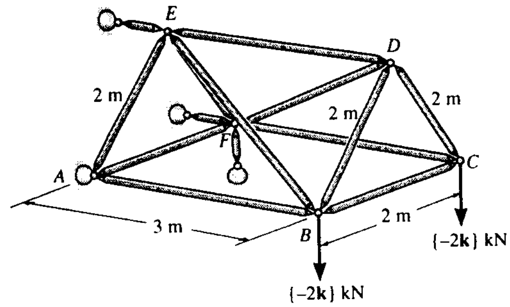


$\Sigma F_z = 0;\qquad \frac{2}{3}F_{BE} + \frac{2}{3}F_{BG} - 2.4 = 0$

$F_{BG} = 1.80\text{ kN (T)}$ **Ans**

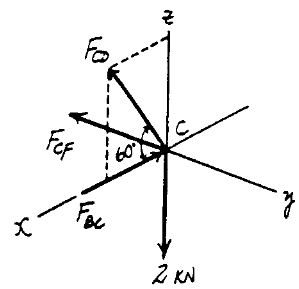
$F_{BE} = 1.80\text{ kN (T)}$ **Ans**

6-62. Determine the force in members *BE*, *DF*, and *BC* of the space truss and state if the members are in tension or compression.



Method of Joints **: In this case, the support reactions are not required for determining the member forces.**

Joint *C*

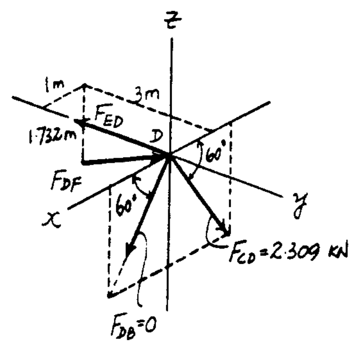


$\Sigma F_z = 0;\quad F_{CD}\sin 60° - 2 = 0 \quad F_{CD} = 2.309\text{ kN (T)}$

$\Sigma F_x = 0;\quad 2.309\cos 60° - F_{BC} = 0$

$F_{BC} = 1.154\text{ kN (C)} = 1.15\text{ kN (C)}$ **Ans**

Joint *D* Since F_{CD}, F_{DE} and F_{DE} lie within the same plane and F_{DB} is out of this plane, then $F_{DB} = 0$.



$\Sigma F_x = 0;\quad F_{DF}\left(\dfrac{1}{\sqrt{13}}\right) - 2.309\cos 60° = 0$

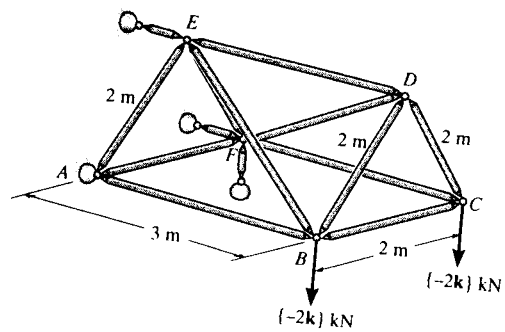
$F_{DF} = 4.16\text{ kN (C)}$ **Ans**

Joint *B*

$\Sigma F_z = 0;\quad F_{BE}\left(\dfrac{1.732}{\sqrt{13}}\right) - 2 = 0$

$F_{BE} = 4.16\text{ kN (T)}$ **Ans**

6-63. Determine the force in members *AB*, *CD*, *ED*, and *CF* of the space truss and state if the members are in tension or compression.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *C* Since F_{CD}, F_{BC} and 2 kN force lie within the same plane and F_{CF} is out of this plane, then

$$F_{CF} = 0 \qquad \textbf{Ans}$$

$\Sigma F_z = 0; \quad F_{CD}\sin 60° - 2 = 0$

$$F_{CD} = 2.309 \text{ kN (T)} = 2.31 \text{ kN (T)} \qquad \textbf{Ans}$$

$\Sigma F_x = 0; \quad 2.309\cos 60° - F_{BC} = 0 \qquad F_{BC} = 1.154 \text{ kN (C)}$

Joint *D* Since F_{CD}, F_{DE} and F_{DE} lie within the same plane and F_{DB} is out of this plane, then $F_{DB} = 0$.

$\Sigma F_x = 0; \quad F_{DF}\left(\frac{1}{\sqrt{13}}\right) - 2.309\cos 60° = 0$

$$F_{DF} = 4.163 \text{ kN (C)}$$

$\Sigma F_y = 0; \quad 4.163\left(\frac{3}{\sqrt{13}}\right) - F_{ED} = 0$

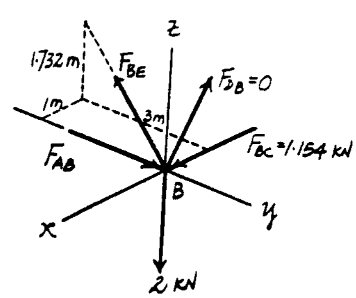
$$F_{ED} = 3.46 \text{ kN (T)} \qquad \textbf{Ans}$$

Joint *B*

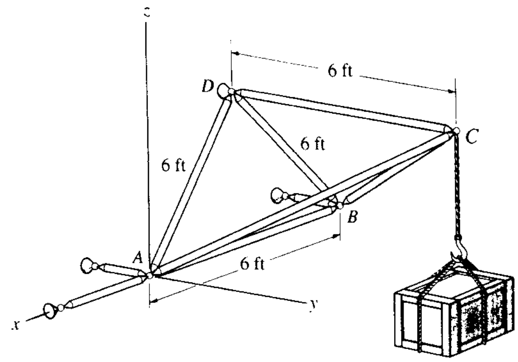
$\Sigma F_z = 0; \quad F_{BE}\left(\frac{1.732}{\sqrt{13}}\right) - 2 = 0 \qquad F_{BE} = 4.163 \text{ kN (T)}$

$\Sigma F_y = 0; \quad F_{AB} - 4.163\left(\frac{3}{\sqrt{13}}\right) = 0$

$$F_{AB} = 3.46 \text{ kN (C)} \qquad \textbf{Ans}$$



***6-64.** Determine the force developed in each member of the space truss and state if the members are in tension or compression. The crate has a weight of 150 lb.



$$\mathbf{F}_{CA} = F_{CA}\left[\frac{-1\mathbf{i} + 2\mathbf{j} + 2\sin 60°\mathbf{k}}{\sqrt{8}}\right]$$

$$= -0.354\,F_{CA}\mathbf{i} + 0.707\,F_{CA}\mathbf{j} + 0.612\,F_{CA}\mathbf{k}$$

$$\mathbf{F}_{CB} = 0.354F_{CB}\mathbf{i} + 0.707F_{CB}\mathbf{j} + 0.612F_{CB}\mathbf{k}$$

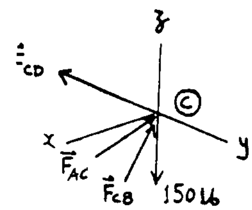
$$\mathbf{F}_{CD} = -\,F_{CD}\mathbf{j}$$

$$\mathbf{W} = -150\,\mathbf{k}$$

$\Sigma F_x = 0;$ $\quad -0.354F_{CA} + 0.354F_{CB} = 0$

$\Sigma F_y = 0;$ $\quad 0.707F_{CA} + 0.707F_{CB} - F_{CD} = 0$

$\Sigma F_z = 0;$ $\quad 0.612F_{CA} + 0.612F_{CB} - 150 = 0$



Solving :

$F_{CA} = F_{CB} = 122.5$ lb $= 122$ lb (C) **Ans**

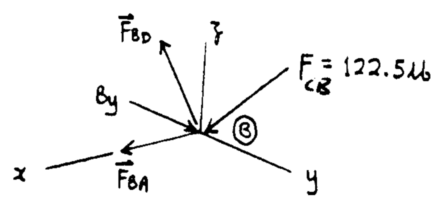
$F_{CD} = 173$ lb (T) **Ans**

$$\mathbf{F}_{BA} = F_{BA}\mathbf{i}$$

$$\mathbf{F}_{BD} = F_{BD}\cos 60°\mathbf{i} + F_{BD}\sin 60°\,\mathbf{k}$$

$$\mathbf{F}_{CB} = 122.5\,(-0.354\mathbf{i} - 0.707\,\mathbf{j} - 0.612\mathbf{k})$$

$$= -43.3\mathbf{i} - 86.6\mathbf{j} - 75.0\mathbf{k}$$



$\Sigma F_x = 0;$ $\quad F_{BA} + F_{BD}\cos 60° - 43.3 = 0$

$\Sigma F_z = 0;$ $\quad F_{BD}\sin 60° - 75 = 0$

Solving :

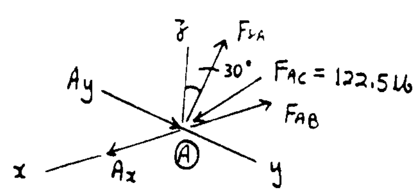
$F_{BD} = 86.6$ lb (T) **Ans**

$F_{BA} = 0$ **Ans**

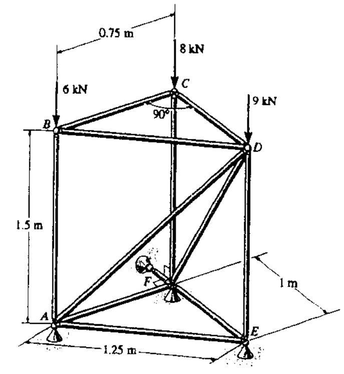
$$\mathbf{F}_{AC} = 122.5(0.354F_{AC}\mathbf{i} - 0.707F_{AC}\mathbf{j} - 0.612F_{AC}\mathbf{k})$$

$\Sigma F_z = 0;$ $\quad F_{DA}\cos 30° - 0.612(122.5) = 0$

$F_{DA} = 86.6$ lb (T) **Ans**



6-65. The space truss is used to support vertical forces at joints B, C, and D. Determine the force in each member and state if the members are in tension or compression.



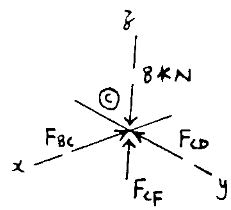
Prob. 6-65

Joint C:

$\Sigma F_x = 0;$ $F_{BC} = 0$ **Ans**

$\Sigma F_y = 0;$ $F_{CD} = 0$ **Ans**

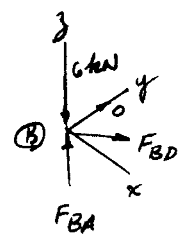
$\Sigma F_z = 0;$ $F_{CF} = 8$ kN (C) **Ans**



Joint B:

$\Sigma F_y = 0;$ $F_{BD} = 0$ **Ans**

$\Sigma F_z = 0;$ $F_{BA} = 6$ kN (C) **Ans**

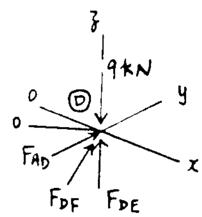


Joint D:

$\Sigma F_y = 0;$ $F_{AD} = 0$ **Ans**

$\Sigma F_x = 0;$ $F_{DF} = 0$ **Ans**

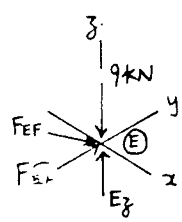
$\Sigma F_z = 0;$ $F_{DE} = 9$ kN (C) **Ans**



Joint E:

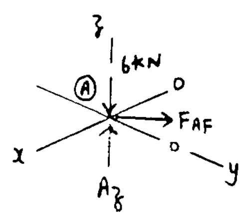
$\Sigma F_x = 0;$ $F_{EF} = 0$ **Ans**

$\Sigma F_y = 0;$ $F_{EA} = 0$ **Ans**

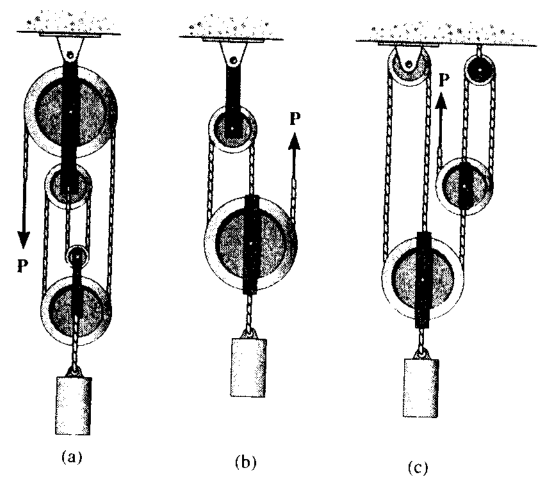


Joint A:

$\Sigma F_x = 0;$ $F_{AF} = 0$ **Ans**



6-66. In each case, determine the force **P** required to maintain equilibrium. The block weighs 100 lb.



Equations of Equilibrium :

a) $+\uparrow \Sigma F_y = 0;\quad 4P - 100 = 0$

$P = 25.0\ \text{lb}$ **Ans**

b) $+\uparrow \Sigma F_y = 0;\quad 3P - 100 = 0$

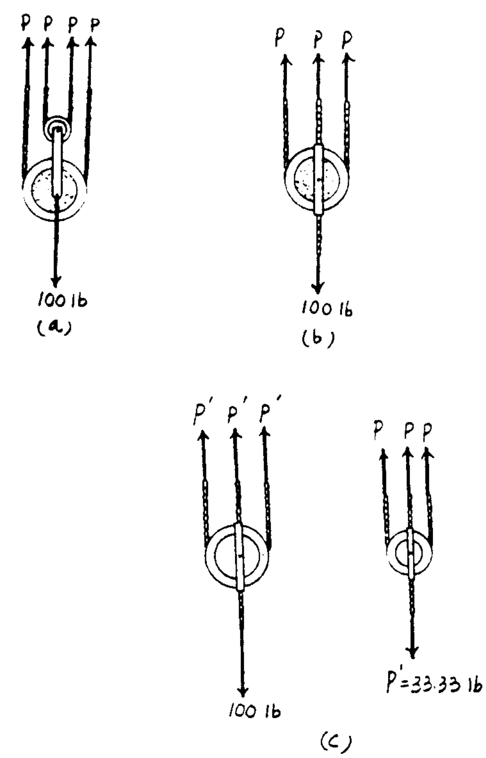
$P = 33.3\ \text{lb}$ **Ans**

c) $+\uparrow \Sigma F_y = 0;\quad 3P' - 100 = 0$

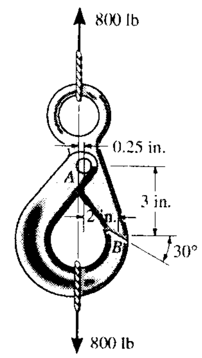
$P' = 33.33\ \text{lb}$

$+\uparrow \Sigma F_y = 0;\quad 3P - 33.33 = 0$

$P = 11.1\ \text{lb}$ **Ans**



6-67. The eye hook has a positive locking latch when it supports the load because its two parts are pin-connected at A and they bear against one another along the smooth surface at B. Determine the resultant force at the pin and the normal force at B when the eye hook supports a load of 800 lb.



$$\curvearrowleft + \Sigma M_A = 0; \quad -F_B \cos 60°(3) - F_B \sin 60°(2) + 800(0.25) = 0$$

$$F_B = 61.88 = 61.9 \text{ lb} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad -800 - 61.88 \sin 60° + A_y = 0$$

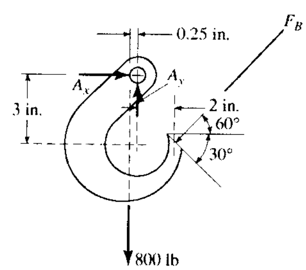
$$A_y = 853.59 = 854 \text{ lb}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - F_B \cos 60° = 0$$

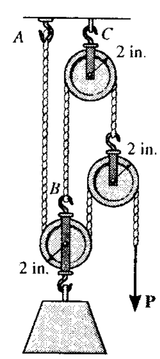
$$A_x = 30.9 \text{ lb}$$

$$F_A = \sqrt{(853.59)^2 + (30.9)^2}$$

$$= 854 \text{ lb} \qquad \textbf{Ans}$$



***6-68.** Determine the force **P** needed to support the 100-lb weight. Each pulley has a weight of 10 lb. Also, what are the cord reactions at A and B?



Equations of Equilibrium: From FBD (a),

$$+\uparrow \Sigma F_y = 0; \quad P' - 2P - 10 = 0 \qquad [1]$$

From FBD (b),

$$+\uparrow \Sigma F_y = 0; \quad 2P + P' - 100 - 10 = 0 \qquad [2]$$

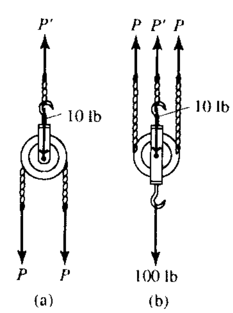
Solving Eqs. [1] and [2] yields,

$P = 25.0$ lb **Ans**

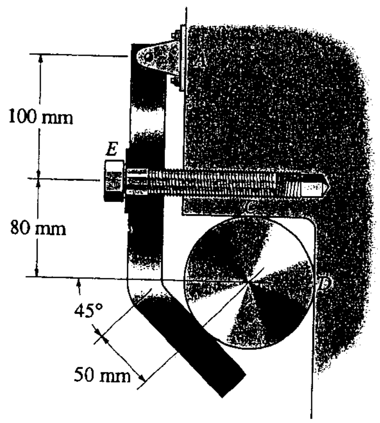
$P' = 60.0$ lb

The cord reactions at A and B are

$$F_A = P = 25.0 \text{ lb} \quad F_B = P' = 60.0 \text{ lb} \qquad \textbf{Ans}$$

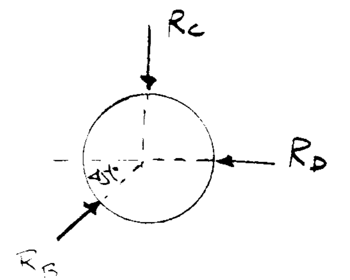


6-69. The link is used to hold the rod in place. Determine the required axial force on the screw at E if the largest force to be exerted on the rod at B, C or D is to be 100 lb. Also, find the magnitude of the force reaction at pin A. Assume all surfaces of contact are smooth.



$$\Sigma F_y = 0; \quad R_C = \frac{1}{\sqrt{2}} R_B$$

$$\Sigma F_x = 0; \quad R_D = \frac{1}{\sqrt{2}} R_B$$

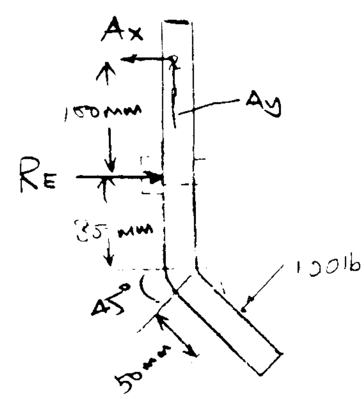


Assume $R_B = 100$ lb

$$R_C = R_D = \frac{100}{\sqrt{2}} = 70.71 \text{ lb} < 100 \text{ lb} \qquad \textbf{(O.K)}$$

$$\curvearrowleft + \Sigma M_A = 0; \qquad -100\sin 45°(50\sin 45°) - 100\cos 45°(180 + 50\cos 45°) + R_E(100) = 0$$

$$R_E = 177.28 = 177 \text{ lb} \qquad \textbf{Ans}$$



$$+\uparrow \Sigma F_y = 0; \qquad -100\sin 45° + A_y = 0$$

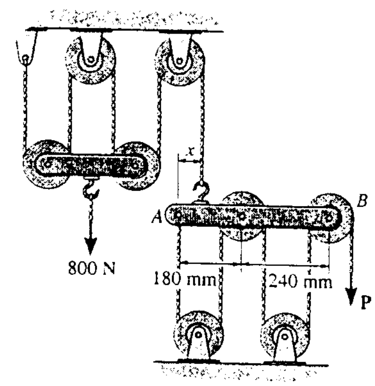
$$A_y = 70.71 \text{ lb}$$

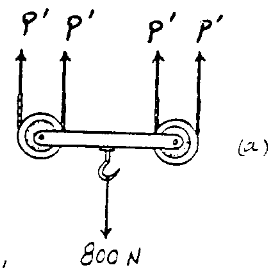
$$\xrightarrow{+} \Sigma F_x = 0; \qquad 177.28 - 100\cos 45° - A_x = 0$$

$$A_x = 106.57 \text{ lb}$$

$$R_A = \sqrt{106.57^2 + 70.71^2} = 128 \text{ lb} \qquad \textbf{Ans}$$

6-70. The principles of a *differential chain block* are indicated schematically in the figure. Determine the magnitude of force **P** needed to support the 800-N force. Also, find the distance x where the cable must be attached to bar AB so the bar remains horizontal. All pulleys have a radius of 60 mm.





