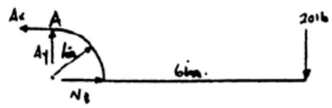
HW7 SOLUTIONS

5–15. Determine the horizontal and vertical components of reaction at *A* and the normal reaction at *B* on the spanner wrench in Prob. 5–7.

$\circlearrowleft + \Sigma M_A = 0; \quad N_B(1) - 20(7) = 0$

$N_B = 140 \text{ lb}$ **Ans**



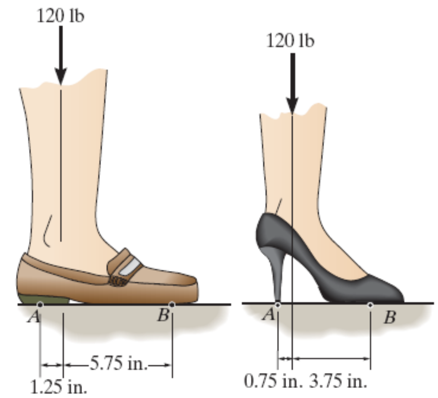
$\xrightarrow{+} \Sigma F_x = 0; \quad -A_x + 140 = 0$

$A_x = 140 \text{ lb}$ **Ans**

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

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

5–19. Compare the force exerted on the toe and heel of a 120-lb woman when she is wearing regular shoes and stiletto heels. Assume all her weight is placed on one foot and the reactions occur at points A and B as shown.

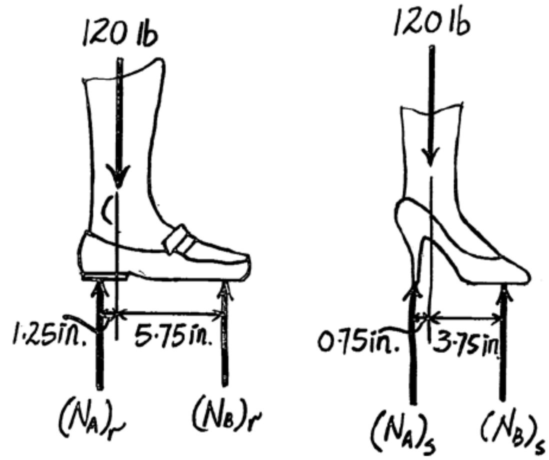


$\circlearrowleft + \Sigma M_B = 0; \quad 120(5.75) - (N_A)_r(7) = 0$

$(N_A)_r = 98.6 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad (N_B)_r + 98.6 - 120 = 0$

$(N_B)_r = 21.4 \text{ lb}$ **Ans.**



Stiletto heal shoe,

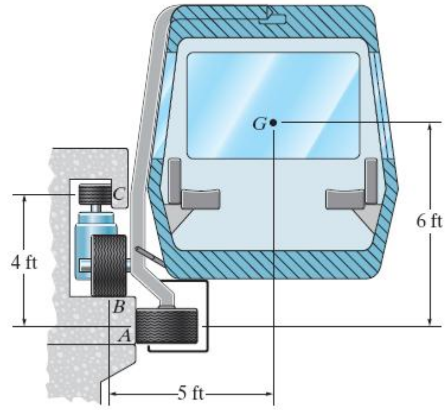
$\circlearrowleft + \Sigma M_B = 0; \quad 120(3.75) - (N_A)_s(4.5) = 0$

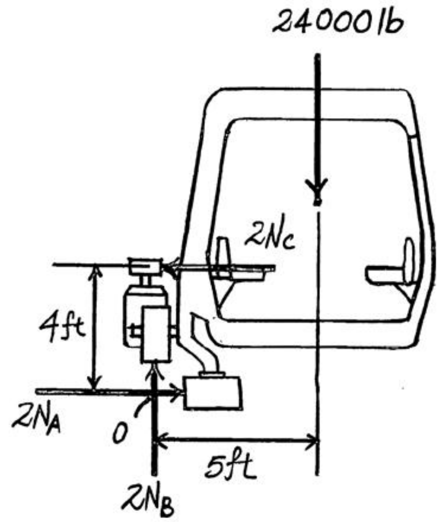
$(N_A)_s = 100 \text{ lb}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad (N_B)_s + 100 - 120 = 0$

$(N_B)_s = 20 \text{ lb}$ **Ans.**

*5–20. The train car has a weight of 24 000 lb and a center of gravity at G. It is suspended from its front and rear on the track by six tires located at A, B, and C. Determine the normal reactions on these tires if the track is assumed to be a smooth surface and an equal portion of the load is supported at both the front and rear tires.





$\circlearrowleft + \Sigma M_O = 0;\quad (2\,N_C)(4) - 24\,000\,(5) = 0$

$N_C = 15\,000 \text{ lb} = 15 \text{ kip}$ **Ans**

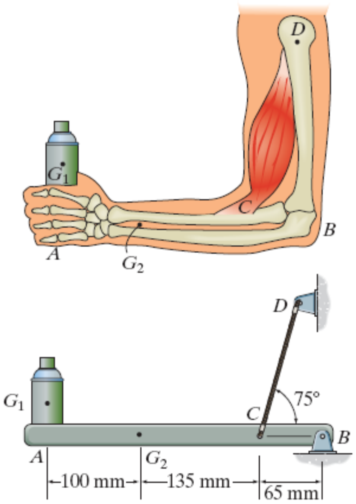
$\xrightarrow{+} \Sigma F_x = 0;\quad 2\,N_A - 2(15) = 0$

$N_A = 15 \text{ kip}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 2\,N_B - 24\,000 = 0$

$N_B = 12 \text{ kip}$ **Ans**

5–26. A skeletal diagram of a hand holding a load is shown in the upper figure. If the load and the forearm have masses of 2 kg and 1.2 kg, respectively, and their centers of mass are located at G_1 and G_2, determine the force developed in the biceps CD and the horizontal and vertical components of reaction at the elbow joint B. The forearm supporting system can be modeled as the structural system shown in the lower figure.



Equations of Equilibrium: From the free - body diagram of the structural system, Fig. *a*, F_{CD} can be obtained by writing the moment equation of equilibrium about point *B*.

$$\circlearrowleft + \Sigma M_B = 0; \qquad 2(9.81)(100+135+65)+1.2(9.81)(135+65) - F_{CD}\sin 75^\circ(65) = 0$$

$$F_{CD} = 131.25\text{ N} = 131\text{ N} \qquad \textbf{Ans.}$$

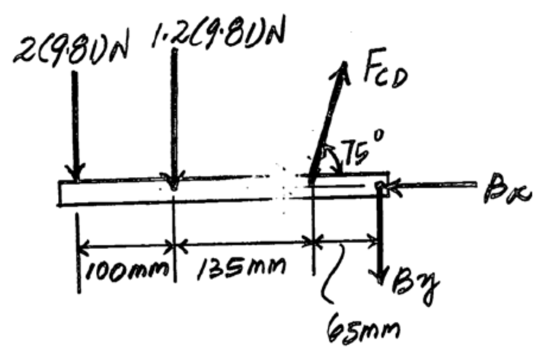
Using the above result and writing the force equations of equilibrium along the *x* and *y* axes,

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad 131.25\cos 75^\circ - B_x = 0$$

$$B_x = 33.97\text{ N} = 34.0\text{ N} \qquad \textbf{Ans.}$$

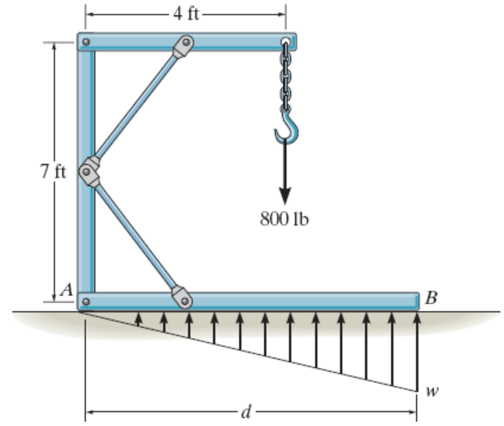
$$+\uparrow \Sigma F_y = 0; \qquad 131.25\sin 75^\circ - 2(9.81) - 1.2(9.81) - B_y = 0$$