Equations of Equilibrium : From FBD(a),

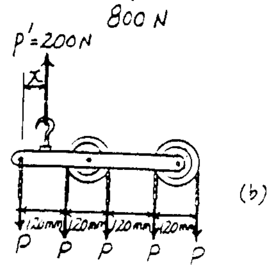
$+\uparrow \Sigma F_y = 0;\quad 4P' - 800 = 0 \quad P' = 200\text{ N}$

From FBD(b),

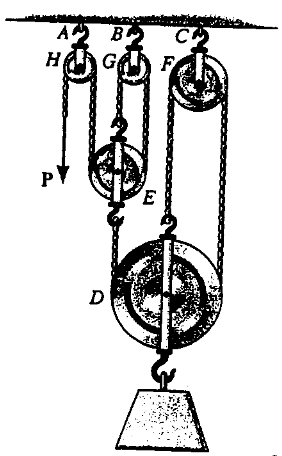
$+\uparrow \Sigma F_y = 0;\quad 200 - 5P = 0 \quad P = 40.0\text{ N}$ **Ans**

$\circlearrowleft + \Sigma M_A = 0;\quad 200(x) - 40.0(120) - 40.0(240) - 40.0(360) - 40.0(480) = 0$

$x = 240\text{ mm}$ **Ans**



6-71. Determine the force P needed to support the 20-kg mass using the Spanish Burton rig. Also, what are the reactions at the supporting hooks A, B, and C?



For pulley D:

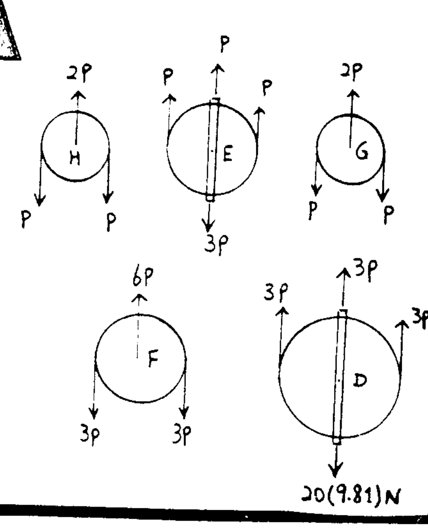
$+\uparrow \Sigma F_y = 0;\quad 9P - 20(9.81) = 0$

$P = 21.8\text{ N}$ **Ans**

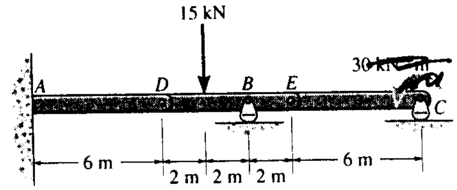
At A, $R_A = 2P = 43.6\text{ N}$ **Ans**

At B, $R_B = 2P = 43.6\text{ N}$ **Ans**

At C, $R_C = 6P = 131\text{ N}$ **Ans**



***6-72.** The compound beam is fixed at A and supported by a rocker at B and C. There are hinges (pins) at D and E. Determine the reactions at the supports.



Equations of Equilibrium : From FBD(a),

$\curvearrowleft + \Sigma M_E = 0; \quad C_y(6) = 0 \quad C_y = 0$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad E_y - 0 = 0 \quad E_y = 0$

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

From FBD(b),

$\curvearrowleft + \Sigma M_D = 0; \quad B_y(4) - 15(2) = 0$
$B_y = 7.50 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad D_y + 7.50 - 15 = 0$
$D_y = 7.50 \text{ kN}$

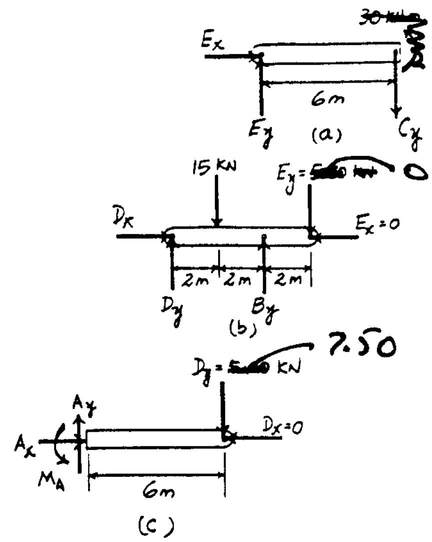
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad D_x = 0$

From FBD(c),

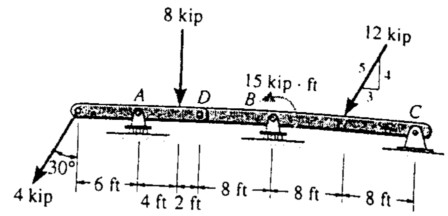
$\curvearrowleft + \Sigma M_A = 0; \quad M_A - 5.00(6) = 0$
$M_A = 30.0 \text{ kN} \cdot \text{m}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y - 5.00 = 0 \quad A_y = 5.00 \text{ kN}$ **Ans**

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



6-73. The compound beam is pin-supported at C and supported by a roller at A and B. There is a hinge (pin) at D. Determine the reactions at the supports. Neglect the thickness of the beam.



Equations of Equilibrium : From FBD(a),

$\circlearrowleft + \Sigma M_D = 0;\quad 4\cos 30°(12) + 8(2) - A_y(6) = 0$

$A_y = 9.595 \text{ kip} = 9.59 \text{ kip}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad D_y + 9.595 - 4\cos 30° - 8 = 0$

$D_y = 1.869 \text{ kip}$

$\xrightarrow{+} \Sigma F_x = 0;\quad D_x - 4\sin 30° = 0 \quad D_x = 2.00 \text{ kip}$

From FBD(b),

$\circlearrowleft + \Sigma M_C = 0;\quad 1.869(24) + 15 + 12\left(\frac{4}{5}\right)(8) - B_y(16) = 0$

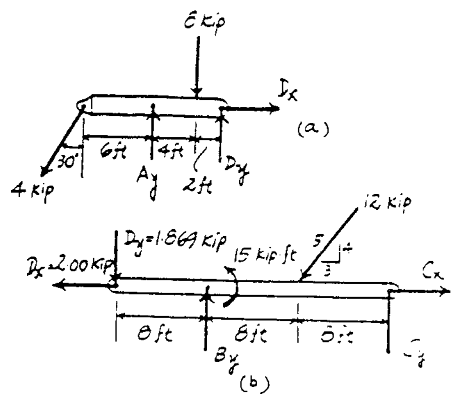
$B_y = 8.541 \text{ kip} = 8.54 \text{ kip}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad C_y + 8.541 - 1.869 - 12\left(\frac{4}{5}\right) = 0$

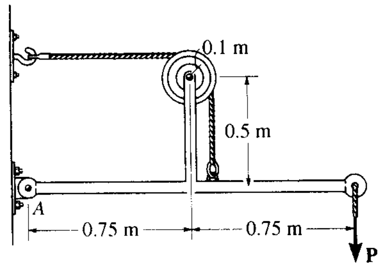
$C_y = 2.93 \text{ kip}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad C_x - 2.00 - 12\left(\frac{3}{5}\right) = 0$

$C_x = 9.20 \text{ kip}$ **Ans**



6-74. 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.

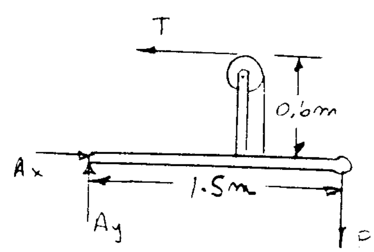


$\circlearrowleft + \Sigma M_A = 0; \quad T(0.6) - P(1.5) = 0$

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

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

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

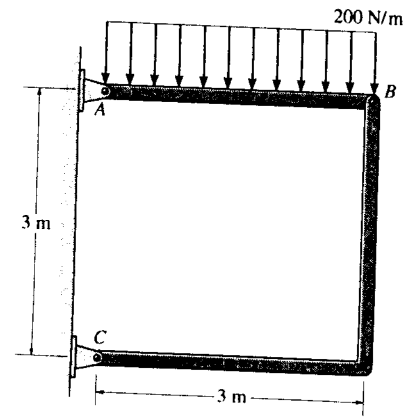


Require.

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

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

6-75. Determine the horizontal and vertical components force at pins A and C of the two-member frame.



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

Equations of Equilibrium :

$\curvearrowleft + \Sigma M_A = 0;\quad F_{BC}\cos 45°(3) - 600(1.5) = 0$

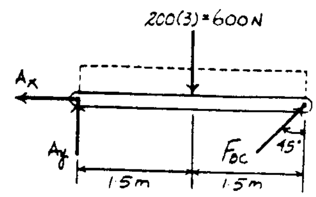
$F_{BC} = 424.26 \text{ N}$

$+\uparrow \Sigma F_y = 0;\quad A_y + 424.26\cos 45° - 600 = 0$

$A_y = 300 \text{ N}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad 424.26\sin 45° - A_x = 0$

$A_x = 300 \text{ N}$ **Ans**

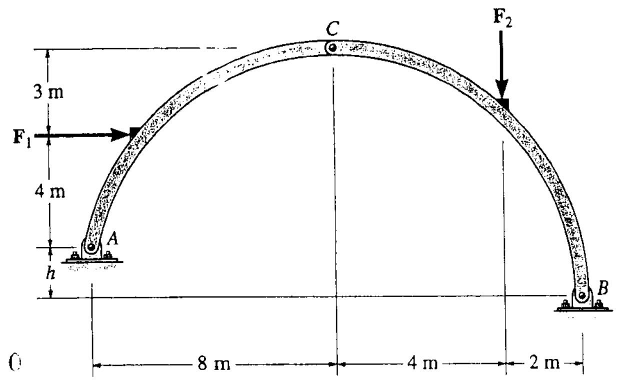


For pin C,

$C_x = F_{BC}\sin 45° = 424.26\sin 45° = 300 \text{ N}$ **Ans**

$C_y = F_{BC}\cos 45° = 424.26\cos 45° = 300 \text{ N}$ **Ans**

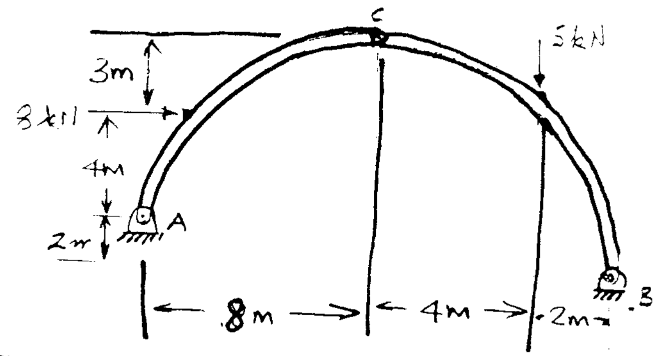
6-76. The three-hinged arch supports the loads $F_1 = 8$ kN and $F_2 = 5$ kN. Determine the horizontal and vertical components of reaction at the pin supports A and B. Take $h = 2$ m.



Member AC:

$\circlearrowleft + \Sigma M_A = 0;\quad -8(4) + C_y(8) + C_x(7) = 0$

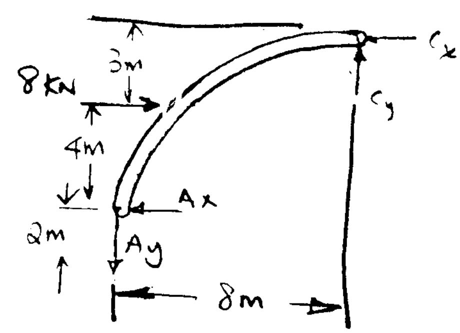
$8C_y + 7C_x - 32 = 0$



$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad 8 - A_x - C_x = 0$

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

$A_y = C_y$



Member BC:

$\circlearrowleft + \Sigma M_B = 0;\quad 5(2) + C_y(6) - C_x(9) = 0$

$6C_y - 9C_x + 10 = 0$

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad C_x - B_x = 0$

$B_x = C_x$

$+\uparrow \Sigma F_y = 0;\quad -C_y + B_y - 5 = 0$

Solving :

$A_x = 5.6141 = 5.61$ kN **Ans**

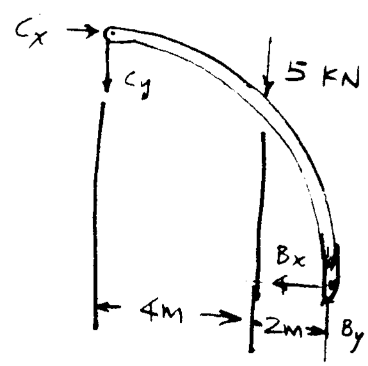
$A_y = 1.9122 = 1.91$ kN **Ans**

$C_x = 2.3859 = 2.39$ kN **Ans**

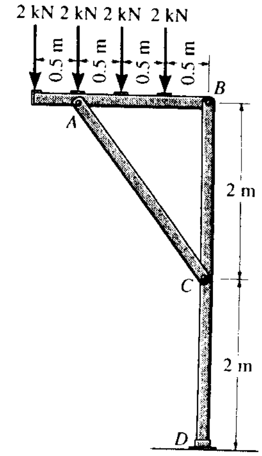
$C_y = 1.9122 = 1.91$ kN **Ans**

$B_x = 2.3859 = 2.39$ kN **Ans**

$B_y = 6.9122 = 6.91$ kN **Ans**



6-77. Determine the horizontal and vertical components of force at pins A, B, and C, and the reactions to the fixed support D of the three-member frame.



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),

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

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

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

$B_y = 1.333 \text{ kN} = 1.33 \text{ kN}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad B_x - 8.333\left(\frac{3}{5}\right) = 0$

$B_x = 5.00 \text{ kN}$ **Ans**

For pin A and C,

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

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

From FBD (b),

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

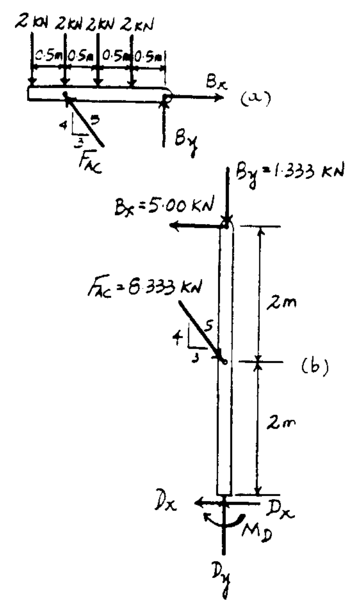
$M_D = 10.0 \text{ kN}\cdot\text{m}$ **Ans**

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

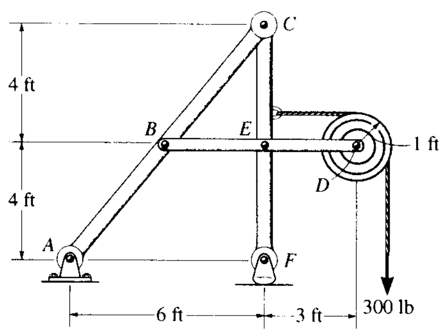
$D_y = 8.00 \text{ kN}$ **Ans**

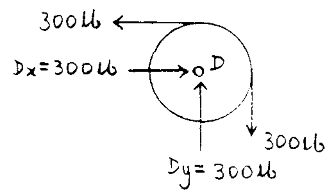
$\xrightarrow{+} \Sigma F_x = 0; \quad 8.333\left(\frac{3}{5}\right) - 5.00 - D_x = 0$

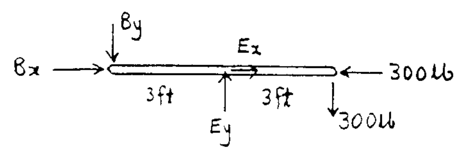
$D_x = 0$ **Ans**

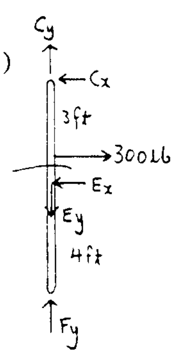


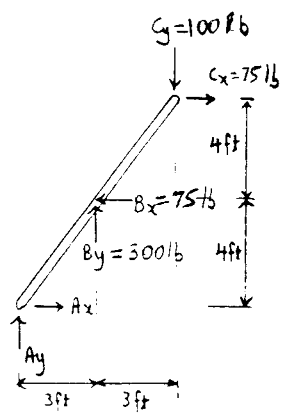
6-78. Determine the horizontal and vertical components of force at C which member ABC exerts on member CEF.











Member BED:

$\circlearrowleft + \Sigma M_B = 0;\quad -300(6) + E_y(3) = 0$

$E_y = 600 \text{ lb}$

$+\uparrow \Sigma F_y = 0;\quad -B_y + 600 - 300 = 0$

$B_y = 300 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0;\quad B_x + E_x - 300 = 0 \qquad (1)$

Member FEC:

$\circlearrowleft + \Sigma M_C = 0;\quad 300(3) - E_x(4) = 0$

$E_x = 225 \text{ lb}$

From Eq. (1) $\quad B_x = 75 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0;\quad -C_x + 300 - 225 = 0$

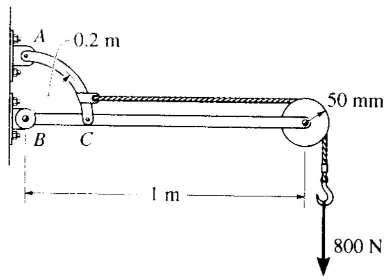
$C_x = 75 \text{ lb}$ **Ans**

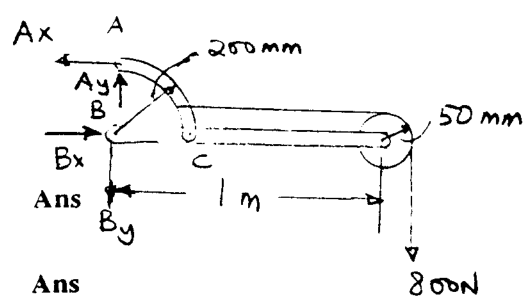
Member ABC:

$\circlearrowleft + \Sigma M_A = 0;\quad -75(8) - C_y(6) + 75(4) + 300(3) = 0$

$C_y = 100 \text{ lb}$ **Ans**

6-79. Determine the horizontal and vertical components of force that the pins at A, B, and C exert on their connecting members.





$\circlearrowleft + \Sigma M_B = 0;$ $\quad -800(1 + 0.05) + A_x(0.2) = 0$

$A_x = 4200 \text{ N} = 4.20 \text{ kN}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad B_x = 4200 \text{ N} = 4.20 \text{ kN}$ **Ans**

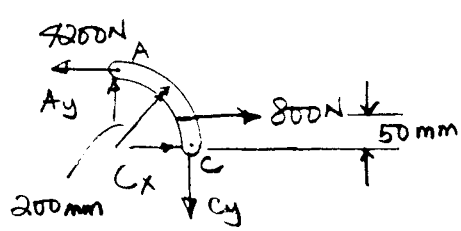
$+\uparrow \Sigma F_y = 0;$ $\quad A_y - B_y - 800 = 0 \qquad (1)$

Member AC :

$\circlearrowleft + \Sigma M_C = 0;$ $\quad -800(50) - A_y(200) + 4200(200) = 0$

$A_y = 4000 \text{ N} = 4.00 \text{ kN}$ **Ans**

From Eq. (1) $\quad B_y = 3.20 \text{ kN}$ **Ans**



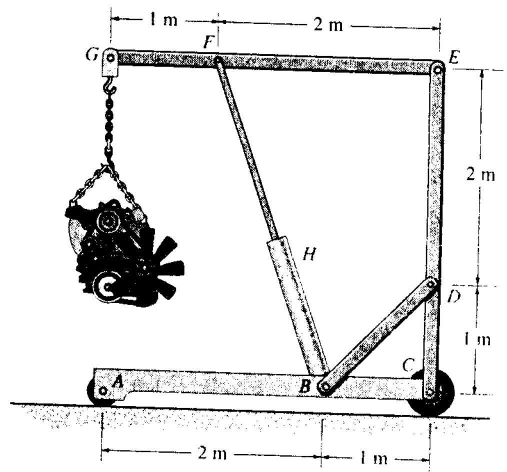
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -4200 + 800 + C_x = 0$

$C_x = 3.40 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad 4000 - C_y = 0$

$C_y = 4.00 \text{ kN}$ **Ans**

*6-80. The hoist supports the 125-kg engine. Determine the force the load creates in member DB and in member FB, which contains the hydraulic cylinder H.



Free Body Diagram : The solution for this problem will be simplified if one realizes that members *FB* and *DB* are two force members.