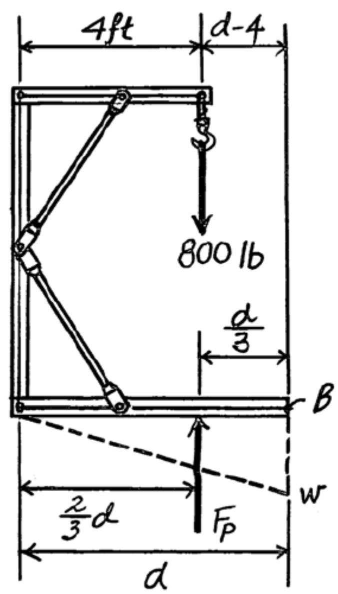
$$B_y = 95.38\text{ N} = 95.4\text{ N} \qquad \textbf{Ans.}$$



(a)

5–35. The framework is supported by the member AB which rests on the smooth floor. When loaded, the pressure distribution on AB is linear as shown. Determine the length d of member AB and the intensity w for this case.





$+\uparrow \Sigma F_y = 0; \quad F_P - 800 = 0$

$F_P = 800 \text{ lb}$

When tipping;

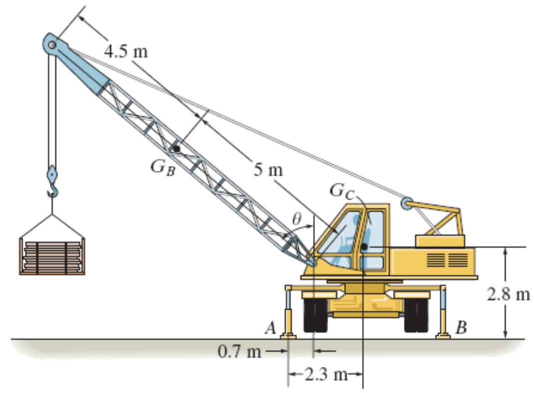
$\circlearrowleft + \Sigma M_B = 0; \quad -800\left(\frac{d}{3}\right) + 800(d-4) = 0$

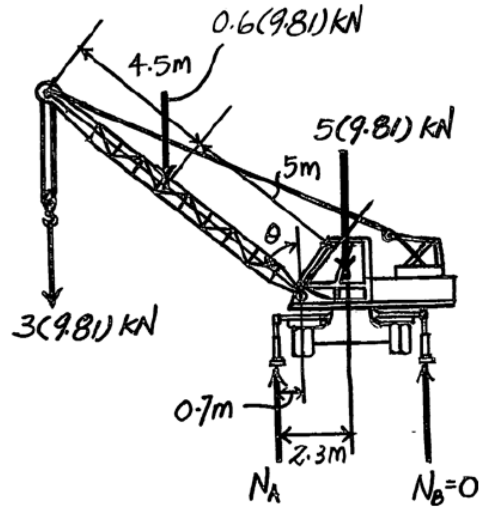
$d = 6 \text{ ft}$ **Ans**

$F_P = \frac{1}{2}wd = \frac{1}{2}(w)(6) = 800$

$w = 267 \text{ lb/ft}$ **Ans**

*5–36. Outriggers A and B are used to stabilize the crane from overturning when lifting large loads. If the load to be lifted is 3 Mg, determine the *maximum* boom angle θ so that the crane does not overturn. The crane has a mass of 5 Mg and center of mass at G_C, whereas the boom has a mass of 0.6 Mg and center of mass at G_B.