Equations of Equilibrium : For FBD(a),

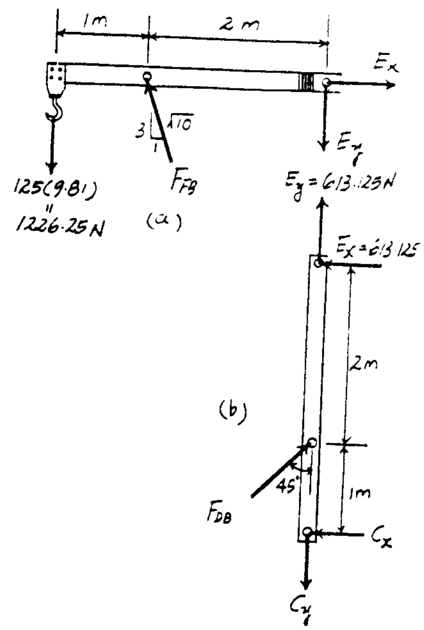
$$\curvearrowleft + \Sigma M_E = 0; \quad 1226.25(3) - F_{FB}\left(\frac{3}{\sqrt{10}}\right)(2) = 0$$
$$F_{FB} = 1938.87 \text{ N} = 1.94 \text{ kN} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad 1938.87\left(\frac{3}{\sqrt{10}}\right) - 1226.25 - E_y = 0$$
$$E_y = 613.125\text{N}$$

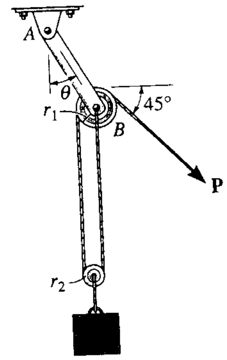
$$\xrightarrow{+} \Sigma F_x = 0; \quad E_x - 1938.87\left(\frac{1}{\sqrt{10}}\right) = 0$$
$$E_x = 613.125 \text{ N}$$

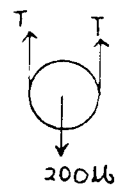
From FBD (b),

$$\curvearrowleft + \Sigma M_C = 0; \quad 613.125(3) - F_{BD}\sin 45°(1) = 0$$
$$F_{BD} = 2601.27 \text{ N} = 2.60 \text{ kN} \qquad \textbf{Ans}$$



6-81. Determine the force P on the cord, and the angle θ that the pulley-supporting link AB makes with the vertical. Neglect the mass of the pulleys and the link. The block has a weight of 200 lb and the cord is attached to the pin at B. The pulleys have radii of $r_1 = 2$ in. and $r_2 = 1$ in.





$+\uparrow \Sigma F_y = 0;\quad 2T - 200 = 0$

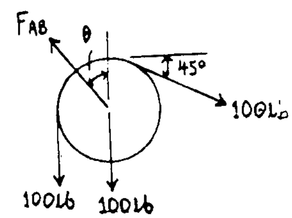
$T = 100$ lb **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad 100\cos 45^\circ - F_{AB}\sin\theta = 0$

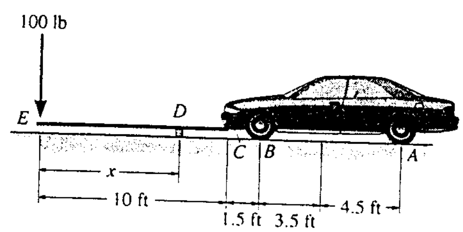
$+\uparrow \Sigma F_y = 0;\quad F_{AB}\cos\theta - 100 - 100 - 100\sin 45^\circ = 0$

$\theta = 14.6^\circ$ **Ans**

$F_{AB} = 280$ lb



6-82. The front of the car is to be lifted using a smooth, rigid 10-ft long board. The car has a weight of 3500 lb and a center of gravity at G. Determine the position x of the fulcrum so that an applied force of 100 lb at E will lift the front wheels of the car.



Free Body Diagram : When the front wheels are lifted, the normal reaction $N_B = 0$.

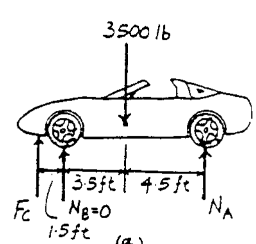
Equations of Equilibrium : From FBD (a),

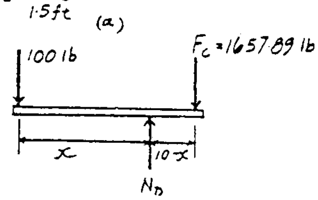
$\circlearrowleft + \Sigma M_A = 0;\quad 3500(4.5) - F_C(9.5) = 0 \qquad F_C = 1657.89$ lb

From FBD (b),

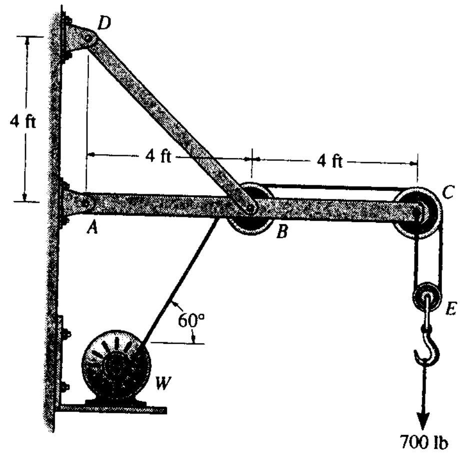
$\circlearrowleft + \Sigma M_D = 0;\quad 100(x) - 1657.89(10 - x) = 0$

$x = 9.43$ ft **Ans**





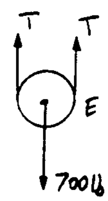
6-83. The wall crane supports a load of 700 lb. Determine the horizontal and vertical components of reaction at the pins A and D. Also, what is the force in the cable at the winch W?



Pulley E:

$+\uparrow \Sigma F_y = 0;\quad 2T - 700 = 0$

$T = 350 \text{ lb}$ **Ans**



Member ABC:

$\circlearrowleft + \Sigma M_A = 0;\quad T_{BD} \sin 45° (4) - 350 \sin 60° (4) - 700 (8) = 0$

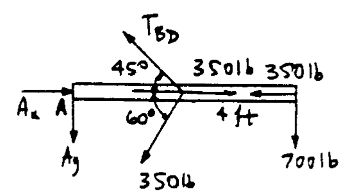
$T_{BD} = 2409 \text{ lb}$

$+\uparrow \Sigma F_y = 0;\quad -A_y + 2409 \sin 45° - 350 \sin 60° - 700 = 0$

$A_y = 700 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 2409 \cos 45° - 350 \cos 60° + 350 - 350 = 0$

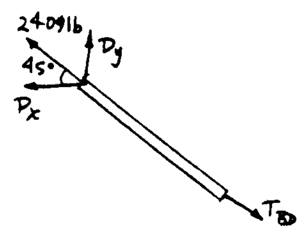
$A_x = 1.88 \text{ kip}$ **Ans**



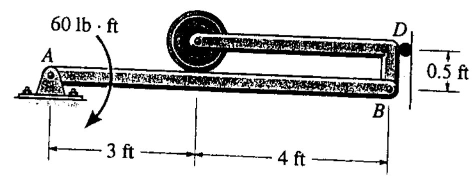
At D:

$D_x = 2409 \cos 45° = 1703.1 \text{ lb} = 1.70 \text{ kip}$ **Ans**

$D_y = 2409 \sin 45° = 1.70 \text{ kip}$ **Ans**

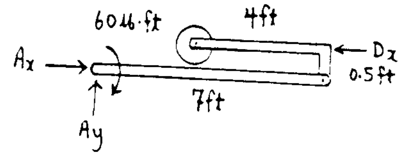


***6-84.** Determine the force that the smooth roller C exerts on beam AB. Also, what are the horizontal and vertical components of reaction at pin A? Neglect the weight of the frame and roller.



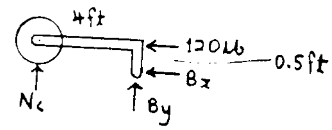
$\circlearrowleft + \Sigma M_A = 0; \quad -60 + D_x(0.5) = 0$

$D_x = 120 \text{ lb}$



$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 120 \text{ lb}$ **Ans**

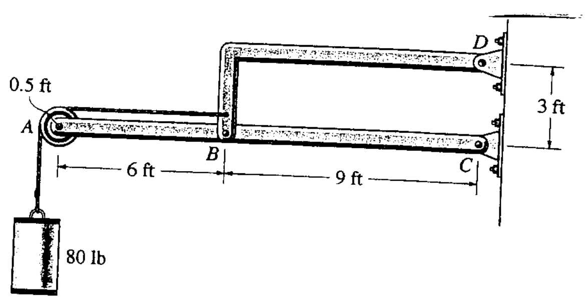
$+\uparrow \Sigma F_y = 0; \quad A_y = 0$ **Ans**



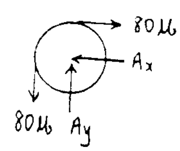
$\circlearrowleft + \Sigma M_B = 0; \quad -N_C(4) + 120(0.5) = 0$

$N_C = 15.0 \text{ lb}$ **Ans**

6-85. Determine the horizontal and vertical components of force which the pins exert on member ABC.



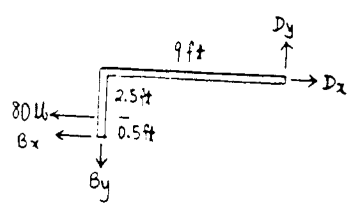
$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 80 \text{ lb}$ **Ans**



$+\uparrow \Sigma F_y = 0; \quad A_y = 80 \text{ lb}$ **Ans**

$\circlearrowleft + \Sigma M_C = 0; \quad 80(15) - B_y(9) = 0$

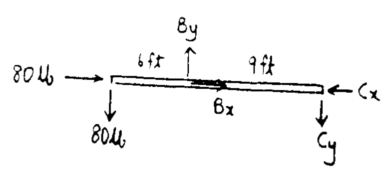
$B_y = 133.3 = 133 \text{ lb}$ **Ans**



$\circlearrowleft + \Sigma M_D = 0; \quad -80(2.5) + 133.3(9) - B_x(3) = 0$

$B_x = 333 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad 80 + 333 - C_x = 0$

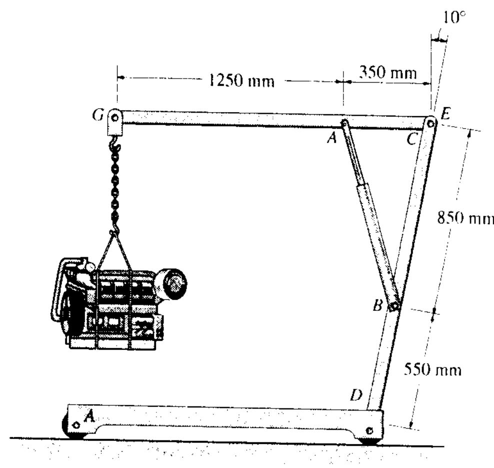


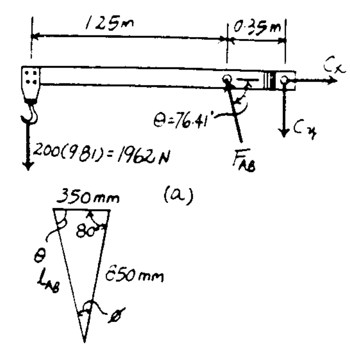
$C_x = 413 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad -80 + 133.3 - C_y = 0$

$C_y = 53.3 \text{ lb}$ **Ans**

6-86. 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 support D.





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,

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

$$\frac{\sin\theta}{850} = \frac{\sin 80^\circ}{861.21} \qquad \theta = 76.41^\circ$$

Equations of Equilibrium : From FBD (a),

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

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

$\xrightarrow{+} \Sigma F_x = 0;\quad C_x - 9227.60\cos 76.41^\circ = 0$

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

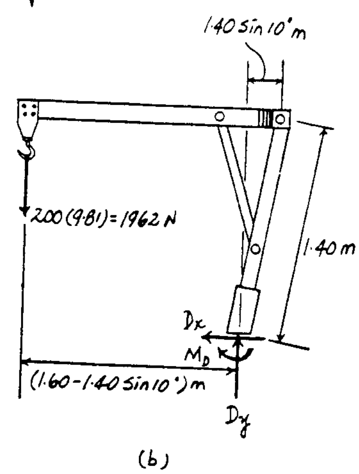
$\xrightarrow{+} \Sigma F_x = 0;\quad D_x = 0$ **Ans**

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

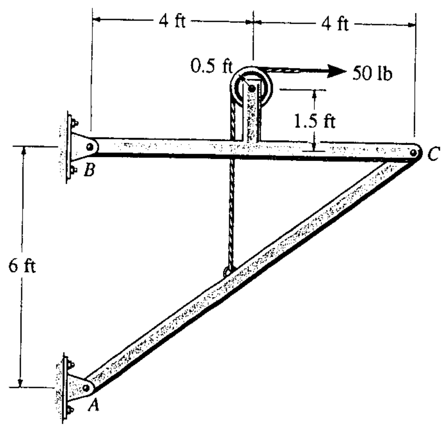
$D_y = 1962 \text{ N} = 1.96 \text{ kN}$ **Ans**

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

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



6-87. Determine the horizontal and vertical components of force at pins B and C.



$\circlearrowleft + \Sigma M_A = 0; \qquad -C_y(8) + C_x(6) + 50(3.5) = 0$

$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x = C_x$

$+\uparrow \Sigma F_y = 0; \qquad 50 - A_y - C_y = 0$

$\circlearrowleft + \Sigma M_B = 0; \qquad -50(2) - 50(3.5) + C_y(8) = 0$

$C_y = 34.38 = 34.4 \text{ lb}$ **Ans**

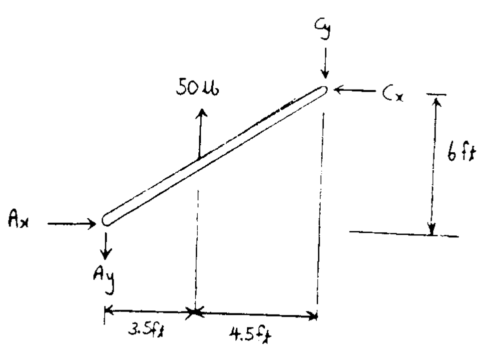
$C_x = 16.67 = 16.7 \text{ lb}$ **Ans**

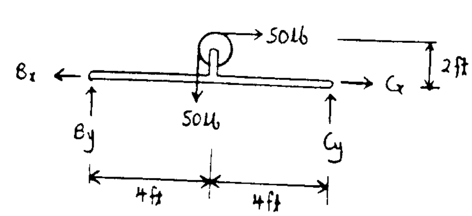
$\xrightarrow{+} \Sigma F_x = 0; \qquad 16.67 + 50 - B_x = 0$

$B_x = 66.7 \text{ lb}$ **Ans**

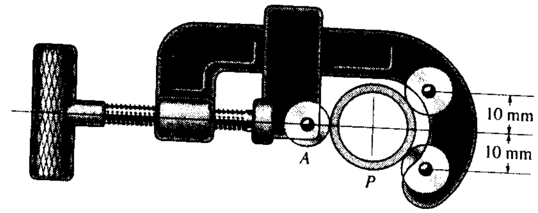
$+\uparrow \Sigma F_y = 0; \qquad B_y - 50 + 34.38 = 0$

$B_y = 15.6 \text{ lb}$ **Ans**

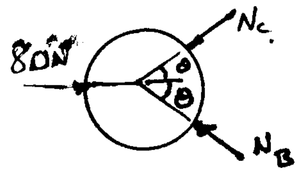




***6-88.** The pipe cutter is clamped around the pipe P. If the wheel at A exerts a normal force of $F_A = 80$ N on the pipe, determine the normal forces of wheels B and C on the pipe. Also compute the pin reaction on the wheel at C. The three wheels each have a radius of 7 mm and the pipe has an outer radius of 10 mm.



$\theta = \sin^{-1}\left(\frac{10}{17}\right) = 36.03°$



Equations of Equilibrium:

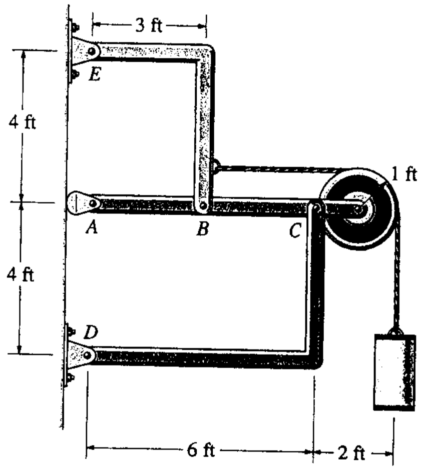
$+\uparrow \Sigma F_y = 0;\quad N_B \sin 36.03° - N_C \sin 36.03° = 0$

$N_B = N_C$

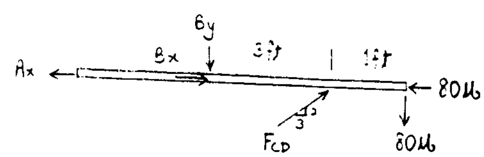
$\xrightarrow{+} \Sigma F_x = 0;\quad 80 - N_C \cos 36.03° - N_C \cos 36.03° = 0$

$N_B = N_C = 49.5$ N **Ans**

6-89. Determine the horizontal and vertical components of force at each pin. The suspended cylinder has a weight of 80 lb.



$\circlearrowleft + \Sigma M_B = 0;\quad F_{CD}\left(\frac{2}{\sqrt{13}}\right)(3) - 80(4) = 0$



$F_{CD} = 192.3 \text{ lb}$

$C_x = D_x = \frac{3}{\sqrt{13}}(192.3) = 160 \text{ lb}$ **Ans**

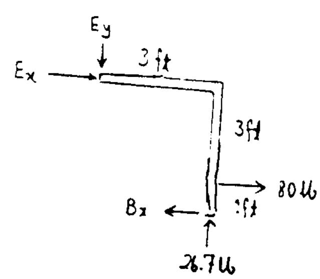
$C_y = D_y = \frac{2}{\sqrt{13}}(192.3) = 107 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad -B_y + \frac{2}{\sqrt{13}}(192.3) - 80 = 0$

$B_y = 26.7 \text{ lb}$ **Ans**

$\circlearrowleft + \Sigma M_E = 0;\quad -B_x(4) + 80(3) + 26.7(3) = 0$

$B_x = 80.0 \text{ lb}$ **Ans**



$\xrightarrow{+} \Sigma F_x = 0;\quad E_x + 80 - 80 = 0$

$E_x = 0$ **Ans**

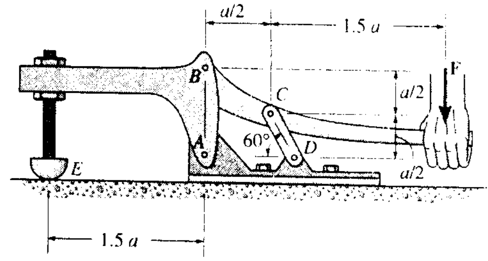
$+\uparrow \Sigma F_y = 0;\quad -E_y + 26.7 = 0$

$E_y = 26.7 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad -A_x + 80 + \frac{3}{\sqrt{13}}(192.3) - 80 = 0$

$A_x = 160 \text{ lb}$ **Ans**

6-90. The toggle clamp is subjected to a force **F** at the handle. Determine the vertical clamping force acting at *E*.



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

Equations of Equilibrium : From FBD (a),

$\curvearrowleft + \Sigma M_B = 0; \quad F_{CD}\cos 30°\left(\frac{a}{2}\right) - F_{CD}\sin 30°\left(\frac{a}{2}\right) - F(2a) = 0$

$F_{CD} = 10.93F$

$+\uparrow \Sigma F_y = 0; \quad 10.93F\cos 30° - F - B_y = 0$

$B_y = 8.464F$

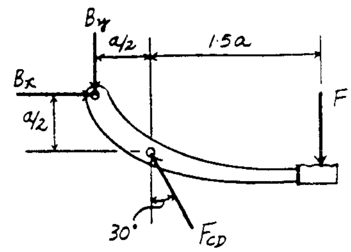
$\xrightarrow{+} \Sigma F_x = 0; \quad B_x - 10.93\sin 30° = 0$

$B_x = 5.464F$

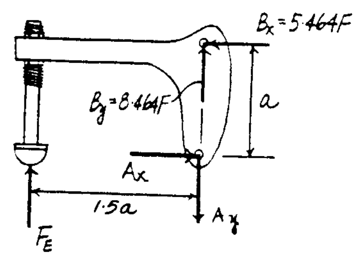
From (b),

$\curvearrowleft + \Sigma M_A = 0; \quad 5.464F(a) - F_E(1.5a) = 0$

$F_E = 3.64F$ **Ans**

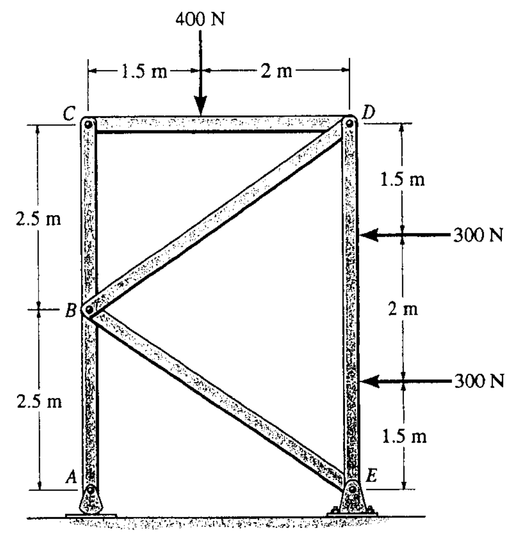


(a)



(b)

6-91. Determine the horizontal and vertical components of force which the pins at A, B, and C exert on member ABC of the frame.



$\circlearrowleft + \Sigma M_E = 0;\quad -A_y(3.5) + 400(2) + 300(3.5) + 300(1.5) = 0$

$A_y = 657.1 = 657 \text{ N}$ **Ans**

$\circlearrowleft + \Sigma M_D = 0;\quad -C_y(3.5) + 400(2) = 0$

$C_y = 228.6 = 229 \text{ N}$ **Ans**

$\circlearrowleft + \Sigma M_B = 0;\quad C_x = 0$ **Ans**

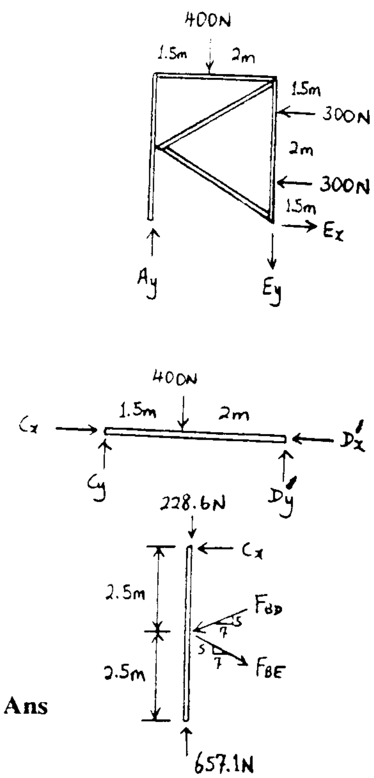
$\xrightarrow{+} \Sigma F_x = 0;\quad F_{BD} = F_{BE}$

$+\uparrow \Sigma F_y = 0;\quad 657.1 - 228.6 - 2\left(\frac{5}{\sqrt{74}}\right)F_{BD} = 0$

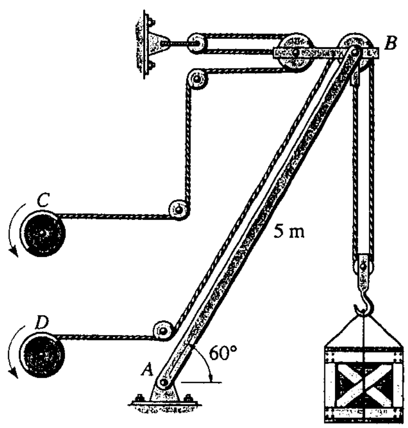
$F_{BD} = F_{BE} = 368.7 \text{ N}$

$B_x = 0$ **Ans**

$B_y = \frac{5}{\sqrt{74}}(368.7)(2) = 429 \text{ N}$ **Ans**

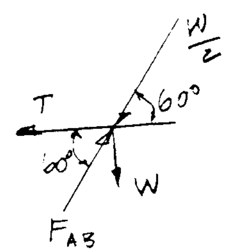


***6-92.** The derrick is pin-connected to the pivot at A. Determine the largest mass that can be supported by the derrick if the maximum force that can be sustained by the pin at A is 18 kN.



AB is a two - force member.

Pin B



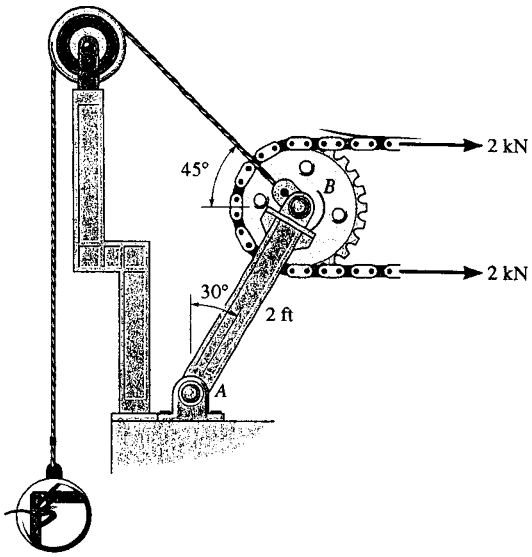
Require $F_{AB} = 18$ kN

$+\uparrow \Sigma F_y = 0; \qquad 18\sin 60° - \dfrac{W}{2}\sin 60° - W = 0$

$W = 10.878$ kN

$m = \dfrac{10.878}{9.81} = 1.11$ Mg **Ans**

6-93. Determine the required mass of the suspended cylinder if the tension in the chain wrapped around the freely turning gear is to be 2 kN. Also, what is the magnitude of the resultant force on pin A?



$\circlearrowleft + \Sigma M_A = 0; \quad -4(2\cos 30°) + W\cos 45°(2\cos 30°) + W\sin 45°(2\sin 30°) = 0$

$W = 3.586 \text{ kN}$

$m = 3.586(1000)/9.81 = 366 \text{ kg}$ **Ans**

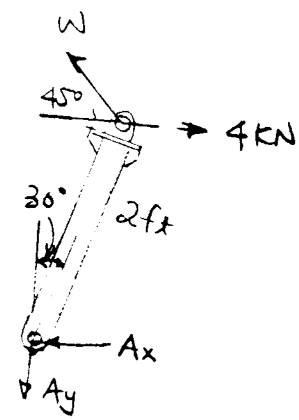
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 4 - 3.586\cos 45° - A_x = 0$

$A_x = 1.464 \text{ kN}$

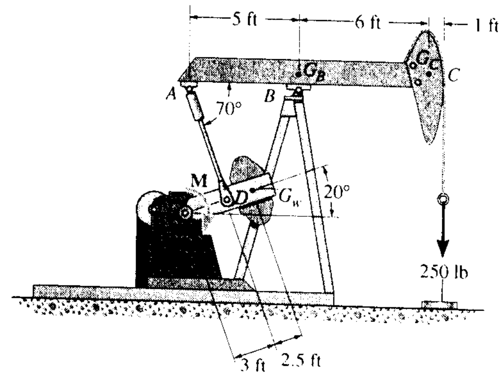
$+\uparrow \Sigma F_y = 0; \quad 3.586\sin 45° - A_y = 0$

$A_y = 2.536 \text{ kN}$

$F_A = \sqrt{(1.464)^2 + (2.536)^2} = 2.93 \text{ kN}$ **Ans**



6-94. The pumping unit is used to recover oil. When the walking beam ABC is horizontal, the force acting in the wireline at the well head is 250 lb. Determine the torque **M** which must be exerted by the motor in order to overcome this load. The horse-head C weighs 60 lb and has a center of gravity at G_C. The walking beam ABC has a weight of 130 lb and a center of gravity at GB, and the counterweight has a weight of 200 lb and a center of gravity at G_W. The pitman, AD, is pin-connected at its ends and has negligible weight.



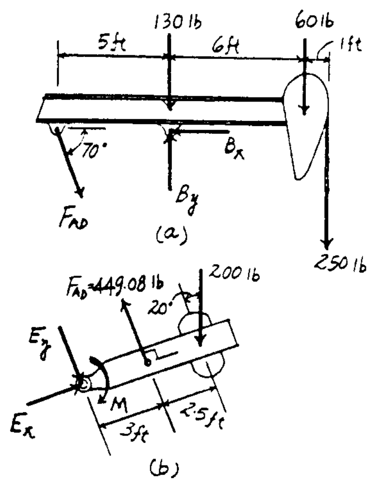
Free Body Diagram : The solution for this problem will be simplified if one realizes that the pitman AD is a two force member.

Equations of Equilibrium : From FBD (a),

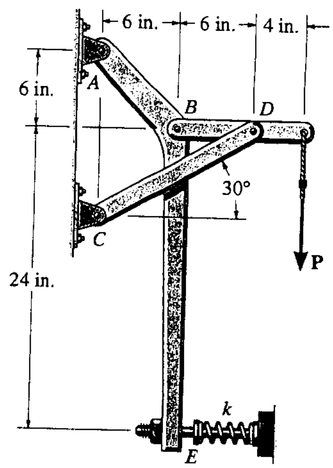
$$\curvearrowleft + \Sigma M_B = 0; \quad F_{AD} \sin 70°(5) - 60(6) - 250(7) = 0$$
$$F_{AD} = 449.08 \text{ lb}$$

From (b),

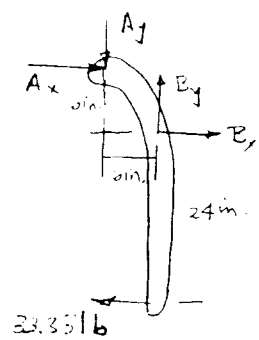
$$\curvearrowleft + \Sigma M_E = 0; \quad 449.08(3) - 200 \cos 20°(5.5) - M = 0$$
$$M = 314 \text{ lb} \cdot \text{ft} \qquad \textbf{Ans}$$



6-95. Determine the force P on the cable if the spring is compressed 0.5 in. when the mechanism is in the position shown. The spring has a stiffness of $k = 800$ lb/ft.



Prob. 6–95



$F_E = ks = 800(\frac{0.5}{12}) = 33.33$ lb

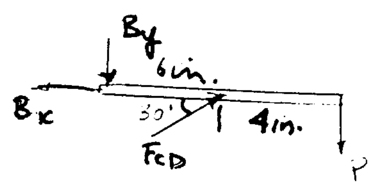
$\circlearrowleft + \Sigma M_A = 0;\quad B_x(6) + B_y(6) - 33.33(30) = 0$

$B_x + B_y = 166.67$ lb (1)

$\circlearrowleft + \Sigma M_D = 0;\quad B_y(6) - P(4) = 0$

$B_y = 0.6667P$ (2)

$\xrightarrow{+} \Sigma F_x = 0;\quad -B_x + F_{CD}\cos 30° = 0$ (3)



$\circlearrowleft + \Sigma M_B = 0;\quad F_{CD}\sin 30°(6) - P(10) = 0$

$F_{CD} = 3.333\,P$

Thus from Eq. (3)

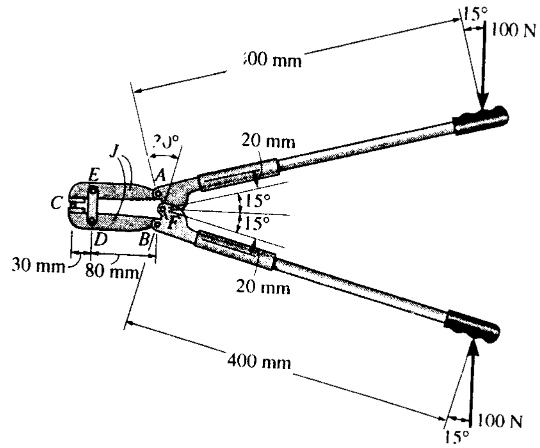
$B_x = 2.8867\,P$

Using Eqs. (1) and (2) :

$2.8867\,P + 0.6667\,P = 166.67$

$P = 46.9$ lb **Ans**

*6-96. Determine the force that the jaws J of the metal cutters exert on the smooth cable C if 100-N forces are applied to the handles. The jaws are pinned at E and A, and D and B. There is also a pin at F.



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

Equations of Equilibrium : From FBD (b),

$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x = 0$

From (a),

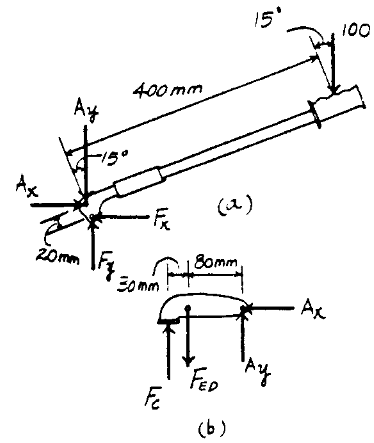
$\circlearrowleft + \Sigma M_F = 0; \qquad A_y \sin 15°(20) + 100\sin 15°(20) - 100\cos 15°(400) = 0$

$A_y = 7364.10 \text{ N}$

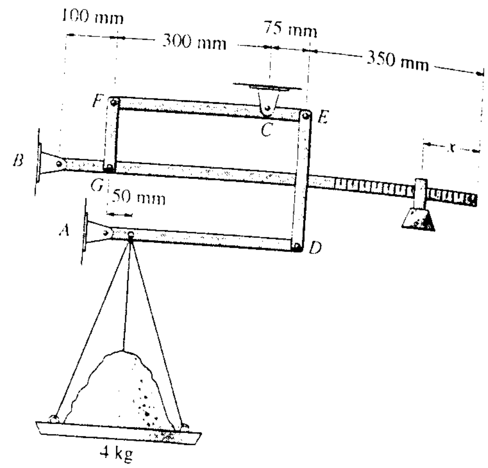
From FBD (b),

$\circlearrowleft + \Sigma M_E = 0; \qquad 7364.10(80) - F_C(30) = 0$

$F_C = 19637.60 \text{ N} = 19.6 \text{ kN}$ **Ans**



6-97. The compound arrangement of the pan scale is shown. If the mass on the pan is 4 kg, determine the horizontal and vertical components at pins A, B, and C and the distance x of the 25-g mass to keep the scale in balance.



Free Body Diagram : The solution for this problem will be simplified if one realizes that members DE and FG are two force members.

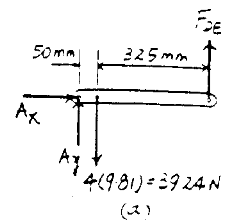
Equations of Equilibrium : From FBD (a).

$\circlearrowleft + \Sigma M_A = 0;\quad F_{DE}(375) - 39.24(50) = 0 \qquad F_{DE} = 5.232\ \text{N}$

$+\uparrow \Sigma F_y = 0;\quad A_y + 5.232 - 39.24 = 0$

$A_y = 34.0\ \text{N}$ **Ans**

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



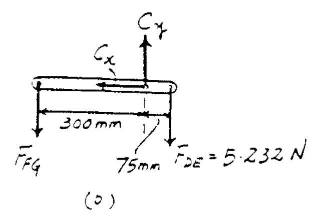
From (b).

$\circlearrowleft + \Sigma M_C = 0;\quad F_{FG}(300) - 5.232(75) = 0 \qquad F_{FG} = 1.308\ \text{N}$

$+\uparrow \Sigma F_y = 0;\quad C_y - 1.308 - 5.232 = 0$

$C_y = 6.54\ \text{N}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad C_x = 0$ **Ans**



From (c).

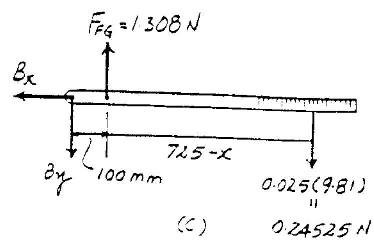
$\circlearrowleft + \Sigma M_B = 0;\quad 1.308(100) - 0.24525(825 - x) = 0$

$x = 292\ \text{mm}$ **Ans**

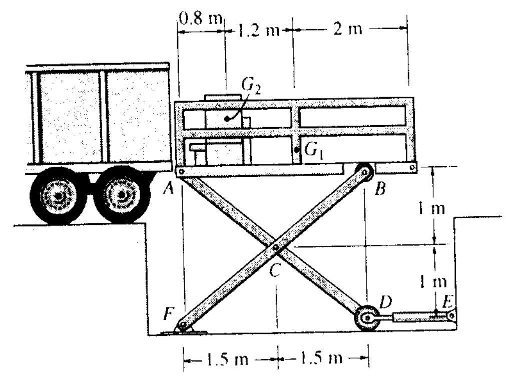
$+\uparrow \Sigma F_y = 0;\quad 1.308 - 0.24525 - B_y = 0$

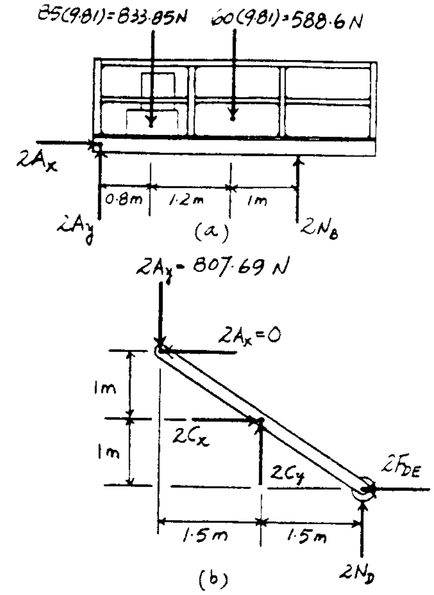
$B_y = 1.06\ \text{N}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad B_x = 0$ **Ans**



6-98. The scissors lift consists of *two* sets of cross members and *two* hydraulic cylinders, DE, symmetrically located on *each side* of the platform. The platform has a uniform mass of 60 kg, with a center of gravity at G_1. The load of 85 kg, with center of gravity at G_2, is centrally located on each side of the platform. Determine the force in each of the hydraulic cylinders for equilibrium. Rollers are located at B and D.





Free Body Diagram : The solution for this problem will be simplified if one realizes that the hydraulic cyclinder DE is a two force member.

Equations of Equilibrium : From FBD (a),

$\circlearrowleft + \Sigma M_A = 0;\quad 2N_B(3) - 833.85(0.8) - 588.6(2) = 0$

$2N_B = 614.76\text{ N}$

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

$+\uparrow \Sigma F_y = 0;\quad 2A_y + 614.76 - 833.85 - 588.6 = 0$

$2A_y = 807.69\text{ N}$

From FBD (b),

$\circlearrowleft + \Sigma M_D = 0;\quad 807.69(3) - 2C_y(1.5) - 2C_x(1) = 0$

$2C_x + 3C_y = 2423.07 \qquad [1]$

From FBD (c),

$\circlearrowleft + \Sigma M_F = 0;\quad 2C_x(1) - 2C_y(1.5) - 614.76(3) = 0$

$2C_x - 3C_y = 1844.28 \qquad [2]$

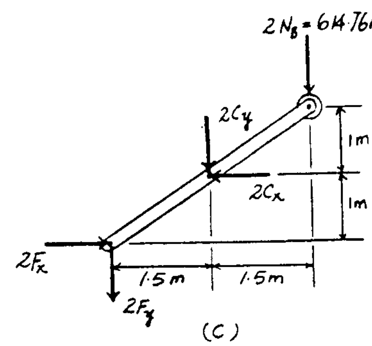
Solving Eqs. [1] and [2] yields

$C_x = 1066.84\text{ N} \qquad C_y = 96.465\text{ N}$

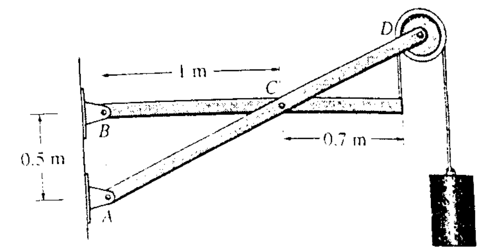
From FBD (b),

$\xrightarrow{+} \Sigma F_x = 0;\quad 2(1066.84) - 2F_{DE} = 0$

$F_{DE} = 1066.84\text{ N} = 1.07\text{ kN}$ **Ans**



6-99. Determine the horizontal and vertical components of force that the pins at A, B, and C exert on the frame. The cylinder has a mass of 80 kg.



Equations of Equilibrium : From FBD (b).

$\curvearrowleft + \Sigma M_B = 0;\quad 784.8(1.7) - C_y(1) = 0$

$C_y = 1334.16 \text{ N} = 1.33 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad B_y + 784.8 - 1334.16 = 0$

$B_y = 549 \text{ N}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad C_x - B_x = 0$ [1]

From FBD (a).