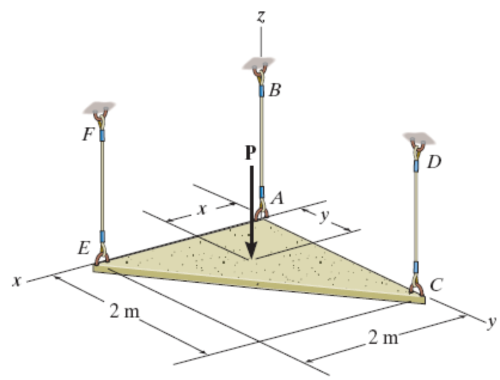


$\circlearrowleft + \Sigma M_A = 0;\quad -5\,(9.81)\,(2.3) + 3\,(9.81)\,(9.5 \sin\theta - 0.7)$

$+ 0.6\,(9.81)\,(5 \sin\theta - 0.7) = 0$

$\theta = 26.4^\circ$ Ans

5–66. Determine the location x and y of the point of application of force **P** so that the tension developed in cables AB, CD, and EF is the same. Neglect the weight of the plate.



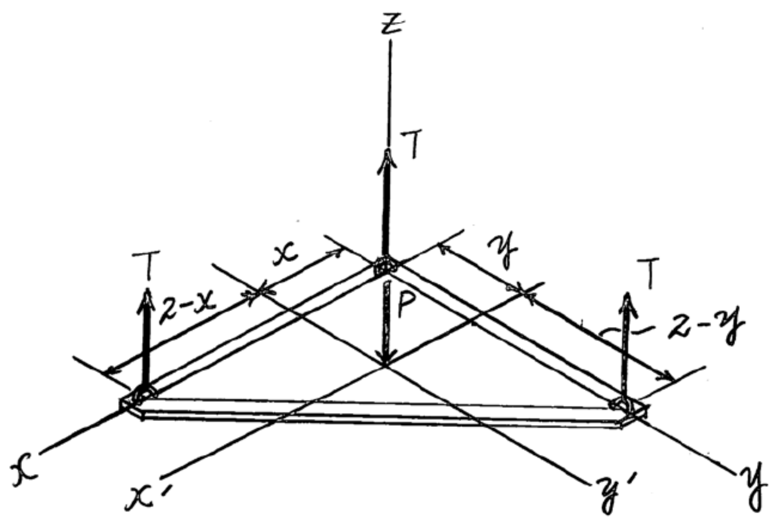
Equations of Equilibrium: From the free - body diagram of the plate, Fig. *a*, and writing the moment equations of equilibrium about the x' and y' axes,

$\Sigma M_{x'} = 0;$ $\quad T(2-y) - 2T(y) = 0$

$y = 0.667 \text{ m}$ **Ans.**

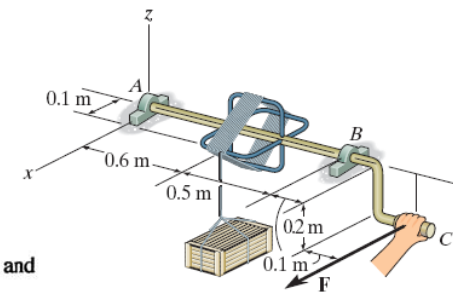
$\Sigma M_{y'} = 0;$ $\quad 2T(x) - T(2-x) = 0$

$x = 0.667 \text{ m}$ **Ans.**



(a)

*5–68. Determine the magnitude of force **F** that must be exerted on the handle at C to hold the 75-kg crate in the position shown. Also, determine the components of reaction at the thrust bearing A and smooth journal bearing B.



Equations of Equilibrium: From the free - body diagram, Fig. a, F, B_z, A_z, and A_y can be obtained by writing the moment equation of equilibrium about the y, x, and x' axes and the force equation of equilibrium along the y axis.

$\Sigma M_y = 0;\quad -F(0.2) + 75(9.81)(0.1) = 0$

$F = 367.875\text{ N} = 368\text{ N}$ **Ans.**

$\Sigma M_x = 0;\quad B_z(0.5 + 0.6) - 75(9.81)(0.6) = 0$

$B_z = 401.32\text{ N} = 401\text{ N}$ **Ans.**

$\Sigma M_{x'} = 0;\quad -A_z(0.6 + 0.5) + 75(9.81)(0.5) = 0$

$A_z = 334.43\text{ N} = 334\text{ N}$ **Ans.**

$\Sigma F_y = 0;\quad A_y = 0$ **Ans.**

Using the result $F = 367.875$ N and writing the moment equations of equilibrium about the z and z' axes,