$\curvearrowleft + \Sigma M_A = 0;\quad C_x(0.5) + 1334.16(1) - 784.8(1.7) - 784.8(1.9) = 0$

$C_x = 2982.24 \text{ N} = 2.98 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad A_y + 1334.16 - 784.8 - 784.8 = 0$

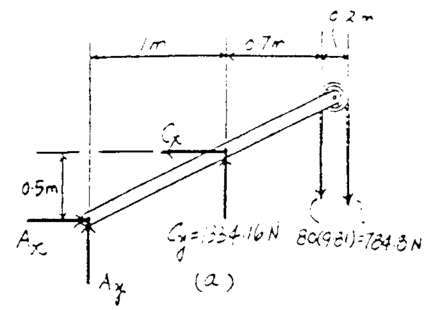
$A_y = 235 \text{ N}$ **Ans**

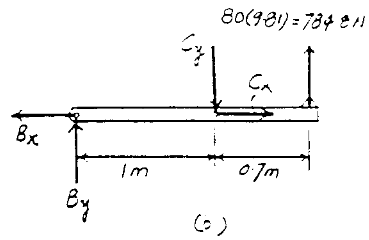
$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 2982.24 = 0$

$A_x = 2982.24 \text{ N} = 2.98 \text{ kN}$ **Ans**

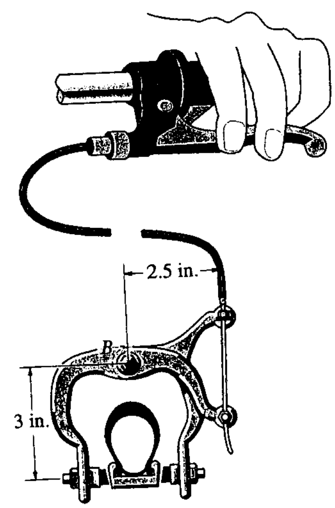
Substitute $C_x = 2982.24$ N into Eq.[1] yields,

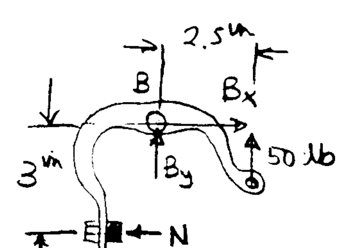
$B_x = 2982.24 \text{ N} = 2.98 \text{ kN}$ **Ans**





***6-100.** By squeezing on the hand brake of the bicycle, the rider subjects the brake cable to a tension of 50 lb. If the caliper mechanism is pin-connected to the bicycle frame at B, determine the normal force each brake pad exerts on the rim of the wheel. Is this the force that stops the wheel from turning? Explain.



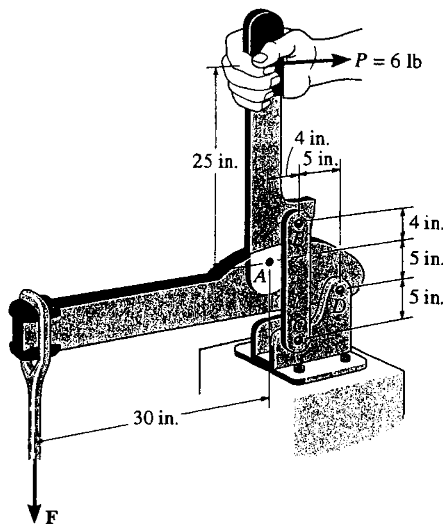


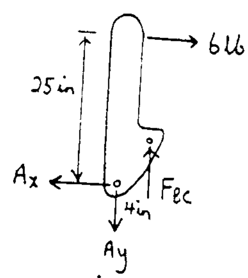
$\curvearrowleft + \Sigma M_B = 0;\quad -N(3) + 50(2.5) = 0$

$N = 41.7 \text{ lb}$ **Ans**

This normal force **does not** stop the wheel from turning. A frictional force (See Chapter 8), which acts along on the wheel's rim stops the wheel. **Ans**

6-101. If a force of $P = 6$ lb is applied perpendicular to the handle of the mechanism, determine the magnitude of force **F** for equilibrium. The members are pin-connected at A, B, C, and D.





$\circlearrowleft + \Sigma M_A = 0; \quad F_{BC}(4) - 6(25) = 0$

$F_{BC} = 37.5$ lb

$\xrightarrow{+} \Sigma F_x = 0; \quad -A_x + 6 = 0$

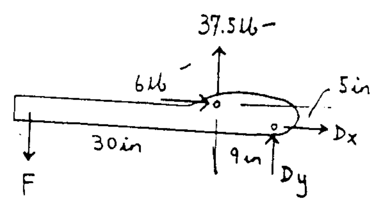
$A_x = 6$ lb

$+\uparrow \Sigma F_y = 0; \quad -A_y + 37.5 = 0$

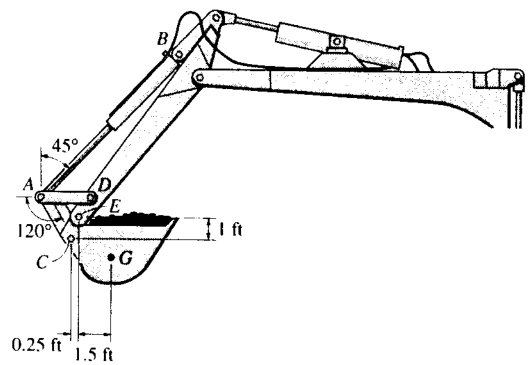
$A_y = 37.5$ lb

$\circlearrowleft + \Sigma M_D = 0; \quad -5(6) - 37.5(9) + 39(F) = 0$

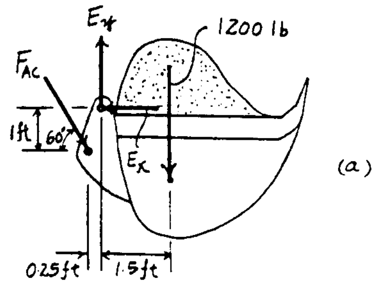
$F = 9.42$ lb **Ans**



6-102. The bucket of the backhoe and its contents have a weight of 1200 lb and a center of gravity at G. Determine the forces of the hydraulic cylinder AB and in links AC and AD in order to hold the load in the position shown. The bucket is pinned at E.



Free Body Diagram : The solution for this problem will be simplified if one realizes that the hydraulic cylinder AB, links AD and AC are two force members.

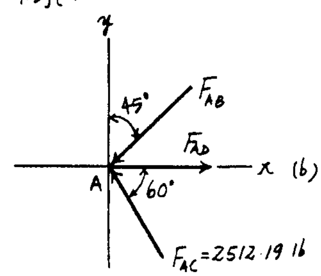


Equations of Equilibrium : From FBD (a),

$$\curvearrowleft + \Sigma M_E = 0; \quad F_{AC}\cos 60°(1) + F_{AC}\sin 60°(0.25) - 1200(1.5) = 0$$

$$F_{AC} = 2512.19 \text{ lb} = 2.51 \text{ kip} \qquad \textbf{Ans}$$

Using method of joint [FBD (b)],



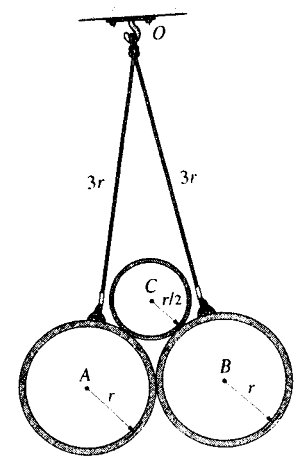
$$+\uparrow \Sigma F_y = 0; \quad 2512.19\sin 60° - F_{AB}\cos 45° = 0$$

$$F_{AB} = 3076.79 \text{ lb} = 3.08 \text{ kip} \qquad \textbf{Ans}$$

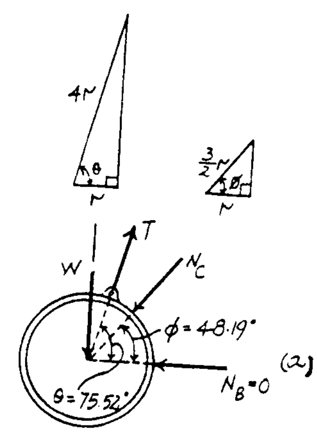
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{AD} - 3076.79\sin 45° - 2512.19\cos 60° = 0$$

$$F_{AD} = 3431.72 \text{ lb} = 3.43 \text{ kip} \qquad \textbf{Ans}$$

6-103. Two smooth tubes A and B, each having the same weight, W, are suspended from a common point O by means of equal-length cords. A third tube, C, is placed between A and B. Determine the greatest weight of C without upsetting equilibrium.



Free Body Diagram : When the equilibrium is about to be upset, the reaction at B must be zero ($N_B = 0$). From the geometry, $\phi = \cos^{-1}\left(\frac{r}{\frac{3}{2}r}\right) = 48.19°$ and $\theta = \cos^{-1}\left(\frac{r}{4r}\right) = 75.52°$.



Equations of Equilibrium : From FBD (a),

$$\xrightarrow{+} \Sigma F_x = 0; \quad T\cos 75.52° - N_C\cos 48.19° = 0 \qquad [1]$$

$$+\uparrow \Sigma F_y = 0; \quad T\sin 75.52° - N_C\sin 48.19° - W = 0 \qquad [2]$$

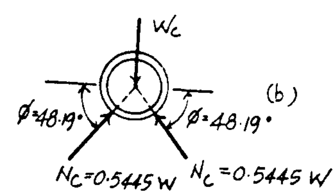
Solving Eq.[1] and [2] yields,

$$T = 1.452W \qquad N_C = 0.5445W$$

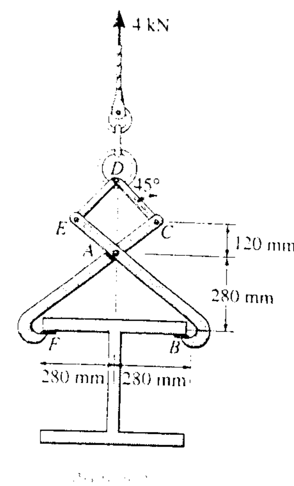
From FBD (b),

$$+\uparrow \Sigma F_y = 0; \quad 2(0.5445W\sin 48.19°) - W_C = 0$$

$$W_C = 0.812W \qquad \textbf{Ans}$$



*6-104. The double link grip is used to lift the beam. If the beam weighs 4 kN, determine the horizontal and vertical components of force acting on the pin at A and the horizontal and vertical components of force that the flange of the beam exerts on the jaw at B.



Free Body Diagram : The solution for this problem will be simplified if one realizes that members ED and CD are two force members.

Equations of Equilibrium : Using method of joint [FBD (a)].

$+\uparrow \Sigma F_y = 0; \quad 4 - 2F\sin 45° = 0 \quad F = 2.828 \text{ kN}$

From FBD (b),

$+\uparrow \Sigma F_y = 0; \quad 2B_y - 4 = 0 \quad B_y = 2.00 \text{ kN}$ **Ans**

From FBD (c),

$$\curvearrowleft + \Sigma M_A = 0; \quad B_x(280) - 2.00(280) - 2.828\cos 45°(120) - 2.828\sin 45°(160) = 0$$

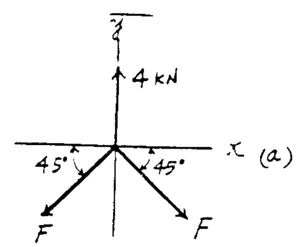
$B_x = 4.00 \text{ kN}$ **Ans**

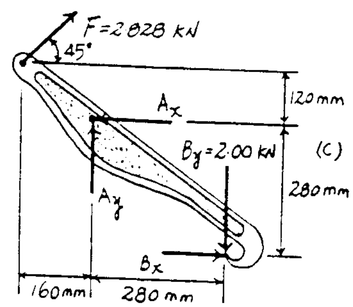
$+\uparrow \Sigma F_y = 0; \quad A_y + 2.828\sin 45° - 2.00 = 0$

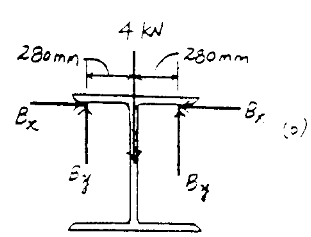
$A_y = 0$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad 4.00 + 2.828\cos 45° - A_x = 0$

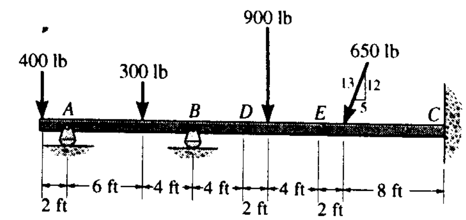
$A_x = 6.00 \text{ kN}$ **Ans**







6-105. The compound beam is fixed supported at C and supported by rockers at A and B. If there are hinges (pins) at D and E, determine the components of reaction at the supports. Neglect the thickness of the beam.



Equations of Equilibrium : From FBD (a),

$\curvearrowleft + \Sigma M_D = 0; \quad E_y(6) - 900(2) = 0 \quad E_y = 300 \text{ lb}$

$+\uparrow \Sigma F_y = 0; \quad D_y + 300 - 900 = 0 \quad D_y = 600 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0; \quad D_x - E_x = 0 \qquad [1]$

From FBD (b),

$\curvearrowleft + \Sigma M_A = 0; \quad B_y(10) + 400(2) - 300(6) - 600(14) = 0$
$B_y = 940 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y + 940 - 400 - 300 - 600 = 0$
$A_y = 360 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad D_x = 0$

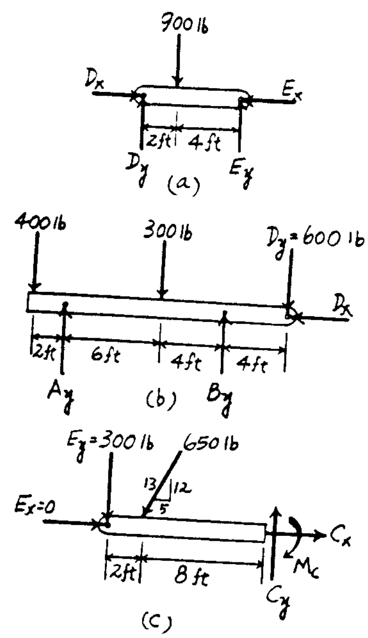
Substitute $D_x = 0$ into Eq.[1] yields $E_x = 0$

From FBD (c),

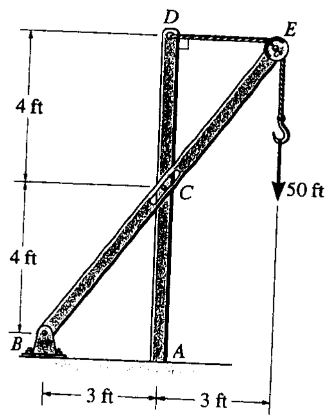
$\curvearrowleft + \Sigma M_C = 0; \quad 300(10) + 650\left(\frac{12}{13}\right)(8) - M_C = 0$
$M_C = 7800 \text{ lb} \cdot \text{ft} = 7.80 \text{ kip} \cdot \text{ft}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad C_y - 300 - 650\left(\frac{12}{13}\right) = 0 \quad C_y = 900 \text{ lb}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad C_x - 650\left(\frac{5}{13}\right) = 0 \quad C_x = 250 \text{ lb}$ **Ans**



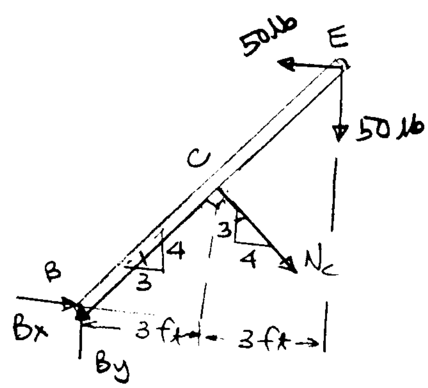
6-106. Determine the horizontal and vertical components of force at pin B and the normal force the pin at C exerts on the smooth slot. Also, determine the moment and horizontal and vertical reactions of force at A. There is a pulley at E.



BCE:

$\circlearrowleft + \Sigma M_B = 0; \quad -50(6) - N_C(5) + 50(8) = 0$

$N_C = 20 \text{ lb}$ **Ans**



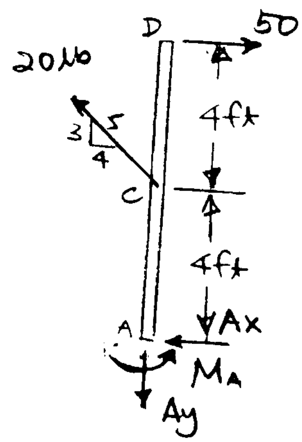
$\xrightarrow{+} \Sigma F_x = 0; \quad B_x + 20(\frac{4}{5}) - 50 = 0$

$B_x = 34 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad B_y - 20(\frac{3}{5}) - 50 = 0$

$B_y = 62 \text{ lb}$ **Ans**

ACD:



$\xrightarrow{+} \Sigma F_x = 0; \quad -A_x - 20(\frac{4}{5}) + 50 = 0$

$A_x = 34 \text{ lb}$ **Ans**

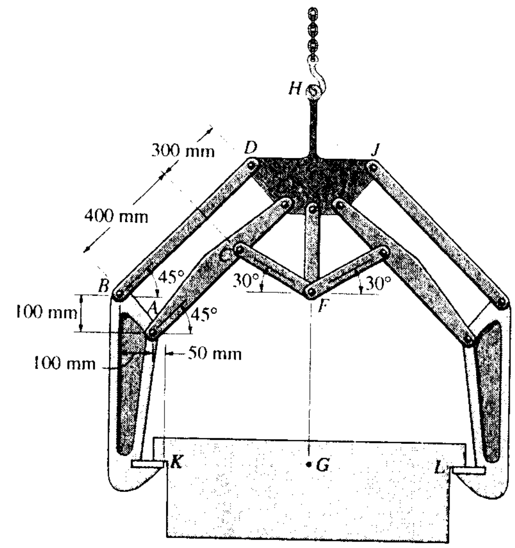
$+\uparrow \Sigma F_y = 0; \quad -A_y + 20(\frac{3}{5}) = 0$

$A_y = 12 \text{ lb}$ **Ans**

$\circlearrowleft + \Sigma M_A = 0; \quad M_A + 20(\frac{4}{5})(4) - 50(8) = 0$

$M_A = 336 \text{ lb}\cdot\text{ft}$ **Ans**

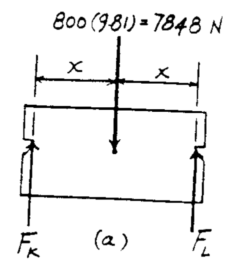
6-107. The symmetric coil tong supports the coil which has a mass of 800 kg and center of mass at G. Determine the horizontal and vertical components of force the linkage exerts on plate $DEIJH$ at points D and E. The coil exerts only vertical reactions at K and L.



Free Body Diagram : The solution for this problem will be simplified if one realizes that links BD and CF are the two force members.

Equations of Equilibrium : From FBD (a),

$\curvearrowleft + \Sigma M_L = 0;\quad 7848(x) - F_K(2x) = 0 \qquad F_K = 3924\text{ N}$



From FBD (b),

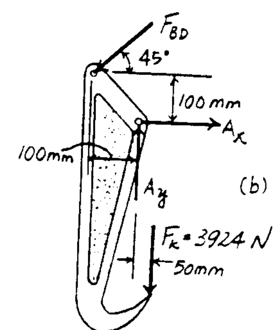
$\curvearrowleft + \Sigma M_A = 0;\quad F_{BD}\cos 45°(100) + F_{BD}\sin 45°(100) - 3924(50) = 0$

$F_{BD} = 1387.34\text{ N}$

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x - 1387.34\cos 45° = 0 \qquad A_x = 981\text{ N}$

$+\uparrow \Sigma F_y = 0;\quad A_y - 3924 - 1387.34\sin 45° = 0$

$A_y = 4905\text{ N}$



From FBD (c),

$\curvearrowleft + \Sigma M_E = 0;\quad 4905\sin 45°(700) - 981\sin 45°(700) - F_{CF}\cos 15°(300) = 0$

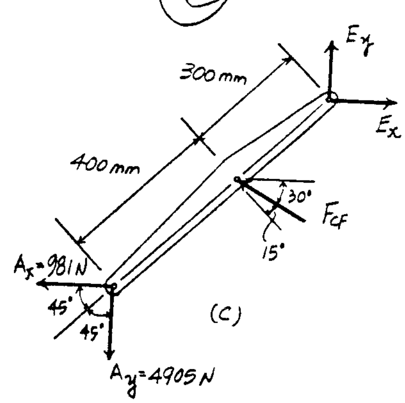
$F_{CF} = 6702.66\text{ N}$

$\xrightarrow{+} \Sigma F_x = 0;\quad E_x - 981 - 6702.66\cos 30° = 0$

$E_x = 6785.67\text{ N} = 6.79\text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad E_y + 6702.66\sin 30° - 4905 = 0$

$E_y = 1553.67\text{ N} = 1.55\text{ kN}$ **Ans**

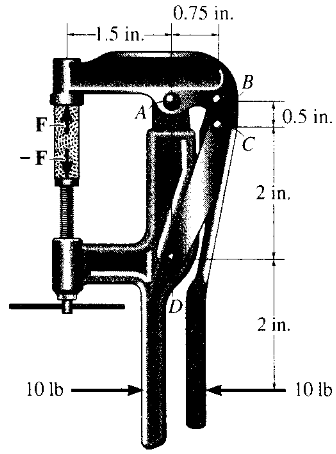


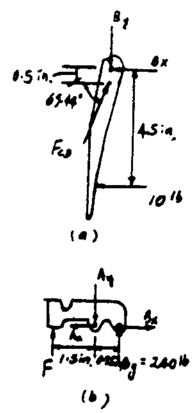
At point D,

$D_x = F_{BD}\cos 45° = 1387.34\cos 45° = 981\text{ N}$ **Ans**

$D_y = F_{BD}\sin 45° = 1387.34\sin 45° = 981\text{ N}$ **Ans**

*6-108. If a force of 10 lb is applied to the grip of the clamp, determine the compressive force F that the wood block exerts on the clamp.





From FBD (a)

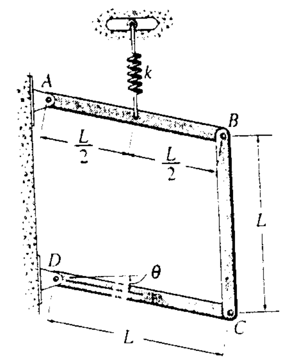
$\curvearrowleft + \Sigma M_B = 0;\quad F_{CD}\cos 69.44°(0.5) - 10(4.5) = 0 \qquad F_{CD} = 256.32 \text{ lb}$

$+\uparrow \Sigma F_y = 0;\quad 256.32 \sin 69.44° - B_y = 0 \qquad B_y = 240 \text{ lb}$

From FBD (b)

$\curvearrowleft + \Sigma M_A = 0;\quad 240(0.75) - F(1.5) = 0 \qquad F = 120 \text{ lb}$ **Ans**

6-109. If each of the three uniform links of the mechanism has a length L and weight W, determine the angle θ for equilibrium. The spring, which always remains vertical, is unstretched when $\theta = 0°$.



Free Body Diagram : The spring stretches $x = \frac{L}{2}\sin\theta$. Then, the spring force is $F_{sp} = kx = \frac{kL}{2}\sin\theta$.

Equations of Equilibrium : From FBD (b),

$$\curvearrowleft + \Sigma M_B = 0; \qquad C_x = 0$$

$$\xrightarrow{+} \Sigma F_x = 0; \qquad B_x = 0$$

$$+\uparrow \Sigma F_y = 0; \qquad B_y - C_y - W = 0 \qquad [1]$$

From FBD (a),

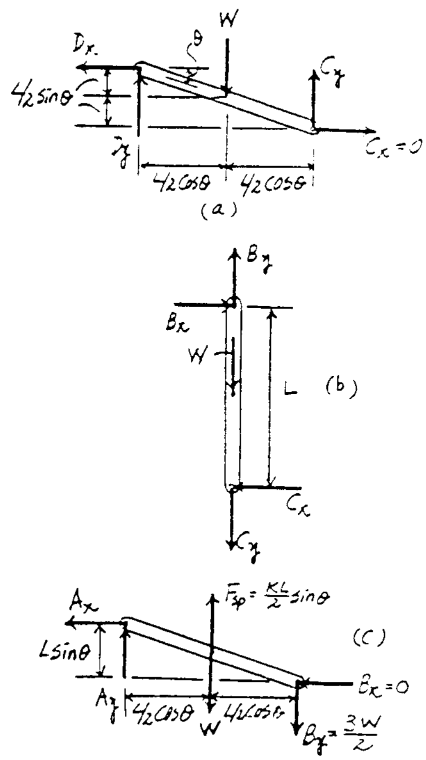
$$\curvearrowleft + \Sigma M_D = 0; \qquad C_y\,(L\cos\theta) - W\left(\frac{L}{2}\cos\theta\right) = 0$$

$$C_y = \frac{W}{2}$$

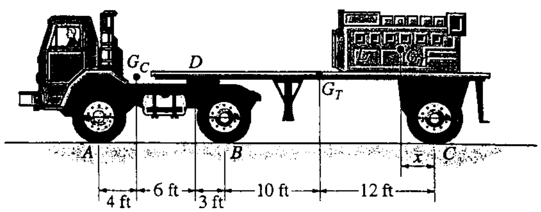
Substitute $C_y = \frac{W}{2}$ into Eq.[1], we have $B_y = \frac{3W}{2}$. From FBD (c),

$$\curvearrowleft + \Sigma M_A = 0; \qquad \frac{kL}{2}\sin\theta\left(\frac{L}{2}\cos\theta\right) - W\left(\frac{L}{2}\cos\theta\right) - \frac{3W}{2}(L\cos\theta) = 0$$

$$\theta = \sin^{-1}\left(\frac{8W}{kL}\right) \qquad \textbf{Ans}$$



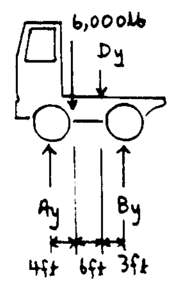
6-110. The flat-bed trailer has a weight of 7000 lb and center of gravity at G_T. It is pin-connected to the cab at D. The cab has a weight of 6000 lb and center of gravity at G_C. Determine the range of values x for the position of the 2000-lb load L so that when it is placed over the rear axle, no axle is subjected to more than 5500 lb. The load has a center of gravity at G_L.



Case 1 : Assume $A_y = 5500$ lb

$\circlearrowleft + \Sigma M_B = 0;$ $\quad -5500(13) + 6000(9) + D_y(3) = 0$

$D_y = 5833.33$ lb



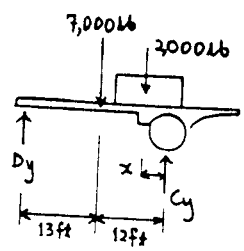
$+\uparrow \Sigma F_y = 0;$ $\quad B_y - 6000 - 5833.33 + 5500 = 0$

$B_y = 6333.33 \text{ lb} > 5500 \text{ lb}$ **(N.G!)**

Case 2 : Assume $B_y = 5500$ lb

$\circlearrowleft + \Sigma M_A = 0;$ $\quad 5500(13) - 6000(4) - D_y(10) = 0$

$D_y = 4750$ lb



$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 6000 - 4750 + 5500 = 0$

$A_y = 5250$ lb

$+\uparrow \Sigma F_y = 0;$ $\quad 4750 - 7000 - 2000 + C_y = 0$

$C_y = 4250 \text{ lb} < 5500 \text{ lb}$ **(O.K!)**

$\circlearrowleft + \Sigma M_D = 0;$ $\quad -7000(13) - 2000(13 + 12 - x) + 4250(25) = 0$

$x = 17.4$ ft

6-110 cont'd

Case 3 : Assume $C_y = 5500$ lb

$+\uparrow \Sigma F_y = 0; \quad D_y - 9000 + 5500 = 0$

$D_y = 3500$ lb

$\circlearrowleft + \Sigma M_C = 0; \quad -3500(25) + 7000(12) + 2000(x) = 0$

$x = 1.75$ ft

$\circlearrowleft + \Sigma M_A = 0; \quad -6000(4) - 3500(10) + B_y(13) = 0$

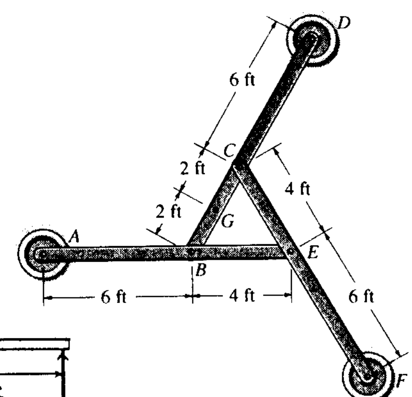
$B_y = 4538.46 \text{ lb} < 5500 \text{ lb}$ **(O.K!)**

$+\uparrow \Sigma F_y = 0; \quad A_y - 6000 - 3500 + 4538.46 = 0$

$A_y = 4961.54 \text{ lb} < 5500 \text{ lb}$ **(O.K!)**

Thus, $1.75 \text{ ft} \le x \le 17.4 \text{ ft}$ **Ans**

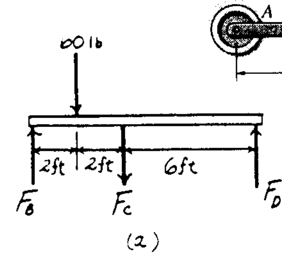
6-111. The three pin-connected members shown in the *top view* support a downward force of 60 lb at G. If only vertical forces are supported at the connections B, C, E and pad supports A, D, F, determine the reactions at each pad.



Equations of Equilibrium : From FBD (a),

$\circlearrowleft + \Sigma M_D = 0; \quad 60(8) + F_C(6) - F_B(10) = 0 \quad [1]$

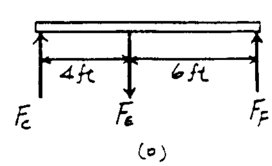
$+\uparrow \Sigma F_y = 0; \quad F_B + F_D - F_C - 60 = 0 \quad [2]$



From FBD (b),

$\circlearrowleft + \Sigma M_F = 0; \quad F_E(6) - F_C(10) = 0 \quad [3]$

$+\uparrow \Sigma F_y = 0; \quad F_C + F_F - F_E = 0 \quad [4]$



From FBD (c),

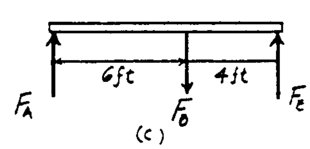
$\circlearrowleft + \Sigma M_A = 0; \quad F_E(10) - F_B(6) = 0 \quad [5]$

$+\uparrow \Sigma F_y = 0; \quad F_A + F_E - F_B = 0 \quad [6]$

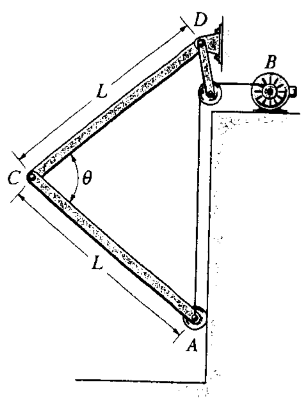
Solving Eqs. [1], [2], [3], [4], [5] and [6] yields,

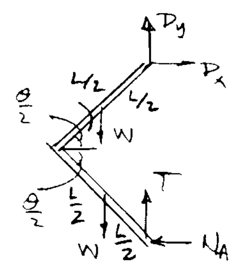
$F_E = 36.73$ lb $\quad F_C = 22.04$ lb $\quad F_B = 61.22$ lb

$F_D = 20.8$ lb $\quad F_F = 14.7$ lb $\quad F_A = 24.5$ lb **Ans**



***6-112.** The aircraft-hangar door opens and closes slowly by means of a motor which draws in the cable AB. If the door is made in two sections (bifold) and each section has a uniform weight W and length L, determine the force in the cable as a function of the door's position θ. The sections are pin-connected at C and D and the bottom is attached to a roller that travels along the vertical track.



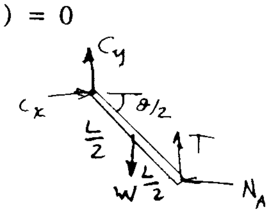


$\circlearrowleft + \Sigma M_D = 0$: $\quad 2(W)(\frac{L}{2})\cos(\frac{\theta}{2}) - 2L(\sin(\frac{\theta}{2}))N_A = 0$

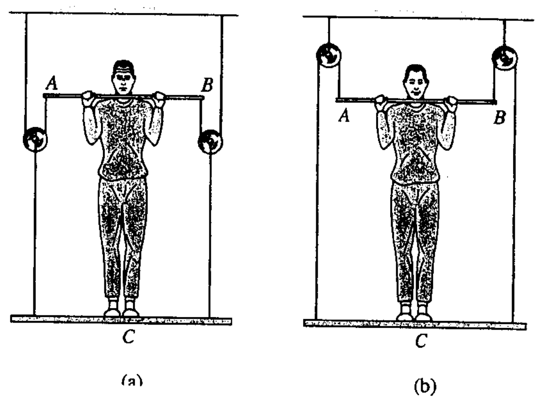
$$N_A = \frac{W}{2\tan(\frac{\theta}{2})}$$

$\circlearrowleft + \Sigma M_C = 0$; $\quad TL(\cos(\frac{\theta}{2})) - \frac{W}{2\tan(\frac{\theta}{2})}(L\sin(\frac{\theta}{2})) - W(\frac{L}{2})(\cos(\frac{\theta}{2})) = 0$

$T = W$ **Ans**

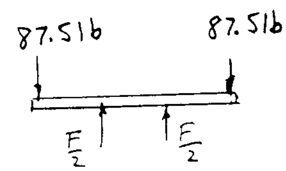


6-113. A man having a weight of 175 lb attempts to lift himself using one of the two methods shown. Determine the total force he must exert on bar AB in each case and the normal reaction he exerts on the platform at C. Neglect the weight of the platform.



(a)

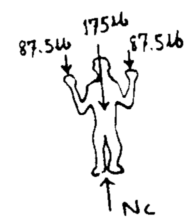
Bar :



$$+\uparrow \Sigma F_y = 0; \quad 2(F/2) - 2(87.5) = 0$$

$$F = 175 \text{ lb} \qquad \textbf{Ans}$$

Man :

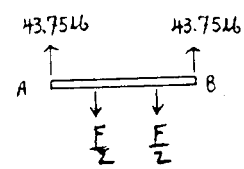


$$+\uparrow \Sigma F_y = 0; \quad N_C - 175 - 2(87.5) = 0$$

$$N_C = 350 \text{ lb} \qquad \textbf{Ans}$$

(b)

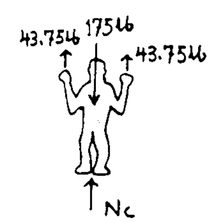
Bar :



$$+\uparrow \Sigma F_y = 0; \quad 2(43.75) - 2(F/2) = 0$$

$$F = 87.5 \text{ lb} \qquad \textbf{Ans}$$

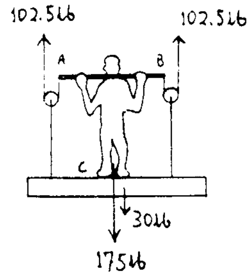
Man :

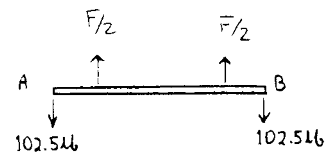


$$+\uparrow \Sigma F_y = 0; \quad N_C - 175 + 2(43.75) = 0$$

$$N_C = 87.5 \text{ lb} \qquad \textbf{Ans}$$

6-114. A man having a weight of 175 lb attempts to lift himself using one of the two methods shown. Determine the total force he must exert on bar AB in each case and the normal reaction he exerts on the platform at C. The platform has a weight of 30 lb.





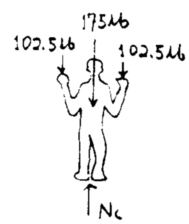
(a)

Bar :

$+\uparrow \Sigma F_y = 0; \quad 2(F/2) - 102.5 - 102.5 = 0$

$F = 205$ lb **Ans**

Man :



$+\uparrow \Sigma F_y = 0; \quad N_C - 175 - 102.5 - 102.5 = 0$

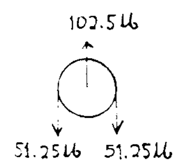
$N_C = 380$ lb **Ans**

(b)

Bar :

$+\uparrow \Sigma F_y = 0; \quad 2(F/2) - 51.25 - 51.25 = 0$

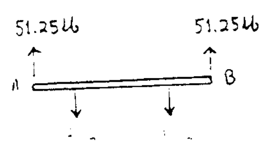
$F = 102$ lb **Ans**

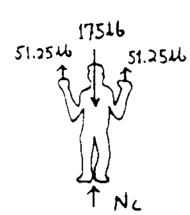


Man :

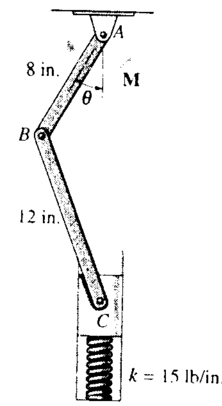
$+\uparrow \Sigma F_y = 0; \quad N_C - 175 + 51.25 + 51.25 = 0$

$N_C = 72.5$ lb **Ans**

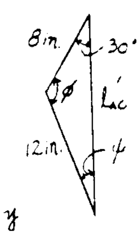




6-115. The piston C moves vertically between the two smooth walls. If the spring has a stiffness of $k = 15$ lb/in., and is unstretched when $\theta = 0°$, determine the couple **M** that must be applied to AB to hold the mechanism in equilibrium when $\theta = 30°$.



Geometry :

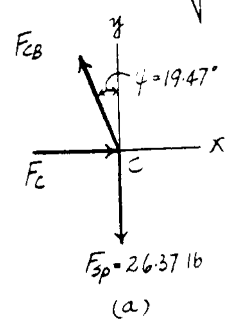


$$\frac{\sin\psi}{8} = \frac{\sin 30°}{12} \qquad \psi = 19.47°$$

$$\phi = 180° - 30° - 19.47 = 130.53°$$

$$\frac{l'_{AC}}{\sin 130.53°} = \frac{12}{\sin 30°} \qquad l'_{AC} = 18.242 \text{ in.}$$

Free Body Diagram : The solution for this problem will be simplified if one realizes that member CB is a two force member. Since the spring stretches $x = l_{AC} - l'_{AC} = 20 - 18.242 = 1.758$ in. the spring force is $F_{sp} = kx = 15(1.758) = 26.37$ lb.



Equations of Equilibrium : Using the method of joints [FBD (a)],

$$+\uparrow \Sigma F_y = 0; \qquad F_{CB}\cos 19.47° - 26.37 = 0$$

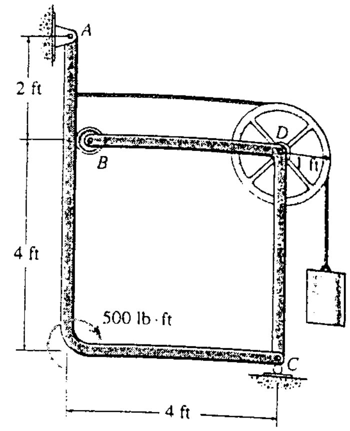
$$F_{CB} = 27.97 \text{ lb}$$

From FBD (b),

$$+\Sigma M_A = 0; \qquad 27.97\cos 40.53°(8) - M = 0$$

$$M = 170.08 \text{ lb} \cdot \text{in} = 14.2 \text{ lb} \cdot \text{ft} \qquad \textbf{Ans}$$

*6-116. The two-member frame supports the loading shown. Determine the force of the roller at B on member AC and the horizontal and vertical components of force which the pin at C exerts on member CB and the pin at A exerts on member AC. The roller does not contact member CB.



Equations of Equilibrium : From FBD (a).

$\curvearrowleft + \Sigma M_A = 0;\quad N_C(4) - 200(5) - 500 = 0 \quad N_C = 375 \text{ lb}$

$\xrightarrow{+} F_x = 0;\quad A_x = 0$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 375 - 200 - A_y = 0 \quad A_y = 175 \text{ lb}$ **Ans**

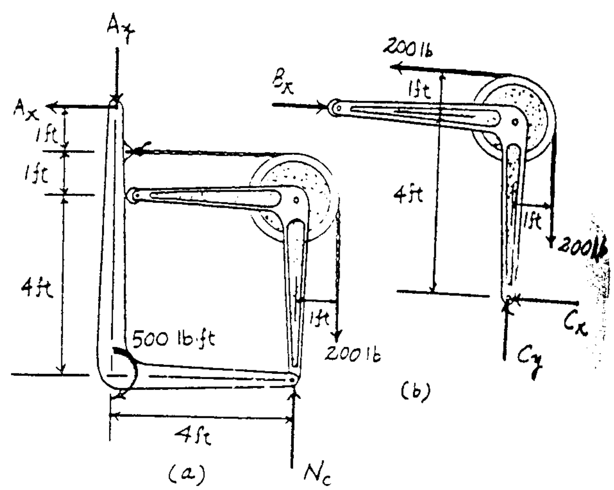
From FBD (b).