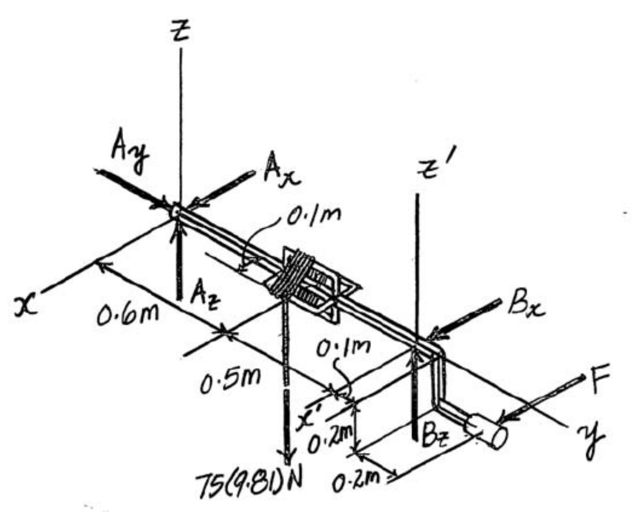
$\Sigma M_z = 0;\quad -B_x(0.5 + 0.6) - 367.875(0.2 + 0.1 + 0.5 + 0.6) = 0$

$B_x = -468.20\text{ N} = -468\text{ N}$ **Ans.**

$\Sigma M_{z'} = 0;\quad A_x(0.6 + 0.5) - 367.875(0.2 + 0.1) = 0$

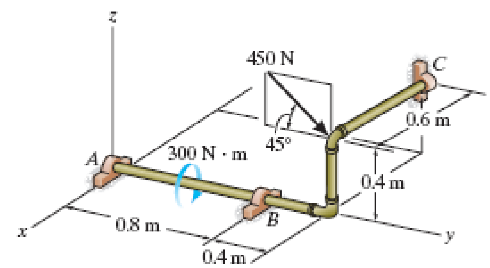
$A_x = 100.33\text{ N} = 100\text{ N}$ **Ans.**

The negative signs indicate that $\mathbf{B}_x$ act in the opposite sense to that shown on the free - body diagram.



(a)

*5–72. Determine the components of reaction acting at the smooth journal bearings A, B, and C.



Equations of Equilibrium: From the free - body diagram of the shaft, Fig. *a*, C_y and C_z can be obtained by writing the force equation of equilibrium along the y axis and the moment equation of equilibrium about the yaxis.

$\Sigma F_y = 0;\quad 450\cos 45° + C_y = 0$

$C_y = -318.20\text{ N} = -318\text{ N}$ **Ans.**

$\Sigma M_y = 0;\quad C_z(0.6) - 300 = 0$

$C_z = 500\text{ N}$ **Ans.**

Using the above results and writing the moment equations of equilibrium about the x and z axes,

$\Sigma M_x = 0;\quad B_z(0.8) - 450\cos 45°(0.4) - 450\sin 45°(0.8+0.4) + (318.20)(0.4) + 500(0.8+0.4) = 0$

$B_z = -272.70\text{ N} = -273\text{ N}$ **Ans.**

$\Sigma M_z = 0;\quad -B_x(0.8) - (-318.20)(0.6) = 0$

$B_x = 238.65\text{ N} = 239\text{ N}$ **Ans.**

Finally, using the above results and writing the force equations of equilibrium along the x and y axes,