$\curvearrowleft + \Sigma M_C = 0;\quad 200(5) - 200(1) - B_x(4) = 0$

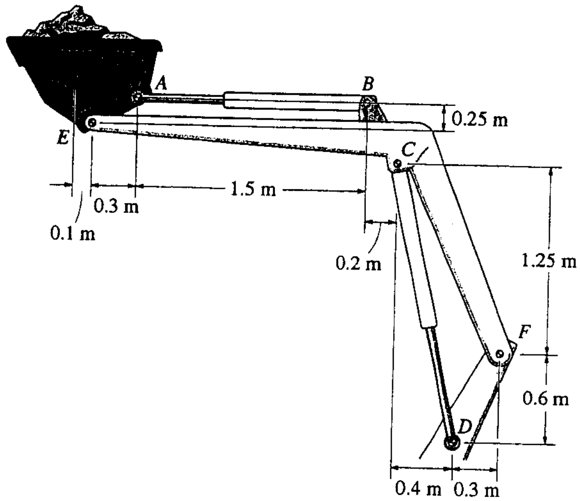
$B_x = 200 \text{ lb}$ **Ans**

$\xrightarrow{+} F_x = 0;\quad 200 - 200 - C_x = 0 \quad C_x = 0$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad C_y - 200 = 0 \quad C_y = 200 \text{ lb}$ **Ans**

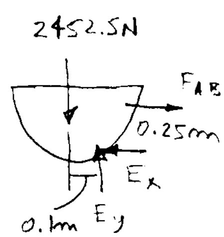


6-117. The tractor boom supports the uniform mass of 500 kg in the bucket which has a center of mass at G. Determine the force in each hydraulic cylinder AB and CD and the resultant force at pins E and F. The load is supported equally on each side of the tractor by a similar mechanism.



$\circlearrowleft + \Sigma M_E = 0; \quad 2452.5(0.1) - F_{AB}(0.25) = 0$

$F_{AB} = 981 \text{ N}$ **Ans**



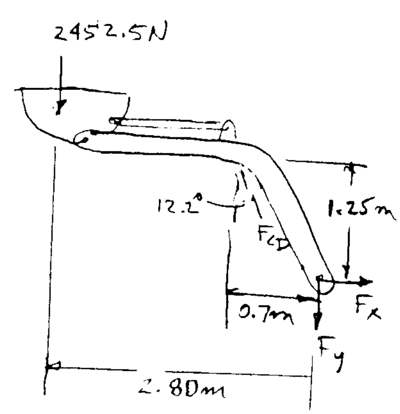
$\xrightarrow{+} \Sigma F_x = 0; \quad -E_x + 981 = 0; \quad E_x = 981 \text{ N}$

$+\uparrow \Sigma F_y = 0; \quad E_y - 2452.5 = 0; \quad E_y = 2452.5 \text{ N}$

$F_E = \sqrt{(981)^2 + (2452.5)^2} = 2.64 \text{ kN}$ **Ans**

$\circlearrowleft + \Sigma M_F = 0; \quad 2452.5(2.80) - F_{CD}(\cos 12.2°)(0.7) + F_{CD}(\sin 12.2°)(1.25) = 0$

$F_{CD} = 16\,349 \text{ N} = 16.3 \text{ kN}$ **Ans**



$\xrightarrow{+} \Sigma F_x = 0; \quad F_x - 16\,349 \sin 12.2° = 0$

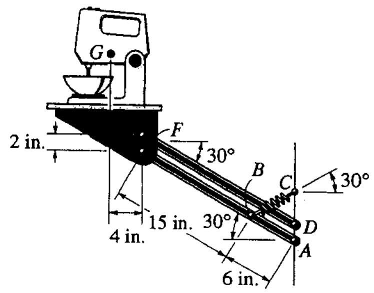
$F_x = 3455 \text{ N}$

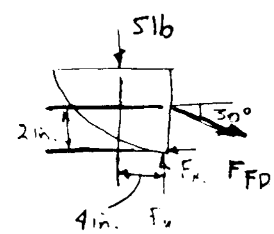
$+\uparrow \Sigma F_y = 0; \quad -F_y - 2452.5 + 16\,349 \cos 12.2° = 0$

$F_y = 13\,527 \text{ N}$

$F_F = \sqrt{(3455)^2 + (13\,527)^2} = 14.0 \text{ kN}$ **Ans**

6-118. The mechanism is used to hide kitchen appliances under a cabinet by allowing the shelf to rotate downward. If the mixer weighs 10 lb, is centered on the shelf, and has a mass center at G, determine the stretch in the spring necessary to hold the shelf in the equilibrium position shown. There is a similar mechanism on each side of the shelf, so that each mechanism supports 5 lb of the load. The springs each have a stiffness of $k = 4$ lb/in. spring.





$\circlearrowleft + \Sigma M_F = 0;\quad 5(4) - 2(F_{ED})(\cos 30°) = 0$

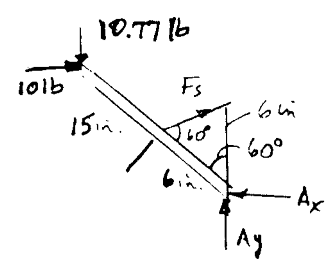
$F_{ED} = 11.547$ lb

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad -F_x + 11.547\cos 30° = 0$

$F_x = 10.00$ lb

$+\uparrow \Sigma F_y = 0;\quad -5 + F_y - 11.547\sin 30° = 0$

$F_y = 10.77$ lb



Member FBA :

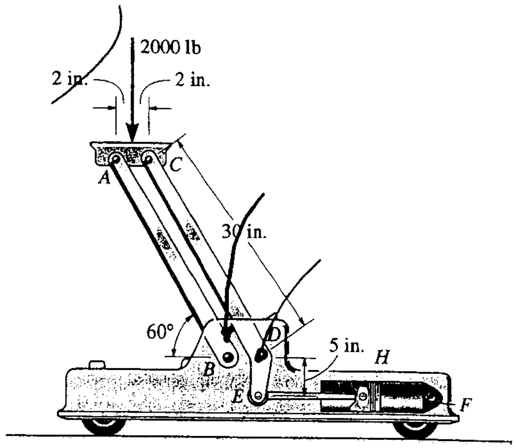
$\circlearrowleft + \Sigma M_A = 0;\quad 10.77(21\cos 30°) - 10(21\sin 30°) - F_s(\sin 60°)(6) = 0$

$F_s = 17.5$ lb

$F_s = ks;\quad 17.5 = 4x$

$x = 4.38$ in. **Ans**

6-119. The linkage for a hydraulic jack is shown. If the load on the jack is 2000 lb, determine the pressure acting on the fluid when the jack is in the position shown. All lettered points are pins. The piston at H has a cross-sectional area of $A = 2\ \text{in}^2$. *Hint:* First find the force F acting along link EH. The pressure in the fluid is $p = F/A$.



$$\circlearrowleft + \Sigma M_C = 0; \quad -F_{AB}(\sin 60°)(4) + 2000(2) = 0$$

$$F_{AB} = 1154.70 \text{ lb}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad C_x - F_{AB}\cos 60° = 0$$

$$C_x = 577.35 \text{ lb}$$

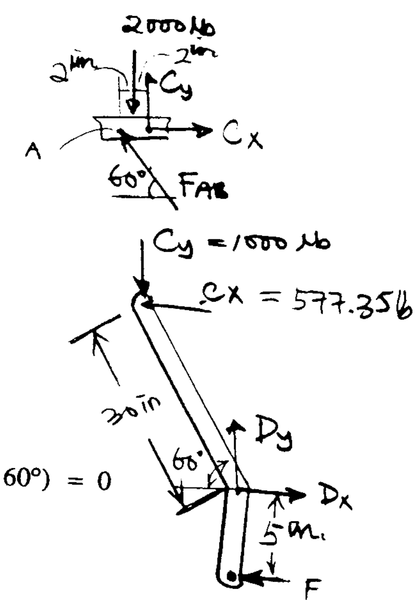
$$+\uparrow \Sigma F_y = 0; \quad C_y + 1154.70\sin 60° - 2000 = 0$$

$$C_y = 1000 \text{ lb}$$

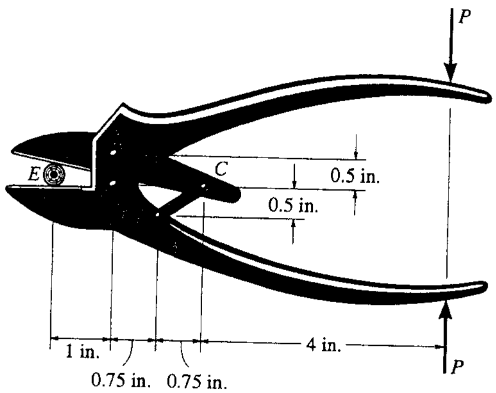
$$\circlearrowleft + \Sigma M_D = 0; \quad -F(5) + 1000(30\cos 60°) + 577.35(30\sin 60°) = 0$$

$$F = 6000 \text{ lb}$$

$$p = \frac{F}{A} = \frac{6000}{2} = 3000 \text{ psi} \qquad \textbf{Ans}$$

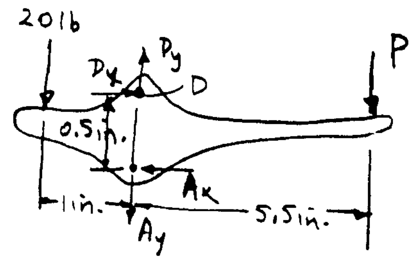


*6-120.** Determine the required force P that must be applied at the blade of the pruning shears so that the blade exerts a normal force of 20 lb on the twig at E.



$\circlearrowleft + \Sigma M_D = 0; \quad -P(5.5) - A_x(0.5) + 20(1) = 0$

$5.5P + 0.5A_x = 20$



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

$\xrightarrow{+} \Sigma F_x = 0; \quad D_x = A_x$

$\circlearrowleft + \Sigma M_B = 0; \quad A_y(0.75) + A_x(0.5) - 4.75P = 0$

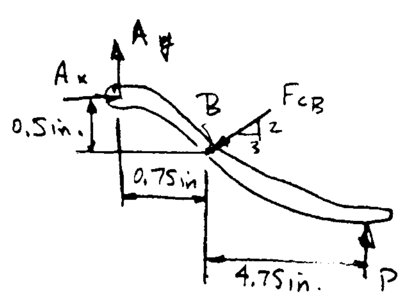
$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - F_{CB}\left(\frac{3}{\sqrt{13}}\right) = 0$

$+\uparrow \Sigma F_y = 0; \quad A_y + P - F_{CB}\left(\frac{2}{\sqrt{13}}\right) = 0$

Solving :

$A_x = 13.3$ lb

$A_y = 6.46$ lb



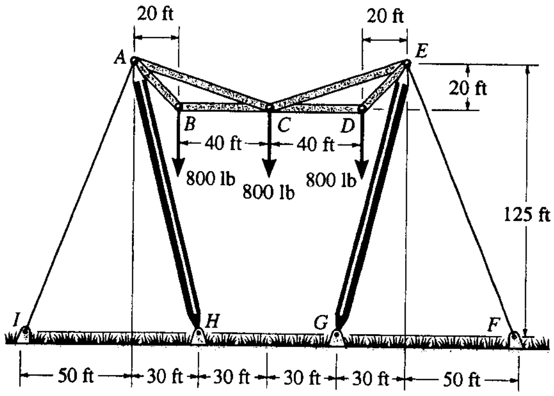
$D_x = 13.3$ lb

$D_y = 28.9$ lb

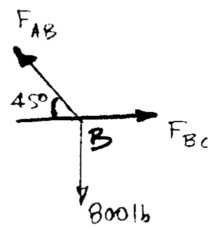
$P = 2.42$ lb **Ans**

$F_{CB} = 16.0$ lb

6-121. The three power lines exert the forces shown on the truss joints, which in turn are pin-connected to the poles AH and EG. Determine the force in the guy cable AI and the pin reaction at the support H.



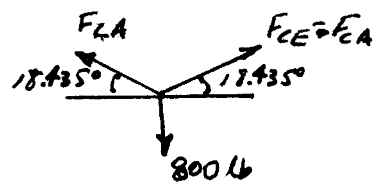
AH is a two–force member.



Joint B :

$+\uparrow \Sigma F_y = 0; \quad F_{AB}\sin 45° - 800 = 0$

$F_{AB} = 1131.37 \text{ lb}$



Joint C :

$+\uparrow \Sigma F_y = 0; \quad 2F_{CA}\sin 18.435° - 800 = 0$

$F_{CA} = 1264.91 \text{ lb}$

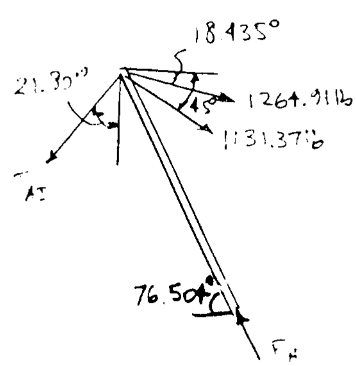
Joint A :

$\xrightarrow{+} \Sigma F_x = 0; \quad -T_{AI}\sin 21.801° - F_H\cos 76.504° + 1264.91\cos 18.435° + 1131.37\cos 45° = 0$

$+\uparrow \Sigma F_y = 0; \quad -T_{AI}\cos 21.801° + F_H\sin 76.504° - 1131.37\sin 45° - 1264.91\sin 18.435° = 0$

$T_{AI}(0.3714) + F_H(0.2334) = 2000$

$-T_{AI}(0.9285) + F_H(0.97239) = 1200$

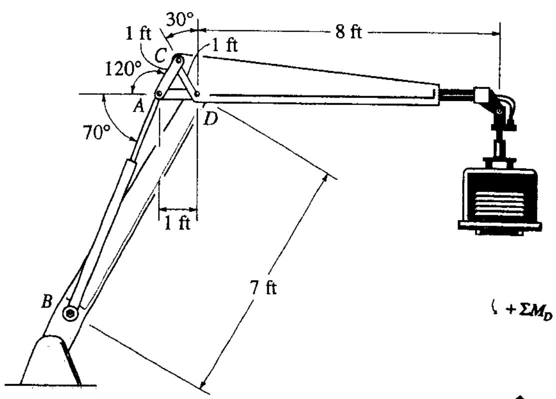


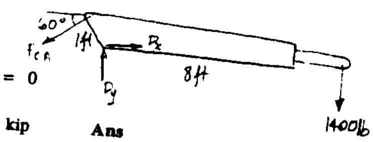
Solving,

$T_{AI} = T_{EF} = 2.88 \text{ kip}$ **Ans**

$F_H = F_G = 3.99 \text{ kip}$ **Ans**

6-122. The hydraulic crane is used to lift the 1400-lb load. Determine the force in the hydraulic cylinder AB and the force in links AC and AD when the load is held in the position shown.





$\circlearrowleft + \Sigma M_D = 0;\quad F_{CA}(\sin 60°)(1) - 1400(8) = 0$

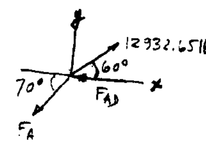
$F_{CA} = 12\,932.65 \text{ lb} = 12.9 \text{ kip}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 12\,932.65\sin 60° - F_{AB}\sin 70° = 0$

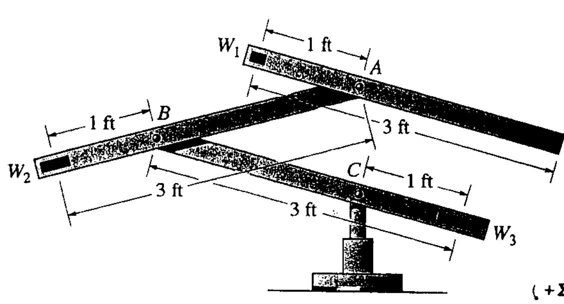
$F_{AB} = 11\,918.79 \text{ lb} = 11.9 \text{ kip}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad -11\,918.79\cos 70° + 12\,932.65\cos 60° - F_{AD} = 0$

$F_{AD} = 2389.85 \text{ lb} = 2.39 \text{ kip}$ **Ans**



6-123. The kinetic sculpture requires that each of the three pinned beams be in perfect balance at all times during its slow motion. If each member has a uniform weight of 2 lb/ft and length of 3 ft, determine the necessary counterweights W_1, W_2, and W_3 which must be added to the ends of each member to keep the system in balance for any position. Neglect the size of the counterweights.



$\circlearrowleft + \Sigma M_A = 0;\quad W_1(1\cos\theta) - 6(0.5\cos\theta) = 0$

$W_1 = 3 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad R_A - 3 - 6 = 0$

$R_A = 9 \text{ lb}$

$\circlearrowleft + \Sigma M_B = 0;\quad W_2(1\cos\phi) - 6(0.5\cos\phi) - 9(2\cos\phi) = 0$

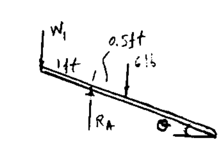
$W_2 = 21 \text{ lb}$ **Ans**

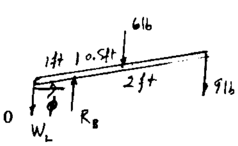
$+\uparrow \Sigma F_y = 0;\quad R_B - 21 - 6 - 9 = 0$

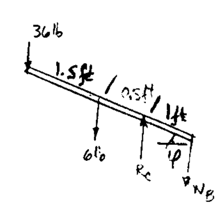
$R_B = 36 \text{ lb}$

$\circlearrowleft + \Sigma M_C = 0;\quad 36(2\cos\varphi) + 6(0.5\cos\varphi) - W_3(1\cos\varphi) = 0$

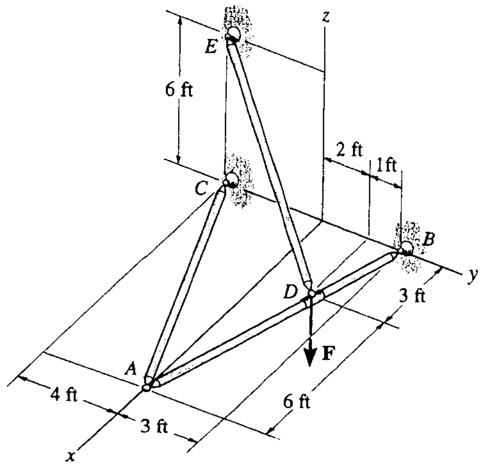
$W_3 = 75 \text{ lb}$ **Ans**





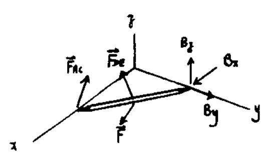


***6-124.** The three-member frame is connected at its ends using ball-and-socket joints. Determine the x, y, z components of reaction at B and the tension in member ED. The force acting at D is $\mathbf{F} = \{135\mathbf{i} + 200\mathbf{j} - 180\mathbf{k}\}$ lb.



AC is a two-force member.

$\mathbf{F} = \{135\mathbf{i} + 200\mathbf{j} - 180\mathbf{k}\}$ lb



$\Sigma M_y = 0;\qquad -\frac{6}{9}F_{DE}(3) + 180(3) = 0$

$F_{DE} = 270$ lb **Ans**

$\Sigma F_z = 0;\qquad B_z + \frac{6}{9}(270) - 180 = 0$

$B_z = 0$ **Ans**

$\Sigma(M_B)_z = 0;\qquad -\frac{9}{\sqrt{97}}F_{AC}(3) - \frac{4}{\sqrt{97}}F_{AC}(9) + 135(1) + 200(3) - \frac{6}{9}(270)(3) - \frac{3}{9}(270)(1) = 0$

$F_{AC} = 16.41$ lb

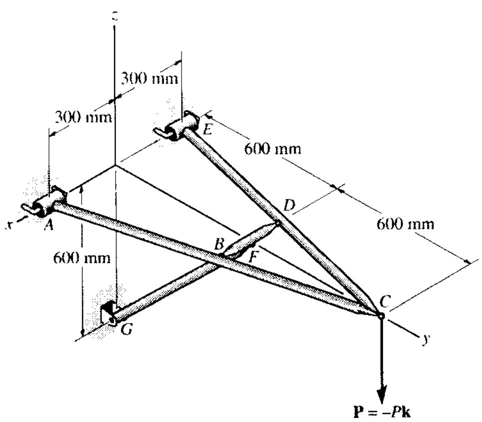
$\Sigma F_x = 0;\qquad 135 - \frac{3}{9}(270) + B_x - \frac{9}{\sqrt{97}}(16.41) = 0$

$B_x = -30$ lb **Ans**

$\Sigma F_y = 0;\qquad B_y - \frac{4}{\sqrt{97}}(16.41) + 200 - \frac{6}{9}(270) = 0$

$B_y = -13.3$ lb **Ans**

6-125. The four-member "A" frame is supported at A and E by smooth collars and at G by a pin. All the other joints are ball-and-sockets. If the pin at G will fail when the resultant force there is 800 N, determine the largest vertical force P that can be supported by the frame. Also, what are the x, y, z force components which member BD exerts on members EDC and ABC? The collars at A and E and the pin at G only exert force components on the frame.



$\Sigma M_x = 0;\qquad -P(1.2) + 800\ \sin 45°(0.6) = 0$

$P = 471\ \text{N}$ **Ans**

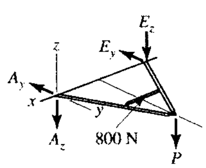
$B_x + D_x = 800\ \cos 45°$

$B_x = D_x = 283\ \text{N}$ **Ans**

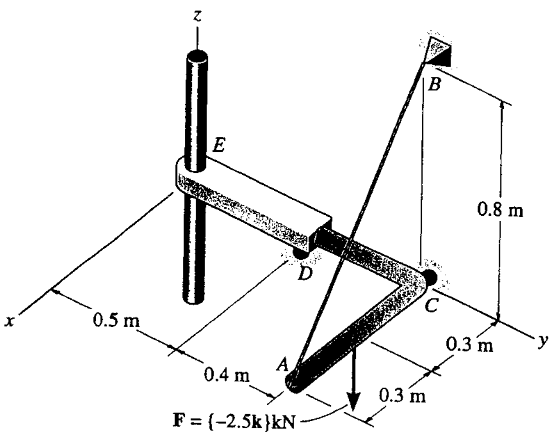
$B_y + D_y = 800\ \sin 45°$

$B_y D_y = 283\ \text{N}$ **Ans**

$B_z = D_z = 0$ **Ans**

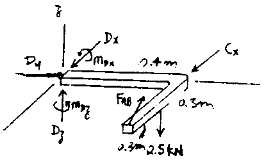


6-126. The structure is subjected to the loading shown. Member AD is supported by a cable AB and roller at C and fits through a smooth circular hole at D. Member ED is supported by a roller at D and a pole that fits in a smooth snug circular hole at E. Determine the x, y, z components of reaction at E and the tension in cable AB.



$\Sigma M_y = 0;\quad -\frac{4}{5}F_{AB}(0.6) + 2.5(0.3) = 0$

$F_{AB} = 1.563 = 1.56\text{ kN}$ **Ans**



$\Sigma F_z = 0;\quad \frac{4}{5}(1.563) - 2.5 + D_z = 0$

$D_z = 1.25\text{ kN}$

$\Sigma F_y = 0;\quad D_y = 0$

$\Sigma F_x = 0;\quad D_x + C_x - \frac{3}{5}(1.563) = 0 \qquad (1)$

$\Sigma M_x = 0;\quad M_{Dx} + \frac{4}{5}(1.563)(0.4) - 2.5(0.4) = 0$

$M_{Dx} = 0.5\text{ kN}\cdot\text{m}$

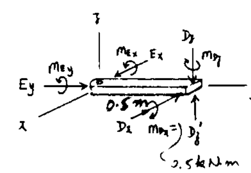
$\Sigma M_z = 0;\quad M_{Dz} + \frac{3}{5}(1.563)(0.4) - C_x(0.4) = 0 \qquad (2)$

$\Sigma F_z = 0;\quad D_z' = 1.25\text{ kN}$

$\Sigma M_x = 0;\quad M_{Ex} = 0.5\text{ kN}\cdot\text{m}$ **Ans**

$\Sigma M_y = 0;\quad M_{Ey} = 0$ **Ans**

$\Sigma F_y = 0;\quad E_y = 0$ **Ans**



$\Sigma M_z = 0;\quad D_x(0.5) - M_{Dz} = 0 \qquad (3)$

Solving Eqs. (1), (2) and (3) :

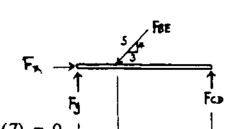
$C_x = 0.938\text{ kN}$

$M_{Dz} = 0$

$D_x = 0$

$\Sigma F_x = 0;\quad E_x = 0$ **Ans**

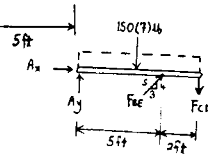
$\circlearrowleft + \Sigma M_F = 0;\quad F_{CD}(7) - \frac{4}{5}F_{BE}(2) = 0$



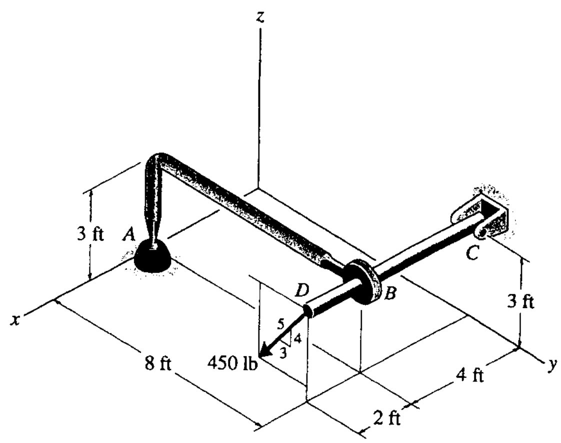
$\circlearrowleft + \Sigma M_A = 0;\quad -150(7)(3.5) + \frac{4}{5}F_{BE}(5) - F_{CD}(7) = 0$

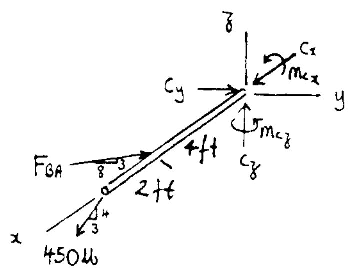
$F_{BE} = 1531\text{ lb} = 1.53\text{ kip}$ **Ans**

$F_{CD} = 350\text{ lb}$ **Ans**



6-127. The structure is subjected to the force of 450 lb which lies in a plane parallel to the y-z plane. Member AB is supported by a ball-and-socket joint at A and fits through a snug hole at B. Member CD is supported by a pin at C. Determine the x, y, z components of reaction at A and C.





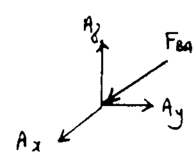
$\Sigma M_x = 0; \quad M_{Cx} = 0$ **Ans**

$\Sigma F_x = 0; \quad C_x = 0$ **Ans**

$$\Sigma F_y = 0; \quad -450\left(\frac{3}{5}\right) + F_{BA}\left(\frac{8}{\sqrt{73}}\right) + C_y = 0$$

$$\Sigma F_z = 0; \quad C_z + F_{BA}\left(\frac{3}{\sqrt{73}}\right) - 450\left(\frac{4}{5}\right) = 0$$

$$\Sigma M_y = 0; \quad 450\left(\frac{4}{5}\right)(6) - F_{BA}\left(\frac{3}{\sqrt{73}}\right)(4) = 0$$



$$\Sigma M_z = 0; \quad M_{Cz} + F_{BA}\left(\frac{8}{\sqrt{73}}\right)(4) - 450\left(\frac{3}{5}\right)(6) = 0$$

$F_{BA} = 1.538 \text{ kip} = 1.54 \text{ kip}$ **Ans**

$C_z = -0.18 \text{ kip}$ **Ans**

$C_y = -1.17 \text{ kip}$ **Ans**

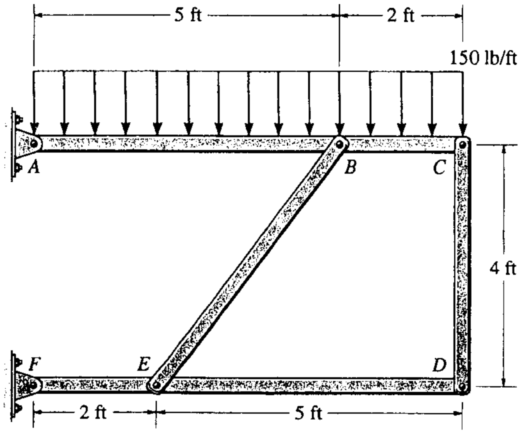
$M_{Cz} = -4.14 \text{ kip}\cdot\text{ft}$ **Ans**

$A_x = 0$ **Ans**

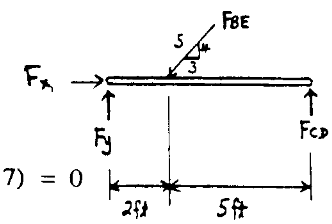
$$A_y = 1.538\left(\frac{8}{\sqrt{73}}\right) = 1.44 \text{ kip}$$ **Ans**

$$A_z = 1.538\left(\frac{3}{\sqrt{73}}\right) = 0.540 \text{ kip}$$ **Ans**

~~*6-128. Determine the resultant forces at pins *B* and *C*~~ on member *ABC* of the four-member frame.

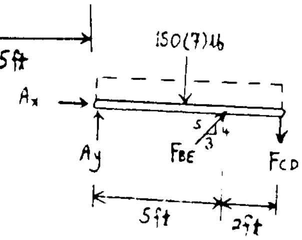


Prob. 6–128



$\circlearrowleft + \Sigma M_F = 0;\qquad F_{CD}(7) - \frac{4}{5}F_{BE}(2) = 0$

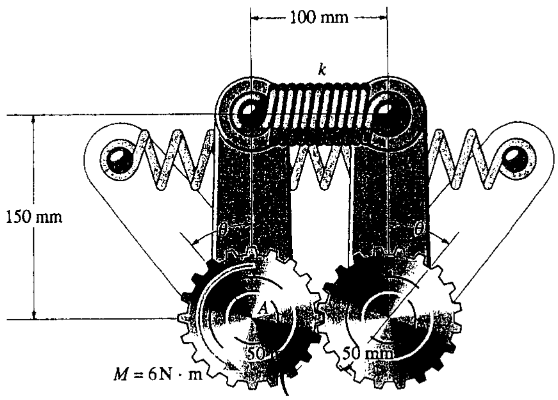
$\circlearrowleft + \Sigma M_A = 0;\qquad -150(7)(3.5) + \frac{4}{5}F_{BE}(5) - F_{CD}(7) = 0$



$F_{BE} = 1531 \text{ lb} = 1.53 \text{ kip}$ **Ans**

$F_{CD} = 350 \text{ lb}$ **Ans**

6-129. The mechanism consists of identical meshed gears A and B and arms which are fixed to the gears. The spring attached to the ends of the arms has an unstretched length of 100 mm and a stiffness of $k = 250$ N/m. If a torque of $M = 6$ N·m is applied to gear A, determine the angle θ through which each arm rotates. The gears are each pinned to fixed supports at their centers.



$\circlearrowleft + \Sigma M_A = 0; \quad -F(0.05) - P(0.15\cos\theta) + 6 = 0$

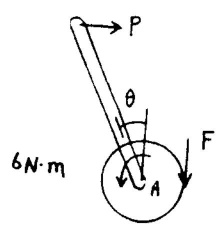
$\circlearrowleft + \Sigma M_B = 0; \quad P(0.15\cos\theta) - F(0.05) = 0$

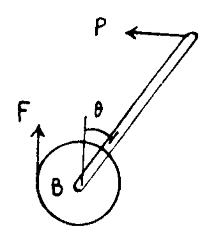
$2P(0.15\cos\theta) = 6$

$2(2)(250)(0.15\sin\theta)(0.15\cos\theta) = 6$

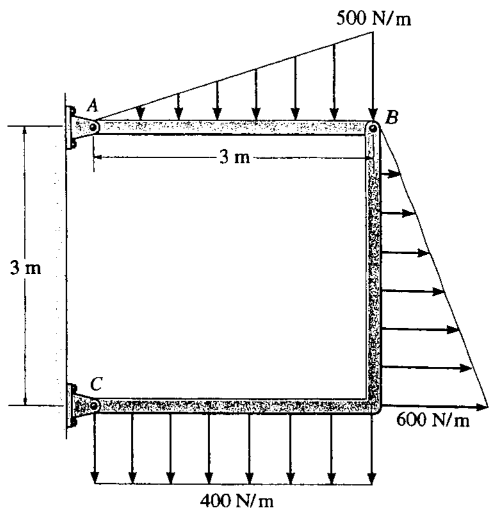
$\sin 2\theta = 0.5333$

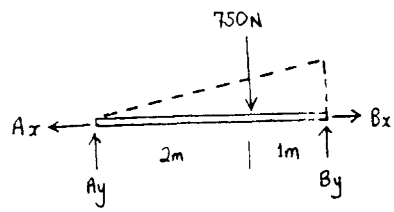
$\theta = 16.1°$ **Ans**





6-130. Determine the horizontal and vertical components of force at pins A and C of the two-member frame.



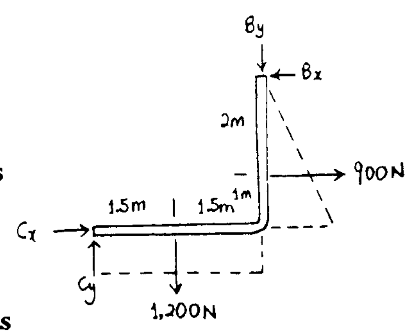


$\circlearrowleft + \Sigma M_A = 0;$ $\quad -750(2) + B_y(3) = 0$

$B_y = 500 \text{ N}$

$\circlearrowleft + \Sigma M_C = 0;$ $\quad -1200(1.5) - 900(1) + B_x(3) - 500(3) = 0$

$B_x = 1400 \text{ N}$



$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -A_x + 1400 = 0$

$A_x = 1400 \text{ N} = 1.40 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 750 + 500 = 0$

$A_y = 250 \text{ N}$ **Ans**

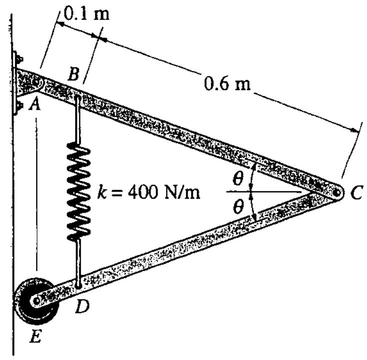
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad C_x + 900 - 1400 = 0$

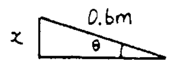
$C_x = 500 \text{ N}$ **Ans**

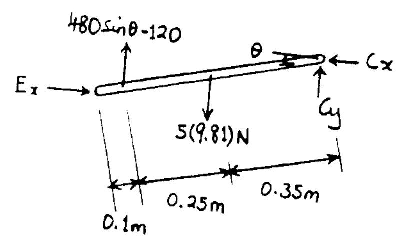
$+\uparrow \Sigma F_y = 0;$ $\quad -500 - 1200 + C_y = 0$

$C_y = 1700 \text{ N} = 1.70 \text{ kN}$ **Ans**

6-131. The spring has an unstretched length of 0.3 m. Determine the angle θ for equilibrium if the uniform links each have a mass of 5 kg.







$x = 0.6 \sin\theta$

$F_{BD} = 400[2(0.6)\sin\theta - 0.3)]$

$= 480 \sin\theta - 120$

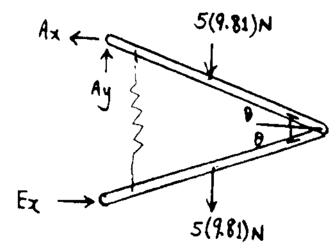
$\curvearrowleft + \Sigma M_C = 0; \quad -(480 \sin\theta - 120)(0.6 \cos\theta) + E_x(0.7 \sin\theta) + 5(9.81)(0.35 \cos\theta) = 0$

$E_x = 411.4 \cos\theta - 127.4 \cot\theta$

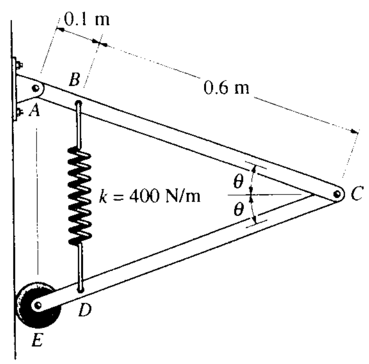
$\curvearrowleft + \Sigma M_A = 0; \quad -5(9.81)(2)(0.35 \cos\theta) + (411.4 \cos\theta - 127.4 \cot\theta)(2)(0.7 \sin\theta) = 0$

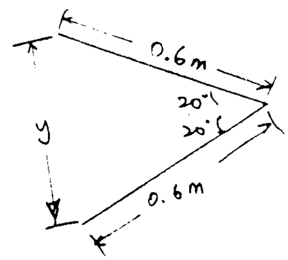
$\sin\theta = \dfrac{212.7}{576}$

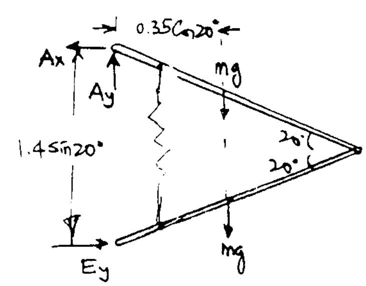
$\theta = 21.7°$ **Ans**



***6-132.** The spring has an unstretched length of 0.3 m. Determine the mass m of each uniform link if the angle $\theta = 20°$ for equilibrium.







$$\frac{y}{2(0.6)} = \sin 20°$$

$$y = 1.2\sin 20°$$

$$F_s = (1.2\sin 20° - 0.3)(400) = 44.1697 \text{ N}$$

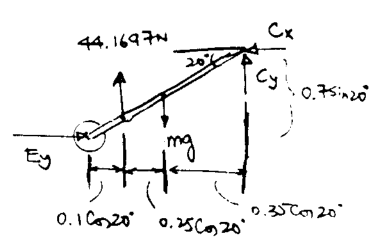
$$\circlearrowleft +\Sigma M_A = 0; \quad E_y(1.4\sin 20°) - 2(mg)(0.35\cos 20°) = 0$$

$$E_y = 1.37374(mg)$$

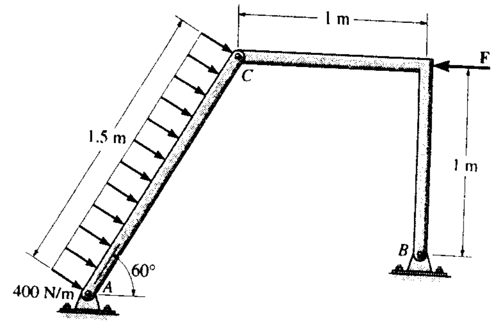
$$\circlearrowleft +\Sigma M_C = 0; \quad 1.37374mg(0.7\sin 20°) + mg(0.35\cos 20°) - 44.1697(0.6\cos 20°) = 0$$

$$mg = 37.860$$

$$m = 37.860/9.81 = 3.86 \text{ kg} \qquad \textbf{Ans}$$



6-133. Determine the horizontal and vertical components of force that the pins A and B exert on the two-member frame. Set $F = 0$.



CB is a two - force member.

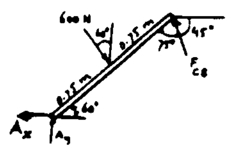
Member AC :

$\circlearrowleft + \Sigma M_A = 0; \quad -600\,(0.75) + 1.5\,(F_{CB} \sin 75°) = 0$

$F_{CB} = 310.6$

Thus,

$$B_x = B_y = 310.6\left(\frac{1}{\sqrt{2}}\right) = 220\text{ N} \quad \textbf{Ans}$$



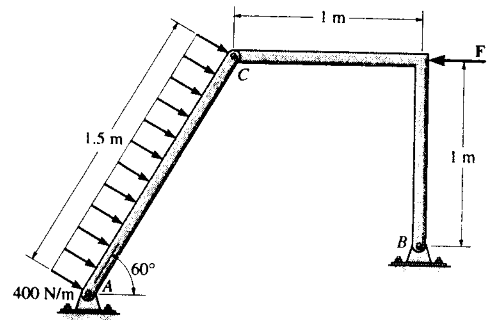
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad -A_x + 600 \sin 60° - 310.6 \cos 45° = 0$

$A_x = 300\text{ N} \quad$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y - 600 \cos 60° + 310.6 \sin 45° = 0$

$A_y = 80.4\text{ N} \quad$ **Ans**

6-134. Determine the horizontal and vertical components of force that pins A and B exert on the two-member frame. Set $F = 500$ N.



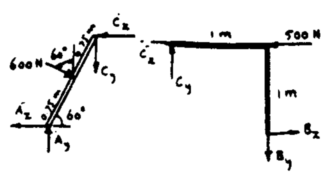
Member AC :

$\circlearrowleft + \Sigma M_A = 0; \quad -600\,(0.75) - C_y\,(1.5 \cos 60°) + C_x\,(1.5 \sin 60°) = 0$

Member CB :

$\circlearrowleft + \Sigma M_B = 0; \quad -C_x\,(1) - C_y\,(1) + 500\,(1) = 0$

Solving,



$C_x = 402.6\text{ N}$

$C_y = 97.4\text{ N}$

Member AC :

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad -A_x + 600 \sin 60° - 402.6 = 0$

$A_x = 117\text{ N} \quad$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad A_y - 600 \cos 60° - 97.4 = 0$

$A_y = 397\text{ N} \quad$ **Ans**

Member CB :

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 402.6 - 500 + B_x = 0$

$B_x = 97.4\text{ N} \quad$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad -B_y + 97.4 = 0$

$B_y = 97.4\text{ N} \quad$ **Ans**