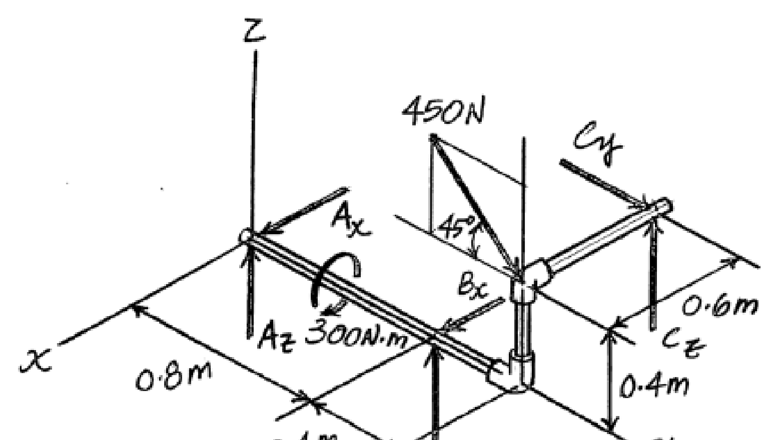
$\Sigma F_x = 0;\quad A_x + 238.5 = 0$

$A_x = -238.65\text{ N} = -239\text{ N}$ **Ans.**

$\Sigma F_z = 0;\quad A_z - (-272.70) + 500 - 450\sin 45° = 0$

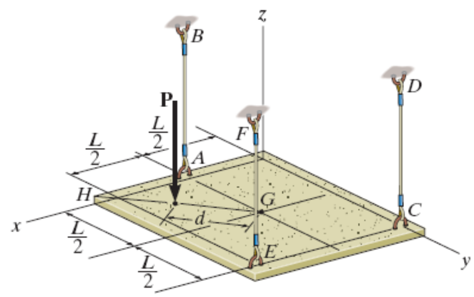
$A_z = 90.90\text{ N} = 90.9\text{ N}$ **Ans.**

The negative signs indicate that $\mathbf{C}_y$, $\mathbf{B}_z$ and $\mathbf{A}_x$ act in the opposite sense of that shown on the free - body diagram.



(a)

5–78. The plate has a weight of W with center of gravity at G. Determine the tension developed in wires AB, CD, and EF if the force $P = 0.75W$ is applied at $d = L/2$.



Equations of Equilibrium: From the free - body diagram, Fig. *a*, T_{AB} can be obtained by writing the moment equation of equilibrium about the x' axis.

$$\Sigma M_{x'} = 0; \qquad 0.75W\left[\frac{L}{2}+\frac{L}{2}\cos 45°\right]+W\left(\frac{L}{2}\right)-T_{AB}(L)=0$$

$$T_{AB} = 1.1402\ W = 1.14\ W \qquad \textbf{Ans.}$$

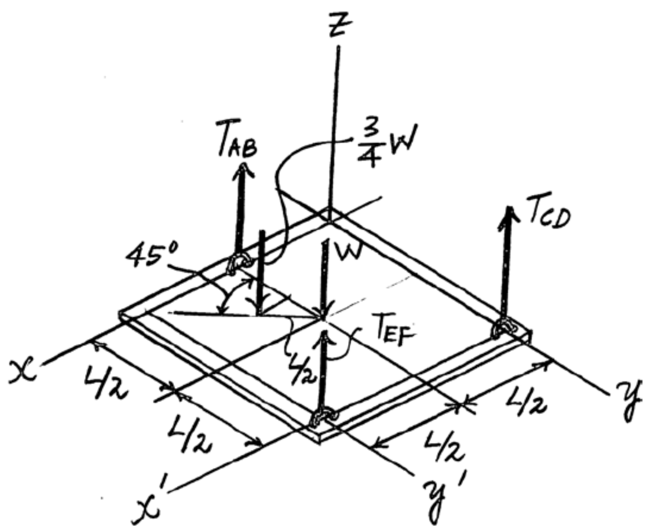
Using the above result and writing the moment equations of equilibrium about the y and y' axes,

$$\Sigma M_y = 0; \quad W\left(\frac{L}{2}\right)+0.75W\left[\frac{L}{2}+\frac{L}{2}\sin 45°\right]-1.1402W\left(\frac{L}{2}\right)-T_{EF}(L)=0$$

$$T_{EF} = 0.570\ W \qquad \textbf{Ans.}$$

$$\Sigma M_{y'} = 0; \qquad T_{CD}(L)+1.1402W\left(\frac{L}{2}\right)-W\left(\frac{L}{2}\right)-0.75W\left[\frac{L}{2}-\frac{L}{2}\sin 45°\right]=0$$

$$T_{CD} = 0.0398\ W \qquad \textbf{Ans.}$$



(a)